Inland fisheries of Europe

EIFAC TECHNICAL PAPER

52

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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by
William A. Dill
730 North Campus Way
Davis, California 95616

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PREPARATION OF THIS DOCUMENT

This document has been prepared in response to the recommendations of the European Inland Fisheries Advisory Commission (EIFAC) to present a synthesis of the state of inland fisheries in Europe. The individual summaries were prepared by the author, working in collaboration with the national authorities. Every attempt has been made to keep the document as up-to-date as possible, but changes in technical and political spheres in European life are proceeding at such a rate as to lead inevitably to some reducing of material.

The present document includes material from 22 European countries, and a second volume will be issued as and when summaries for the remaining countries become available.

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ABSTRACT

This document presents a summary of the geographical, historical, technical and institutional infrastructure of inland fisheries in European countries set out to standardize format for ease of comparison.

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I am particularly grateful to Dr R.L. Welcomme, Chief, Inland Water Resources and Aquaculture Service of the Fishery Resources and Environmental Division, and present Secretary of EIFAC, and Mr J.–L. Gaudet, former Secretary of EIFAC, and now Senior Fishery Planning Officer of the Fisheries Department of FAO, for their inception of this review, aid in obtaining information from official contacts in the countries treated, and patience during the years the review was prepared.

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Thanks are also extended to the EIFAC National Correspondents or their designees whose response to queries from the Secretariat of EIFAC concerning the inland fisheries of their countries helped prepare this review. Some of the Correspondents remained anonymous; their aid cannot be recorded. Others, acting in another capacity, but providing specific data on the waters or fisheries of the country indicated, are included among the “Correspondents”. They follow: Drs E. Kainz, E. Bruschek and J. Hemsen (Austria); Dr J.A. Timmermanns (Belgium); Mr A. Demetropoulos and Dr D. Stephanou (Cyprus); Dr J. Rosa and Dip. Ing. A. Szabo (Czechoslovakia); Dr J. Dahl (Denmark), Mr K. Westman (Finland), Dr H. Koops, Prof. Dr H. Mann, and Prof. Dr K. Tiews (Federal Republic of Germany); Drs K. Pint-r and Z. Thuranszky (Hungary); Mr T. Gudjonsson (Iceland); Dr C. Moriarty and Mr J. Power (Ireland); Drs C.M. de Angelis, E. Gelosi, M. Mancini and E. Sommani (Italy); Dr M.F. Broggi (Liechtenstein); Ing. N. Koenig (Luxembourg); Dr B. Steinmetz (Netherlands), Dr B. Jonsson and Mr K.W. Jensen (Norway), Drs T. Backiel, M. Bninska and M. Leopold (Poland); Drs H. Marrer and E. Staub (Switzerland); Dr F. Aksiray (Turkey); and Profs N. Fijan and K.M. Apostolski (Yugoslavia).

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Statistics on salmonoid culture have been provided by the Fédération Européenne de la Salmoniculture (FES).

Finally, I am grateful to my wife, Gail, whose continued support has been indispensable.

Overall responsibility for the present publication, including its evaluations and prognostications, rests squarely upon the writer. If any of these should be wrong, a likely occurrence when working at a distance both in time and space, both these and the inevitable errors of fact can be corrected by the countries involved.

[1] The term "late" has not been applied to any of these men or women even if they are deceased. Their spirit is still alive and some of the others may be "late" by the time this acknowledgement is published. After all, does one usually speak of the "late J.C.W.T. Mozart", or, to be closer in time, the "late H. Moore" or "late J.P. Sartre"?

CONTENTS

DEFINITIONS, SOURCES AND TREATMENT

1. THE TITLE

The term "inland fisheries" as used here is not closely defined because inland waters (eaux continentales) intergrade with the salty or euhaline waters of the sea. The waters discussed in this review include natural flowing or lotic waters such as rivers or streams, including their smaller elements such as springs, brooks, rivulets, or rills; artificial canals; and static or lenitic waters such as natural lakes and tarns, and artificial lakes or reservoirs. They also include lagoons (étangs, Strandseen, or Haffs), i.e., coastal areas of shallow static water which have a permanent or temporary connection with the sea. In general, the waters included are fresh or limnetic, but may also include those with a mixtue of fresh and salt water, known as brackish or mixohaline, characteristic of estuaries or river mouths, fjords, and lagoons. It must be noted that a "sea" such as the Baltic has such low salinity that it supports not only marine forms but some truly freshwater fishes. Conversely, some "brackish" waters of the Mediterranean (mixoeuhaline) may be more saline than the open ocean.

The fishes discussed are primarily freshwater forms, but also include the diadromous fishes which migrate between fresh and salt water; examples are the anadromous Atlantic salmon (Salmo salar) and catadromous European eel (Anguilla anguilla). Some of the brackish water or lagoon fishes are also included, e.g., the grey mullets (Mugil spp.), and gilthead (Sparus auratus). As stated above, although no exact definition of inland fisheries can be given, most of the European fishes of major economic importance which have general dependence on fresh or brackish water have been included. Freshwater crayfish are also discussed, but the crustaceans and molluscs of brackish water have not been included since the emphasis here is on finfishes. It is agreed that the distinction is somewhat arbitrary.[1]

The other part of the title, "Europe", refers to that part of the Eurasian continent west of the Urals excluding the USSR. The larger associated islands of the Atlantic and Mediterranean are included as is all of Turkey which is partly in Europe and partly in Asia. All of the European countries are reviewed except the Democratic Republic of Germany (for which data were not readily available), and Monaco and Vatican City (Holy See) which do not have inland fisheries.[2]

[1] Some of the difficulties inherent in distinguishing between inland and marine fishing areas, whether based on locality, species caught, craft, gear involved, or administrative agency, are discussed in Coordinating Working Party on Atlantic Fishery Statistics (1980) which says in part: "It has been suggested that the practice of declaring all waters above the mean tide levels, including the coastal lagoons and estuaries, as part of the inland water area, as being the only practical solution. These are the areas as recognized to be inland by IPFC, COPESCAL, CIFA and EIFAC."

[2] It should be noted that the FAO Yearbook of Fishery Statistics in its objective and all-inclusive way, continues to list the inland fisheries of Monaco and Vatican City as: "none", "nil", "zero", or "negligible".

2. GEOGRAPHICAL OR PLACE NAMES

An attempt has been made to use the same geographical or place names that are used in the country under discussion, within the limits that the alphabet or language permits.

However, "conventional" names have been used for certain geographical entities which are: (i) universally known by these names, or (ii) lie upon the borders of two or more countries which use quite different names. Examples of the first category are the use of "Rome" rather than the proper Italian Rome (since "Rome" is generally accepted throughout the world), or "Rhine" and "Danube" for these great international rivers which bear varying names throughout their courses and are better known by the more universal terms. As an example of the second category, the term “Lake Ohrid” is used for the international border lake known as Ligen i Ohrit in Albania, but as Ohridsko Jerezo in Yugoslavia.

When using place names which have several variations, an attempt has been made to indicate the name actually used within the country in question by underlining it the first time it appears. Thus, while discussing the Danube, the name Donau is indicated in Germany or Austria, in Czechoslovakia it is the Dunaj, in Hungary it is the Duna, in Yugoslavia and Bulgaria the Dunav, and in Romania the Dunărea. Standard accents or diacritical marks are generally used.

3. NAMES OF FISHES

For purposes of uniformity, the comon and scientific names of the fishes mentioned are, with but a few exceptions, those used in “European Inland Water Fish: A Multilingual Catalogue” (Blanc, et al., 1971) which was designed to stabilize nomenclature within the EIFAC countries. In general these also agree with those used in the FAO Yearbook of Fishery Statistics. When listed, the species usually follow the taxonomic order used in these references.

4. REFERENCES

References specific to only one country appear in section 10 for the country under review.

References referring to more than one country or of a general nature, such as a European geography, are listed under “General References”.

Not all of the references are cited in the text, but it is thought useful to list them as indicative of source material.

5. UNITS OF MEASUREMENT

The metric system is used throughout for all measurements of length, area, capacity, weight, temperature, time, etc.

The following abbreviations are used:

Millimetre	mm
Centimetre	cm
Metre	m
Kilometre	km
Square metre	m^2
Hectare (10 000 m^2)	ha
Square kilometre (100 ha)	km^2
Litre	1
Cubic metre	m^3
Cubic kilometre	km^3
Gramme	g
Kilogramme	kg
Tonne (metric ton)	t
Second	s or sec
Hour	h
Year	year
Cubic metes per second	m^3/s
Kilowatt	kW
Milligrams per litre	mg/l

Parts per thousand	ppt
Parts per million	ppm

6. EXPLANATION OF THE SECTION OUTLINE

0 - The official name of the country and status is consistent with that of the United Nations (UN).

1 - AREA: Derived from each country's own statistical yearbook wherever possible, otherwise taken from standard sources such as the UN Statistical Yearbook.

2 - POPULATION: For consistency, unless otherwise specified, derived from "World Population Prospects, Estimates and Projections as Assessed in 1984" (UN, 1986).

3 - PHYSICAL GEOGRAPHY: Wherever possible, each country's statistical yearbook or its other official publications have been used for specific data such as boundaries, dimensions, altitudes, etc. Otherwise, standard sources such as international yearbooks, basic geographies, or encyclopaedias have been used. Where authorities generally agree, it has not been thought necessary to reference each fact. References have been cited, however, where wide discrepancies occur (e.g., some of the tables on aquacultural production), or where credit seems due.

4 - CLIMATE: Statistical Yearbooks and other standard sources have been used.

5 - HYDROGRAPHY AND LIMNOLOGY: Official yearbooks or standard gazetteers have been used where possible to list the lengths of rivers or shorelines. Although an attempt has been made to achieve consistency, lengths have been calculated differently by different sources and so may not appear uniformly here. It is further to be noted that the grand total of river lengths given for any country or sub-area cannot be taken too seriously. River lengths are calculated from cartographic data. The reliability of the result depends upon the quality of the map, its scale, and the accuracy of the determiner. For example, Lockerman (1958) has pointed out that calculations of the length of the Nile vary from 6 484 km to 6 671 km depending upon whether one uses maps of the scale of 1:1 000 000 or mainly those of 1:250 000 and 1:100 000. Similarly, Håkanson (1978) has shown that a shoreline of a lake (e.g., Lake Vanern) is about 1 000 km if determined on a map on a scale of 1:1 000 000, but about 1 900 km from a map on the scale of 1:50 000.

Similarly, the number of lakes calculated for a country may depend upon the scale of the map used, as well as the definition of a "lake".

Statistics on runoff have been derived primarily from Van der Leeden (1975) and ECE (1978). More recent statistics are, of course, available, but their determination is often difficult, and there is some advantage in using a common authority (such as Van der Leeden) in order to make comparisons easier.

6 - LAND AND WATER USE: The percentages shown in the tables of Pattern of Land Use have been calculated from records of actual areas shown in the source.

Most railway and road statistics and passenger car densities stem from standard yearbooks or almanacs, or are based on calculations using data from other sources. The standard authorities differ greatly in their data concerning the length of roads and railways. Consequently, all such figures must be considered as relative.

Energy statistics, unless otherwise noted, are from the 1987 Yearbook of Energy Statistics.

7 - FISH AND FISHERIES: Although every FAO Yearbook of Fishery Statistics since Volume 36 (published 1974) has been examined for catch statistics, the final versions in the tables using FAO statistics were almost all derived as follows: period of 1965–69 from Vol. 36, period of 1984–87 from Vol. 64, and period of 1970–83 from the FAO Fisheries Department's Fishery Statistical Database (FISHDAB) which furnishes computer print-outs. FISHDAB is the most accurate source available for the FAO figures since it is updated annually, while the printed Yearbooks may provide provisional data which awaits revision. However, it must be noted that in the FISHDAB tabulations, unless the catches are reported numerically, i.e., from one metric ton up, the catch for an individual species or species group which is represented for each country appears there only as "0". In the printed Yearbooks this symbol or similar ones ("0.0" and "00") have had varying meanings, including "negligible" or "insignificant", or - depending upon the years of coverage - a variable numerical amount. With the general approval of the FAO Fishery Information, Data and Statistics Service, I have, therefore, lumped all the zeros to mean: probably nil, negligible or insignificant; or less than 50 metric tons during the 1965–73 period, or less than half a metric ton during later years.

7. MAPS AND TABLES

The maps, which are composites from many sources, usually indicate only some of the major geographic entities or points of reference (such as cities) which are described in the text. Often, only the larger or best known rivers, lakes, reservoirs, canals, or lagoons are shown. The same applies to regions, mountain ranges, bays, or other geographic units. In some cases, such as in the Netherlands where the hydrographic pattern is constantly changing, the maps can by no means be considered definitive.

For each country, the map precedes the text. The tables are numbered consecutively, from Table 1 on, within the report for each country.

N.B. National borders as at 2 October 1990

THE INLAND FISHERIES OF EUROPE

INTRODUCTION

> "Interest in freshwater fish and in the biology of fresh waters in Europe extends back for centuries". (A.V. Holden, Third Chairman of EIFAC, 1981)

This is an attempt to make a total review of the inland fisheries of Europe. In one sense, it is an "encyclopaedia": it strives to cover most branches of knowledge on the subject, is written with a broad brush, and is not completely plagued with every citation, equivocation, and reference used in some scientific papers. Being an encyclopaedia, it cannot be completely up-to-date, and in its original version was intended to be dependent upon secondary rather than primary sources - in short, a compilation of compilations.

> "That would be very simple if these blessed geographies, encyclopaedias and atlases were ever able to agree upon any given fact. But apparently they are not". (Henrik Willem Van Loon, 1940)

I have, therefore, had to alter the original plan, refer back to original sources, and cite them where it appears useful. (As Karl Lagler was wont to say: "In the event of doubt, return to the basic source.") To the extent that this has been done, it has increased accuracy, albeit at the expense of simplicity.

In another sense, this paper is a fishery "geography", since, with respect to each country of Europe, it treats of its location, physical features, climate, hydrography, and the use that is made of its land and waters as they influence its inland fisheries and aquaculture, both with respect to their early state and the ways in which these resources have been developed. There is precedent here for the use of the term "geography". Coull (1972) uses this term in his "Fisheries of Europe: an Economic Geography", although, misleadingly, his book is devoted to marine fisheries with the exception of 14 lines on Europe's inland fishery resources. Furthermore, as Mills (1895) said, in his "Bathymetrical Survey of the English Lakes": "Geography, rightly considered, is not a mathematical science concerned with the description and delineation of an unchanging arrangement… It has to take into account of processes of change, to concern itself with a certain range of time past and time to come, in order to comprehend the present position of affairs". This review has, therefore, attempted to trace some of the beginnings of inland fisheries in Europe and the trend of their development as a key to their future.

> "I shall have to go back…and trace my story from its small beginnings up to these recent times…" (Livy, ca 26 B.C.)

Having raised the question of historical background, let us consider the immediate forerunners of the present review.

Individual descriptions of the inland fisheries of a number of European countries have been prepared over a long period. But regardless of their quality or degree of completeness, many have had limited distribution or have been written in languages unfamiliar to many readers, and have thus lacked general accessibility. Some, when written by nationals or members of State fishery administrations, have, very naturally, tended to minimize the shortcomings of the national fisheries or to overpraise them. (How often have we not heard the phrases: "Teeming with fish", or "An angler's paradise", or "Managed in accordance with the most advanced scientific techniques"?) Furthermore, some of these descriptions are out of date or so vague that the reader cannot tell whether they refer to the present or to a state of the fishery ten or fifteen years ago.

Of even more importance, is the fact that when the material on each country is prepared by a different author and not published under a common and critical editorship, the different accounts are not readily comparable. It is difficult to determine: the relative type, size, or importance of their inland fisheries; the extent or manner in which they are changing; the state of their environment; extent of their exploitation; or methods of management. Without such facts, one cannot prognosticate their future.

In addition to such diversity in coverage, hence lack of ready comparability, the accounts or statistics of many inland fishery "catches" fail to distinguish between the harvest through capture from fisheries of open waters or those of large artificial reservoirs (whether stocked or unstocked), and the production derived from true aquaculture confined to units such as drainable ponds or tanks, or other enclosures where the fish are often fed (artificially or through augmented fertilization) and can be totally or almost totally harvested. Other difficulties with regard to statistics will be enumerated later in this chapter; they need not be considered here.

The conclusion, however, is that these and other problems have troubled the individual expository papers on European inland fisheries for many years. I have, therefore, accepted the principle of W.M. Chapman, perhaps the most knowledgeable fishery scientist of this century. As Chapman once told me, it is far better to have most of the information on one subject pass through the mind of one man and emerge as a synthesis rather than depend upon a collection of individual reports.

> "Look into your affairs often, and cause them to be reviewed…" (Sir Walter of Henley, 13th Century)

One of the first attempts to review the status of European inland fisheries in a comparable way was made by the Food and Agriculture Organization (FAO) in a paper prepared for the first International Inland Fisheries Meeting, held in Helsinki, 24–26 July 1956. Questionnaires on a given array of topics were sent to the then 20 FAO Member Governments of Europe. It was hoped that their response would inform these and other governments of what was being done in the field of European inland fisheries, and assist them to formulate policies for the development of this sector of their economy. The items covered for each country were: population, area, number and extent of water areas, number of fishermen, total annual catch, number of fish culturists, number and extent of fish farms, production through pond culture, and public stocking. Inquiries were also made as to: methods of management, protection of fish stocks, research programmes, and the extent of international cooperation. The document was presented only in tabular form as illustrative of what FAO hoped to present later in more comprehensive form (see FAO, Biology Branch, Fisheries Division, 1956). Following the Helsinki meeting, with information received from other European countries, the paper was revised for the inaugural session of the European Inland Fisheries Advisory Commission (EIFAC) held in Dublin, 25–30 April 1960 (see FAO, Biology Branch, Fisheries Division, 1960). Four years later, with the addition of new material and now representing 13 countries but with almost unchanged format, the tables were revised as EIFAC (1964).

Meanwhile, independently of the action taken above, the General Fisheries Council for the Mediterranean (GFCM) circulated a questionnaire to its Member Governments in 1958 to provide information on their inland fisheries. The data collected from six European countries, similar to that procured by FAO and EIFAC, were published as GFCM Secretariat (1959).

Despite these attempts by FAO, EIFAC and GFCM to provide an overall picture of the inland fisheries of Europe, and the subsequent issue by these agencies of a long series of papers on various phases of these fisheries, it was found that there were still great lacks in the information available. excessive detail or ambiguities in some responses, and obvious errors or inconsistencies in others.[1] Furthermore, reliance on tabular presentation alone did not really meet the ends of such a review: provision of a clear "picture" of a fishery, its geographical and hydrographical basis, and the keys to its future.

1 The subjects treated, together with bibliographical references, are listed in Dill (1976), Holden (1981), and subsequent publications by FAO, EIFAC and GFCM

Accordingly, the FAO Fisheries Department, in cooperation with the Secretariat of EIFAC, embarked upon a different approach to the matter. Under the direction of a single author, it produced a group of "country" reports for 25 European countries using easily available material supplemented by a few statistics derived from the EIFAC Member Governments through a questionnaire (EIFAC/74/Circ.10) issued November 1974[2]. This review, "The Inland Fisheries of Europe" was presented by the author as a meeting paper at the Ninth Session of EIFAC at Helsinki, 7–15 June 1976 (Dill, 1976). The Commission asked that it be expanded, and all of the EIFAC countries were requested through their official Correspondents to correct the paper so that it could be revised.

2 Response to this questionnaire and subsequent answers from the countries used in revisions are cited in the specific references as "(name of country)/EIFAC/(date)"

The author then worked intermittently on revision of the original paper, and completed the manuscript in 1985. Unfortunately, there were some financial difficulties in publishing it at that time, necessitating another revision based on the author's compilations during the next five years, as well as another series of reviews by individual EIFAC countries.

Most, although not all, of the countries have supplemented the Helsinki draft, but no additional questionnaires have been sent to them, and greater reliance has been placed on using the literature emanating from or descriptive of the countries. Furthermore, an attempt has been made to correct past mistakes in reporting, or - lacking the information to correct them - at least document their origin. As already stated, this has made the revision a bit more intricate, but has also made it more accurate. The components of the present review and some of the reasoning behind their selection are described below.

> <u>"Ordinarily treated, the river is like the veins of a leaf; broadly viewed, it is like the entire leaf"</u> (William Morris Davis, 1899)
>
> <u>"…the river cannot be understood without some knowledge of what happens on the land around it"</u> (E.D. Le Cren, 1972)

In short, we cannot consider the fisheries unless we have some knowledge of the waters which hold these resources, and neither rivers, lakes, or other watercourses can be understood unless we have some knowledge of the land or the geography of the considered country.

An outline of the material intended as coverage for each country in this new review is given in Table 1. (The same general form has been adopted for use in resource surveys for the countries of other continents by FAO's Fishery Resources and Environment Division, and was used by Dill and Ben-Tuvia (1988) in describing the inland fisheries of Israel, an EIFAC country although not on the continent of Europe.)

Although information on each subject within the outline has not always been available for each of the countries, its components represent an ultimate checklist of the material considered desirable to present. An explanation of terms used in this review, and the derivation and use of information is given in the chapter entitled “Definitions, Sources and Treatment”.

With respect to each country in the review, the sections of Table 1 numbered 1 to 5 describe its location and its physical and biological features. Why are all of the components included? A few examples should suffice. For example, area and population not only present an immediate impression of the size and importance of a country, but are among its determiners of fishing pressure and the necessity or ability to manage a fishery. Latitude affects the rhythm of daylight and dark, which in turn may influence both productivity and reproduction, and coupled with altitude is a determiner of lake circulation. The basic rocks, soil, vegetational cover, and man's cultural elements determine water chemistry, and this in turn aquatic productivity. Climate affects water temperatures. Most freshwater biologists consider the thermal regime of a river as the primary physical factor influencing its aquatic life, and river water temperatures follow the mean air temperature. Climate determines the growing season, fishing seasons, and the transport of fishery products. Obviously, the number and size of the rivers, lakes and reservoirs, their physical attributes, and their hydrological regimes, are all among the determiners of their faunal assemblages and their types of fisheries.

> “We may conclude then that in every respect the valley rules the stream…It is also clear that changes in the valley wrought by man may have large effects” (H.B.N. Hynes, 1975)

Furthermore, the fisheries cannot be understood without knowledge of man's use of land and water. Some of the changes engendered by this use are very old, for example, the early destruction of forests in Cyprus, or the drainage of lakes to create agricultural land as practised by the ancient Romans. Some of the changes are very new, for example, the disposal into streams of oxygenconsuming effluents from concentrated feeding lots for domestic animals, or entrance of warm water from nuclear plants.

Some effects on fisheries of man's land and water use are immediately apparent, e.g., the erection of a dam which creates a new lenitic entity but bars ascent of migratory fishes, the abstraction of water from a river for hydroelectric or irrigation use, or construction of a canal that enables mixing of fish stocks from formerly discrete drainages. Other changes are more subtle, e.g., the replacement of a mixed woodland with one species (today, usually a conifer) with a subsequent change in the supply of ions in the river system which may lead to changes in the composition of its fish population. Pollution, population pressures, increased ability to exploit fisheries through road construction or vehicle ownership; all of man's uses of his lands and waters are vital in determining the type of fishery, its size, quality, use, and duration.

Fundamental to maintenance of a fishery is a supply of water adequate in quantity and quality. Fish must share this water with other users, but their mutual supply is finite, and in most countries there is an intense competition for its use. The actual amount of water used (for agriculture, industry and domestic supply) depends upon many factors such as rainfall, soil, prevalent crops, and degree of industrialization. Thus, in Hungary, for example, agriculture uses about 30 percent of the water and industry uses about 25 percent. At the other end of the European scale, the United Kingdom uses only about 1 percent of its water for agriculture and about 75 percent for industry. It requires about 12 000 litres of water to produce 1 ton of sugar beets, or 500 000 litres of water to produce 1 ton of wheat. Thirty-five thousand litres of water are required to make a ton of woodpulp in Finland. It requires 295 000 litres of water to make a ton of steel, or 2 000 000 litres of water to produce a ton of rayon in Belgium. It takes 30 000 litres of water to do a ton of washing in Sweden, 90 litres of water to produce a litre of beer, and in the UK, about 20 percent of the water is used just to flush toilets.[1] Fisheries must compete for water for all such uses. As G.F. White (1977) said: “There is a continuing strain between power development and fisheries, between irrigation and fisheries, and between different territories within a river basin…These conflicts cannot be fully eliminated but in many instances can be softened”[2]. Section 6 in each country review treats of some of these problems.

1 Sources for these or similar statements are found in: Smith (1972), Van der Leeden (1975), Hardy (1977), ECE (1978), and USSR (1978)

2 Surprisingly enough, many geographers of Europe spend for more time on a discussion of the geological events that shaped a country than the present hydrography or land and water use. An exception is Hoffman's 1977 “Geography of Europe” which stresses both the effects on the continent caused by man's activities, as well as those engendered by the physical bases. With respect to the influence of man's land and water use on inland fisheries and what can be done about it, simplified outlines are found in Le Cren (1972), and Dill, Kelley and Fraser (1975)

Table 1

Country outline - Inland Fisheries of Europe

0. COUNTRY NAME (Resume)

    Official name, location
    Description
    Hydrography/limnology
    Land and water use
    Fish, fishing, aquaculture
    Prospect

1. AREA (Year if variable)

2. POPULATION (Year) - Density

3. PHYSICAL GEOGRAPHY

    General location
    Latitude and longitude
    Distance from other areas
    Dimensions
    Altitudinal ranges
    Boundaries
    Coastline: length, type, islands
    General description: geology, physiographic areas, mountains, plains, swamps, drainages, etc.
    Vegetation, forests, etc.
    Rocks, soil
    Cities, villages, ports

4. CLIMATE

    Type, zone
    Temperature: mean annual, summer, winter ranges
    Precipitation: mean annual, range (annual and areal)

Frost, snow, ice, glaciers
Growing season
Evaporative rate
Sunshine: length, radiation

5. HYDROGRAPHY AND LIMNOLOGY

Area and percent of inland waters
Runoff (rainfall, upstream, leaving the country)
Drainage in general: slope, pattern
Types of waters

5.1 <u>Rivers</u>

Number, size, length, area, basin
Discharge
Major rivers: length, direction, flow, type, use, fishing
Faunal zones
Gradients, falls, canyons, etc.
International rivers

5.2 <u>Lakes</u>

Location, number, origin
Type
Area, depth, volume, elevation, dimensions
Retention time
Water chemistry, productivity
Major lakes: description, fish, fisheries

5.3 <u>Reservoirs</u>

As above
Types of dams and regulation and use

5.4 <u>Canals</u>

Location, number, types, use
Fish and fisheries

5.5 <u>Other waters (Fjords, lagoons, coastal, etc.)</u>

As above

6. LAND AND WATER USE

Table of land and water use
Rural or urban
Agriculture: crops, animal husbandry, drainage, fertilization, pesticide use, etc.
Irrigation: extent, type, dams
Forestry
Mining
Industry: extent, location, type
Power: hydro, thermal, nuclear
Transportation: canals, highways, railroads
Ground water
Pollution
Fisheries: marine, inland, aquaculture

Tourism
Overall water use and demand

7. FISH AND FISHERIES

Species: number, types, special groups, exotics

7.1 Capture Fisheries

Major concerns, conflicts, etc.

7.1.1 Commercial fishing

Catch, 1965–83
Where practiced
Catch of specific groups
Methods
Number of fishermen
Economics

7.1.2 Sport fishing

Catch
Where practiced
Species and how classed
Catch of special groups
Methods
Number of anglers: domestic, foreign
Economics

7.2 Aquaculture

Species involved
Type of culture (pond, raceway, etc.)
Production (kg/ha/yr)
Seasons, growth, size
Use: consumption, stocking, export
Imports/exports
Special aspects: lagoon culture, sea ranching, etc.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS

8.1 Ownership and availability

8.2 Administration: concerned Ministry and Divisions

8.3 Management: legislative authority, licensing, revenue, methods, etc.

8.4 Investigation: scientific services, research

8.5 Taining

8.6 International agreements

9. STATE OF THE FISHERY

9.1 Yield

By unit area (productivity and to fisherman)
Changes in yield (weight, species)
Aquacultural yield

9.2 Factors affecting the fishery

Inland waters: extent, size, type, variety
Species present
Terrain, climate, growing season, etc.
Populatin density
Land and water use
Pollution
Runoff per caput
Accessibility to fish
Fishing tradition
Revenue
Management
Aquacultural considerations

9.3 Prospect

The future of inland fisheries, especially those concerned with land and water use
The relative roles of commercial and sport fisheries
The role of aquaculture

10. REFERENCES SPECIFIC TO THE COUNTRY

Only those specific to the individual country and not listed in the General References.

"Fish that are generally thought to be the same are given different Latin names when they cross political borders." (Lindsey, 1988)

With sections 1 to 6 as background, we finally come to fish and fisheries themselves (section 7 in each review). The inland fish fauna of each country can be determined in many scientific and popular publications; some of the principal references are listed in this paper. It is been thought useful, however, to use one standard reference and a standard order as far as possible (see Names of Fishes in the next chapter). Furthermore, little attempt has been made to discriminate closely between species or sub-species. For example, most of the white fishes or coregonids (Corigonidae) are simply listed as Coregonus spp.[1].

1 "The systematics of whitefish has long been a field of intense research, and taxonomy one of fervent dispute" (Heinonen, 1988). Many lakes contain more than one (sometimes as many as five) fully sympatric native stocks. Introduction of coregonids by man has created new problems, and factors such as transplantation, pollution, or over-fishing often lead to hybridization or introgression

"It is an interesting aside that unreliable statistics plague fishery evaluations. The lack of reliability seems to stem from the desire of the data gatherers to please 'rather than be honest'." (SCOPE, 1972)

The term "fisheries" itself concerns catch or capture or sometimes "production" through aquaculture. Here one requires - or at least desires - accurate statistics. Unfortunately, at least the first sentence of the quotation given above appears to hold for many of the European fishery statistics.

There are many reasons for unreliability in inland fishery statistics. First of all, the nature of the fishery (often small, widely dispersed, or infrequent) makes it impossible to have frequent checks by competent authorities. Often the catches are reported voluntarily. Many of these are reported inaccurately, sometimes by design in order to avoid taxes. Other reports of capture which are dependent upon questionnaires lack accuracy either because of design, inertia, or perhaps faulty memory. Sometimes, even when a governmental office collects rather accurate statistics they are altered by another (governmental) office either through lack of knowledge of the subject, to fit in with an established pattern, or perhaps to pad the results in order to appear more important. Some statistics are simply carried over from one year to another without change. Some are simply sloppy.

But even if the original statistics are reported reasonably accurately in a governmental publication, their subsequent appearance in secondary or tertiary sources is often incorrect. The Organisation for Economic Co-operation and Development (OECD) has been a decided offender in this regard with respect to some of its figures on aquacultural production. For example, OECD (1986) has used the term “sea trout”, which should be applied only to the species Salmo trutta, to mean any trout raised in sea water. Thus it may actually be speaking of rainbow trout (Oncorhynchus mykiss). OECD has also often used the term “aquaculture” as synonymous with “inland fisheries”. A third fault of some OECD statistics has been their failure to distinguish between round or live weight and gutted weight, even though the original statistics have been perfectly clear (e.g., Norwegian statistics which say, in two languages: “Tonn rund vekt” and “Tons live weight”).

The FAO Yearbook of Fishery Statistics (and some other FAO publications) all secondary sources-have also made mistakes in their interpretation of governmental statistics. (It must be emphasized here that the Organization relies upon the receipt of accurate information from its Member Governments; it does not create the statistics.) Nevertheless, it too has confused species (listing the Swiss “Weissfische” as coregonids rather than as cyprinids as intended (see the chapter on Switzerland). It has been - at the least - confusing through its original policy of combining the actual “catch” from commercial capture fisheries with “production” from commercial aquaculture, and in some cases by confusing the catch of recreational fishermen with that of commercial fishermen. It has also been guilty of not always distinguishing between the production used for stocking (e.g., fry or yearlings) from the marketable or consumable product.

One fault with some of the earlier statistics in the FAO Yearbooks was that originally the inland catches were presumed to be inconsequential in comparison with the gigantic catches made by some of the sea-fishing countries, and were therefore rounded off or placed in mediocre categories such as “not available”, “none”, “nil” or “zero” or given a symbol denoting a very small quantity. Another fault lay in the fact that even in cases where FAO had misinterpreted the original data (for which it could often be excused), the country contributing the data seems rarely to have informed FAO of the mistake.[1]

1 It seems probable to me that errors in the citation of marine catches were caught at an earlier stage

Various examples of errors and misinterpretations, especially in the FAO Yearbooks of Fishery Statistics are given in the text for individual countries. The reader may think that I have over-elaborated some of the weaknesses of these Yearbooks. One should note, however, that I have drawn freely from them and included one or more tables of “nominal catches” for most countries which are based upon their information. Despite any present faults, the FAO Yearbooks of Fishery Statistics provide the finest secondary "catch" statistics in the world, are the easiest to obtain, and are the recognized sources for many other publications. They indicate the trends in fishery development, and the author's "criticism" stems only from a strong desire to improve them.

Furthermore, steps have already been taken to correct some of the deficiencies. Some of the considerations with respect to these were outlined by the FAO Inland Water Resources and Aquaculture Service (1984), and at the request of EIFAC, FAO has begun a special inland water "catch" enquiry (personal communication from M.A. Robinson, 20 March 1990). Noteworthy among the advances made has been the issuance of "Aquaculture Production 1984–87" by the FAO Fishery Information, Data and Statistical Service (FAO Fisheries Circular No. 815) in January 1989 and its subsequent Revision 1 in November 1989. Eventually, a system may be erected which will provide far greater accuracy.

It is also apparent that many of the recent non-FAO statistics on inland fishery catch and aquacultural production are misleading. As with the FAO figures, I have attempted to interpret them whenever possible. Meanwhile, note that any statistics reproduced here - whether derived from FAO, other intergovernmental agencies, individual governments, or other sources - lack complete reliability. They are often based on what is most readily available to the interested public, and are often copied from secondary sources without being checked for accuracy. They are often estimates, in most cases these are probably too low, and some of them will have changed by the time this review has been published. As the Goncourt Journals of 1861 said: "La statistique est la première des sciences inexactes".

> "<u>… in considering the management of a fishery for any specific purpose, it is sobering to know that the majority of constraints arise externally to the fishery</u>" (R.L. Welcomme, 1978)

Section 8 of the outline, which treats of the ownership of waters, the administration, management and investigation of inland fisheries, and international agreements concerning fishing waters, may be balanced by the quotation above. I have emphasized this conclusion in another paper, pointing out that the patterns of change in fisheries and their consequent changes in administration and management are due to a multiplicity of factors in which, for example, fishing itself is only one element (Dill, 1978).

One should also note that section 8 is probably obsolete already. Sometimes the changes in administration and management are only cosmetic, i.e., the same people or groups continue to do much the same work only under different titles. On the other hand, sometimes the changes are of a more fundamental nature, e.g., a country that has had a strong central system of research or management may shift to one where greater reliance is placed upon regional offices. In passing, one might note that one European country changed the Ministry in charge of inland fisheries four times in as many years!

Finally, section 9 attempts to describe the yield from Europe's inland fisheries, bring together the factors affecting both capture fisheries and aquaculture, and indicate their prospect. Again, one must conclude that the land, valley, and their use by man rule the fisheries, and to quote Welcomme (1978) again it is now apparent that:

> "<u>It seems to be a general rule in industrialized countries where food is readily available, that there is a succession in fisheries use from subsistence to commercial to recreational use".</u>

In Summing it up

Although now small economically from a commercial standpoint, the inland fisheries of Europe are an important part of our culture and they and their waters deserve recognition. Most encyclopaedists, geographers and compilers of national yearbooks seem not to have recognized this point. Thus, the land and water use table of the Swiss Yearbook of Statistics classes its lakes and rivers as "unproductive" areas. (They furnish at least 15 percent of the country's consumable fish supply and are certainly "productive" of recreation and tourism.) Aside from such derogation of the hydrological resource, and despite the absorbing European interest in fish and fishing, most of these books provide a minimum of information on the subject. For example, in all of its 490 pages, the official handbook "Britain 1979" in its section on "fauna", devotes 22 lines to birds, 13 to mammals (including those extinct), 10 to insects, 6 to its 14 species of reptiles and amphibians, and only 8 lines (of which 4 are on water pollution) to its 30 or more species of freshwater fishes. This minimal treatment of fish is in a country where angling is the second most popular sport for males. "Modern Switzerland" (1978), a book of 515 pages, which has chapters on food production, tourism, and leisure activities, mentions such uses of water as: swimming, canoeing, sailing, and (when congealed) curling, but has not one word on the fishes or fishing in Switzerland. To mention one more official yearbook, the Annuaire Statistique de la France (1986), reporting on a country thronged with fishermen and in the top European bracket of commercial trout production, provides no information on either its catch in the inland capture fishery or its trout culture, although it does provide statistics on the female members of the "Fédération française de twirling batôn".[1]

[1] The number of licenses in 1986 was 16 858

Well, this present review is also deficient in not telling one everything one might like to know about the inland fisheries of Europe. It rarely considers, for example, either the politics or the economic structure of any country. It is fully recognized that the type of fishery development within each country is dictated to a considerable extent by its type of government. However, the type of economy, whether capitalistic, planned, or a mixture of both, of most European countries is well known to most readers. If one wishes to glean figures on GNP, market data, population growth, or economic structure one can turn to many other publications. Moreover, the fact that this review is published under the aegis of an impartial international organization and that many governments (and, therefore, their fishery policies) may change almost overnight - witness the startling recent changes - has determined my reluctance to enlarge upon this issue.

It is also true that this review is not completely up-to-date. However, the statistics of many countries are often not issued until several years after the data are collected, and inquiries made of various countries have sometimes required a year or more for response (same have never responded).

It can also be admitted that the amount of space given to each country or to each segment within a country is unbalanced. To a large extent this is due to the amount of information that has been available to me rather than to the importance of the subject. Better unbalanced, however, than to have no review at all.

I have two last apologies. There are numerous minor discrepancies with respect to statistics on total yield, or catches, or various other data. Such minor differences (often emanating from different sources or published at different times) are obviously of little importance. Had I been unduly concerned with such matters, the space in this review devoted to footnotes might approach that devoted to text. Moreover, actual figures often mean little to the reader; therefore, proportions, ratios or percentages are often substituted. It is the trend which is of most importance.

The last apology is that there is a good deal of repetition. It has been thought best, however, to repeat something (such as the scientific names of fishes) so that the sections on an individual country can be read without reference to another portion of the paper.

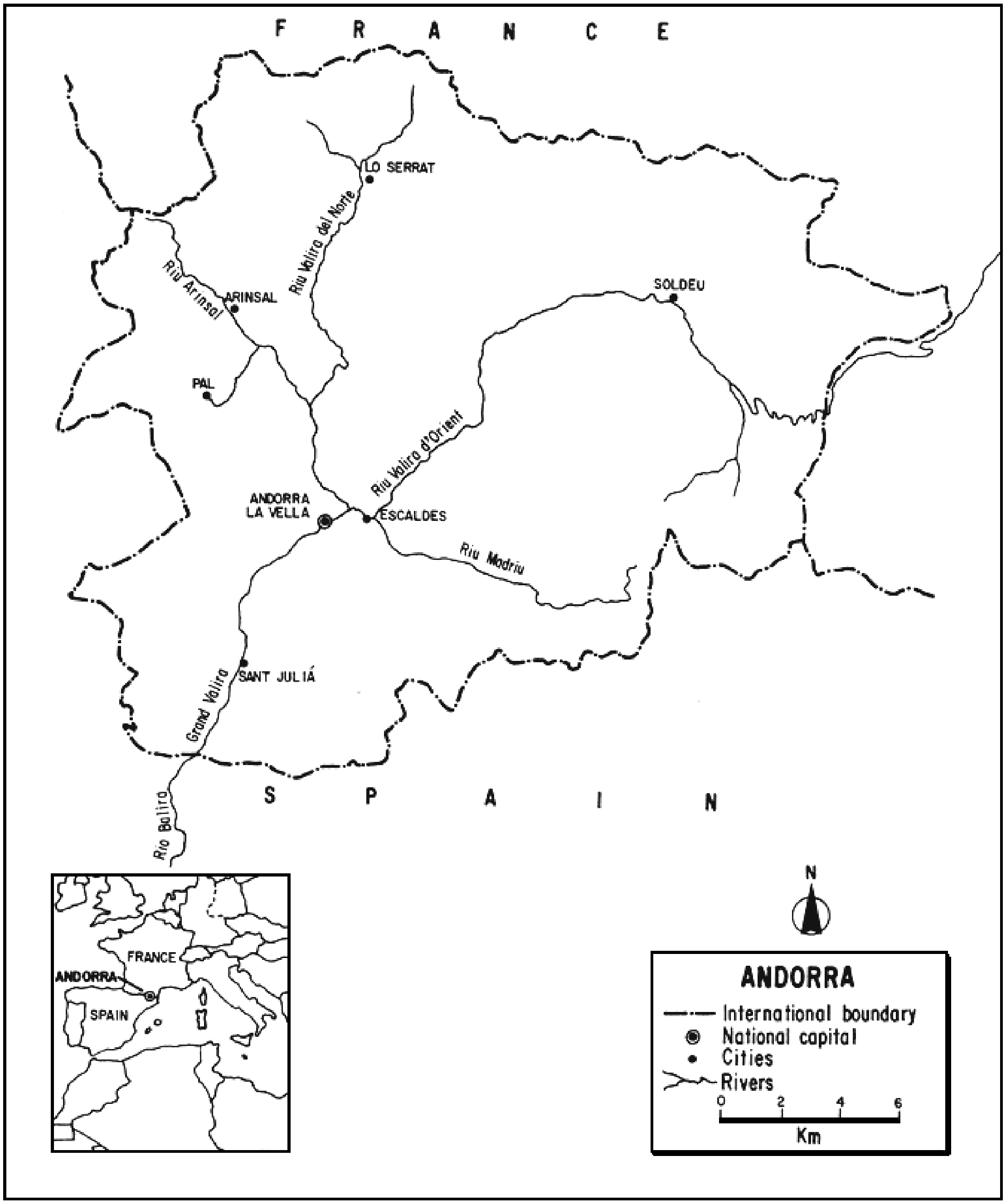
I conclude, therefore, with C. Delano Smith (1979):

> "…it has to be admitted at the outset, this is a book destined soon to be rewritten. But there comes a time in the history of every subject when a total review is necessary, if only to see the way forward."

It is believed that the outline is sound, that much of the material will be useful for many years, and that the text can be amended easily. Furthermore, it is hoped that when authentication of more data is really needed, that it will be exact, well referenced, and not glossed over in an attempt to create an aura of contemporaneity.

With a history of over thirty years of working with European fishery scientists, aquaculturists, and administrators, including six years as Secretary of EIFAC, I consider this review to be a labour of love.

William A. Dill


F R A N C E
LO SERRAT
Riu Valira del Norte
Riu Arinsal
ARINSAL
SOLDEU
PAL
Riu Valira d'Orient
ANDORRA
LA VELLA
ESCALDES
Riu Madriu
SANT JULIÁ
Grand Valira
S P A I N
Rio Balira
N
FRANCE
ANDORRA
SPAIN
ANDORRA
International boundary
National capital
Cities
Rivers
0 2 4 6
Km

ANDORRA

The Valleys of Andorra is an autonomous co-principality in the Eastern Pyrenees in southwest Europe. Bounded by France and Spain, it is under their joing suzerainity.

Largest of the mini-states (after the Holy See, Monaco, San Marino, Liechtenstein and Malta), its agricultural and pastoral economy has shifted to tourism and trade.

Its terrain is high, its climate is alpine, and it has only one river basin, the Valira. Its fishing is one of angling, especially for trout and pike.

1. AREA: 453 km^2

2. POPULATION: 48 000 (est. 1987) Density: 106 inh/km^2

3. PHYSICAL GEOGRAPHY

The co-principality of landlocked Andorra is situated between 42°26' and 42°39'N latitudes and 1°25' and 1°48'E longitudes, on the southern slopes of the Eastern Pyrenees.

Roughly circular, it is only 30 km (E–W) long and 27 km (N–S) wide. Its altitudinal range is from about 900 m to 3 050 m with an average elevation of about 1 830 m.

Andorra has a perimeter of 125 km, being bounded by France on the north and east for 60 km and by Spain on the south and west for 65 km.

It is surrounded by peaks, 1 500 to 3 000 m in height except on the southwest and most of the country is mountainous, with gorges, defiles, narrow valleys which end in steep cirques, and little level surface. Chestnut and walnut trees grow only at the lowest elevation, evergreen oaks, birch, pines and firs are common in higher areas. There are, however, no trees at the highest altitudes which support only alpine plants.

4. CLIMATE

The climate is temperate, alpine, cool and dry. The summers are warm or mild. The winters, at this high elevation, are severe with a long and heavy snowfall that blocks passes and remains for several months. The temperature varies greatly with altitude. Most of the rain falls in spring and autumn. The driest month is January with 74 mm and the wettest is May with an average of 105 mm.

5. HYDROGRAPHY AND LIMNOLOGY

Situated in a single drainage basin, Andorra's main stream, the Riu Valira (also known as Balira), only about 52 km long, has two distinct branches. One of these, the Valira del Norte (24 km), and its principal tributary, the Arinsal River, drain western Andorra. The Valira del Orien (28 km) drains the eastern part and has a tributary, the Madriu. The two branches unite in southwest Andorra to form the Gran Valira which leaves the country to join the Segre River 11 km south of the border in northeastern Spain. The Segre is a tributary of the Ebro; thus, all of Andorra's drainage is Mediterranean.

There are also some small natural lakes, and there has been impoundment for hydroelectric purposes. Lake Englolasters in south-central Andorra has had its water level raised 10 m by a dam.

6. LAND AND WATER USE

The exact extent of inland water in Andorra with respect to the total area of the principality cannot be determined from easily-available land use tables such as Table 1. It is obviously very small.

Table 1

Pattern of land use in Andorra, 1986

	Percent
Arable and permanent crops	2.2
Permanent pasture	55.6
Forests and woodland	22.2
Other land	20.0
Total	100.0

Source: 1987 FAO Prod.Yearb., 41 (Publ. 1988)

Because of its mountainous nature, less than 3 percent of the land is suitable for crops despite terracing at higher elevations. In addition, drought above 1 400 m and flooding by seasonal torrents at lower elevations places restraints on agriculture. There is, however, some irrigation using surface water, especially in the high meadow areas. Tobacco, cereals, potatoes and vegetables are cultivated. Most of the cropped land is used for hay production for animal feed. Cattle, goats and especially sheep are grazed as a principal use of the land. They follow the seasons, grazing at higher altitudes during the summer, and a considerable number of sheep are brought in from France and Spain.

There is a little quarrying and mining for iron, lead and alum.

Once densely forested, much of Andorra's forest land has been destroyed by over-grazing and use for charcoal. Today, reforestation, chiefly with pines, is progressing, and rotational cropping is practised. Nevertheless, the forested area is decreasing.

The hydroelectric potential is still large, although a number of hydroelectric plants have been established. Energy production from this source was about 110 million kWh in 1973 (U.S. Dept. State, 1982). Most of the power is exported to France and Spain.

Industry is very light, concentrating on tobacco, woollen products, furniture, leather and distilled liquors.

There are no international airports or railways in Andorra, and the road system is not extended. It is, however, adequate for the country, having a density of about 0.2 km/km^2 (1979) and there is a high percentage of automobile ownership, about 620 per 1 000 people (1983). Buses are, however, the principal of mass transport.

Tourism has become the principal industry of this formerly pastoral country. Trade, duty-free markets, fairs, festivals and skiing contribute to this. In 1982, about 73 percent of the population was foreign, and about ten million people visited the country. There is a heavy concentration of people in the capital, Andorra la Vella, leaving much of the country in a still rural state where both angling and hunting (there is a season for chamois) continue.

7. FISH AND FISHERIES

No catch statistics for Andorra's fisheries are available. The FAO Yearbooks of Fishery Statistics merely indicate that they are nil or insignificant.

The streams contain brown trout (Salmo trutta), the introduced pike (Esox lucius), other freshwater fish and crayfish.

There is some sport fishing - trout fishing in Andorra is often praised in popular accounts - and probably some subsistence fishing as well. Most of the fish for domestic consumption are, however, imported from Spain.

No information on aquaculture in Andorra is available.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION

No information on the administration and management of fisheries in Andorra is available to the author.

The overall governmental authority is shared equally by the President of France and the Bishop of Urgel in Spain. There is a general legislative Council of the Valleys, and a system of local government within the principality's seven parishes.

9. STATE OF THE FISHERY

The topography and climate of Andorra indicate that it has suitability only for the colder water species of fish, a short growing seasons and limited production. The yield is obviously small in view of the size of the country and its waters.

9.1 Prospect

Sport fishing, especially for trout will continue on a limited basis and as a minor tourist attraction.

Unless the pattern of land and water use changes drastically, Andorra's water should remain suitable for fishing.

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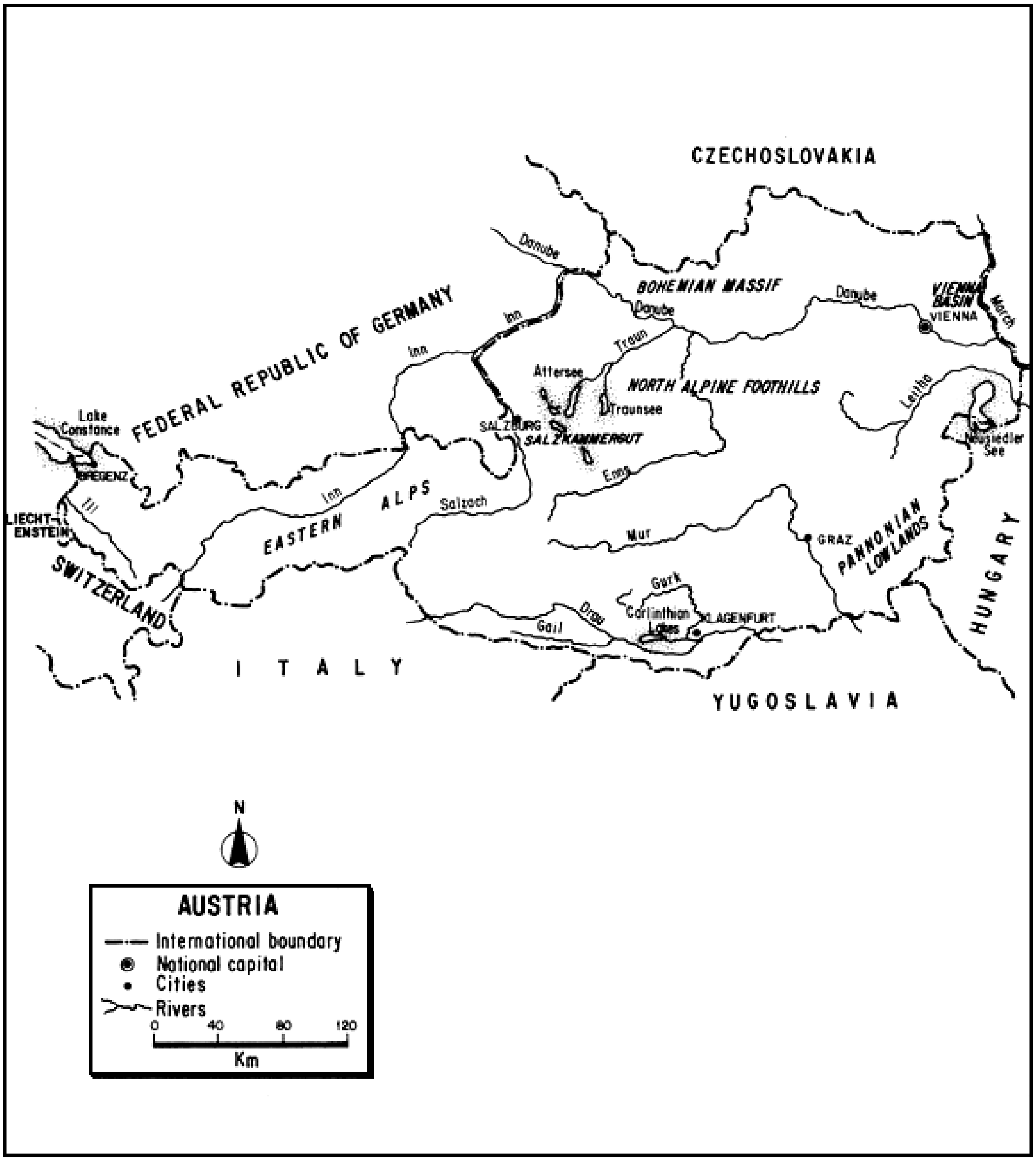
Anon., Andorra (Lingua Catalana - Lengua Española). Llibre Turistic. Colleccio “As de Coeur”, 64 p. (Undated but published after 1981)


CZECHOSLOVAKIA
FEDERAL REPUBLIC OF GERMANY
Danube
Inn
BOHEMIAN MASSIF
VIENNA BASIN
VIENNA
March
Treun
Attersee
NORTH ALPINE FOOTHILLS
Traunsee
Leitha
Lake Constance
BREGENZ
SALZBURG
SALZKAMMERGUT
Neusiedler See
Enns
Ill
LIECHTENSTEIN
Salzach
EASTERN ALPS
Mur
GRAZ
PANNONIAN LOWLANDS
SWITZERLAND
Gurk
Drau
Carlinthian Lakes
KLAGENFURT
Gail
HUNGARY
ITALY
YUGOSLAVIA
N
AUSTRIA
International boundary
National capital
Cities
Rivers
0
40
80
120
Km

AUSTRIA

The Republic of Austria, the most mountainous state in Europe after Switzerland, lies in central Europe surrounded by seven other countries. Dominated by the Eastern Alps and the Danube drainage, this forested country is threaded by swift mountain streams and has a complement of large and beautiful Alpine lakes.

Good care of forests and water has a long tradition in Austria, but effluents from ever-increasing industry and more intensive agricultural practices have created severe pollution problems in some areas. Of late years, there has been a moderate growth in aquaculture, especially of trout, but a decrease in commercial fishing - now almost completely confined to lakes. Sport fishing for cold water species continues to be the dominant aspect of Austria's inland fisheries.

1. AREA: 83 855 km^2
2. POPULATION: 7 507 000 (est. 1990) Density: 90 inh/km^2
3. PHYSICAL GEOGRAPHY

Austria is situated between 46°22' and 49°1'N latitudes and 9°32' and 17°10'E longitudes in southcentral Europe.

Its extreme length is 573 km (E–W); its greatest breadth is 294 km (N–S). However, shaped like a pear, its long western neck which occupies about half the length of the country, is sometimes only 34 km in width. Two-fifths of the total area are higher than 1 000 m. The highest point is 3 797 m; the lowest is 115 m (Neusiedler See).

Austria is bounded on the north by the Federal Republic of Germany for 815 km, on the north and northeast by Czechoslovakia for 574 km, on the east by Hungary for 354 km, on the south by Yugoslavia for 330 km and by Italy for 430 km, on the southwest and west by Switzerland for 168 km, and by Liechtenstein on the east for 36 km.[1]

[1] The boundaries of these frontiers are taken from Republik Österreich (1986)

Austria falls into five geographical units:

(i) The Eastern Alps, averaging about 900 m in elevation, occupy most of the country's western neck. Constituting about 63 percent of the country, they fan out as they cross the country easterly. These Alps are divided into three chains: a northern range of limestone, a high central Alp of crystalline rocks, and a southern limestone range, the Carnic Alps and Karawaken. The three chains are separated by great furrows: the Inn, Salzach and Enns in the north, and the Mur, Mürz, and Drau in the south.

(ii) The North Alpine Foothills, about 300–750 m in elevation, extend across the expanded eastern extension of the country to the Carpathian Foothills in the extreme east. Collectively, this area constitutes about 11 percent of the country's area.

(iii) The Bohemian Massif or Plateau, north of the Foothills, is separated from them by the easterly flowing Danube which traverses the country. These granitic and gneissic highlands rising to about 1 000 m constitute about 10 percent of Austria.

(iv) The Vienna Basin in the extreme east is a small (4 percent) but fertile area, about 150 to 450 m in elevation.

(v) The Pannonian Lowlands, south of and separated from the Vienna Basin by the Carpathian Foothills, occupy the eastern and southeastern zones of the country (about 12 percent) and include the lowermost area of Austria, the Neusiedler See.

Austria is well wooded except at high altitudes (above about 2 100 m) and in some of its lowlands. Below the topmost Alpine areas of bare rock, ice and snow fields are extensive mountain meadows and forests. Above 1 200 m, the forest is mostly coniferous (spruce, fir, pine and larch); below this level deciduous trees such as beech, birch and oak are dominant. Large areas below 600 m have been cleared for agriculture and summer pastures break the forest land above. In the lower, drier areas, especially in the east, there is a steppe vegetation of coarse grasses and shrubs, and there are extensive reed beds (Phragmites) around the Neusiedler See.

Most of Austria's arable land lies in the eastern lowlands where loess has helped form good black earths, brown soils and loam. But as one proceeds west the percentage of arable land declines to form less than five percent of the land in the western neck. The Alps themselves (see above) are divided into: limestone and flysch (eroded sandstone) in the north, granites and gneisses covered with schists in the central area, and limestones and dolomite in the south. The productivity of the lakes in the Eastern Alps is partly dependent upon these mineral bases.

4. CLIMATE

The temperate climate is not extreme but varies sharply owing to great differences in elevation. Summers are relatively cool, winters are mild with much rain in the lowlands and heavy snow in the mountains.

The average annual temperatures in the valleys range between 7° and 10°C; in the mountains they drop to -6°C or lower. In the valleys the highest average monthly temperatures (usually in July) are 17° to 21°C, while the lowest average monthly temperatures (January) are -1° to -7°C.

The average annual precipitation is 1 200 mm rising to a maximum of 3 000 mm in the mountains although less than 500 mm in parts of the eastern plains. The highest incidence of rainfall is in the summer. Snowfall varies from about 500 mm in the east to 10 m or more at high elevations. Snow covers the valleys for 30 to 90 days and is perpetual in the high mountains.

Ice-cover on lakes is largely dependent upon their elevation, e.g., the 505 m Wallersee is covered for about 63 days, from mid-January to mid-March. The Danube may freeze over from late December to mid-February.

5. HYDROGRAPHY AND LIMNOLOGY

On the whole, Austria has abundant surface water resources. Table 5 indicates that 1 120 km^2 or 1.3 percent of the country's area is covered by inland waters. This is obviously a minimum figure and does not include the myriad of small streams and lakelets in the mountains.

Ninety-six percent of the country drains into the Danube (Donau) system which flows into the Black Sea. Two areas drain to the North Sea (Atlantic): one in the far west which flows to the Rhine (Rhein), and a small area northwest of Vienna which drains into the Elbe basin. Another small area in the Tyrol drains into Italian streams to eventually reach the Adriatic through the Po.

The approximate annual run-off is 661 mm or 55 000 million m^3. The total annual river discharge leaving the country is, however, about 90 000 million m^3, as 35 000 million m^3 are received from upstream countries (Van der Leeden, 1975; ECE, 1978).

5.1 Rivers (Flüsse).

The total length of Austria's rivers is about 100 000 km (Bruschek, 1971; Austr. Fed. Chancellery, 1978). Guntschl (1965) says that 86 700 km carry fish populations.

Table 1 lists the major rivers of Austria. The discharges of 15 of its important rivers are shown in Table 2, and data on the discharge of the second largest river in Austria, the River Inn, are given in Table 3.

Danube. The largest river in the country, which also has the most extensive drainage basin, is the Danube (Donau in Austria and Germany). It rises on the eastern slopes of the Black Forest in the Federal Republic of Germany and enters Austria from the northwest to be joined by the Inn - at that point a larger stream. The Danube then flows within Austria for 350 km or about one-eighth of its entire course. Within Austria it is still considered to be a mountain or Alpine river, above the lower cyprind zone, as it drops rapidly for about 145 m toward the Hungarian plain to enter Czechoslovakia and form the Austrian/Czechoslovakian border for 6 km. It has a medium head of 0.44 percent (44 cm/km), which is very high for a navigable river. Because of the high velocity of flow and little depth at low water, navigation is hindered but this section is a great energy resource. Twelve hydroelectric dams with locks and plants are planned in an overall plan for development of the Austrian section (Fenz and Neiger, 1976). Such dams serve to stabilize the flow of the Danube, make it more of a lacustrine system, and thus affect the aquatic fauna.

Most of the variations in flow of the upper Danube are caused by inflow from the German tributaries along its right bank, and water meadows have been used for discharge of peak floods. However, the Danube has a number of major feeders which flow for a considerable distance within Austria and reach it before it leaves the country. These include the Inn (and its tributary the Salzach), Traun, Enns, Ybbs, and Traisen. Another major tributary, the March, originates in Czechoslovakia (where it is called the Morava) and forms an 80-km boundary between Austria and Czechoslovakia in its lower course. Austrian streams joining the Danube below Austria include the: Leitha, Raab, Mur and Drau.

Most of Austria's streams are clear, cold and rapid. They are generally - good waters for trout and grayling and at least almost always in the barbel (Barbus barbus) zone..

Table 1

The major rivers of Austria

River	Length (km) Total	Length (km) In Austria	Area of basin (km^2) Total	Area of basin (km^2) In Austria
Rhine	1 320	23	224 400	2 332
Ill	72	72	1 281	1 229
Danube	2 848	350	817 000	80 648
Lech	250	90	4 126	1 338
Inn	510	280	26 131	15 913
Salzach	225	225	6 704	5 544
Traun	153	153	4 277	4 277
Enns	254	254	6 080	6 080
Ybbs	126	126	1 293	1 293
Traisen	70	70	900	900
Kamp	153	153	1 753	1 753
Schwechat	64	64	1 181	1 181
March	352	80	26 658	3 675
Thaya	290	135	13 404	2 249
Leitha[a]	191	167	2 380	2 148
Raab	283	84	10 114	4 550
Rabnitz	177	60	4 816	2 111
Drau	749	261	40 400	11 828
Gail	122	122	1 403	1 209
Gurk	158	158	2 584	2 584
Lavant	72	72	969	969
Mur	444	348	13 824	10 321
Mürz	85	85	1 513	1 513
Sulm (sch)	70	70	1 113	1 113
Elbe	1 144	--	145 800	--
Lainsitz	143	15	4 232	710

[a] With the Schwarza

Source: Republik Österreich, Österreichischen Statistichen Zentralamt (1986)

Table 2

Discharge of some major rivers in Austria

River and station		Basin area km^2	Mean Period 1951–60	annual flow, m^3/s 1967
Rhine	Lustenau	6 110	230.0	278.0
Bregenzer Ache	Kennelbach	826	47.1	50.8
Inn	Innsbruck	5 794	167.0	205.0
Salzach	Oberndorf	6 111	241.0	269.0
Inn	Schärding	25 664	757.0	853.0
Danube	Linz	79 490	1 477.0 2 468.0[a]	1 717.0
Traun	Wels	3 499	130.0	139.0
Enns	Liezen	2 116	63.3	79.0
Steyr	Pergern	898	36.4	36.2
Enns	Enns	6 071	199.0	232.0
Ybbs	Opponitz	507	20.4	23.0
Kamp	Stiefern	1 493	11.2	11.8
Danube	Wien-Nussdorf	101 700	1 916.0 1 920.0[a]	2 227.0
Raab	Feldbach	689	5.81	5.43
Mur	Leoben	4 392	80.1	90.5
Mur	Landscha	8 340	139.0	149.0
Isel	Lienz	1 199	38.3	43.0
Drau	Villach	5 266	158.0	166.0
Gail	Notsch	936	35.7	35.8
Drau	Annabrücke	7 566	230.0	240.0

[a] Period 1901–50

Source: Van der Leeden (1975) after Hydrograph. für Centralburo, Vienna, 1972

5.2 Lakes (Seen)

The total area of Austria's natural lakes is about 500 km^2 (Bruschek, 1971). There are about 88 lakes covering an area of 225 km^2 in addition to two large international lakes. The principal Austrian lakes are listed in Table 4 Excluding the two international lakes, the other 27 all-Austrian lakes listed in the table total 207 km^2 in area.

Lake Constance/Konstanz/Bodensee. Only about 11 percent or about 60 km^2 of Lake Constance, in the Rhine (Rhein) drainage and the third largest lake in Central Europe, belongs to Austria, where it is called the Bodensee. Only a portion at the southeast end of its main body, the Obersee, abuts on Austria at Bregenz. The Austrian section has a shoreline of about 26 km or 15 percent of the area of the Obersee. This basin, once oligotrophic, is now between meso- and eutrophic, and the composition of the major fish stocks in the Obersee has shifted from coregonids to cyprinids and perch. In 1970 the entire lake was reported to have an annual harvest of 4 000 t, and during the 1970–74 period, Austria's share of the catch was said to be 18 percent. For a further description of Lake Constance, see section 5.2 in the review of the Federal Republic of Germany or of Switzerland. See also section 8.4 (below) concerning international agreements on the water quality and fisheries of Lake Constance.

Neusiedler See.[1] The Neusiedler See lies in the extreme eastern portion of Austria, shared with Hungary where it is called Lake Fertö. It is the largest area of lacustrine water within Austria and is at the country's lowest elevation, 115 m. About 32 km in length (N–S) and 4–10 km wide (E–W), it is a tectonically formed steppe lake, totally unlike the characteristically glacial lakes of the country, and one which has almost dried up at times. Its reported area varies both with the year and the author consulted. It is assumed here that Löffler (1979) is close to the mark. He says that at an elevation of 115.5 m above sea level, the total area of the lake approaches 300 km^2, of which about 200 km^2 are covered by the reed (Phragmites), and that at its deepest the present basin is about 113.5 m above sea level. In the same publication, Hacker (1979) says that the Austrian portion of the lake is about fourfifths of the total area, i.e., about 240 km^2 at elevation 115.5 m. Kusel-Fetzmann (1979) also states that the total area is about 300 km^2, about 50 percent is covered with reeds, and its depth is 0.5–2.0 m, maintained since 1965 at 1.75 m through an agreement between Austria and Hungary. Wurzer et al. (1982) agree that the total area of the lake is 300 km^2, but that the area of open water is about 150 km^2. One of the latest estimates indicates that the total area of the Neusiedler See without its reed belt is 152 km^2 of which the Austrian portion is 132 km^2 (Republik Österreich, 1986).[1]

[1] This is essentially the same description that is used in section 5.2 of the review for Hungary

[1] Some estimates in addition to those cited in the main text follow. Erdei (1968) cited under Hungary, says that the Neusiedler See has a total area of 335 km^2 of which three-fourths is in Austria, i.e., 251 km^2. Kovary (1971) (cited under Hungary) gives its total area as 320 km^2 of which 268 km^2 are Austrian. Fodor (1984), cited under Hungary, gives its total area as 335 km^2 of which 248 km^2 are Austrian

Table 3

Discharge of the Inn River, Austria

River and station	Basin area km^2	Mean monthly discharge, m^3/s								
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Inn River, Scharding	25 665	376	400	556	734	1 030	1 330	1 380	1 070	743
		410	346	591	908	1 627	2 372	1 592	1 084	928
		376	552	518	765	1 255	1 479	1 678	1 685	953
		513	545	725	937	1 415	1 679	1 422	999	767
		452	416	474	904	911	1 081	1 177	1 149	782
		Oct.	Nov.	Dec.	Max. flow m$_3$/s	Date	Min. flow m^3/s	Period of record/year		
		569	465	403	-	-	-	1951–60		
		500	346	444	3 720	Jun. 12	241	1965		
		565	527	563	3 650	Jul. 24	276	1966		
		491	371	357	2 551	Jun. 9	248	1967		
		838	429	337	2 510	Aug. 8	262	1968		

Source: Van der Leeden (1975) after Unesco (1971)

Fed by mountain water, including one tributary of consequence, the Wulka, this high-silicate water is mixed with soda-containing ground water from old sediments. The lake water has a high salt content which has ranged from about 1.8 g/l to 16 g/l depending upon the year and the depth of the water. The volume of the Neusiedler See varies from 180 to 250 million m^3. Its theoretical water retention time is about one year, and its discharge is only about 0.5 to 2.0 m^3/sec. (Wurzer et al., 1982). Normally, its only outlet (artificial) is the Hanság Canal which proceeds to the Moson Danube in Hungary. The lake is turbid, gets high phosphate loading, and contains many water weeds in addition to its reed belts. Summer water temperatures are high; they reach 25° to 30°C.

Ice-cover lasts 10 to 97 days, and in 1928/29 the lake froze to the bottom with severe effects upon its fish population.

Table 4

The principal natural lakes of Austria

Lake	Province	Total area km²	Elevation (m)	Depth (m) Max.	Depth (m) Mean	Volume million m³	Theoret. reten. time	Disch. m³/s	Drainage basin km²
Constance (Bodensee)[a]	Vgb	539.0	395.0	252.0	92.0	48 430.0	4.5	360.0	10 900
Neusiedler See[b]	Burg	300.0	115.0	1.8	1.1	180–250	1.0	0.5–2.0	1 000
Attersee	OÖ	45.9	469.2	170.6	84.2	3 944.6	7.0	17.8	463.5
Traunsee (Gmundner See)	OÖ	25.6	422.0	191.0	89.7	2 302.0	1.0	74.2	1 417
Wörthersee	Ktn	19.38	439.0	85.2	42.1	816.32	9.5	2.3	164.0
Mondsee	OÖ	14.21	481.0	68.3	36.0	510.0	1.7	9.2	247.0
Millstätter See	Ktn	13.28	588.0	141.0	89.0	1 176.6	7.0	5.4	276.0
Wolfgangsee	OÖ/Sbg	13.15	538.0	114.0	47.1	619.0	3.9	5.38	124.8
Ossiacher See	Ktn	10.79	501.0	52.0	19.9	215.1	2.0	3.5	154.8
Hallstätter See	OÖ	8.58	508.0	125.2	64.9	557.0	0.5	37.3	646.5
Achensee	Tirol	6.8	929.0	133.0	66.8	481.0	1.6	10.0	218.1
Weissensee	Ktn	6.53	930.0	99.0	36.0	238.1	11.0	0.69	50.0
Wallersee (Seekirchner See)	Sbg	6.39	505.0	24.0	9.4	71.0	0.8	3.95	110.0
Obertrumer See	Sbg	4.8	502.8	35.0	14.1	86.0	1.7	1.8	57.6
Zeller See	Sbg	4.55	749.5	68.4	39.2	178.2	4.1	1.34	54.7
Grundlsee	Stm	4.14	709.0	63.8	32.2	170.0	0.9	5.94	125.0
Irrsee (Zellersee)	OÖ	3.47	533.0	32.0	15.3	53.0	1.7	1.36	27.5
Niedertrumer See	Sbg	3.25	502.9	40.0	14.8	48.0	4.7	0.5	11.2
Plansee	Tirol	2.85	976.0	76.5	45.4	129.48	0.57	3.7	45.5
Fuschlsee	Sbg	2.66	663.0	67.3	37.4	99.5	2.9	1.2	29.5
Faaker See	Ktn	2.2	554.0	29.5	14.9	32.71	1.2	0.87	35.6
Altausseer See	Stm	2.1	712.0	52.8	34.6	72.0	0.6	3.8	54.5
Heiterwanger See	Tirol	1.35	976.0	60.0	40.4	54.49	0.29	1.9	69.0
Keutschacher See[c]	Ktn	1.33	506.0	15.6	10.6	14.02	1.0	0.61	28.6
Grabensee	Sbg	1.26	502.8	13.0	7.2	9.0	0.23	2.5	64.8
Klopeiner See	Ktn	1.11	446.0	46.0	22.6	24.9	11.5	0.07	4.4
Lunzer See	NÖ	0.86	608.0	33.7	20.0	13.0	0.3	1.35	27.0
Erlaufsee	NÖ/Stm	0.58	835.0	38.0	21.2	12.4	1.5	0.26	10.0
Piburger See	Tirol	0.134	813.0	24.6	13.7	1.8	2.7	24 l/s	2.65

[a] Numerical data apply to all of Lake Constance which is shared with the Federal Republic of Germany and Switzerland. The Austrian portion constitutes only about 60 km² of that section of the lake called the Obersee

[b] Shared with Hungary. The entire area of the lake without reed beds is about 152 km², and the Austrian portion without reed beds is 132 km²

[c] Water supply modified from natural state

Source: Sampl et al. (1989)

The lake now contains about 23 species of fish, including introductions, according to Hacker (1979). Fourteen of these are cyprinids, including the exotic silver carp (Hypopthalmichthys molitrix) and grass carp (Ctenopharyngodon idella). The lake also contains pike (Esox lucius), three percids, and the introduced European eel (Anguilla anguilla). In 1975, Austria and Hungary signed an international agreement concerning the management of the lake's fisheries especially with respect to stocking.

For many years there have been plans to drain the Neusiedler See and convert it into agricultural land, despite its poor soil. It now appears that the lake will continue as a unique resource, including its wealth of birdlife, as well as its highly fluctuating fishery.

Other Austrian lakes. Although considerable attention has been paid to the Neuseidler See (because of its size and uniqueness) it is completely atypical compared to the majority of Austria's sub-Alpine and Alpine lakes formed through glacial action. (See Table 4 for their listing in order of size.) Most of these lakes lie above 400 m, are oligotrophic, have a seasonal circulation, and are very attractive scenically. The two major groups, those of the Salzkammergut (a mountainous area in the Traun drainage mainly in Öberösterreich) and the Carinthian lakes (in the Drau drainage of Austria's southermost province, Kärnten) are of outstanding beauty and attract many tourists not only for fishing, but for other sports. Among the best known and largest lakes of the Salzkammergut are the: Attersee, Traunsee, Mondsee, Wolfgangsee and Hallstätter See. The largest and best known of the Carinthian lakes are the: Wörthersee, Milistätter See, Ossiacher See, Weissensee, Faakersee, Keutschacher and Klopeiner See.

The largest lake completely within the confines of Austria is the 45.9 km^2 Attersee. The second largest all-Austrian lake (25.6 km^2) and also the deepest (191 m) is the Traunsee which also has the largest Austrian drainage basin of 1 417 km^2.

Most of these lakes have waters cold enough to support good populations of coregonids, char and trout, but may also be suitable for warmer water forms, such as cyprinids. Thus, the Traunsee at 422 m, has surface water temperatures ranging from 2.6°C in January to 18.9°C in August, and at a depth of 20 m ranges from 2.8°C in January to 11.3°C in October. It has a professional fishery for coregonids, and supports salmonids, pike and cyprinids. In the Salzkammergut, the Mondsee at 481 m is the warmest of the larger lakes attaining 20–22°C. At 469 m the Attersee may even attain a temperature of 25° in some of its bays. The Carinthian lakes are considered to be the warmest of Austria's mountain lakes and bathing is popular here. On the Ossiacher See (elevation 501 m), offshore temperatures may attain 24°C in July and August. Swimming and other watersports are practiced, and the sport fishery includes pike, pike-perch and perch, wels, tench and carp.

All in all, the mountain lakes of Austria get heavy use both from residents and tourists. Bathing, sailing, motorboating, wind-surfing, some commercial fishing (now being phased out), and sport fishing all compete to some extent.

5.3 Reservoirs (Stauseen)

In 1977, Austria had 59 Alpine reservoirs with a total area of 6 212 ha (Austria/EIFAC, 1979). Some of these are enlargements of natural lakes. Fifteen of Europe's 152 “high dams” (those in the USSR not included) are in Austria.

6. LAND AND WATER USE

The population of Austria is about 42 percent rural, and about 45 percent of the land is devoted to agriculture on small farms. Cereals, potatoes, sugar beets, wine grapes, fruit and vegetables are raised, but dairying and livestock production on meadows and pastures are paramount. The best arable land is in the eastern part of the country. The central areas are the most heavily wooded. The western areas have little crop production but produce about a third of the animal products.

Because of climatic conditions, water demands for irrigation are not great. Less than 0.5 percent of the country receives irrigation which is almost always used supplementally. Water use for agriculture is so small that it has little effect on fisheries. Drainage has not been a major factor in Austrian land use, although there were early attempts to drain Neusiedler See despite its ecological interest and fishery yield (Sauerzopf, 1979). Fertilizer use is below the European average.

Austria ranks about third in Europe in timber resources; it was ninth in roundwood production in 1985. About 85 percent of the wood is coniferous. Cutting is carefully controlled to preserve the terrain against slides and soil erosion, as well as to protect reservoirs and maintain the forest as a tourist attraction. Sustained forest yield is a goal of the Government.

Table 5

Pattern of land use in Austria, 1986

	Percent
Arable and permanent crops	18.0
Permanent pasture	23.7
Forest and woodland	38.5
Other land	18.5
Inland water	1.3
Total	100.0

Source: 1987 FAO Prod.Yearb., 41 (Publ. 1988)

There are a variety of mineral resources in Austria. Those of significance include antimony, magnesite, graphite, lignite, iron and other metals, salt, gas and oil.

The growth of industry is evident. Despite Austria's lack of coal, iron and steel production is the primary industry. Food processing and chemical industries are next in importance, followed by the manufacture of textiles, ceramics and paper. Most of the important manufacturing enterprises are located in the east (Vienna, Linz and Graz) with smaller concentrations in Styria, the Rhine Valley, the west and southwest. Water pollutants include effluent from most of these industries, and together with sewerage and agricultural effluents, industry constitutes a major source of pollution. In 1972, it was considered that 27 percent of the total length of Austria's 100 000 km of rivers was polluted (13 percent heavily and 14 percent marginally) and that 225 km had been rendered fishless (Holden and Lloyd, 1972). Pollution control is however, considered important, especially in view of Austria's position as an upstream country, its large lake area, and its importance as a tourist and recreational centre. In the meantime, public sewerage has reached over half of the people, most wastes are not discharged into lakes, and now only a few kilometers of rivers are fishless.

Austria is one of the foremost (about sixth largest) producers of hydroelectric power in Europe due to its abundant water resources and steep terrain. In 1987, its total installed electrical capacity was 16 045 000 kW of which 10 575 000 kW (66 percent) was hydroelectric. Most of the installations are in the mountains and Alpine foothills on flowing streams with high drops, or on the Danube where a twelve-stage series of power stations is under construction. Their development, which is still expanding, may sometimes affect fisheries adversely. A nuclear plant is under construction on the Danube. The future of both hydroelectric and nuclear development is unsure because of powerful environmental interests.

All of the 350 km of the Danube within Austria and about 80 km of its tributary the March (along the Austria-Czechoslovakia border) are navigable to powered shipping.

Another 400 km of rivers are considered navigable in a more limited sense, e.g., for log rafting. The Danube normally freezes over from late December to mid-February, but is kept open by ice-breakers most of the time. The Austrian terrain is not conducive to major canal construction. Automobile road density is high for a mountainous area, 1.7 km/km^2, and passenger car ownership is 355 per 1 000 people (1988). There is a good electrified railroad system.

The use of surface water in Austria, except to regulate rivers and their ports, is practically limited to industrial purposes. Otherwise, the water supply is mostly ground or spring water with which the country is liberally and widely supplied. Karst water is found over one-sixth of the total area.

The annual consumption of fish during the 1982–84 period was about 6.5 kg per caput.

Tourism is very important in this Alpine country with its wealth of natural countryside, forests, rushing streams, lakes, spas, ski slopes, and cultural centres. Angling, especially on streams is one of the tourist attractions (see section 7.1).

7. FISH AND FISHERIES

Most of the drainage in Austria is Danubian, and Busnita (1967a) lists 54 species of fishes belonging to 14 families from the Austrian Danube. Exclusive of the Cyprinidae, major Austrian species include: brown trout (Salmo trutta), Huchen (Hucho hucho), char (Salvelinus alpinus), coregonids (Coregonus spp.), grayling (Thymallus thymallus), pike (Esox lucius), European catfish or wels (Silurus glanis), burbot (Lota lota), European perch (Perca fluviatilis), and pike-perch (Stizostedion lucioperca). The introduced rainbow trout (Oncorhynchus mykiss) and the European eel (Anguilla anguilla), which is not native to the Danube, are also major species in the catch. The major native cyprinids include: common carp (Cyprinus carpio), common bream (Abramis brama), bleak (Alburnus alburnus), Schied (Aspius aspius), barbel (Barbus barbus), white bream (Blicca bjoerkna), Näsling (Chondrostoma nasus), dace (Leuciscus leuciscus), orfe (L. idus), chub (L. cephalus), roach (Rutilus rutilus), rudd (Scardinius erythrophthalmus), tench (Tinca tinca), and Russnase (Vimba vimba). Two introduced cyprinids, the grass carp (Ctenopharyngodon idella) and silver carp (Hypophthalmichthys molitrix) have been established in some Austrian waters, e.g., the shallow Stubenbergsee.

Table 6 presents the nominal “catches” for the waters of Austria as compiled by FAO for the period of 1965–88. As with similar tables for other countries, the lumping of species and lack of distinction between fish derived from the capture fishery and those from pond culture diminishes its usefulness[1]. An interpretation of the table will be given below.

[1] Variance in reporting to the Federal Government by the governments of Austria's nine provinces or Bundesländer may also make statistical accuracy difficult

Table 6

Nominal catches in the waters of Austria, 1965–88 (in tons)

	Common carp (Cyprinus carpio)	Freshwater fishes n.e.i.	Rainbow trout (Oncorhynchus mykiss)	Total
1965	...	5 100	...	5 100
1966	...	4 900	...	4 900
1967	...	4 200	...	4 200
1968	...	4 000	...	4 000
1969	...	4 000	...	4 000
1970	1 100	1 300	800	3 200
1971	1 000	1 200	700	2 900
1972	800	1 100	700	2 600
1973	700	900	600	2 200
1974	680	850	540	2 070
1975	670	840	530	2 040
1976	770	970	620	2 360
1977	900	870	700	2 470
1978	900	800	2 000	3 700
1979	1 200	700	2 200	4 100
1980	1 200	700	2 400	4 300
1981	1 100	700	2 600	4 400
1982	1 150	750	2 600	4 500
1983	1 000	700	3 000	4 700
1984	1 100	600	2 700	4 400
1985	1 250	550	2 700	4 500
1986	1 300	600	2 700	4 600
1987	1 200	600	2 800	4 600
1988	1 300	600	3 200	5 100

... data not available

Source: 1965–69 - Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–88 - FAO Fish.Dept., Fishery Statistical Database (FISHDAB)

7.1 Capture Fisheries

7.1.1 Commercial fishing

At one time, commercial fisheries were of importance in some of the larger Austrian rivers such as the Danube, Inn, Drau, Traun and Enns. For example, Busnita (1967) stated that the Austrian catch in the Danube was about 200 t annually. Today, however, only a few fishermen holding old fishing rights occasionally fish the rivers with nets and really not professionally (Austria/EIFAC, 1979). Ecological changes in the resource, the rise in sport fishing, and poor prices for cyprinids are among the factors in its decline.

For all practical purposes then, commercial fishing in Austria is confined to static waters: in some of the lakes, and in some reservoirs where the owners conduct the fishing. The major components of this catch are: whitefish (Coregonus spp.) and char, followed by brown trout, pike, common carp and other cyprinids, wels, pike-perch and eel. The tonnage listed in Table 6 under “freshwater fishes” probably represents most of this catch[1]. Some other figures are also available; undoubtedly all are estimates. Bruschek (1971) thought that Austrian commercial fishermen took about 1 000 t of foodfish from streams and lakes in 1970. Austria/EIFAC (1979) offered the following estimates for commercial fish catch in Austria: 1 400 t in 1963, 1 200 t in 1973 and 1 000 t in 1978. Although the trend is down, there are areas where the catch has built up, e.g., in the 6.8 km^2 Achensee, the commercial catch of coregonids rose from 271 kg in 1971 to 5 117 kg in 1978 (Wurzer et al., 1982).

[1] It is believed that the "catch" in Table 6 specified as "common carp" and "rainbow trout" represents cultivated fish (see section 7.2)

Whatever the catch, and overall it is declining, the number of fulltime professional fishermen in Austria was between only 160 and 180 circa 1980.

Austria once had a crayfish (Astacus astacus) fishery, but it declined during the last century with the spread of crayfish plague (Aphanomyces astaci). Two American species (Oronectes limosus and Pacifastacus leniusculus) have been introduced as substitutes.

7.1.2 Sport fishing

The number of sport fishermen in Austria in 1979 was estimated at about 220 000 or almost three percent of the total population.

It is difficult to obtain statistics on the sport catch in Austria, but as early as 1963 there were indications that it attained 2 100 t or 60 percent of the total take of 3 500 t by the capture fishery (EIFAC, 1964). By 1978, it was estimated to total at least 2 500 t or 70 percent of the entire capture fishery again specified as 3 500 t (Austria/EIFAC, 1979).

Sport fishing in Austria is especially attractive to both local and foreign anglers. Among the more important trout streams are the Traun, Salzach, Mur, Lammer, Enns and Alm. In addition to trout (mainly brown), grayling and the giant huchen are particularly prized. Other fishes taken by recreational fishermen include: char, pike, pike-perch, perch and various cyprinids, especially carp and tench.

The provinces (Lander) issue licences for sport fishing but most fishing is actually in the hands of private individuals or associations, and a private fishing permit issued by the proprietor or his lessee is also necessary. Broadly speaking, stream salmonids and grayling may be taken only on fly. Spin fishing is permitted for larger fish such as pike and wels, and natural bait is usually allowed only for phytophagous fish. There are some rather complex regulations (closed seasons, size limits, etc.) in Austria concerning sport fishing. One of the best guides to the subject, as well as to fishing areas is "Fishing in Austria" (Angelsport in Osterreich) issued by the Austrian National Tourist Office.

Fishing clubs which lease rights from private owners may also stock their areas. About 50 t of cultivated trout and about the same amount of cultivated carp are stocked annually in private waters for special licence fee fishing (Brown, 1977, 1983).

7.2 Aquaculture

The major fishes cultivated in Austria are rainbow trout and common carp. A personal communication from Dr J. Hemsen (21 January 1980) states that all of the trout and carp "catches" shown in Table 6 as made during the 1970–78 period were actually produced through aquaculture. It will be noted, however, that there is almost no agreement of these Table 6 figures with those in Table 7 which provides estimates of the production of cultivated trout and carp in Austria derived from other "official" or standard sources. This, and other inconsistencies even within the same Table 7 make it difficult to accept most of the figures.

The truth of the matter seems to be that: (i) many of the figures in Table 7 actually emanate from the same general source, despite the varying authorships; (ii) they are all very gross estimates, and (iii) even the original source may have used different bases at different times. With respect to the last point, figures on “official” or “commercial” production of both trout and carp may differ from the country's overall aquacultural production which includes that of “amateurs”. For example, Brown (1977, 1983) says that in 1975, the 72 members belonging to the Association of Austrian Trout Producers might be considered as commercial operators, but that there were also about 800–825 producers who cultivated trout for their household consumption or as a hobby. Similarly, he says that there are two carp producing associations with a membership of about 40 producers, but that there are also an estimated 160 small enterprises and hobbyists who are not commercial producers.[1] One assumes that Brown's production figures include only the output from commercial units. Emphasis on this general point is reinforced by the statement that: “The big trout farmers are joined in the Union of Trout Farmers of Austria (Osterreichischer Forellenzüchter Verband); the official production of these breeders is about 1 000 to 1 220 t/year. But there are a lot of smaller ponds, so-called hobby ponds, which produce together nearly the same as the big ones. So the whole production of trout in Austria lies between 2 000 and 2 500 t/year. With respect to carp cultivation…the small ponds…are producing about 50 percent more than the official unified carp farmers, and the carp production is officially around 900 t, but really between 1 200 and 1 400 tons a year” (Austria, 1980).

[1] Both EIFAC (1964) and Austria/EIFAC (1979) said that the total number of carp and trout producers in Austria was 150

Finally, with respect to trout production, one has the illuminating statement from Hemsen (1982) that: “We have to estimate the production from the consumption of dry food. The production for the years 1980 and 1981 was estimated in that way to a high of about 2 000–2 500 tons a year”.

It seems clear that none of the Austrian production figures (Tables 6 and 7) are very accurate. The trend in its aquacultural production is, however, quite clear. Carp production, although rising in recent years, has been rather constant. Conversely, trout production has increased decidedly; it is perhaps 30 times greater now than it was 20 years ago. Nevertheless, production of either species is small. The estimated value of all aquacultural production of finfish in Austria during the 1984–87 period varied between US$ 9.2 million (1985) and US$ 15 million (1987) (FAO Fish.Info.Data and Stat.Serv., 1989).

Trout are produced primarily in central and western Austria in raceways and in ponds. Net-cage culture is not significant in Austria. Market size is between 250 and 300 g, which requires between 14 and 20 months (average 17 months) of growth. Most trout are sold alive, but the market for smoked trout is increasing. A large trout farm produces 100 t or more. In 1988 about 450 t of trout and salmon were imported and also most of the eyed eggs are imported.

Carp production is centred in the north (Lower Austria) and southeast (Styria and Burgenland). In 1970 there were about 2 000 ha of carp ponds in Austria (Bruschek, 1971) and in 1978 about 2 550 ha (Austria/EIFAC, 1979). Matěna and Berka (1987) say the total area of ponds in Austria is about 3 500 ha. There are only a few producers with 50-ha pond area and more. Earthern ponds are used with water added only to offset evaporation. The climatic conditions in the northern part require a longer growing period (three to four years); in south Austria it requires only two to three years to attain the market size of 1 600–2 000 g. The average yield in the growing ponds is 550 kg/ha/year. Most carp are sold alive. About 500 t are imported from Czechoslovakia, Yugoslavia and other eastern European countries.

Table 7

Estimated production of cultivated trout in Austria (t)

Source	1967	1970	1973	1976	1978	1980	1981	1983	1984	1985	1986	1987	1988	1989
Bruschek (1971)	100	300	-	-	-	-	-	-	-	-	-	-	-	-
Austria/EIFAC (1974)	-	-	300[a]	-	-	-	-	-	-	-	-	-	-	-
Hemsen (1978)	-	-	-	1000	-	-	-	-	-	-	-	-	-	-
Giorgetti and Ceschia (1982)	-	-	-	-	1200	-	-	-	-	-	-	-	-	-
Shaw, Shaw and Thomas (1981)	-	-	-	-	-	1300	-	-	-	-	-	-	-	-
Hemsen (1982)	-	-	-	-	-	-	1400	-	-	-	-	-	-	-
Fish Farm.Int. 11(7)(1984)	-	-	-	-	-	-	-	2400	-	-	-	-	-	-
Fed.Inst.Fish.Management Scharfling (1985/86/87/88)	-	-	-	-	-	-	-	-	2700	2700	2860	2740	-	-
FAO Fish.Info.Data and Stat.Serv.(1989)	-	-	-	-	-	-	-	-	3000	3000	2950	2950F	-	-
FES (1986)	-	-	-	-	-	-	-	-	-	2500	-	-	-	-
FES (1989)	-	-	-	-	-	-	-	-	-	-	-	-	3200	3200
Butz (1989)	-	-	-	-	-	-	-	-	-	-	-	-	3200	-
Estimated production of cultivated carp in Austria														
Kainz (1969)	600	-	-	-	-	-	-	-	-	-	-	-	-	-
Bruschek (1971)	-	600	-	-	-	-	-	-	-	-	-	-	-	-
Austria/EIFAC (1974)	-	-	600[a]	-	-	-	-	-	-	-	-	-	-	-
Brown (1977)	-	-	-	600	-	-	-	-	-	-	-	-	-	-
Austria/EIFAC (1979)	-	-	-	-	700	-	-	-	-	-	-	-	-	-
Brown (1982)	-	-	-	-	-	600[a]	-	-	-	-	-	-	-	-
Kainz (1984)	-	-	-	-	-	-	1000	1000	-	-	-	-	-	-
Fed.Inst.Fish.Management Scharfling (1985/86/87/88)	-	-	-	-	-	-	-	-	1100	1200	1100	1100	-	-
FAO Fish.Info.Data and Stat.Serv.(1989)	-	-	-	-	-	-	-	-	1000	1100	1160	1200	-	-
Butz (1989)	-	-	-	-	-	-	-	-	-	-	-	-	1100	-

[a] Probable data, judging from the text; actually unspecified

F - FAO estimate

A few other fishes are cultivated in Austria, primarily tench, grass carp (Ctenopharyngodon idella), pike-perch, and the coregonids, Coregonus lavaretus. As most of these fish are produced in conjunction with common carp, it is difficult to obtain good figures on their yield. Bruschek (1971) stated that the total production in Austrian carp ponds in 1970 was about: 550 t of common carp, 12 t of tench, 10 t of Coregonus, 4 t of pike-perch, and 3 t of rainbow trout. Brown (1977, 1983) states that in addition to carp and trout, annual production in Austria is about as follows: 30 t of tench, 20 t of grass carp, and 5 t of coregonids. It requires between two and three years to raise the tench to market size of 200–300 g and between three and four years to raise grass carp to market size of 3 000–4 000 g. Some pike and grayling for stocking are exported.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership

Fishing in Austria is mostly controlled by private individuals or fishing associations and there are only a few State fishing rights. The nine provincial government do, however, require and issue annual fishing licences.

Owners of fishing rights are obliged to be members of a fishing district and are responsible both to local fisheries authorities and organizations.

8.2 Administration and Management

Austrian fisheries fall within the competence of the Ministry for Agriculture and Forestry. The Ministry does not have a separate fishery office, but includes this work within a section dealing with animal husbandry.

The actual administration of fisheries is handled by the nine semi-autonomous governments (Landesregierungen) which keep in touch with the Federal Ministry. Within the provinces, fisheries are handled by their respective agriculture and forestry departments - administered together with allied responsibilities such as animal husbandry or nature and game conservation. The different provincial governments are usually responsible for fishery legislation; consequently the fishing laws vary from one Bundesland to the other. They also keep records of fishing rights and issue licences.

Most of the provinces have their own fishery organizations, autonomous administrative units prescribed by law and responsible for fishery administration and promotion for the province.

In addition, there is an Austrian Fisheries Corporation, encompassing the entire country and concerned with the promotion of Austrian fisheries, which consists of fisheries organizations, cooperatives, scientific institutes, etc.

8.3 Investigation and Education

A number of scientific and research services are concerned with Austrian fisheries.

(i) The Federal Institute of Fisheries Management (Bundesanstalt für Fishereiwirtschaft) at Scharfling, O.Ö is principal among these. Directly responsible to the Federal Ministry of Agriculture and Forestry, it is concerned with research, training, advice to fishermen and the protection of fisheries. It is also responsible for the fish breeding station at Kreuzstein am Mondsee.

(ii) Institute for Hydrobiology and Fisheries Management of the University for Agriculture (Institut für Hydrobiologie und Fischereiwirtschaft der Universität für Landwirtschaft) in Vienna.

(iii) Federal Institute for Water Quality (Bundesanstalt für Gewässergüte) at Vienna-Kaisermühlen.

(iv) Institute for Fisheries Science of the Veterinary University (Institute für Fischkunde der Tierärztlichen Universität) in Vienna.

(v) Institute of Fisheries Research of the University of Innsbruck, Innsbruck.

On a smaller scale, various zoological university institutes are also active in the field of fishery biology. All of these institutes are under the Ministry of Science.

8.4 International Agreements

Austria has bilateral agreements with Czechoslovakia, the Federal Republic of Germany, and Hungary concerning the use of boundary waters. It has a trilateral agreement with the Federal Republic of Germany and Switzerland on water quality in Lake Constance, belonging to the Internationale Gewässerschutz Kommission für den Bodensee. Since 1893, fish management of Lake Constance has been regulated by the Internationale Bevollmächtigen-Konferenz für die Bodenseefischerei.

Along with the other Danube countries, Austria belongs to the Danube Commission which deals with navigation and related matters.

[1] Based largely on Gaudet (1974), a revision sent to EIFAC by Austria in 1979, and Austria/EIFAC (1989)

9. STATE OF THE FISHERY

9.1 Yield

The “nominal catch” in Austria was 2 000 t in 1938, had fallen to only 300 t in 1948, and then gradually rose to 4 000 t (double the 1938 catch) in 1959, and to 4 900 tons by 1964 (FAO Yearbook of Fishery Statistics, 36). Reference to Table 6 shows that the catch which then attained a high point of 5 100 t in 1965 declined to only 2 040 t in the next ten years (1975) and then rose again to 5 100 t in 1988. It is obvious, however, that a decline has occurred in the commercial capture fishery, and that aquacultural production has increased.

With respect to yield per unit area, the following yields were achieved: 20–200 kg/ha in managed streams, 8–30 kg/ha in 22 000 ha of lakes and 7 kg/ha in Neusiedler See, without the catch of sport fishing in the lakes (Austria/EIFAC, 1989). Such yields from lakes are considered quite low.

Bruschek (1971) stated that the average yield of carp for food in Lower Austria amounted to 200–300 kg/ha/year. In southern Styria and Burgenland, where the water temperature is higher and water chemistry better, he cited average yields of 500–800 kg/ha/year for consumable carp. Acceptance of the 1978 figures (section 7.2) for an Austrian pond are of 2 550 ha, of which about 2 000 ha are used for the production of carp for food and a production of 1 100 t provides an average yield of 550 kg/ha/year (Austria/EIFAC, 1989).

9.2 Factors Affecting the Fishery

Austria is well supplied with an abundance of mountain lakes and streams ensuring a variety of fishing, especially for cold-water species. Such waters do not have the high yields of warmer, more fertile waters but do produce “quality” fishing, e.g., for trout, char, grayling and coregonids. Even Austria's largest river, the Danube, still retains a mountain character, not becoming a “plains” or cyprinid river until it has left the country. Dredging, navigation and pollution have, however, altered its character, as has drainage of several of its arms.

Major deterrents to the maintenance of good fishing in Austria include hydroelectric development (which affects fish migration, diminishes stream flow and taps mountain lakes) and water pollution. The latter danger, which has become increasingly severe with the growth of intensive agriculture and industrialization, has already affected a considerable portion of the fishery (see section 6). It may be noted, however, that the amount of water available per caput per annum for waste dilution is still quite high. From run-off originating solely from rainfall on Austrian territory, it is 7 326 m^3, and based on total discharge leaving the country is 11 989 m^3. Both figures are well above the estimated European average of 5 000 m^3 per caput per annum.

Carp culture is hampered by the relatively small area of country suitable for its maintenance and the climatic conditions which generally require three years for fish to grow to a desirable size. Trout culture, although continuing to be small scale, with slow growth when using cold water and sometimes limited water supplies, has better opportunities for expansion. In fact, in recent years it has expanded through use of water of good quality from new dams and pumped supply.

General traditions of good land and water use are among the most important factors contributing to preservation of the Austrian fisheries. Management of the fisheries varies considerably throughout the country because of the strong sense of individualism in the provinces - each of which, incidentally, corresponds approximately with the upper part of a river basin.

9.3 Prospect

The abundance of cold water in Austria and the beauty of its Alpine stream and lake area make sport fishing very attractive both to residents and tourists. Pollution control and continuance of good land and water practices are necessary to ensure its continuance.

The commercial capture fisheries, an old tradition, will persist in some of the lakes (as in other Alpine countries) for some time, but will be far outstripped by recreational fisheries and other uses of these waters.

A moderate growth in aquaculture should continue, especially for trout - for which there is a good market. Carp farming has a lower profitability but will be maintained since there is little other use for its ponds.

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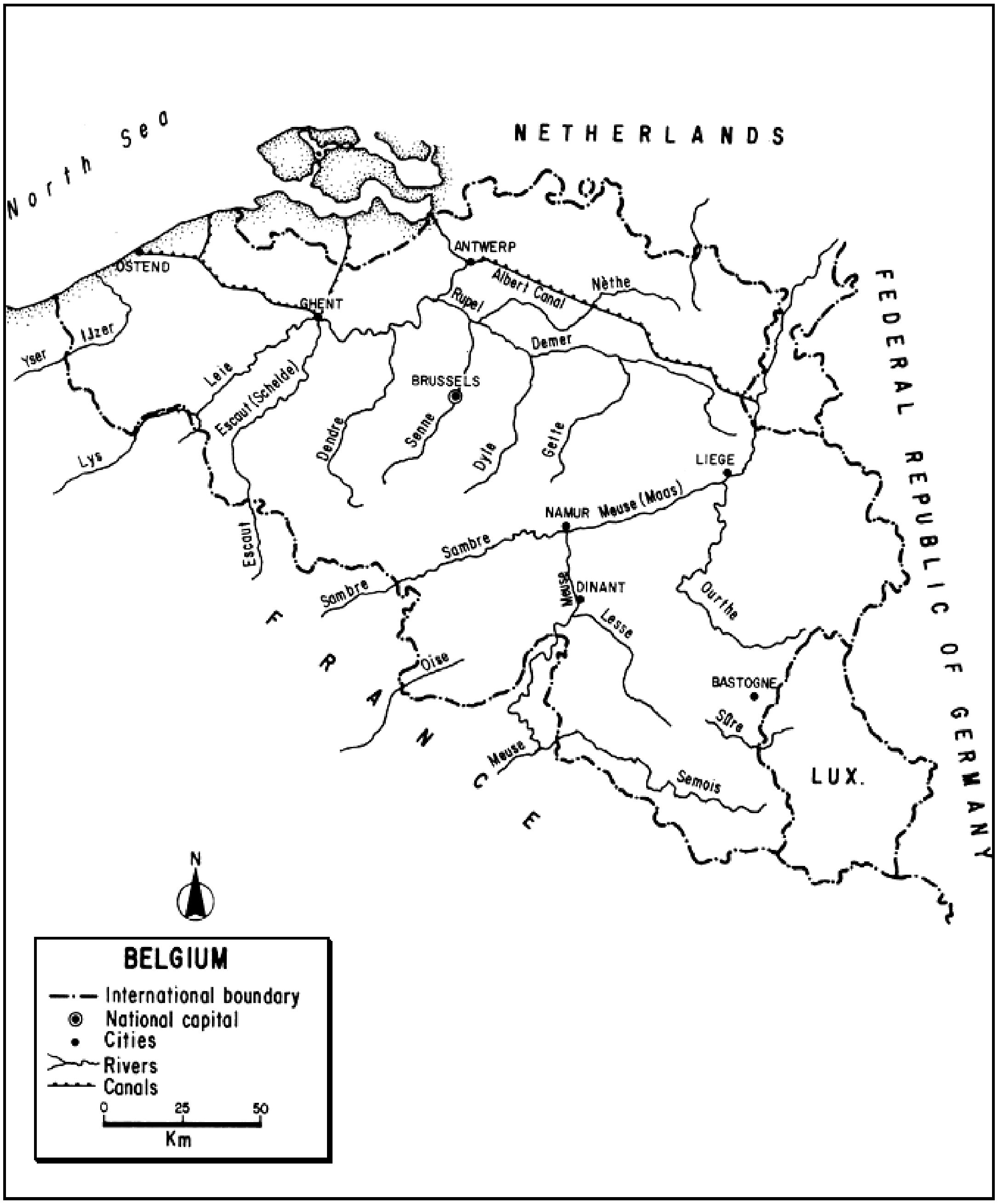
North Sea
NETHERLANDS
FEDERAL REPUBLIC OF GERMANY
FRANCE
LUX.
OSTEND
GHENT
ANTWERP
BRUSSELS
LIEGE
NAMUR
DINANT
BASTOGNE
Albert Canal
Nèthe
Rupel
Demer
Yser
IJzer
Leie
Escaut (Schelde)
Lys
Dendre
Senne
Dyle
Gette
Meuse (Maas)
Sambre
Escaut
Meuse
Lesse
Ourthe
Oise
Sûre
Semois
N
BELGIUM
International boundary
National capital
Cities
Rivers
Canals
0
25
50
Km

BELGIUM

The Kingdom of Belgium, on the North Sea in northwestern Europe, is a country of flat and gently sloping lands backed by low forested hills. Small as it is, its access to the sea, well-tilled terrain, temperate climate and (originally) its resources of iron and coal have enabled it to become a leading industrial country and to support one of the densest populations in Europe.

Its rivers are small, but canalized and linked with canals they provide an intricate system of waterways heavily used for transport and the disposal of wastes. Additional use of surface waters, especially through withdrawals for intensive industry and an absence of natural lakes preclude maintenance of a freshwater commercial fishery.

Some aquaculture for trout and warmwater fishes, and angling for coarse fishes in lowland waters and salmonids in upland streams represent Belgium's inland fishery.

1. AREA: 30 519 km^2

2. POPULATION: 9 949 000 (est. 1990) Density: 326 inhabitants/km^2

3. PHYSICAL GEOGRAPHY

Belgium is situated in northwestern Europe between 49°30' and 51°30'N latitudes and 2°30' and 6°23'E longitudes.

Roughly triangular in shape, its extreme length is about 280 km (NW-SE); its greatest breadth is about 181 km (NE-SW). Its altitudinal range is from about -5 m to 693 m, but its mean elevation does not exceed 175 m.

Belgium is bounded on the northwest by the North Sea for 65.5 km, on the north and northeast by the Netherlands for 450 km, on the east by the Federal Republic of Germany for 162 km, on the southeast by Luxembourg for 148 km, and the west and southwest by France for 620 km.[1]

[1] The lengths of these boundaries are taken from Annuaire Statistique de la Belgique, Tome 107, 1987. Belgium also has a tiny (7 km^2) exclave completely within Dutch territory. This exclave, Baarle-Hertog, is 6 km north of the Belgian border

The northern part of the country is called Flanders and the southern part Wallonia, but physiographically, the country can be divided into: (i) Lower Belgium, a flat northern lowland; (ii) Central Belgium, a region of low plateaux, and (iii) High Belgium in the south and southeast.

Maritime Flanders, that portion of the northern lowland along the North Sea, has a straight, broad, sandy beach backed by dunes with few openings to the sea. Inshore are polders (reclaimed marsh lands), protected by seawalls, dunes and dikes, covering 494 km^2 and interspersed with drainage canals. Toward the interior the land rises gently, generally to not over 20 m.

In Central Belgium, the plateaux are split in half by the highly populated valley of the Sambre and Meuse Rivers which forms an industrial crescent between them. To the north of the valley is the Northern Low Plateau (80–100 m); to the south is the Southern Low Plateau (to 200 m), with more forest and pastureland.

South of the central region, there arises another more rugged plateau, that of High Belgium or the Ardennes, dissected by trout streams into an area of rounded hills, forests, pasture lands and moors. This is the highest land in Belgium, with hills from 400 to 693 m, but much of it is not over 330 m. The extreme south of the country is occupied by Belgian Lorraine, a continuation of the scarplands of Luxembourg. Population density in the Ardennes is only about 50 inh/km^2 as compared with over 1 000 inh/km^2 in the densely populated area to its north.

There is little natural vegetation on Belgium's cultivated lands, and forests have been largely removed except in areas of poor soil or steep slopes. About 55 percent of the trees are deciduous (beech, oak and birch) and 45 percent coniferous (imported Scots pine and spruce are common).

Soils vary from sand dunes, clays and fertile loess in the north to acid and eroded sandstones and shales in the south. The latter reflect their composition in the calcium-poor and neutral (pH 7) waters of the Ardennes.

The coastline is short, sandy and straight. It has few harbours, the beaches have high recreational use, and it is not suitable for aquacultural development.

4. CLIMATE

The climate is maritime, temperate and cold. It is mild and humid in the coastal area with hotter summers and colder winters inland.

The average annual temperature is 8.3°C; extremes are -12°C and 32°C. On the coast, the mean temperatures are 3.3°C in January and 16.6°C in July. They are similar in central Belgium (2.2°C and 17.5°C, respectively) but the extremes are greater in hilly regions.

The average annual precipitation is about 835 mm, ranging from 700 mm on the plain to over 1 000 mm in the Ardennes. Monthly rainfalls vary little throughout the year; fog and drizzle are the rule. Deficiencies may occur in the summer, however, causing low water flows.

The number of days with temperatures below freezing are about as follows: 30 on the coast, 60 in the central area and 120 in the Ardennes. Snow is common but rarely remains long. In Flanders there are about 15 days of snow; in the Ardennes about 30.

5. HYDROGRAPHY AND LIMNOLOGY[1]

The total area of Belgium's inland waters aside from artificial fish ponds has been estimated as constituting about 25 900 ha (0.85 percent of the country's total area) composed of 24 000 ha of rivers and canals and 1 900 of artificial reservoirs.[2] Comparison of these data (derived from Belgium/EIFAC, 1975, 1977, 1980, 1989) with the estimate of the extent of inland waters shown in Table 2 (28 000 ha) indicates a reasonable agreement.

The approximate annual run-off in Belgium is 360 mm or 11 000 million m^3. In receipt of an annual discharge of 5 000 million m^3 from upstream countries, the annual river discharge leaving Belgium is 16 000 million m^3 (Van der Leeden, 1975; ECE, 1978).

Most of the country drains to the northeast into the Netherlands through the Escaut/Schelde and the Meuse/Maas. A few streams such as the Sûre/Sauer in the eastern Ardennes are in the Rhine drainage. A small area (Oise) drains to the Seine in France. A few minor streams flow directly into the North Sea.

[1] As Belgium has two official languages (French and Dutch) more than one name is used for some waters. The English equivalents of the major types of waterbodies are given in these two languages

[2] More exact figures are provided by Water and Forest Administration (1980): 12 752 ha of navigable or floatable watercourses and canals, and 10 646 ha in all other watercourses (non-navigable)

5.1 Rivers (Rivières/Rivieren)

The total length of Belgium's rivers is about 26 600 km; their total area including canals is about 24 000 ha (Belgium/EIFAC, 1975, 1977, 1980).

The discharge of 11 rivers in Belgium is shown in Table 1.

Table 1

Discharge of twelve Belgian rivers

River and station	Basin area km^2	Mean daily discharge, m^3/s Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Maximum daily flow m^3/s	Date
Scheide (Escaut) River Basin															
Leie River, St. Elouis-Vijve	3 190	47.5	58.1	45.9	25.8	35.8	32.9	22.2	19.3	14.6	10.9	26.0	46.0	104	16.01.68
Escaut River, Kain	5 091	17.1	30.5	29.9	24.7	20.9	30.8	25.6	20.8	17.2	14.2	18.3	22.6	170	01.01.67
Mass (Meuse) River Basin															
Ourthe River, Angleur	3 626	74.6	84.6	77.5	86.3	39.4	26.7	19.1	72.0	33.1	14.1	39.5	53.4	635	11.12.67
Vesdre River, Chaudfontaine	680	15.2	17.5	15.9	16.2	6.31	5.12	3.66	19.9	6.35	2.56	8.18	8.76	-	-
Ambleve River, Martinrive	1 044	21.6	22.4	23.9	26.2	11.8	7.74	5.63	25.9	12.1	3.39	12.4	15.1	-	-
Ourthe River, Hamoir	1 597	30.5	36.4	30.3	37.0	18.7	11.3	8.26	18.9	10.6	4.34	18.8	27.1	-	-
Mause River, Ampsin-Neuville	16 400	242.0	285.0	294.0	268.0	189.0	157.0	103.0	73.5	63.1	41.6	122.0	188.0	2 000	03.01.67
Mehaigne River, Moha	345	2.65	4.11	2.55	1.89	1.63	2.09	1.71	2.08	1.29	0.790	1.81	3.07	-	-
Eau d'Heure River, Jamioulx	324	4.81	6.26	3.86	4.18	2.57	1.82	1.28	1.52	1.14	0.789	2.18	3.58	-	-
Lesse River, Gendron Pont	1 314	22.7	28.9	21.1	26.9	15.6	9.43	7.54	9.42	4.99	2.35	13.5	19.8	-	-
Viroin River, Treignes	554	11.4	12.1	7.87	12.7	6.61	6.19	3.41	2.97	1.73	0.929	6.99	8.31	-	-
Semois River, Membre	1 235	31.2	26.8	34.3	36.0	17.9	15.2	9.19	5.86	5.12	3.74	21.8	24.1	-	-

Source: Van der Leeden (1975) after Hydrologisch Jaarboek van Belgie, 1971

The hydrographic system in Belgium is well developed and maintained by abundant rains except for summer deficiencies. With little slope in their lower courses, some of the larger rivers which meander over wide floodplains (6–8 km) have had their courses artificially stabilized to prevent floods. Near the coast is a maze of drainage ditches, some once tidal creeks. Pumping is necessary to maintain canal levels and pump excess water into the sea.

Belgian streams, as in France, are customarily grouped into four zones named by their most characteristic fish and dependent upon their gradient (hence strength of current), temperature, substratum and amount of aquatic vegetation. Popularized by Huet (1949, 1954, 1962) and proceeding generally downstream, these zones are as follows:

(i) Trout zone - rocky and swift with well oxygenated water;

(ii) Grayling zone - less rocky and less swift;

(iii) Barbel zone - quiet water with vegetation;

(iv) Bream zone - very slow and tranquil, pond-like. Other fish: carp, tench, eel, perch, pike.

Not all Belgian rivers posses all these zones. A simpler classification lumps the first two zones as “salmonid” and the last two as “cyprinid”.

The higher parts of Belgium (Ardennes) are generally in the trout zone grading into the grayling zone as they descend, e.g., East and West Ourthe, Lesse, Amblève, Warche. The lower extent of the large rivers, Semois, Ourthe, Lesse and all of the Meuse are in the barbel zone. The Escaut basin is a cyprinid region, primarily a bream zone, and the lower river which is affected by tides is a smelt (Osmerus) zone.

The major river systems of Belgium are described briefly below.

Meuse/Mass. The major river of Belgium is the canalized Meuse/Mass, which enters from France on the south and proceeds northeasterly to form a 48-km segment of the Belgo-Dutch border and then continues into the Netherlands to empty into the North Sea at the end of its total journey of 950 km, of which about 192 km is in Belgium. En route, it has drained most of Belgium south of its valley. The Meuse has an annual discharge of 273 m^3/sec, but can drop to under 30 m^3/sec for over three months.

Within the confines of Belgium, the most important tributaries of the Meuse, proceeding downstream, are the 80-km Lesse entering from southeast Belgium, the 190-km Sambre (which originates in France) and the Our the, like the Lesse, a totally Belgian river. The Ourthe, which drains about 12 percent of the country, originates in the southeast from two branches, each about 50 km in length and proceeds north for 135 km to join the Meuse at Liège. Its main tributaries are the 93-km Amblève and its affluent, the 48-km Warche, and the 73-km Vesdre entering near its mouth. There are a number of reservoirs on these tributaries. Also originating in Belgium, but entering the Meuse in France, is the 180-km Semois.

Escaut/Schelde. Arising in France as the Escaut, this river enters Belgium west of Mons and flows north and east across the country. Its estuary, the harbour of Antwerp, joins the North Sea in the Netherlands. Of its total length of about 430 km, about 330 km are navigable through locks. Heavily used, at Antwerp where it has a mean annual discharge of about 80 m^3/s, it is extremely polluted - having picked up industrial and sewage effluent from several centres such as Lille, Brussels and Ghent.

Much of lower and central Belgium is in the Escaut drainage. Proceeding downstream from the Belgo-French border, the major tributaries are as follows: the 214-km Lys (Leie) which rises in France and forms a small part of the Franco-Belgian boundary, the 88-km Dendre (Dender) and the Rupel. The Rupel, in itself only 12 km long, is formed by the confluence of the Nèthe (Nete) and the 97-km Dyle (Dijle).

Other drainages. The Sûre/Sauer, a trout and grayling river of 177 km, rises in southeastern Belgium and passes through Luxembourg to join the Moselle (Rhine basin).

The Oise, which also drains only a small portion of Belgium, flows south into France to join the Seine.

Finally, there are the streams of the coastal basin: the small Yser/IJzer, a canalized maritime river which enters from France, and several others which flow directly into the North Sea. Their flows are almost nil in summer.

5.2 Lakes and Reservoirs (Lacs/Meren, Lacs de barrage/Stuwmeren)

Belgium has no natural lakes although some of its reservoirs are called lakes. There are about ten artificial reservoirs mostly built for water supply and to produce hydroelectric power, with a total area of about 1 900 ha, and it is planned to double their capacity by the year 2000 (ECE, 1978).

Five of these are in the Ourthe drainage. The eutrophic Nisramont at the confluence of the east and west branches of the Ourthe with an area of 47 ha and a volume of 3 million m^3 was formed in 1952. Four other reservoirs with a total area of 440 ha and total capacity of 71 million m^3 lie on tributaries of the Ourthe. The largest of these (the largest reservoir in Belgium) is the oligotrophic Barrage d'Eupen on the Vesdre, over 125 ha in extent with a capacity of 25 million m^3. Below it lies the 80-ha oligotrophic Barrage de Gileppe built on a tributary of the Vesdre in 1878; and two mesotrophic reservoirs, Robertsville and Butgenbach, are on the Warche. The Lake of Virelles, another reservoir over 125 ha in area, and the Eau d'Heure reservoir over 600 ha are situated in southern Belgium.

Fishing in Belgium's reservoir lakes is not generally good. For example, the reservoirs of Eupen and Gileppe have a pH of 5 and contain few fish.

5.3 Canals (Canaux/Kanalen)

Belgium has an extensive canal system linking its most important natural waterways, so that, in effect, any of its river or canal ports is linked with Antwerp, the Netherlands, Germany and France. In 1988, its navigable waterways totalled 1 537 km, of which more than half were canals.

Some are large ship canals, e.g., the Ghent-Terneuzen Canal has a minimum depth of 8.8 m and the Brugge-Zeebrugge Canal a minimum depth of 8 m; the canal linking Brussels with the Rupel and Escaut/Schelde rivers has a minimum depth of 5.8 m and width of 25 m, and the Albert Canal, connecting the Escaut and the Meuse, has a depth of 5.5 m and a width of 102 m. A total of about 320 km can accommodate vessels up to 2 000 tons, about 560 more km can take vessels of 600 t, and the smaller canals allow the passage of shallow draught boats of 3 to 15 t.

Both the navigation canals and the drainage canals of Flanders provide angling. Heavily used canals are usually muddy and without much plant growth. Modern canals with cement sides provide fewer fish than older canals, and canal pollution is quite heavy.

6. LAND AND WATER USE

Table 2

Pattern of land use in Belgium and Luxembourg, 1986[a]

	Percent
Arable and permanent crops	24.3
Permanent pasture	21.1
Forest and woodland	21.0
Other land	32.7
Inland water	0.84
Total	100.0

[a] Highly representative of Belgium alone which represents 92.2 percent of the combined area of the two countries.

Source: 1987 FAO Prod.Yearbk., 41 (Publ. 1988)

Although Belgium is now considered to be about 97 percent urban, its small-farm intensive agriculture furnishes about 90 percent of its country's needs, although only a small part of its GNP. Beets, flax, potatoes and cereals are important crops, but with the basic orientation toward livestock there is a large amount of carefully nurtured pastureland.

In the northwestern area almost all of the land has been deforested, drained and tilled, and its shallow lagoons were filled in centuries ago - both naturally and with the aid of man. Fertilizer use is heavy: about 300 kg/ha/year (1984). The use of irrigation is mainly supplemental - during summer deficiencies and for frost protection and there are no large irrigation projects affecting fisheries[1]. Agricultural water demand not only for irrigation but for animal production and dairying is, however, increasing.

[1] The FAO Production Yearbook persists in listing a use of irrigation in Belgium and Luxembourg of only about 1 000 ha between 1969 and 1986, although the Commissariat royal au problème de l'eau (1967) and Framji and Mahajan (1969) stated that 9 170 ha in Belgium were irrigated in 1965 and estimated that 49 000 ha would be irrigated by 1980.

There is some rather important forestry in the southeastern area, although Belgium/Luxembourg ranks only about nineteenth in European forest production.

Although Belgium's original industrial economy was partly based on its mineral resources, especially coal, most of its ores have been depleted.

Industrial development, which began in the early 19th century, is very intensive. On a per caput basis, Belgium (and Luxembourg) are the world's largest steel producers and a wide variety of non-ferrous metals are also produced. Machine building, metalworking, chemicals, food processing and textiles are other major industries.

In addition to the heavy load of effluents from these and other industries (including agriculture), much of the sewage of large cities and many small towns is still untreated - thus contributing further to the pollution problem. It is one of the most serious in Europe, but considerable efforst are made for water purification.

Belgium has one of the most extensive rail and highway systems in the world, their respective densities being about 1 km/km^2 and 4 km/km^2. Even so, its navigable waterways, with a density of about 0.05 km/km^2, continue to carry an important cargo. The use of such waterways places great stress on the country's water resources and their potential fisheries. Their use involves barriers or deterrents to fish migrations, changes in natural levels and flows, channel dredging, other modifications of the substratum and the ensurance of wide distribution of pollutants throughout the network.

On the other hand, in this country of low terrain and limited volume of water, there is little development of hydroelectric power; there are only a few small stations, mostly in the Ardennes. In 1985, total installed electrical capacity in Belgium was 14 152 thousand kW, of which only 1 326 thousand (9.4 percent) was hydroelectric and 5 425 thousand (38 percent) was nuclear.

There is an active sea fishery but no commercial fishing for freshwater fish in Belgium. The supply of fish (mostly imported) for human consumption was 18.1 kg per caput in 1987.

With respect to over-all water use in Belgium, in 1972, 93 percent of its water was derived from surface sources, and 91 percent of all use was industrial (ECE, 1978). Recreational use of Belgium's inland waters is very high, including: sailing, motor boating, kayaking, water-skiing and angling.

7. FISH AND FISHERIES

The fishes occupying the most important place in Belgium's inland water fishery are listed in Table 3. Studies in the Ourthe drainage basin, which represents 12 percent of the entire country, show that 80 percent of its fish stock is composed of six species: barbel (23.5 percent), brown trout (21.5 percent), chub (13.4 percent), hotu (12.5 percent), grayling (5.2 percent) and dace (4.5 percent) (Phillipart, 1982).

Table 3

Most common exploited inland fisheries of Belgium

European eel (Anguilla anguilla)
Brown trout (Salmo trutta)
Grayling (Thymallus thymallus)
Pike (Esox lucius)
Common carp (Cyprinus carpio)
Bream (Abramis brama)
Bleak (Alburnus alburnus)
Barbel (Barbus barbus)
Hotu (Chondrostoma nasus)
Gudgeon (Gobio gobio)
Dace (Leuciscus leuciscus)
Chub (L. cephalus)
Minnow (Phoxinus phoxinus)
Roach (Rutilus rutilus)
Rudd (Scardinius erythropthaimus)
Tench (Tinca tinca)
European perch (Perca fluviatilis)
Pike-perch (Stizostedion lucioperca)

Other native fishes are, of course, caught in small numbers, and a number of fishes have disappeared from their original habitats. The Atlantic salmon (Salmo salar) can no longer tolerate the rivers of Belgium, e.g., it disappeared from the Ourthe in

1930–40. Some introduced fishes are now present in limited areas: rainbow trout (Oncorhynchus mykiss), American brook trout (Salvelinus fontinalis), two black basses (Micropterus dolomieu and M. salmoides), the American pumpkinseed (Lepomis gibbosus) and American bullhead (Ictalurus sp.).

Several different species of crayfish, both native and introduced are resident in Belgian waters but are neither abundant or fished heavily. See Gerard (1986) for an account.

Some years ago, FAO Yearbooks of Fishery Statistics did not list catches of inland fishes in Belgium, merely saying that they were not available. Recent editions, however (e.g., from Vol. 41, published in 1988) list the annual "catch" of "freshwater fishes" in Belgium from 1970 to 1987 as "0", a figure which is defined in the Yearbooks as more than zero but less than 50 t during the 1970–73 period, and since then as more than zero but less than half a ton.

Belgium/EIFAC (1975, 1977, 1980) and Timmermans (1986, 1988) all state that there are no inland commercial fishermen nor any inland commercial catch in Belgium. It could be assumed, therefore, that the FAO inland catch statistics for 1970–85 refer to the products of aquaculture, but reference to section 7.2 demonstrates that even if this were so, the early FAO statistics were grossly underestimated. From 1986 onward FAO breaks the catch down further (see section 7.2).

7.1 Capture Fishery (sport)

It must first be noted that there are two major classes of anglers in Belgium: those fishing in running waters under public fishing regulations (whose statistics are presented below), and those fishing in closed or private waters (see section 8.1).

The sport catch in Belgian rivers and canals circa 1974 was estimated to total about 466 t by about 240 000 anglers (Belgium/EIFAC, 1975). This did not include the unknown catch in private fishing ponds. Six years later (1980) the estimate of sport catch in Belgium was similar: 485 t by 220 000 licensed fishermen, primarily of cyprinids with an estimated value of 73 million Belgian francs (Admin. des eaux et forêts, 1982).

At a later date, Timmermans (1986) believed that the captures had not been augmented but estimated the number of anglers as about 300 000. Even later he (Timmermans, 1988) estimated the catch in public waters as being about 494 t in 1985 and 498 t in 1986 by about 210 000 anglers[1]. The catch in private waters as well as the number of its anglers remained unknown.

[1] More exact figures as to the number of licenses delivered are: 212 190 in 1980 and 218 323 in 1981 (Inst. Nat. de Stat., 1982), 228 677 in 1984 and 224 889 in 1985 (Inst. Nat. de Stat., 1987)

Table 4 showing the catch in public waters in 1974 illustrates its composition. Although the reported catch in Belgium is composed predominantly of cyprinids, other "finer" fishes enter the sport catch. In fact, in order of preference both for capture and for eating, a study in the province of Liège (one eighth of the country) showed the following ranking: trout, roach, pike, graying and perch (Gilon, 1982).

Sport fishing in Belgium is essentially practised by angling either with bait or artificial lures. Sport fishermen may also use devices such as nets, pots and crayfish and eel traps, but only in very limited areas..

Table 4

Sport fishing catch in public waters of Belgium, 1974

	Metric tons
Roach (Rutilus rutilus)	142.3
Brown trout (Salmo trutta)	63.4
European eel (Anguilla anguilla)	50.5
Common carp (Cyprinus carpio)	27.9
Pike (Esox lucius)	21.9
Tench (Tinca tinca)	10.2
Pike-perch (Stizostedion lucioperca)	1.5
Others (about one-third Abramis brama)	129.6
Total	447.3

Source: Brown (1977, 1983). Although originally presented as the catch in Belgium and Luxembourg, it is understood from Belgium/EIFAC (1980) that only the Belgian catch is represented.

The number of sport fishermen in Belgium based on licence issue has risen from 130 931 in 1948 to 224 889 in 1985. This constitutes about 2.2 percent of the total population. Although this percentage is not large, one must take into consideration the relatively small original area of inland water in Belgium and its degradation through industrial, agricultural and domestic use. Given the opportunities, the Belgian fisherman has apparently sought out the possibilities within his country. Circa 1980, his average annual expenditure for fishing gear and equipment was estimated to be BF 5 227. Furthermore, the Belgian tourist agencies, including the National Tourist Office, issue very explicit information on angling to attract foreign visitors. It has, however, been noted that many of the more affluent Belgians seek fishing in other countries where the water is in better condition, and that the total number of anglers within Belgium itself seems to have stabilized.

7.2 Aquaculture

Exact data on aquaculture in Belgium are difficult to obtain. Belgium/EIFAC (1980) states that there are about 12 500 artificial fish ponds in Belgium totalling about 9 400 ha in area. These ponds are of two general types: angling ponds and production ponds. Most of the ponds are fishing ponds. Some of the production ponds are run by amateur fishculturists, i.e., by anglers or angling societies who use extensive methods to raise fish to stock angling waters. The other production ponds are run by professional fishculturists who practise more intensive means of cultivation. There is no exact information on the number, size of ponds, or production for the different categories of fish which are produced in Belgium.

Nevertheless, some specific information provided by Brown (1977; 1983) is detailed below. In 1975 there were 18 rainbow trout and brown trout farms in Belgium using both pond and raceway units. About 300 t of rainbow trout were produced in 1979, mostly from eggs imported from Italy, Denmark and France. Most of the rainbow production was used as food although a few catchable-size fish were stocked in public waters for angling. All of the brown trout were destined for restocking both public and private waters either as fingerlings or small adults.

With respect to cyprinids, Brown (1977 and 1983) states that in 1975 there were 19 culturists of fish such as common carp, tench and roach who also raised small quantities of pike. The carp, produced in earthern ponds, were destined primarily for stocking in private angling ponds or streams, but a few tons were sold for food. The supply of domestically raised carp was estimated at less than 100 t annually. About 213 t were imported, mainly from France, and about 416 t were exported, mainly to the Federal Republic of Germany. Tench and roach, also cultivated in earthern ponds with little or no feeding or fertilization, achieve an annual production of between 200 and 300 kg/ha resulting in a total yield of about 200 t. About 700 t are imported. Only a few tons of this amount are destined for immediate food consumption; the remainder of these fish are used for stocking fishing waters. The released fish are at catchable sizes of 250 to 300 g.

Brown further states that although there is no separate culture of pike or pike-perch in Belgium, most carp producers stock a few fingerlings of these predators in their ponds to be harvested at the end of the first or second summer of growth. The total production of these two species is probably not over 20 t. About 50 t are imported and about 10 t are exported. Only small quantities, 2–3 t, are used as food; the remainder are used for stocking fishing waters.

Despite the general statement above concerning fish production in Belgium, and since Brown's figures seems to be rather old, are not always specific as to what year they relate, and have not been verified, various other estimates follow. Belgium/EIFAC (1980) estimated that collectively about 1 500 t of cyprinids were produced annually in Belgium's artificial ponds and reservoirs using a theoretical estimate of production of about 150 kg/ha/year. They also estimated that the professional fishculturists produced about 500 t of these cyprinids, mainly common carp, tench and roach, with an average production of about 350 kg/ha/year.

It was also estimated by Belgium/EIFAC (1980), the European Federation of Salmonid Breeders (FES), and others that trout production by professionals is about 300 t annually, but for the most part, Belgian trout culturists sell imported trout, about 2 800 t annually. Giorgetti and Ceschia (1982) list an annual production of 300 t of trout in Belgium during the 1974–78 period. Fish Farm.Int. (1982) lists Belgium's annual trout production as 300 t for 1978–81 and as 400 t in 1982, and Fish Farm.Int. (1984) lists it as 400 t in 1983.

The most recent estimates for Belgian trout production available to me are: those of Timmermans (1988) who estimated about 500 t in 1985 and about 650 t in 1986, FAO (1989) which listed the annual rainbow trout "catch" in 1986 as 350 t and that in 1987 as 380 t, FAO Fish.Info.Data and Stat.Serv. (1989) using the same figures (but calling them "aquaculture production"), and Belgium/EIFAC (1989) which estimated a production of 600 t of trout in 1988.

With respect to the production of "Cyprinidés et voraces" (cyprinids and predatory fish such as pike, pike-perch, and perch), Timmermans (1988) estimated a production of about 575 t in both 1985 and 1986. FAO (1989) listed the annual "catch" of common carp as 20 t in both 1986 and 1987, and FAO Fish.Info.Data and Stat.Serv. (1989) used the same figures but called it "aquaculture production".

Timmermans (1988) also estimated the aquacultural production of cichlids ("tilapias") and other warm-water fish in Belgium to be about 100 t in 1985 and 200 t in 1986. The Belgian "Tilapia" "catch" in both 1986 and 1987 was 200 t according to FAO

(1989), and 160 t in both 1986 and 1987 according to FAO Fish.Info.Data and Stat.Serv. (1989).

One can only conclude that aquacultural production in Belgium is relatively small and relatively static. The value of the entire aquacultural production (finfish only) of Belgium during the 1984–87 period ranged from US$ 547 000 (1984) to 1 872 000 (1987) (FAO Fish.Info.Data and Stat.Serv., 1989).

Ackefors (1989) states that there are 36 production fish farms in Belgium: 22 for trout and 14 others which produce mainly carp but also species such as cichlids, tench and roach.

One of the newest aquacultural developments in Belgium is the trial use of industrially heated water from unclear power stations to rear fish: eel, carp, trout and cichlids. European eel has not been normally cultivated in Belgium although for some time small quantities of elvers have been captured in its rivers to be restocked in other inland waters. However, in 1988 there were five eel farms in Belgium, using recirculation systems with a scheduled annual production of 72 t and 2 more farms planned to produce 63 t annually. Cichlids are well accepted as food by many Belgians and several species are used: Sarotherodon niloticus, Tilapia aurea and T. hornorum. Lately, some fish culturists have started to raise bait fishes and a pilot plant has started to raise crayfish.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership

There are two classes of fishing waters in Belgium:

(i) Closed waters which do not communicate with running waters or are separated from them by screens which block the passage of fish. These waters are not under fishing regulations, except for public closed waters, and

(ii) Running waters, sub-divided into: (a) navigable and floatable waters which are regarded as part of the Public Domain and designated as such where the fishing right belongs to the State, and (b) non-navigable or non-floatable waters where the fishing right belongs to the riparian owner or a fishing society (see section 5). These waters are under fishing regulations.

Fishing in running waters in Belgium is exclusively for the sport fisherman. It is necessary to have a State licence or permit to fish in running waters and in the case of non-navigable waters to also obtain authorization from the holder of the fishing right. Belgium issues a variety of fishing permits, dependent upon the method used, area, etc. They are obtainable at post-offices.

8.2 Administration and Management

The three Regional Administrations (Flenders, Wallonice, Brussels) are responsible for the administration (policing, monitoring and conservation) of inland fisheries in Belgium.[2]

In addition to these administrations, there are the following:

(i) The Fishery Funds controlled by the Administrations which are used to restock inland waters, enforce protective laws, and improve the fishery in general.

(ii) Provincial Fishery Commissions (one for each of Belgium's nine provinces) to administer the above funds, coordinate the efforts of local fishing associations, and execute other measures to improve inland fishing.

(iii) A Central Committee which controls and coordinates the activities of the Provincial Fishery Commissions and submits propositions for the use of the Fishery Funds.

A special service for inland fisheries has been created for some years, within the Administrations to be supported both by the government and fishermen.

8.3 Investigation and Education

The Belgian Government has a Water and Forest Research Station, composed of two sections: (i) Forest Biology, and (ii) Animal biology including Wildlife Biology and Fishery Biology. Activities of the latter section include: limnology and fishery biology, pond culture, stocking of inland waters, and protection of inland waters including pollution, aquatic plants, fish diseases and predators.

Training in fishery biology, aquaculture and allied subjects, is carried out at several Belgian universities.

8.4 Other Concerned Agencies

The Ministry of Health occupies itself with fishery problems when they are concerned with water pollution. Circa 1980, about 40 000 fishermen were grouped into about 600 local fishing societies to improve the protection and use of fishery resources. These societies are often grouped into federations.

8.5 International Agreements

The outlines of an international statute dealing with the Meuse/Maas and Escaut/Schelde with respect to their use by Belgium and the Netherlands was laid down in 1839 and amended since then. Negotiations with respect to new treaties were still in progress in 1983. A Belgian-Dutch Commission was established in 1978 to study matters arising from the management of small rivers and ground water extraction.

A trilateral agreement concerning boundary streams exists between Belgium, France and Luxembourg.

[1] Based mainly on Gaudet (1974), material received by EIFAC from Belgium in 1979, Aptekman (1979), Admin. des eaux et forêts (1982) and Gilon (1982) and updated by Belgium/EIFAC (1989). Aptekman's interpretation of section 8.1 differs somewhat from the others, but does not materially affect the conclusions.

[2] It may be noted that in the past it was the Ministry of Agriculture, acting through its Direction générale des Eaux et Fôrets, that bore this responsibility

9. STATE OF THE FISHERY

9.1 Yield

The yield from angling in Belgium rivers and canals in 1986 was estimated at about 498 t (see section 7.1). On the basis of a river and canal area of about 24 000 ha (section 5.1), the angling yield would then be about 20.7 kg/ha/year. As much of Belgium's lower river and canal area is polluted and the upper sections of the higher streams not very fertile, it is obvious that the yield in more productive areas of Belgium is much higher.

The estimated yield of 350 kg/ha/year (section 7.2) for carp and other cyprinids by professional aquaculturists is not high.

9.2 Factors Affecting the Fishery

The total extent of inland waters in Belgium, less than one percent of the country's total area, is not large, and since it consists primarily of rivers and canals cannot offer as much variety nor as productive fishing as can a country with natural lakes or many reservoirs.

The fish fauna is relatively diversified, although lacking in anadromous fishes, and water pollution has caused replacement of some of the more desirable and sensitive fishes by more tolerant species of less angling interest. For example, trout, grayling and barbel have been partly displaced in some areas by chub and dace.

The trout streams of Belgium lie in an area where the terrain is generally acid - therefore not very productive - and in the richer lower areas pollution has damaged water quality. On the credit side, there is a reasonably long growing season for fish judged from overall climatic conditions.

With therefore, no more than average natural conditions for the development of inland fisheries, the factors affecting Belgium's fisheries are primarily those determined by land and water use. In relation to its size and population (density 326 inh/km^2), it is the most highly industrialized country in Europe. With its very short coastline, no great rivers and most of them slow-moving, with much untreated sewage and many industrial wastes, intensive agriculture, maximum use by shipping of internal waterways and a recipient of waste from riparian states, Belgium's water pollution problems are severe - especially in the lower rivers. Circa 1970 its pollution of rivers and canals was considered the worst in Europe, and in 1972, over 50 percent of its rivers were considered polluted (Holden and Lloyd, 1972). Since that time, a considerable effort has been made to alleviate water pollution and the situation has improved. Still, with an annual runoff of only 1 608 m^3 per caput, water pollution, often of a complex nature, is a major deterrent to the maintenance of inland fisheries in Belgium.

Although the role of agriculture in Belgium continues to decline, its water demands are increasing as are those of other industries and domestic supply (see section 6). Furthermore, although underground water is preferred for many uses, it has to be piped long distances. Consequently, greater reliance is being placed on water from surface sources.

Although not used to any great extent for the production of hydroelectric power, where streams have been used for this purpose there has been an effect on fisheries through creation of barriers to migration, and changes in water fluctuation and stream habitat. The generation of power by other means (thermal and nuclear) does, however, require the use of large quantities of water and results in the production of thermal and some nuclear effluent.

Forests which cover about one fifth of the country are now used largely for recreation. They aid the watersheds and hence the fisheries.

Finally, there is the direct effect of fishing upon the resource and its supplementation by stocking. Although the percentage of licensed anglers to total population is not high in Belgium (only about 2.3 percent are licensed), it is high in relation to the amount of inland fishing area. Furthermore, the accessibility to fishing areas in Belgium is extremely high. There is a very dense network of roads, 94 percent of them are paved, and there is about one bridge (or potential fishing spot) for each 16 km of road. Belgium has about 339 private automobiles per 1 000 (1986) people, and (based on Gilon, 1982) about 77 percent of the people use a private car to reach their fishing areas. In the Ourthe basin, it is considered that anglers remove about 20 percent of the standing stock of fish annually (Phillipart, 1982). It appears that the overall possibility of over-use of the resource is high. This, however, is true with all uses of the country's aquatic resources - industrial, agricultural, domestic or recreational. Fishing is only one of the latter uses; it must compete with other sports often occupying the same areas, e.g., sailing, canoeing, kayaking, motor-boating and water-skiing, most of which are highly organized in Belgium.

9.3 Prospect

In view of the intense use of limited surface water resources, coupled with extreme and complex pollution, no development of commercial capture fisheries for food can be anticipated. Similarly, and also in view of topographic and climatic conditions, neither the prospects for coastal or interior aquaculture are promising.

The best hope in Belgium is maintenance of recreational fishing in the higher areas with low population density, and further extension into lower areas when pollution is abated. Steps which may improve the inland fisheries include lessened dependence on fresh waters by industry through desalinization, maintenance of more stable reservoir levels, use of heated effluents to raise fish, and greater stocking of public waters. Nevertheless, the way is long.

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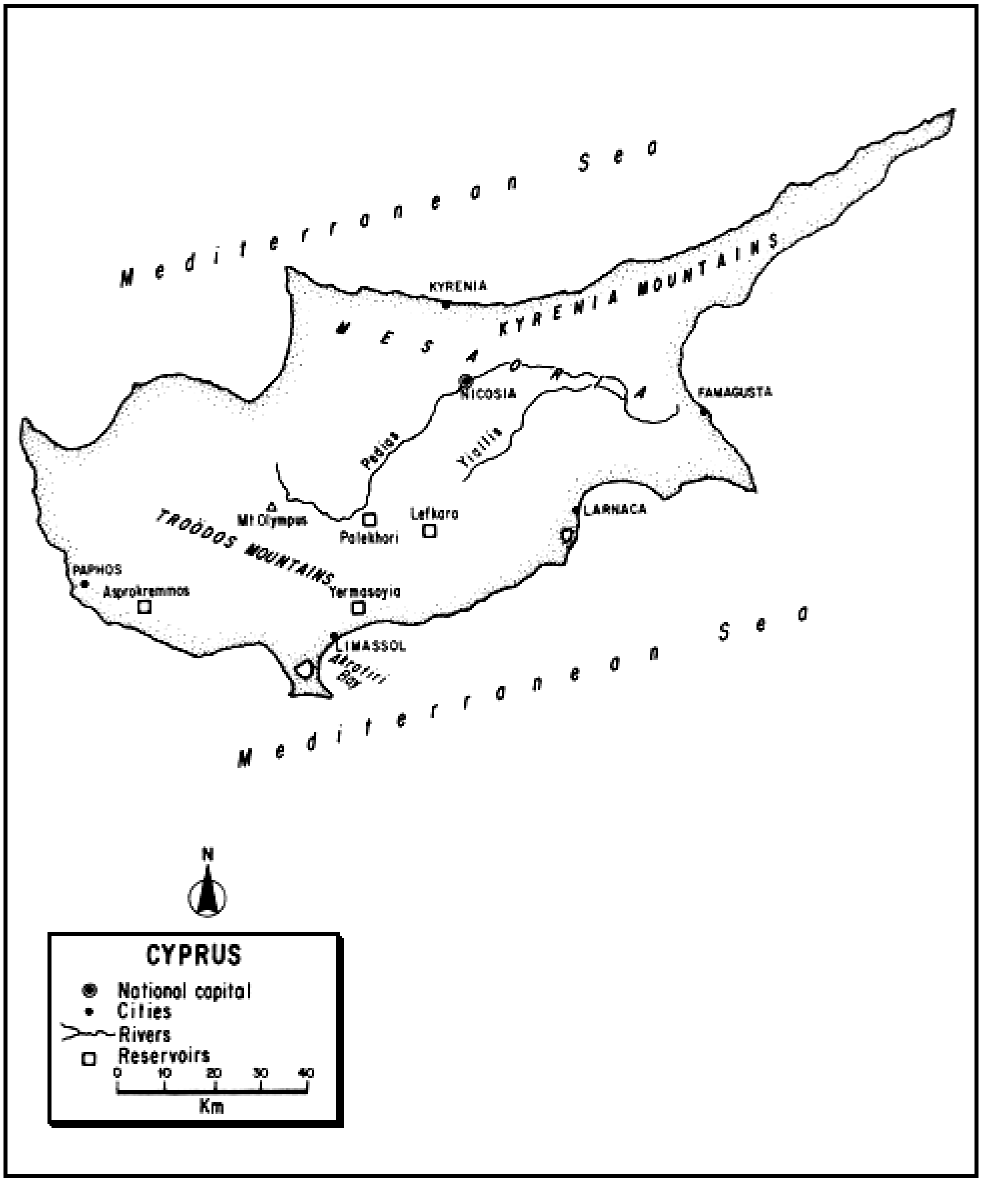
Mediterranean Sea
KYRENIA
KYRENIA MOUNTAINS
MESAORIA
NICOSIA
FAMAGUSTA
Pedias
Yialias
Mt Olympus
Palekhori
Lefkara
LARNACA
TROÖDOS MOUNTAINS
PAPHOS
Asprokremmos
Yermasoyia
LIMASSOL
Akrotiri Bay
Mediterranean Sea
N
CYPRUS
National capital
Cities
Rivers
Reservoirs
0 10 20 30 40
Km

CYPRUS[1]

The Republic of Cyprus, lying in the extreme northeastern corner of the Mediterranean Sea, is its third largest island. Two-thirds mountainous and one-third plain, with a narrow coastal fringe, it is primarily an agricultural land. Intensely Mediterranean in climate, this water-deficient country lacks freshwater lakes and few of its streams are perennial. Most of its freshwater resources lie in irrigation reservoirs.

Although sea-girt, it lacks a fishing tradition, and originally lacked a fauna of fluvial fishes. Those freshwater fishes now present, both warm-and cold-water species, have all been introduced recently.

Various attempts have been made to establish aquaculture, e.g., with trout, sparids and sea bass. There is now a small trout industry in the mountains and marine fish farms on the coast. Aside from aquaculture, inland fisheries are primarily recreational and confined to reservoirs.

[1] Since 1974, the northern area of the island has been under the control of the "Turkish army which sustains" a de facto division of the island and the self-proclaimed "Turkish Republic of Northern Cyprus"

1. AREA: 9 251 km^2

2. POPULATION: 704 000 (est. 1990) Density: 70 inh/km^2

3. PHYSICAL GEOGRAPHY

Cyprus, the third largest island in the Mediterranean Sea, lies between 34°33' and 35°34'N latitudes and 32°16' and 34°33'E longitudes. It is about 75 km south of Turkey, 105 km west of Syria and 380 km north of Egypt.

Its maximum length (E–W) is 240 km, and its greatest breadth (N–S) is 100 km. The altitudinal range is from sea level to 1 954 m.

Two mountain ranges flanking a central undulating plain occupy most of the country. The northern range, the narrow Kyrenia or Pendtadhaktylos, is a series of bare jagged peaks extending along the coast and rising to 909 m. A single, anticlinal fold of sedimentary rocks, mostly limestone, it is porous with a thin soil cover. The southern range, the Troödos or Olympus, occupies the south centre of Cyprus. Its limestone cap eroded, it is dominated by a great igneous dome of diorite, basalt and serpentine rising to 1 954 m. Largely impervious, it has some deeply cut valleys and more soil and forests than the bare Kyrenia.

Between these two ranges is a great lowland, the Mesaoria Plain, extending across the country for 96 km and opening to the sea in both east and west. Treeless, cultivated, or vegetated with garigue, and varying in width from 24 to 48 km, this depression occupies one-third of the island. Traversed by several alluvial floodplains, it was the most populated and principal agricultural area of Cyprus, before 1974.

The native vegetation of Cyprus is Mediterranean, dominated by drought-resistant plants, maquis on the lower hills and forest above. The most important native trees are Brutia pine (Pinus brutia), cypress, cedar, carob, olive and oak. Trees such as eucalyptus and casuarina have been imported. About one-fifth of the island is still forested, but the forests have suffered greatly through overexploitation, clearing and grazing[2]. Natural pastures are scarce.

Many of the soils have a calcareous base; much of the Troödos area has silicate soils. Soil erosion is common.

North of the Kyrenia and south of the Troödos are coastal plains. Indented, with both rocky and sandy beaches, the coast extends for 782 km.

[2] "In ancient times, the plains of Cyprus were thickly overgrown with forests…and could not be cultivated" (Strabo, XIV. 65)

4. CLIMATE

The climate of Cyprus is intensely Mediterranean, with short mild winters, heavy showers from November to March, and long parched summers.

The mean annual temperature is 19°C with a mean summer maximum of 27°C and mean winter minimum of 12°C. The complete range has included temperatures from -3°C to 43°C.

The mean annual rainfall is 483 mm, ranging from about 1 100 mm in the mountains to 250 mm in the Mesaoria. Rainfall is erratic. Cyprus suffers from periodic droughts and there are about 340 days of sunshine.

There is no frost along the coast but it may be sharp at heights. Snow will fall at elevations over 900 m in the southern mountains between December and March.

5. HYDROGRAPHY AND LIMNOLOGY

Van der Leeden (1975), using 1965 figures, records the approximate annual runoff in Cyprus as only 37 mm or about 300 million m^3, and ECE (1978) also lists the annual runoff as 300 million m^3. However, Bunge (1980) and Kyriakidis (1983) state that there is an estimated 600 million m^3 of usable runoff from annual rainfall. In any event, surface water resources in Cyprus are very limited, and summer droughts are common. Most of the area other than the crystalline Troödos is permeable. Springs are rare, few streams are perennial.

5.1 Rivers

Most of the 35 streams are small and impermanent. Melting snow supplies water to a number of these until late April. Others are merely winter torrents which go dry during the summer.

Among those streams of appreciable size and flow are the: Kouris, Vasilikos, Serakhis, Xeropotamos, Karyotis and Dhiarizos. The longest stream, the 100-km Pedios, flows from the Troödos eastward through the Mesaoria but does not reach the sea.

The discharge of a principal "river", the Kouris, is shown in Table 1.

Table 1

Discharge of the Kouris River (Erimi) in Cyprus, 1954–66

	Mean monthly discharge, m^3/s												
Basin area km^2	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
351	2.0	1.8	1.9	0.7	0.4	0.05	0.02	0.00	0.08	0.1	0.2	1.3	0.7

Source: Van der Leeden (1975) after Unesco, 1971

5.2 Lakes and Lagoons

There are only two major natural lakes in Cyprus. Akrotiri, a brackishwater lake about 11 km^2 in area at maximum level, has some fishery value. Larnaka Salt Lake, exploited for salt production, has a thriving population of the brine shrimp, *Artemia salina*. Both lakes may dry up during the summer months. Although Amanieu and

Laserre (1981) list 4 040 ha of lagoons at Adana in Cyprus, this is apparently a mistake, since such an area is not mentioned in any other literature available to the author, and ADC (1979) states that Cyprus has few “shallow lagoons or estuaries”.

5.3 Reservoirs

The main purpose of dam construction in Cyprus was to provide water for irrigation and the domestic requirements of towns, villages, the flourishing tourist industry and the growing local industry. The result has been the construction from 6 million t in 1960 to 300 million t in 1988. Twenty-one reservoirs coverning the area of 1 292 ha and having a capacity of 268 million t were stocked with fish and are used for angling.[1]

The reservoirs which are stocked with fish are usually mesotrophic-eutrophic. Their water has a high pH and is hard, especially that of dams lying in the lowland chalks. Highland dams lie on diabase igneous rock. The water temperature of the lowland reservoirs varies between 12°C and 29°C; that of the highland reservoirs between 8°C and 27°C. Cyprus dams are built in areas with altitudes ranging from about 30 m to 1 570 m.

The reservoirs which are used for angling are listed in Table 2.

[1] EIFAC (1989) listed the area of reservoirs in Cyprus as 1 177 ha

6. LAND AND WATER USE

Cyprus is still predominantly agricultural (see Table 3). The contribution of the agricultural sector to the Gross Domestic Product is about 20 percent. About 35 percent of the population is rural and 65 percent urban. Most farmers own their own land, and 18 percent of the economically active people are in agriculture. Chief crops include: potatoes, barley and wheat, citrus fruits, olives, carobs, the vine, cotton, tobacco and grapes. Stock rearing, especially of sheep, goats and cows is also important.

Limited by a chronic water shortage and over-exploitation of ground water supplies, dry farming is the usual practice. However, the demand for irrigation to increase production is great, and in 1983 about 94 000 ha (or 10 percent of the total area) were under irrigation. The construction of reservoirs for this purpose has been a boon to inland fisheries.

The clearing of forests for agriculture, their use for charcoal, and over-grazing by goats has greatly reduced the original forest and harmed the water resource. At present, about one-fifth of the forest land produces industrial timber and the rest is used to protect catchments. Afforestation is carried out on a relatively large scale in burnt areas, gaps within forests, and areas which have been declared forests. The area reforested in 1988 was 600 ha. Marshlands have also been drained in the past.

There is an ever-increasing light industry, e.g., clothing, cement, beverages, food processing, medicinal products. The main products which are exported are the industrial which represent in value 70.62 percent of the total exports and the agricultural (27.5 percent). In 1987 the total installed electric power capacity was 369 000 kW, all of which was thermal produced solely from imported heavy fuel oil. Streams are, therefore, not affected by hydroelectric development.

The contribution of the mining industry to the national economy during the 1930–70 period was of great importance. The mining sector declined since 1970 due to depletion of the richer ore bodies. The use of water in mining is considered indispensable in Cyprus, but everyone using water for mining operations is required to assure that water leaving the area is not detrimental to aquatic life.

Table 2

Twenty-one Cyprus reservoirs used for angling and the fish present

Reservoir	Altitude (m)	Volume ('000m^3)	Area (ha)	Mean depth (m)	Fish
Prodhromos	1 570	110	2.6	4.2	trout, mosquito fish
Palekhori	700	620	11.0	5.6	trout, mosquito fish
Kalopanayiotis	550	390	4.7	8.3	trout, mosquito fish
Xyliatos	502	1 220	9.6	12.7	trout, mosquito fish
Lefkara	290	13 850	65	21.3	trout, carp, roach, bleak, grey mullet, mosquito fish, eel, crayfish
Kafizes	260	113	2	5.6	trout, carp, mosquito fish
Lefka	250	368.45	4.5	8.2	trout, eel, carp, black bass, roach, perch, mosquito fish
Lymbia	200	220	8.5	2.6	carp, catfish, black bass, perch tilapia, eel, mosquito fish, crayfish
Athalassa	170	20	1	2	carp, goldfish, tilapia, mosquito fish, catfish, eel, crayfish
Kouris	150	115 000	340	33.8	roach, pike-perch, carp, mosquito fish
Dhypotamos	131	13 700	96	14.3	tench, mosquito fish
Kalavasos	126	17 100	87.5	19.5	carp, black bass, mosquito fish
Ayia Marina	120	320	3.3	9.7	carp, mosquito fish
Evretou	102	25 800	126	20.5	Tilapia, carp, mosquito fish
Polemidhia	100	3 700	11	33.6	carp, catfish, eel, perch, bass, mosquito fish, roach
Pomos	75	840	8.3	10.1	carp, mosquito fish
Mavrokolymbos	70	2 180	17.5	12.5	carp, roach, mosquito fish
Argaka	65	1 150	10.7	10.7	carp, roach, mosquito fish
Yermasoyia	60	13 600	110	12.4	carp, roach, bass, bleak, grey mullet, silver bream, perch, mosquito fish
Asprokremmos	30	51 000	259	19.7	carp, bass, mosquito fish
Akhna	39	6 800	115	5.9	carp, Tilapia, tench, mosquito fish, crayfish

Source: Cyprus/EIFAC (1989)

Table 3

Pattern of land use in Cyprus, 1987

	Percent
Arable and permanent crops	17.1
Permanent pasture	0.5
Forests and woodland	13.3
Other land	69.0
Inland water	0.1
Total	100.0

Source: 1987 FAO Prod.Yearb., 41 (Publ. 1988)

The island is easily accessible by 11 974 km of roads (1986) of which about one-half are paved, providing a road density of 1.3 km/km^2. Passenger car ownership is 250 per 1 000 people. There are no public railroads, and obviously no inland waterways.

Marine fisheries have never been very important in the Cypriot economy. Good ports were lacking, most of the people lived inland for security, the eastern Mediterranean is unproductive, and most fishing was of a subsistence nature. Thirty-five years ago, the marine catch was only about 400 t annually, and in 1987 it was still only 2 555 t. Fishing is significant mainly as a source of useful protein and luxury food for the tourist industry. The per caput supply, including imported fish, was only 13.35 kg/year circa 1987. Inland fisheries and aquaculture (both freshwater and marine) have been developed to some extent lately, and the supply of trout is below local demand at times.

In 1972, 21 percent of Cyprus' consumptive water use was supplied by surface water of which 20 percent went to agriculture. Eighty-seven percent of the country's total water use was for agriculture (ECE, 1978).

Tourism, revolving around sea, sun, and antiquities is the most significant foreign exchange earner with over one million tourists in 1987, but angling is by no means a tourist attraction.

7. FISH AND FISHERIES

Aside from the European eel (Anguilla anguilla), all of the fishes of the inland waters of Cyprus have been introduced, most of them since 1969. There is now a population of about 19 species.

The common carp (Cyprinus carpio) and roach (Rutilus rutilus) are now present in both lowland and highland reservoirs. Bleak (Alburnus alburnus) is present as a forage fish, as is the mosquitofish (Gambusia affinis) which is also used for mosquito control. Largemouth black bass (Micropterus salmoides), European perch (Perca fluviatilis), and channel catfish (Ictalurus punctatus) are also found in lowland reservoirs. Rainbow trout (Oncorhynchus mykiss) are raised commercially (see below) and fingerlings stocked in mountain dams above 250 m. A small trout population also exists in some mountain brooks.

Other aquatic species which have been introduced in recent years are: crucian carp (Carassius carassius), goldfish (C. auratus), silver carp (Hypothalmichthys molitrix), grass carp (Ctenopharyngodon idella), catfish (Clarias sp.), eastern (American) brook trout (Salvelinus fontinalis), brown trout (Salmo trutta), the cichlids ("tilapia") (Tilapia nilotica and Sarotherodon aureus), tench (Tinca tinca), pike-perch (Stizostedion lucioperca) and the crayfishes Pacificastacus leniusculus, and Astacus fluviatilus and Procambarus clarkii.

In general, this inter-continental mix of species has been introduced to provide food and sport through aquaculture, but mirror carp and grass carp are also used to control aquatic plants in irrigation reservoirs, and silver and grass carp have been introduced in a cement-lined canal for the same purpose. Goldfish are also produced for ornamental use.

7.1 Capture Fishery

There is no commercial fishery in the inland waters of Cyprus, but the irrigation reservoirs are used for sport fishing. This sport started around 1969 with the expansion of water development, introduction of various species of freshwater fishes, and issuance of licences for recreational fishing.

About 21 reservoirs with an area of about 1 292 ha and capacity of 267 million m^3 were stocked with fish and available to the public for angling in 1988. The annual yield of fish was estimated in 1977 to be 15–20 t (Cyprus/EIFAC, 1977).

About 3 500 angling licences were issued in 1988. There are several angling clubs, run mostly by foreigners but in close contact with the Department of Fisheries.

Owing to the water conditions, trout fishing depends largely on one-year-old fish. About 20 000 young trout are stocked every year in highland dams, mostly in winter. Trout fishing is allowed as from spring each year. Although there is a small wild trout population in the mountains, angling is not permitted in the mountain streams. There is some catch and release fishing, and some angling for subsistence.

7.2 Aquaculture

Bertram (1944) recommended the introduction of carp farming into Cyprus as a means of expanding its fishery activity, and in 1945 common carp (Cyprinus carpio) from Palestine were introduced into the Syrianokhori Swamp area. Since then, a number of aquacultural surveys have been made in Cyprus (see, for example, FAO, 1970). Carp have been reintroduced, and other exotic fishes now resident in Cypriot reservoirs have also been imported (see section 7).

Sometime prior to 1974, there was a private grey mullet (Mugilidae) farm in Cyprus using a local species. In 1979 there was a production of about 1 t of grey mullet in tanks and ponds at the experimental farming station at Boghaz (a governmentally established station now in the Turkishoccupied area). Experimental culture of grey mullets has also been carried out on a semi-extensive basis in brackish-supersaline gravel pits in the Akrotiri area[1]. Since the opportunities for marine or brackish water aquaculture in Cyprus seem to outstrip those for strictly freshwater aquaculture, there has been a considerable development of experimental facilities for its prosecution. Aside from the construction of an experimental farming station now in Turkish-occupied area, the Cyprus Department of Fisheries has run a small hatchery at Paphos on the southwest coast since 1981 for the experimental production of euryhaline fish such as the sea bass (Dicentrarchus labrax) and Sparidae. In early 1989, a new experimental station was started at Meneou (Larnaca) for the development of commercial aquaculture in salt water. In 1988, three commercial fish farms worked on an intensive basis for the hatching and culture of sea bass and sparids. Six tons of these cultured species were marketed in 1988, and exports of over a million young sea bass and sparids were made to Greece. One ton of sea bass was raised each year in 1984, 1985 and 1986, and two tons of sparids in 1987 according to FAO Fish.Info.Data and Stat.Serv. (1989). Small quantities of cichlids ("tilapia") and trout reared in brackish water have also been produced as side products. The cichlid production was as follows: 3 t (1984), 2 t (1985), 2 t (1986) and 1 t (1987) according to FAO Fish.Info.Data and Stat.Serv. (1989). European eel (Anguilla anguilla) imported from the United Kingdom as elvers in 1978, have been experimentally cultured and some were stocked in reservoirs circa 1981. Cyprus, which has had a propensity for introducing many exotic fish, has also experimented with American cutthroat trout (Oncorhynchus clarkii) in 1980 and with Atlantic salmon (Salmo salar) and coho salmon (Oncorhynchus coho) in 1988. There have also been attempts to raise rainbow trout (Oncorhynchus mykiss) in salt water.

1 Six tons of mullet were taken in the marine capture fishery of Cyprus in 1987

With respect to strictly freshwater culture, however, the only fish successfully cultured commercially in Cyprus is rainbow trout. The centre for the work on freshwater fish culture (as well as the management of inland waters) is the governmental

Experimental Stational at Kalopanayiotis. One of the functions of the station is the production of trout to provide most of the needs for rearing in private farms and cages. The trout is “all-female”. In 1987 about 0.5 million young trout were sold to the private sector for ongrowing, and every year the station produces about 3 t of commercially sized trout.

There are (1989) four private commercial trout farms, built mainly on leased forestry land.[2] The farms work on an intensive basis, with an annual production of around 50 t (see Table 4).

2 EIFAC (1989) stated that Cyprus had five trout farms totalling 0.3 ha

In 1985 the Department of Fisheries undertook experimental cage culture of trout in reservoirs. In 1988 about 15 t were produced in cages, and the commercial production of trout from dams is expected to double the local production soon. The environmental impact of trout cage culture is being followed through water monitoring.

The trout is sold either fresh (gutted), or smoked (whole or fillets). The larger quantity of trout is consumed by the tourist industry. There is a shortage of trout, which is more acute during certain seasons and its price is high compared to that of European countries.

Table 4

Nominal catches by species in the inland waters of Cyprus, 1972–87
(in tons)

	Freshwater fishes	Trouts n.e.i. *Salmo* spp.
1972	0	
1973	0	
1974	41	
1975	31	
1976	31	
1977	31	
1978	31	
1979	31	
1980	31	
1981	36	
1982		46
1983		50
1984		56
1985		53
1986		53
1987		47

0 - more than zero but less than 50 t

Source: 1972–73 - Yearb.Fish.Stat.FAO, 44 (Publ. 1978)
1974–81 - FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1982–87 - Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

The FAO Yearbook of Fishery Statistics first listed “catches” of unidentified “freshwater fishes” in Cyprus in 1972, and continued use of this term to cover the entire “catch” in the country's inland waters for some time. Now, however (see FAO Yearbook

64, published 1989) it lists the entire inland fish "catch" of Cyprus as "trouts". See Table 4.

It has been ascertained from various sources, especially Cyprus/EIFAC (1974) and Cyprus/EIFAC (1989) that all of the fish listed in Table 4 relate only to the trout cultivated there. Furthermore, the production ("catch") of trout in Cyprus in 1972 was actually 12 t, that of 1973 was 40 t, and that of 1988 was 51 t (Cyprus/EIFAC, 1989). The scientific name Salmo spp. given in Table 4 should actually be Oncorhynchus mykiss since this is the scientific name now used to designate rainbow trout.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT AND INVESTIGATION[1]

8.1 Ownership and Availability

The ownership of all water, surface or underground, is generally vested in the Government of the Republic of Cyprus. The use of water for domestic purposes is granted priority over its use for agriculture, industry or tourism.

Aquatic resources are Government property.

The area around the high water level of the reservoirs up to a certain level belongs to the Government and is open to anyone.

The dams belong either to the: (a) Government, as Government Water Works, or (b) Irrigation Divisions, which are formed by the landowners who are the users of the dams' water.

The dams of category (a) are managed either by the Water Development Department or by Water Works Committees, while those of category (b) by Irrigation Committees, the members of which are elected among those of the Irrigation Division.

The maintenance of the dams of both categories is undertaken by the Water Development Department.

Most of the major dams of category (a) are designed for over-annual storage and no maintenance problems are faced. Water for domestic purposes is supplied only from the Government Water Works, directly through special water treatment plants, or indirectly, by the enrichment of the aquifer where boreholes for pumping drinking water exist.

8.2 Administration

The administration of all fisheries, marine or inland, as well as of aquaculture, rests in the Ministry of Agriculture and Natural Resources acting through its Department of Fisheries. (This Ministry is also the major one for policy making in connection with water resources and water development works.)

The Department of Fisheries exercises its powers under the relevant laws to formulate by-laws and regulations for the development, exploitation, management, protection, etc., of all fishery resources.

The Department is divided into four Divisions:

(i) Fishing Industry;
(ii) Resources;
(iii) Fishing Shelters, and
(iv) Fish Culture and Inland Water Management

The latter Division has three Sections: Freshwater Fish Culture, Marine Farming, and Inland Waters Management.

In addition, the Department has a Preventive Service (in District offices) to carry out law enforcement, and various Technological and Research Sections.

8.3 Other Concerned Agencies

(i) The Cyprus Tourism Organization aids in encouraging angling and releasing fishing information. It also funds projects which aim at promoting the recreational use of the reservoirs. These projects mainly refer to the provision of facilities to the anglers and the general public and are formulated by a technical committee which consists of representatives of the Department of Fisheries, the Cyprus Tourism Organization, Town Planning and Housing, Water Development and the Forestry Department, and

(ii) Local angling clubs also assist the recreational fishing programme by collecting voluntary angling statistics, collecting fish for restrocking, etc.

8.4 Licensing

Fishing licences are required by the Department of Fisheries for fishing in reservoirs, but angling is not permitted in the mountain streams. Riparian rights do not exist. Only bank fishing is allowed and the use of boat in the reservoirs is prohibited.

Originally, licences were issued free of charge for each reservoir separately, and for limited periods. By the end of 1981, however, legislative measures were introduced which allowed the collection of fees for the issue of fishing licences in reservoirs.

Angling with a single rod and line has been allowed. Restrictions also exist on bag size, hours and seasons of fishing (mainly in reservoirs stocked with trout), size of fish (for trout and bass), etc.

8.5 Scientific Services

Aquaculture research and development support comes from the Department of Fisheries which cooperates closely with other related government departments. The legal framework for the establishment and operation of fish farms is being defined. The government provides technical assistance and support and there is close contact between the commercial sector and the Department of Fisheries. The government also provides long-term, low interest loans and leases, and suitable government land for the setting up of commercial fish farms.

[1] Based on information sent to EIFAC by Cyprus in 1979, Demetropoulos (1982), Stephanou (1982, 1988), Kyraikidis (1983) and Cyprus/EIFAC (1989)

9. STATE OF THE FISHERY

9.1 Yield

The annual yield of fish to anglers from Cypriot reservoirs was reported by Cyprus/EIFAC (1977) to be about 15–20 t and Stephanou (1982) stated that about 300 ha of reservoirs were available for public fishing for game and coarse fish. The yield using these rough figures would, therefore, be from 50 to 67 kg/ha/year. Given the circumstances of reservoir production in Cyprus (see sections 5.4 and 7.1), and considering that only bank fishing is permitted, these appear to be very adequate yields.

The mean catch per rod-hour in 1980 was 305 g in Yermasoyia Reservoir (Stephanou, 1981).

9.2 Factors Affecting the Fishery

The very small extent of inland water in Cyprus, and the artificial nature and heavy use of most of these waters obviously limits any possibility of large fish production.

Altitudinal and climatic differences do permit a range of species combinations from trout to semi-tropical fishes, and the long growing season and basic fertility of the terrain should promote rapid growth.

The smallest reservoirs usually dry up during summer months, and medium-sized ones are periodically lowered or drained for maintenance during the winter. Successive collection, storage, and stocking of fish in such reservoirs is difficult, and even in the larger reservoirs where this may not be necessary, conditions are better for recreational than for commercial fishing.

Water pollution, according to Stephanou (1982), is not considered to be a problem in the inland waters of Cyprus, especially in the mountain reservoirs. Furthermore, the act of pollution is covered by rather strict laws. Nevertheless, this is a factor that will increase, especially since large increases in ground water are unlikely, and the present annual runoff per caput is very low. Estimates can range from 426 m^3 to 852 m^3, depending upon the total runoff figures one accepts (see section 5).

Sport fishing by organized or semi-organized anglers who seek permits amounts to only about 0.5 percent of the total population.

9.3 rospect

The serious shortage of water is by far the most important deterrent to the development of inland fisheries and freshwater aquaculture in Cyprus. Water use for agriculture, domestic supply, industry, and tourism sharply limit the supply that can be devoted to other users. Furthermore, excessive extraction of underground water has already resulted in intrusions of sea water and soil salinization in some areas, and most newly irrigated land will have to depend largely on surface water.

Of course, some integration of agriculture and aquaculture is feasible, and the treated effluents of sewage treatment plants may someday be utilized for fish production in Cyprus. Furthermore, water development ranks very high in Cyprus' development budget. For example, in 1979, the budget for water development was 1½ times that for the road network, twice that for agriculture, and 5 ¼ times that for commerce and industry (Fisher, 1980). Water losses can be curtailed by greater use of improved irrigation systems, control of excessive pumping, groundwater recharge, use of low-quality water, and increased protection of catchments (a move toward the latter end was made some time ago when tethering of goats in forest areas was made compulsory). Conversion of sea water to fresh water is also in prospect, as are some long distance water transfers.

Increases in public sport fishing can, therefore, be envisioned with moves to conserve water, enlarge reservoir capacity, and increase use of the present system.

With respect to aquaculture, the shortage of freshwater resources and shallow coastal lagoons or estuaries is a limiting factor. Fish cage culture in reservoirs could contribute substantially to the increase of freshwater fish production. Marine aquaculture could offer a long-term solution to the shortage of fresh fish which is now faced in Cyprus with the operation of commercial land-based installations working on an intensive basis.

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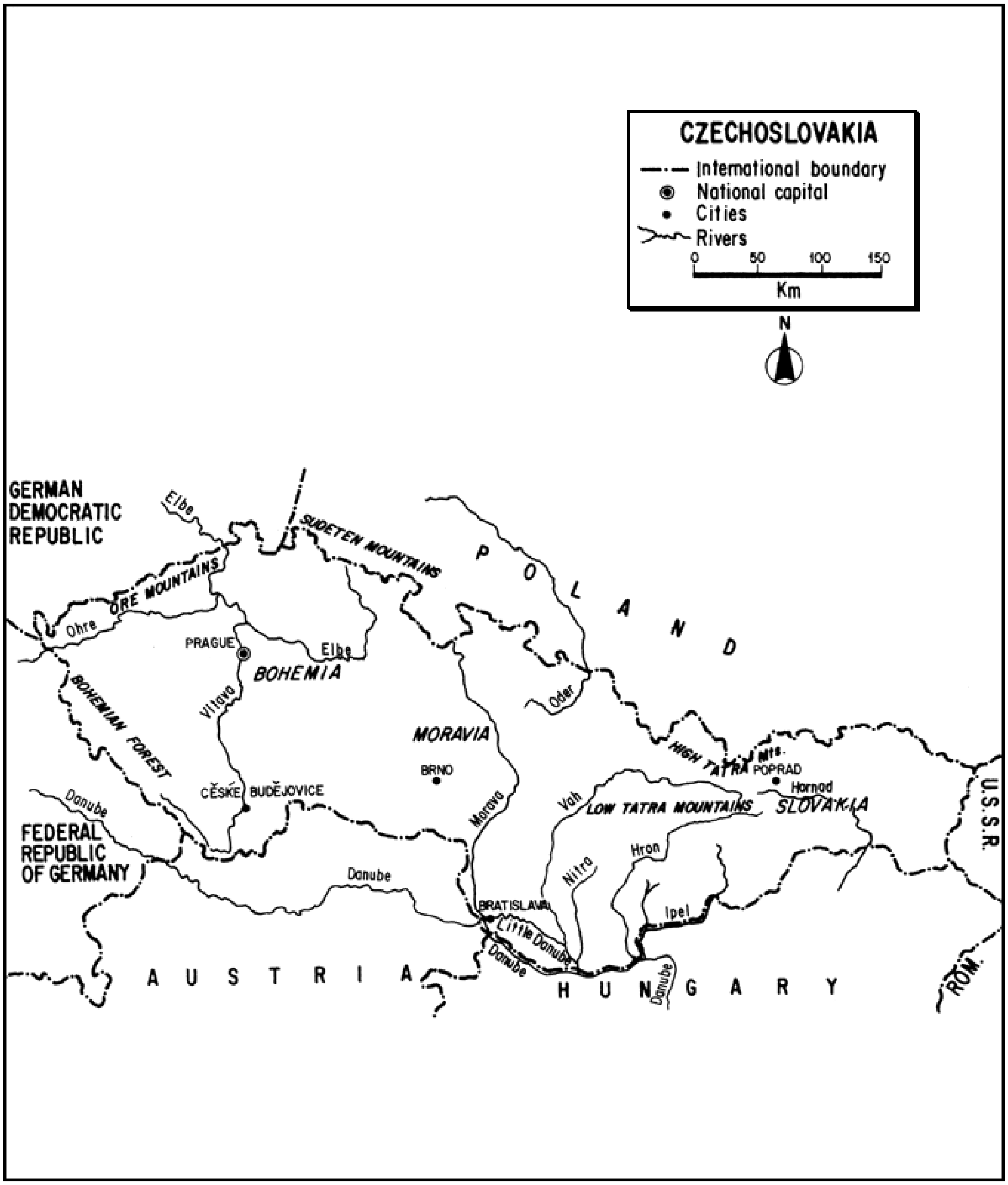

CZECHOSLOVAKIA
International boundary
National capital
Cities
Rivers
0
50
100
150
Km
N
GERMAN DEMOCRATIC REPUBLIC
Elbe
SUDETEN MOUNTAINS
ORE MOUNTAINS
Ohre
PRAGUE
Elbe
BOHEMIA
Vltava
BOHEMIAN FOREST
POLAND
Oder
MORAVIA
BRNO
ČESKÉ BUDĚJOVICE
Danube
FEDERAL REPUBLIC OF GERMANY
Danube
Morava
HIGH TATRA Mts.
POPRAD
Hornad
Vah
LOW TATRA MOUNTAINS
SLOVAKIA
U.S.S.R.
Hron
Nitra
Ipel
BRATISLAVA
Little Danube
Danube
Danube
AUSTRIA
HUNGARY
ROM.

CZECHOSLOVAKIA

Most central of the European states, the Czech and Slovak Federative Republic (once known as the Czechoslovak Socialist Republic) is landlocked, surrounded by six other countries. Politically, it is divided into two republics: the Czech Republic and Slovak Republic. Its three major physiographic regions, Bohemia, Moravia and Slovakia, encompass an essentially mountainous, forested and agricultural area which has become one of the most industrialized sections of Eastern Europe.

The headwaters of rivers draining northwards to the Baltic and North Seas, it also drains south to the Black Sea via its boundary stream, the Danube.

Lacking marine waters, with few natural lakes, no great development of large reservoirs, and with heavy demands upon its rivers, Czechoslovakia's principal concentration with respect to fish production lies in aquaculture. Here, a 700-year tradition continues with emphasis on carp culture but with a growing involvement with other species, including trout.

Commercial fishing is fast diminishing in importance, being replaced by recreational fishing for both warm-water and salmonoid species.

1. AREA: 127 900 km^2[1]

[1] Czech Republic has an area of 78 864 km^2; Slovak Republic has an area of 49 036 km^2

2. POPULATION: 15 829 000 (est. 1990) Density: 124 inh/km^2

3. PHYSICAL GEOGRAPHY

Landlocked in eastern central Europe, Czechoslovakia lies between 47°43' and 51°03'N latitudes and 12°05' and 22°34'E longitudes.

Its greatest length (E–W) is 752 km, and it varies in width from 97 to 280 km. Its highest point is 2 655 m; its lowest is 163 m.

It is bounded by six countries: the German Democratic Republic for 459 km on the northwest, the Federal Republic of Germany for 356 km on the southwest, Poland for 1 310 km on the north, Austria for 570 km and Hungary for 679 km on the south, and the USSR for 98 km on the east[2].

[2] Boundaries from Worldmark (1984)

Czechoslovakia is a mosaic of hills and depressions with some high peripheral mountains. Uplands (200–600 m) occupy about 70 percent of the country, mountains (above 600 m) occupy about 20 percent, and lowlands only about 10 percent.

The country can be divided into three major regions: the Bohemian Plateau in the northwest, mountainous Slovakia in the east, and the transitional Moravian Lowland between them.

Bohemia, occupying two-fifths of the country, is a gently rolling plateau, mainly between 450 and 600 m, almost encircled by densely forested mountains up to about 900 m. It is rimmed by the higher Sudeten Mountains on the northeast, the Ore Mountains on the northwest, the Bohemian Forest and Sumava mountains on the southwest, and the less prominent Moravian Hills on the southeast. Crystalline rocks predominate.

Slovakia, the eastern two-fifths of the country, has areas of rich lowland in the south, but most of its central and northern extent is dominated by parallel ridges of the rugged Carpathian arc of crystalline slates and limestones. These include the somewhat central Low Tatras and the High Tatras which rise above 2 000 m and are shared with Poland. It is drained primarily by tributaries of the Danube River.

Spanning central Czechoslovakia between these two major regions, is the smaller Moravian corridor, a hilly tectonic depression open to the north and south. Sloping generally south, it is dissected by the Morava and its tributaries to drain into the Danube. It also has a northerly drainage, the Oder, toward the Baltic.

Mixed deciduous and coniferous forests cover 35 percent of the country. Above the treeline (1 200–1 500 m), alpine meadows and moors predominate. At lower altitudes, spruce, beech, fir, oak, maple, ash and other species occupy the forest zone. In lowlands steppe-type vegetation predominates.

Soils are varied: 50 percent podzols, 20 percent brown soils, 10 percent chernozems, and some stony mountain, alluvial, humus-carbonate, and peat soils.

The western part of the country is more urban and industrial than the mountainous Carpathian area.

4. CLIMATE

The temperate climate is transitional: continental climate prevails, but the western area shows a maritime influence.

The mean annual temperature of 9°C varies from -3.7°C in the highlands to 10.5°C in the Danube lowlands. The July mean is 20°C and winter mean about -2.2°C.

The average annual precipitation is 742 mm, averaging about 865 mm in high areas and 610 mm in low areas, with a country-wide range from 450 to 1 500 mm. Its seasonal distribution is about as follows: 24 percent spring, 38 percent summer, 23 percent autumn, and 15 percent winter. The maximum rainfall is in July, the minimum in January.

Snow cover lasts generally for 70–80 days, and the mountains are snow-covered from early November through April. Snow persists all year in some high places in the Tatras.

The growing season is about 200 days in the southern regions and less than 100 days in the mountains.

5. HYDROGRAPHY AND LIMNOLOGY

The total area of Czechoslovakia's inland waters is about 248 956 ha or about 1.9 percent of the total area of the country. Of this area of inland waters, 154 905 ha are in Bohemia and Moravia and 94 051 ha in Slovakia (Czechoslovakia/EIFAC, 1989). See also Table 3.

These figures, which emanated from a statistical yearbook (1988) of the Federative Republic agree generally with the figures in Table 3 (which are rounded). I have found some other, rather puzzling, enumerations, but of these only the ones in printed form (and thus readily available to the public) are mentioned below:

(i) 65 000 ha of inland waters (EIFAC, 1989);
(ii) 132 000 ha of water “including” 54 000 ha of ponds (Anon., 1982);
(iii) 135 000 ha of reservoirs including rivers of which 52 030 ha are in ponds (with no mention of natural lakes) (Vacek, 1983);

(iv) 187 300 ha of water area, including 106 833 ha of natural lakes and 25 543 ha of man-made lakes, with a total area of only 78 684 ha considered suitable for fishery management (FAO, 1979).

There are some obvious mistakes in the four estimates given above. For example, FAO (1979) has misread the manuscript upon which it was based (Anon. 1979) and mistakenly substituted the manuscript's figure for the area of its country's running waters for that of its natural lakes[1]. All in all, I consider the figure of 248 956 ha for the extent of inland waters in Czechoslovakia to be the most accurate available.

[1] Although Anon. (1979) is really the manuscript used as the basis for FAO (1979), an FAO Fishery Country Profile, I have used it here as the major reference because of its direct emanation from someone in Czechoslovakia

The average annual runoff from rainfall on Czechoslovakian soil is 220 mm or 28 000 million m^3. About 62 000 million m^3 is received annually from upstream countries, resulting in a total annual river discharge of 90 000 million m^3 leaving the country (Van der Leeden, 1975; ECE, 1978).

Czechoslovakia is the headwater area of several of the major watersheds of Europe. Overall, about 54 percent of its surface water drains into the Black Sea via the Danube and its tributaries, 39 percent drains into the North Sea via the Elbe Basin, and 7 percent drains into the Baltic via the Oder and Vistula basins.

5.1 Rivers (Řeky)

Bohemia constitutes a hydrographic unit with a centripetal pattern around the Vltava-Elbe. Moravia forms a distinct hydrographic region with an axis along the Morava River. Slovakia is drained primarily by tributaries of the Danube, but these do not represent a unit as many flow parallel in their upper courses and converage near their confluence. Most Bohemian and Moravian rivers follow turbulent middle courses, tending to flow in narrow gorge-like valleys. The Danubian tributaries are generally rapid, carrying sediments which create large alluvial fans and form obstacles to navigation.

With the exception of the Danube, the rivers have a maximum runoff in the spring following snowmelt and a summer minimum. The Elbe, for example, varied between 1 907 and 121 m^3/sec. in 1968 (Van der Leeden, 1975), and the ratio of minimum to maximum flow of some Czechoslovakian streams can approximate 1 to 250. The Danube, which is fed by Alpine snow, has a marked summer maximum. Only six Czechoslovakian rivers have a mean annual flow of over 100 m^3/sec., and only the Danube has a really large flow. See Table 1 for length of the principal rivers, and Table 2 for the flow of three principal rivers.

Danube. The Czechoslovakian section of this river (the Dunaj in Czech) is 172 km in length, from the mouth of the Morava River to the mouth of the Ipel. It is shared with Austria and Hungary as a boundary.

At the Morava junction, it leaves the slopes of the Alps and enters the Danube or Hungarian Plain. It has already become a great river, carrying only about twice as much water at maximum as in the minimum months of flow, and when it leaves Czechoslovakia the flow is about 50 percent greater on the average. Such an increase in flow is probably largely responsible for the finding that in recent years the quality of water in the Czechoslovakian section of the Danube has not changed much, and is actually purer than the water entering from Austria (Tržilova and Miklošovičova, 1977).

Soon after entering Czechoslovakia, the Danube splits into two channels. The southern is the Danube proper, the northern is called the Little Danube (Maly Dunaj).

The Little Danube joins the Vah near where the latter meets the main Danube. Between the two is marshland and diked channels.

About 70 km below the Morava (i.e., 1 880 km above its mouth at the Black Sea), the river has broken its slope and become more of a plains river. Busnita (1967) considers that most of the Danube from the 1 791-km mark to its mouth is a cyprinid zone. At one time this lower area of the Czechoslovakian river had many arms, swamps, and side lakes. During the last century, man has reclaimed much of this area, but it still remains productive for fish.

The main channel of the Morava-Ipel section measures (7 937 ha and the area of river arm beds situated along both sides (i.e., Czechoslovakia on the north, Hungary on the south) totals 3 114 ha. The area of more or less regularly inundated plain, demarcated with flood dams, is about 7 km in width at its upper end, 1.5 km at its lower end, and totals about 23 000 km^2 in area (Holčik and Bastl, 1976).

Throughout the section, the river has a velocity of about 2.0–2.5 m/sec., and a flow at its upper end from about 1 400 to 2 700 m^3/sec. For further details on the Danube, see especially the chapters on Austria and Hungary.

Table 1

Principal rivers of Czechoslovakia

Basin and river	Length in Czechoslovakia (km)
Elbe (Labe) Basin	
Elbe	364
Jizera	164
Vltava (Moldau)	430
Luznice	208
Sazava	220
Berounka	247
Ohre	256
Oder (Odra) Basin	
Oder	132
Opava	114
Moravica	102
Vistula (Visla) Basin	
Poprad	108
Danube (Dunaj) Basin	
Danube	172
Morava	365
Becva	118
Dyje	263
Jihlava	180
Vah	391
Orava	112
Nitra	232
Hron	276
Ipel	89
Slana	98
Hornad	168
Laborec	130

Source: Melezin (1957)

Tributaries of the Danube. Proceeding downstream, the first Czechoslovakian tributary of the Danube is the Morava, a boundary stream with Austria (where it is called the March) for 80 km. With a total length of 365 km, it drains four-fifths of Moravia. The other major tributaries drain western Slovakia, flowing generally southward from the Tatras. The Vah (Waag) is 391 km long with an average discharge of 158 m^3/sec. Below it are the Nitra, Hron and Ipel, the latter a boundary stream with Hungary where it is called the Ipoly.

Elbe. Almost all of Bohemia is drained by the Elbe (called Labe in Czech). Rising in the Sudeten Mountains, it is joined by the 430-km Vltava (Moldau) near Prague. Also collecting water from the Ohre River, it proceeds through a narrow gap to enter the German Democratic Republic as a major stream and proceed through it and the Federal Republic of Germany to its mouth on the North Sea. The total length of the Elbe is 1 137 km of which 364 km is in Czechoslovakia.

Oder. The Oder (Odra in Czech) rises in northern Czechoslovakia and flows through Poland (that country's second largest river) to its mouth in the Baltic in the German Democratic Republic, a journey of 906 km.

Table 2

Discharge of three rivers in Czechoslovakia

River and station	Mean monthly discharge, m^3/sec								
	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sep.
Elbe (Labe) River Decin	287	392	550	496	305	247	249	198	195
Morava River, Moravsky Jan	101	135	216	187	117	84.2	76.0	65.7	66.7
Danube River, Bratislava	1 419	1 635	2 096	2 385	2 486	2 746	2 725	2 250	1 733
	Oct.	Nov.	Dec.	Year		Period of record			
Elbe River	218	265	265	305		1931–60			
Morava River	58.8	102	95.4	109		1931–60			
Danube River	1 525	1 517	1 402	1 993		1931–60			

Source: Unesco (1969)

Vistula (Visla in Czech) drainage. The Poprad River, rising in the High Tatras of Slovakia drains only a small area of Czechoslovakia, through which it flows for 108 km to join the Vistula (Wisla) in Poland which proceeds for 1 047 km to the Baltic Sea.

5.2 Lakes (Jezera)

The statement by Anon. (1979) that Czechoslovakia has 350 ha of natural lakes, almost exclusively small and oligotrophic, the best estimate available to the author, probably refers to glacial or cirque lakes in the mountains. These glacial lakes include the Certovo and Cerne Jezero in the Sumava Mountains of Bohemia, and Strbske and Propradske Pleso in the Carpathians. A complex of small lakes is found in central Bohemia in the area of the Trebon and Budejovice basins. These occupy small kettlelike depressions in heavy clay deposits; many serve as fish ponds.

Some literature indicates that Czechoslovakia has a large number of "lakes" (e.g., a travel book by Fodor, 1983, alludes to 22 000 "lakes" in the country). Such statements undoubtedly refer to fish ponds, some of which have been established for hundreds of years and are well integrated with ecological consistency, creating a pleasant landscape.

5.3 Reservoirs (Vōdni Nādrže)

There are 25 543 ha of “man-made lakes” which are not fish ponds (Anon., 1979). Some of these exist as a series of dams, e.g., those on the Vltava near Prague. The largest reservoir, Orlik, has a capacity of 720 million m^3.

It has been estimated (ECE, 1978) that by the year 2000, Czechoslovakia will increase its storage volume in reservoirs by 250 percent.

6. LAND AND WATER USE

Czechoslovakia is essentially an urban (68 percent) and industrial country, but with over half its land devoted to agriculture mainly on collective and State farms. Cereals, sugar beets, and potatoes are major crops, and livestock farming is the most important element. Although introduced here many years ago, given the country's climatic conditions, irrigation is a relatively minor use of water, only about 2 percent of the land being irrigated (1986). Fertilizer use is almost twice the European average.

Table 3

Pattern of land use in Czechoslovakia, 1986

	Percent
Arable and permanent crops	40.2
Permanent pasture	12.8
Forests and woodland	36.0
Other land	9.0
Inland water	2.0
Total	100.0

Source: 1987 FAO Prod.Yearb., 41 (Publ. 1988)

The country is well forested and ranks about seventh in roundwood production in Europe. Forest care is good and watersheds preserved, although mismanagement some years ago led to irregularities in stream flow and erosion, and what is thought to be acid rain is affecting its trees.

Its large-scale industries are dependent upon its important resources of coal and lignite. However, many of the country's environmental problems stem from its use of lignite with a high sulphur content. Its output of oil and ferrous ores is inadequate for domestic use, most non-ferrous ores are limited, and it lacks fertilizer minerals. Ceramic minerals, mercury, antimony, and uranium are mined.

Industry, which is mostly concentrated in the west, employs about half of the working population. Machinery, steel, armaments, textiles, glass and china, chemicals, beer, and clothing are major products.

Czech legislation (1973) requires that agricultural and forested land be used so that both water quantity and quality are improved. Nevertheless, pollution is a grave problem in Czechoslovakia, especially with intense water use. Industrial, agricultural, and sewage wastes are all important.

In 1987, Czechoslovakia's total installed electrical capacity was 21 017 000 kW, of which 2 890 000 kW (13.7 percent) was hydroelectric and 3 520 000 kW was nuclear.

Its heavy dependence on thermal power (69 percent) is a reflection both of its fossil fuel resources and the relative difficulty of developing hydropower on its streams. Irregularities in seasonal flow and winter icing limit its use. Although Czechoslovakia plans to produce 50 percent of its power by the year 2000 through nuclear means, the potential for hydropower is still open and may well be used.

Czechoslovakia has good internal transportation by rail and road with a road density in 1989 of about 0.6 km/km^2. Passenger car ownership, however, is low, only about 166 vehicles per 1 000 circa 1989. It also has about 480 km of navigable waters, mainly on the Danube, Elbe, Vlatava, Oder and Morava. Linkage is therefore made with the Black Sea, the Baltic and the North Sea. By lesser standards, waters such as the Vah, Hron, Orava, Kysuca and Poprad are also used, e.g., to float logs. The systems are not linked by canals. Transport on the Elbe and Danube is interrupted by ice six to eight weeks of the year.

Industry uses by far the greater share of surface water, perhaps seven times as much as domestic supply or agriculture. Ground water is extensively used for drinking purposes, lessening the demands for use of surface water.

Commercial capture fisheries are almost non-existent; aquaculture is a much more important industry (see section 7). FAO (1979) states that the country's primary sector of fisheries employed 1 462 people in 1977 and the secondary sector 2 220, including research workers. The per caput consumption of fish is rather low. Excluding fish caught by angling, it is 6.6 kg annually, 5.5 kg sea fish and 1.1 kg freshwater fish (Anon., 1982).

Tourism is important. About 19 million foreigners visited the country in 1986. Spas are world famous and wide spread, and their development as well as that of ski resorts also attracts anglers.

7. FISH AND FISHERIES

There are about 70 species of inland fishes in Czechoslovakia of which 17 are exotic. In the Czechoslovakian Danube alone, Busnita (1967) lists 54 species in 14 families. Of these, about eight families are of commercial importance. Genera found in this Danubian section during both summer and winter include: Esox, Abramis, Alburnus, Aspius, Leuciscus, Rutilus, Scardinius, Perca, Gymnocephalus, and Stizostedion. Many of the streams of Czechoslovakia are trout waters with good populations of brown trout (Salmo trutta) and grayling (Thymallus thymallus) and small but prized populations of the giant huchen (Hucho hucho). However, small cyprinids prevail in most open waters, constituting about 80 percent of the fish stocks (Anon. 1988). Other fishes, including the introduced ones, will be discussed below.

Table 4 contains the official catch statistics for 1965, 1970, 1975, 1980–87 compiled by FAO from data furnished by the Government of Czechoslovakia. No distinction is made here between fish derived from capture fisheries and those by aquaculture, but main portion actually represents cultivated fish. The totals also include angler catches[1]. Some examples to prove this reasoning follow.

[1] For example, note the very close correspondence of the catch statistics in Table 4 for 1977 with the following statement by Anon. (1979): “The catch of fish…in 1977 reached 17 958 t. Most part was produced by the State Fishery which supplied 14 464 t while angler's catch was 3 492 t”. Compare also, the returns for 1985 for Tables 4 and 6

Europa (for example, 1974, 1982 and 1988) provides essentially the same figures as in Table 4 for the 1970–85 period, although distinguishing only between carp and other fishes. It states that its figures apply only to fish “caught” by the State

Fisheries and members of the Czech and Slovak fishing unions. For example, of the total "catch", the amount in tons taken from State Fisheries fish ponds was: 10 735 (1970); 11 114 (1971), and 12 306 (1972). This may indicate that in each of these years about 3 000 t originated from a capture fishery and, indeed, Czechoslovakia/EIFAC (1989) states that the State Fisheries "produced" (i.e., cultured) its fish and that the Unions "caught" their fish.

Another series of figures is presented by Vacek (1983) who listed the "total fish production…for human consumption" in Czechoslovakia during the 1953–78 period. He specified that: "In (such) published data, the catch by anglers is not given because this catch and consumption are outside the marketplace". The indication is that all of these fish are pond-reared, species not specified. All of his figures will not be repeated here since they are generally close to those listed for carp "catches" in Table 4, but for comparative purposes a few are listed below.

Year	Total fish (t) (Vacek, 1983)	Carp (t) (Table 4, FAO)
1953	5 620	---
1965	8 890	9 000
1970	10 454	11 300
1975	13 631	13 818
1978	13 470	13 886

Another set of comparisons to be made is presentation of a set of figures by Berka (1982) showing "fish production" in Czechoslovakia by the entire country and its two Republics in 1975 and 1980 (see Table 5). Czechoslovakia/EIFAC (1989) states that the "production" from "streams and dam lakes" is actually from angling.

Similarly, Table 6, based on data from the official Czechoslovakian statistical yearbook for 1988, shows both aquacultural production and angling catch in Czechoslovakia during the 1983–85 period. In transmitting this table to FAO/EIFAC, Czechoslovakia/EIFAC (1989) termed the production from aquaculture "market fish only", and stated that "no fish (shown in the table) originated from commercial capture fisheries."

Table 4

Nominal catches by species in the inland waters of Czechoslovakia, 1965, 1970, 1975, 1980–87 (in tons)

	Common carp (Cyprinus carpio)	Tench (Tinca tinca)	Pike (Esox lucius)	Pikeperch (Stizostedion lucioperca)	Freshwater fishes, n.e.i.	Trouts (Salmo spp.)	Total
1965	9 000	-	-	-	1 800	200	11 000
1970	11 300	-	-	-	1 900	200	13 400
1975	13 818	-	-	-	2 613	509	16 940
1980	12 295	-	-	-	2 744	918	15 957
1981	12 816	-	-	-	2 763	924	16 503
1982	14 351	-	-	-	2 842	848	18 041
1983	15 618	-	-	-	3 020	887	19 525
1984	15 700	-	-	-	2 941	1 047	19 688
1985	16 110	483	309	188	1 822	1 062	20 034
1986	17 049	378	375	183	2 156	1 112	21 253
1987	16 652	419	357	183	2 062	1 063	20 736

Source:1965 and 1970 - Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1975, 1980, 1981 - FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1982–87 - Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

Table 5

Fish production in Czechoslovakia in 1975 and 1980 (in tons)

Fish from ponds	Czech Republic	12 575	12 778
	Slovak Republic	383	571
	Czechoslovakia	12 958	13 349
From other culture facilities	Czech Republic	324	528
	Slovak Republic	57	120
	Czechoslovakia	381	648
From streams and dam lakes[a]	Czech Republic	2 096	2 445
	Slovak Republic	1 198	1 558
	Czechoslovakia	3 294	4 003
Total	Czecho Republic	14 995	15 751
	Slovak Republic	1 638	2 249
	Czechoslovakia	16 633	18 000

[a] Angling catch

Source: Berka (1982)

Table 6

Aquacultural production and angling catch in Czechoslovakia, 1983–85 (in tons)

	1983	1984	1985
Aquaculture	14 245	14 654	15 009
Angling	5 280	5 034	5 025
Total	19 525	19 688	20 034
Individual species of fish			
Carp	15 582	15 700	16 110
Tench	348	322	482
Pike	423	345	309
Pike-perch	208	258	188
Trout	887	1 047	1 062
Other fishes	2 077	2 020	1 883

Source: Czechoslovakia/EIFAC (1989)

Finally, Table 7, constituting part of a national report from Czechoslovakia presented to EIFAC, shows both aquacultural production and angler's catch in Czechoslovakia during 1986. Anon. (1988) states that similar data for 1987 would hardly differ.

Table 7

Aquacultural production and angling catch in Czechoslovakia, 1986 (in tons)

	Common carp	Tench	Phytophagous fishes[a]	Pike	Pikeperch	Coregonids	Rainbow trout[b]	Total
Aquaculture								
State Fisheries Czech Republic	13 292	303	508	32	9	328	593	15 065
State Fisheries Slovak Republic[c]	722	18	29	2	1	21	98	891
School Fish Farm Fishery School	700	29	-	1	-	-	-	730
Other producers (estimated)	10	-	-	-	-	-	-	10
Total	14 724	350	537	35	10	349	691	16 696
Angling in Open Waters								
Czech Anglers Union	2 304	62	15	216	105	2	105	2 809
Slovak Anglers Union	1 036	13	10	127	69	1	237	1 493
Total	3 340	75	25	343	174	3	342	4 302
Grand Total	18 064	425	562	378	184	352	1 033	20 998

a According to Anon. (1979) the “herbivorous species” are grass carp, silver carp and bighead. Vacek (1983) indicates that these are the three major “phytophagous fish”

b Although the rainbow trout is the principal salmonid to be cultivated in Czechoslovakia, it seems doubtful to me that it is the principal one caught by anglers.

c Data for 1985

Source: Basic data from Table 1 in Anon. (1988), modified from information furnished by Czechoslovakia/EIFAC (1989)

It can only be said that apart from relatively small differences or errors in some of the reports referred to above, that language differences in expression of the items involved make comparisons difficult. The key to this puzzle is that various reports from Czechoslovakia which are written in English speak of “market fish” which FAO and others have considered to be “commercially caught fish”. Comparable English-language terms for “market fish” would be “fish of economic importance” or all those “used” by man. In Czechoslovakia, as in Hungary, the term “market fish” may also apply to sport fish. Similarly, much of the data emanating from Czechoslovakia in English uses the term “production” to include both aquacultural production and the catch made by capture fisheries.

As will be seen below, it will be quite clear that the greatest quantity of fish originating in Czechoslovakia is produced in ponds (aquacultural production), and the next greatest amount taken by angling. During the past decade, no fish have been considered in official Czechoslovakian statistics as being “commercially” caught.

7.1 Capture Fisheries

7.1.1 Commercial fishing

As has been indicated above, there is now no recognized commercial fishing in Czechoslovakia. However, in the past most of the commercial catch was derived from the Danube, its overflow waters, and the mouths of its tributaries.

Busnita (1967) stated that the catch in the main stem of the Czechoslovakian Danube was 350 t annually. Holčik and Bastl (1977) list smaller annual catches from the 172-km Czechoslovakian Danube and the mouths of its tributaries during the 1954–57 and 1961–75 periods; they range from a low of 61.6 t in 1955 to a high of 280.7 t in 1967. The total yield from this section in 1975 was 173.2 t. Their figures are said to represent the combined catch of both commercial and sport fishermen (the latter based on estimates until 1975), and must be considered approximate.

Anon. (1982) states that the annual commercial harvest from open waters in Czechoslovakia is about 100 t taken by the Czech and Slovak Anglers Unions. Although these “unions” or associations are primarily for anglers, some professional fishermen are employed within their frame, especially on the Danube (Anon., 1979). Vacek (1983) states that only about 60–70 t are taken annually through net fishing.

7.1.2 Sport fishing

Recreational fishing in Czechoslovakia is in the domain of the special interest social organizations, the Czech and Slovak Angler's Unions. It occurs in rivers, canals, natural lakes, and manmade lakes with emphasis today on the latter waters.

Anon. (1982) has stated that the Angler's Unions are active on more than 72 000 ha of “open waters (water courses, lakes)” and also manage 25 000 ha of reservoirs. Anon. (1982) also stated that the length of the river network managed by these Unions is 100 000 km, and that they use a pond area of 3 550 ha to raise fish for stocking both trout and coarse fishing districts. They also produce some salmonids for marketing according to FAO (1979). Vacek (1983) indicates that most of the fishery exploitation of running waters and artificial lakes lies essentially with the Angler's Unions who use 71 500 ha of such waters out of a total of 83 170 ha.

Havelka (1972) stated that the annual catch by anglers from “flowing waters managed by fish farmers and anglers amounted to about 2 000 t (ca. 65 kg/ha or 14 kg/angler)”. Czechoslovakia/EIFAC (1975) also gave the annual yield to anglers as more than 2 000 t. By 1977, according to Anon. (1979) the angler's annual catch was 3 492 t or about 16 kg/angler, and Vacek (1983) states that statistics of the Angler's Unions indicate a total catch of 3 500 t by Czechoslovakian anglers in 1978, an increase of about 30 percent from 1970. Anon. (1982) which listed the angler's catch as about 3 000 t annually, gave the average annual catch per angler as 10–12 kg in trout waters, and 18–23 kg in coarse fish waters. Anon. (1988) indicates that the angling catch in 1986 was 4 302 t. EIFAC (1989) states that the annual catch of 298 000 sport fishermen in Czechoslovakia (sometime between 1982 and 1988) totalled 4 600 t or 15.4 kg per angler.

Anon. (1979) states that the composition of the angler's catch in 1975 was as follows: common carp (52 percent); bream, Abramis brama (9 percent); pike (7 percent); trout, char and grayling (5 percent); chub, Leuciscus cephalus (4 percent); nase, Chondrostoma nasus (3 percent). One can assume that the remaining 20 percent of the catch was composed primarily of other cyprinids such as Aspius aspius, roach (Rutilus), barbel (Barbus sp.) and tench (Tinca tinca), as well as European catfish (Silurus glanis), pike-perch (Stizostedion lucioperca), eel (Anguilla anguilla) and perch (Perca fluviatilis).

A somewhat different catch composition is shown in Table 7 which shows the angler's catch in Czechoslovakia in 1986: common carp (78%), pike (7.9%), trout (7.9%), pike-perch (4%), tench (1.7%), “phytophagous” fishes (0.6%), coregonids (0.07%). Czechoslovakia/EIFAC (1989) says that “coarse fishes” were not included in this summation.

Vacek (1983) states that in 1965, 120 000 anglers were registered in Czechoslovakia, the number rising to over 200 000 by 1978. Anon. (1982) using figures submitted in 1979, said that the number of organized anglers exceeded 245 000, with an annual increase of 5 percent. FAO (1979), who said that angling was considered the second most important sport in the country (just after football), boosted the number of anglers to more than 249 000 and Anon. (1988) said that the number of anglers (1986–87) was over 300 000. Even so, this was only 1.9 percent of the total population at the time.

Participation in angling involves membership in the Czech or Slovak Angler's Union, including participation in special courses and examinations. The Unions, which are organized locally, regionally and centrally, have a variety of activities including the management and protection of fisheries and their waters and education of their members.

A principal form of management is fish stocking by fish farms run by the Unions. Anon. (1979) states that about 9 million yearlings are stocked annually: carp (46 percent), salmonids (38 percent), pike-perch (88 percent), tench (5 percent), pike (3 percent), and some chub and nase. Elvers are also imported and stocked.

7.2 Aquaculture

Fish culture has been practised in Czechoslovakia for almost 700 years. Ponds designed purely for fish breeding have been known since the Twelfth Century, and during the Fourteenth Century, and during the Fourteenth Century the total area of fish ponds in Bohemia and Moravia alone is estimated to have been about 75 000 ha. In the Sixteenth Century, in the golden era of Bohemian fish pond management, 180 000 ha of ponds were registered. Some of these old ponds are extremely large, e.g., the largest pond in Czechoslovakia (Rožmbersky), which was built 1584–90, has a surface area of 742 ha according to Matěna and Berka (1987). Due to wars and the intensification of agriculture, both the number and area of ponds decreased significantly to only 79 000 ha in the year 1787 (Dyk and Berka, 1988). Today, the total area of fish ponds in Czechoslovakia is estimated at about 52 200 ha and the total number of ponds is about 5 000 (Anon., 1978; 1988; EIFAC, 1989). Total aquacultural production in 1986 was 16 696 t (see Table 7).[1]

[1] FAO Fish.Info.Data and Stat.Serv. (1989) estimate aquacultural production in Czechoslovakia for each year of the 1984–87 period. However, its figures are so similar to those in Table 4 that they will not be repeated here. As has already been shown, Table 4 (and therefore the reference above) includes angler's catch

Primary attention is given to the common carp (Cyprinus carpio) which represents about 90 percent of pond fish production. In 1986, Czechoslovakian ponds produced 14 724 t of carp (Table 7). The scale carp is still predominant, but emphasis is being placed on increase in mirror carp.

A second group of pond fish on which interest is focussed included circa 1979: tench (4.2 percent); rainbow trout, (Oncorhynchus mykiss) (1.7 percent), two introduced coregonids, Coregonus lavaretus and C. peled (2.7 percent); pike, Esox lucius (0.3 percent); pike-perch (0.1 percent); and some European catfish, Silurus glanis, American brook trout (char) Salvelinus fontinalis, and brown trout, Salmo trutta. The herbivorous Chinese carps, introduced in 1962, are also on trial: the grass carp (Ctenopharyngodon idella), silver carp (Hypophthalmichthys molitrix), and bighead (Aristichthys nobilis) (Anon., 1979). To this list may be added the imported bigmouth buffalo (Ictiobus cyprinella) and black buffalo (I. niger) now on trial in Czechoslovakia. Marcel (1979) stated that the Czechoslovakian production of trout (mostly rainbow) for food was about 500 t annually and that of coregonids about 300 t. Berka (1982) says that good results were gained in salmonoid culture, especially rainbow trout, with production increasing from 328 t in 1975 to 651 t in 1980, but that the production of supplementary fish (tench, coregonids, pike, pike-perch and herbivorous carps) had no increasing tendency, comparing 1 041 t of production in 1975 as against only 966 t in 1980.

Of Czechoslovakia's total aquacultural production in 1986 (Table 7), common carp constituted about 88%, followed by trout (4%), phytophagous fishes (3.2%), tench (2.1%) and coregonids (2.1%).

It will be noted that a hybrid of Coregonus lavaretus and C. peled is the only coregonid now bred by fish farmers in Czechoslovakia. This hybrid also reproduces in Czechoslovakian reservoirs but since there is no regular commercial fishing it forms only a small part of the angling catch (Vostradovský, et al., 1988).

About 80 percent of the total pond area in the country is owned by the State Fisheries and of the total area, more than 90 percent is located in southern Bohemia and southern Moravia. On the whole, Czechoslovakia has 52 200 ha of fish ponds. Of this area, the State Fisheries Corporation manages 40 600 ha in the Czech Republic and 1 120 ha in the Slovak Republic. These are grouped into 16 State Fish Farms (EIFAC, 1989). The remaining 10 480 ha of ponds are managed by the Secondary Technical Fish Farming School, the Czech Anglers Union and Slovak Anglers Union, agricultural cooperatives, and other users. The Anglers' Unions use the ponds for the production of fish to be stocked in open waters where the members practise sport fishing.

In 1973, the average annual pond fish production in Czechoslovakia was 290 kg/ha according to Krupauer (1973a) who said that this value was derived from the use of cadastral area and "…conversion to the actual productive area would result in an increase of average crops to 320 kg/ha within the State Fisheries Trust as a whole". FAO (1979) says that the annual average production of Bohemian and Moravian ponds is about 350 kg/ha and that in Slovakia, due to better climate and lower altitude, it is about 540 kg/ha. In 1987, 412 kg/ha of fish increment (not production) was reached in ponds of the State Fisheries Farms in the Czech Republic compared with one of 312 kg/ha in 1980 (Berka, 1989). In 1986, the average annual pond fish production in Czechoslovakia (using the total extent of its fish ponds) was 320 kg/ha.

For years, there has been heavy reliance in Czechoslovakia on the production of natural foods, using fertilization in ponds. Berka (1982) says that about 60 percent of the country's total fish pond production is secured on this basis. A great deal of organic fertilizer was used, but in the last 20 years there has been a shift to use of mineral fertilizer, and artificial feeding is also practised. About 50 kg/ha/year of NPK is used and about 23 000 t of food are fed: 95 percent for carp and tench and 5 percent for trout. Feed conversion is reported as 1.5 for carp and 3 for trout by FAO (1979). Berka (1982) reports pond fish feed conversion as between 1.7 and 1.9. Vacek (1983) reports carp feed conversion between 1971 and 1978 as 1.49 and 1.8. Almost all of the feed is produced domestically.

Duck breeding in Czechoslovakia has been combined with carp culture since 1950, having risen from 95 t of slaughter ducks in 1953 to 10 630 t in 1978 (Vacek, 1983). By 1980, the State Fisheries concern was producing 12 060 t of ducks and duck production in State Fishery farms represented more than 87 percent of the total Czechoslovakian market production (Berka, 1982).

Crayfish (Astacus astacus), once fairly important in Czechoslovakia, have declined in fish ponds because of incompatibility with present culture methods (Krupauer, 1973).

In addition to traditional pond fish culture, Czechoslovakia practises cage culture (e.g., for trout), in the warm water emitted by both thermal and nuclear plants, and trout culture in silos (towers).

Most carp are sold alive, but production of semi-finished products is increasing. The customer has generally wanted a carp weighting 1.5 kg which may take up to three years to rear. Using the usual methods, two-year-old carp may weigh 1–1.5 kg and three-year-olds about 2 kg. Marketable carp are distributed to retail centres shortly before Christmas. Traditionally, about 70 percent are sold in December. Some cultivated fish are exported: carp, tench, pike-perch, and the eggs of huchen and rainbow trout.

In addition to aquaculture for food, fish ponds are also useful for water retention, as a source of agricultural water, and as a source of recreation. Furthermore, both the Angling Unions and the State Forestry have hatcheries which raise fish to stock angling waters.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership

According to Fisheries Law, ownership of fishing waters and the right of fishing is held by the State, and implemented through the State Fisheries, State Forestry, and the Czech and Slovak Angling Unions and their organizations.

8.2 Administration

8.2.1 Central

The authorities responsible for control and direction of fisheries are the Ministries of Agriculture and Food of the Czech Republic and Slovak Republic under the aegis of the Federal Ministry of Agriculture and Food.

The Departments of these Ministries control projects concerning fishery development, capital investment, technical development, production plans, science, research, and fishery education. They administer fishery laws and approve plans for stocking and fishing in open waters. Separate sections of Environment Protection and Formation in these Ministries direct much of the fishery work.

(i) The State Fisheries, State Enterprise in the Czech Republic, directed its subordinate organizations within the Czech Republic, including direction of the Fisheries Research Institute, and manages production plants (fish farms, etc.);

(ii) The General Directorate of the Poultry Institute directed the State Fisheries in the Slovak Republic until 1988; starting in 1989 the State Fisheries of the Slovak Republic was created as a State Enterprise paralleling that of the Czech Republic in scope but without research, and

(iii) The Czechoslovak Angler's Union is a top union body for coordination of activities in the Angler's Unions: the Czech Angler's Union and the Slovak Angler's Union. These, with Central and Regional Committees direct the activity of anglers in local organizations, management of fishery districts, production of stocks, issuance of fishing licences, education, etc.

8.2.2 Regional

The Departments of Agriculture, Forestry and Water Management of Regional National Committees direct fisheries in flowing and other free (open) waters, supervise water quality and legal regulations, can allow exceptions to the Fisheries Law, and establish protected regions and preserves in their individual territories. The same Departments within District National Committees have somewhat similar prerogatives.

8.3 Management

Some aspects of fishery management not outlined above are covered here.

(i) Possession of an angling licence is conditioned by membership in the Czech or Slovak Angling Union. Regional, or all-union licences can be issued by the Czech or Slovak Unions for fishing for coarse fish, trout, and huchen (the latter only in the Slovak Republic);

(ii) In some waters belonging to the State Fisheries, limited licensing depends on the manager, and licences for fishing in water courses managed by the State Forests, National Corporation, are issued by their directors, and

(iii) Some reservoirs are managed by State farms and collective farms, and part of the water courses (mostly mountain torrents) are administered by the Ministry of Forestry and Water Management.

8.4 Investigation and Education

8.4.1 Scientific and technical development of fisheries is secured by the:

(i) Fisheries Research Institute, Vodnany, of the Czech Republic, with its research stations, attached to the State Fisheries, české Budějovice, and also subordinated to the Ministry of Agriculture and Food;

(ii) Fisheries and Hydrobiology Institute, Bratislava, directed by the Research Institute of Animal Husbandry, Nitra, and sub-ordinated to the Ministry of Agriculture and Food of the Slovak Republic.

Other Institutes dealing to some extent with fisheries are the:

(i) University of Agriculture, Chair of Fisheries and Protection of Biosphere, Brno;
(ii) University of Agriculture, Chair of Physiology and Zoology, Prague;
(iii) University of Agriculture, Chair of Nature Protection and Fisheries, české Budějovice;
(iv) Institute of Systematic and Ecological Biology of the Czechoslovak Academy of Sciences, Brno;
(v) Institute of Physiology and Genetics in Animal Husbandry of the Czechoslovak Academy of Sciences, Liběchov;
(vi) Institute of Landscape, Biology of the Czechoslovak Academy of Sciences, české Budějovice;
(vii) Charles University, Zoological Laboratory, Prague;
(viii) Comenius University, Zoological Institute, Bratislava;
(ix) National and regional museums, and
(x) State veterinary institutes.

8.4.2 Educational facilities for fisheries include the:

(i) University of Agriculture, Brno, for specialization in fisheries and hydrobiology;
(ii) Other agricultural universities (in Prague, české Budějovice) and veterinary colleges (in Brno and Kosice) giving lectures in fisheries;
(iii) Secondary Fisheries Technical School in Vodňany for education of medium-level technical cadres, and
(iv) Apprentice School at Třeboňfor fishery specialists.

8.5 International Agreements

Czechoslovakia has bilateral agreements with Austria, the Democratic Republic of Germany, Hungary, Poland and the USSR concerning use of boundary waters.

It has a trilateral agreement with the Democratic Republic of Germany and Poland concerning the Nysa or Nysa Luzycka (also known as the Niesse), which rises in Czechoslovakia and forms a Polish boundary with the Democratic Republic of Germany.

It has a quinquelateral agreement concerning the Tisza River with Hungary, Romania, the USSR and Yugoslavia.

Along with other Danube countries, Czechoslovakia belongs to the Danube Commission which deals with navigation and related matters. It also adheres to the Convention on Fisheries of the Danube together with Bulgaria, Hungary, Romania, the USSR and Yugoslavia to take joint action to protect the river's fish stocks.

[1] This section is based primarily on material sent to EIFAC by the Government of Czechoslovakia in 1979, and Anon. (1982), and updated by Czechoslovakia/EIFAC (1989)

9. STATE OF THE FISHERY

9.1 Yield

Table 4 shows that the production of carp had increased 50 percent between 1965 and 1975, and that production of trout had more than quadrupled between 1965 and 1980. As has been noted before, the bulk of "catch" in Table 4 is aquacultural production. The commercial catch from open waters has declined sharply.

FAO (1979) states that "according to latest estimates", the annual production of fish or ichthyomass in Czechoslovakian waters is about as follows: natural lakes, 50 kg/ha; trout streams, 100 kg/ha; man-made lakes, 200 kg/ha; irrigation channels, 300 kg/ha; rivers, 450 kg/ha. Another source (Czech.Nat.Comm. FAO/UN, 1979) provides these ranges for annual protection of ichthyomass: trout waters, 100–300 kg/ha (exceptionally 1 000); submontane coarse fish waters, 300–800 kg/ha (exceptionally 1 500); lowland coarse fish rivers, 100–400 kg/ha; inundated arms of big rivers, 800 kg/ha. This source also says that the available annual yield in rivers ranges between 30 and 60 percent of the ichthyomass.

It is further stated (Anon. 1979) that the average annual catch by anglers is about: 90 kg/ha from rivers, 20 kg/ha from trout streams, and 20 kg/ha from man-made lakes. Anon. (1988) says that angler catches commonly reach about 100 kg/ha/year in coarse fish waters and about 40 kg/ha/year in trout waters.

More specific figures for one area of the country are provided by Holčik and Bastl (1976) who state that the 172-km section of the Czechoslovakian Danube including the adjacent river arms of 3 114 ha (total 11 051 ha) yielded on the average 41.4 kg/ha annually during the 1961–72 period.

The mean annual production of fish ponds in Czechoslovakia has already been cited in section 7.2, i.e., somewhere in the neighbourhood of say, 350 kg/ha. FAO (1979) refined figures for fish ponds as follows: 10 percent with a mean annual production of 1 200 kg/ha, 55 percent with 309 kg/ha, 24 percent with 200 kg/ha, and 11 percent with 80 kg/ha or less. Vacek (1983) says that high intensity fish farming produces yields of over 1 000 kg/ha/year, secondary intensity farming yields of 300–400 kg/ha/year, and other methods much less.

9.2 Factors Affecting the Fishery

The total water resources of Czechoslovakia are simply not large enough to supply adequately the combined needs of its urban and industrial development, its agricultural base and an inland fishery. Its rivers are relatively small (some of the best known are only headwater systems), and even the great Danube is only peripheral to the country. Its natural lakes are small, few in number, not very productive, and reservoir development has not been extensive. Furthermore, in artificially controlled waters, fluctuation in flow and water level affect fisheries adversely.

The hazards of pollution and demands for water use render extreme danger to any type of inland fishery. It has been estimated that within a few years each drop of water in Czechoslovakia will be reused about ten times. Circa 1972, 5.5 percent of the lengths of its rivers were considered to be polluted and 1 500 km of its rivers had been rendered fishless. The annual runoff per caput is about 5 686 m^3 based on the total discharge leaving the country. Based only on the 28 000 million m^3 originating within Czechoslovakia it is only 1 769 m^3 per caput annually, well below the European average.

In the past, conditions for fish production were much better along the floodplains of rivers such as the Danube. The trophic base (whether benthos or plankton) and reproductive environment is generally better in the river arms and overflow areas than in the main channels. Reclamation of bottom land, channelling, diking, and changes in flood regime have been factors in changing these wild fisheries.

Overall within the country, commercial fisheries have now decreased to a minimum, not only from declines in fish populations, but because of the high proportion of economically less preferred species. Their purchase price is low and therefore there is no real market for them.

Aquacultural production in Czechoslovakia also has its problems. Factors unfavourable for its success are:

(i) The ancient pond systems (some 400 years old) which require change;

(ii) The relatively cold climate for carp culture, requiring three years for the fish to reach consumption weight (the growth period is generally not more than 160 days/year, cf. with crop growing period in section 4);
(iii) Unavailability of sufficient complete (but high cost) industrial fish feeds, and
(iv) Poor water quality due to pollution and excess nitrification from agricultural water.

Nutrient runoff from arable land is more prevalent in Czechoslovakia than in many other European countries, and in some cases, as much as 100 times the level of nitrate considered optimal to fish stocks is found in pond inlets (Berka, 1982; Vacek, 1983).

9.3 Prospect

The traditional commercial capture fishery, now almost gone, will decline further with diminishment of water quality (affecting taste as well as viability) and floodplain environment.

Sport fishing will continue to increase as a recreational activity.

Despite the factors weighing against it, the long tradition of fish culture will continue to keep it viable, and changes in the methods used will support its development. For example, despite the consumer's general requirement for carp of 1 500 g as a minimum acceptable size (taking three years to produce), new processing methods including frozen cuts can produce this requirement in two years. Other new techniques such as those to increase the success of reproduction, aeration, and the use of polyculture will increase production.

A Fishery Development Concept accepted by the Ministry of Agriculture and Food of Czechoslovakia in 1987 presumed that the domestic “production” of fish in Czechoslovakia would rise to 16 980 t by the year 1990 and 19 900 t in the year 2000, from which about 5 600 t would be taken from natural waters. (One presumes that most of the latter would be taken by anglers.) Since the area devoted to fish ponds was not considered to grow perceptibly, the increase in pond fish production would have to be achieved by a better yield per hectare. To achieve this target growth, it was planned to raise yields by the year 1990 in Bohemia/Moravia to about 400 kg/ha/year, and in Slovakia to about 600 kg/ha/year. Overall, the plan envisaged that by the year 2000 Czechoslovakian fish consumption in product weight would rise to 7.2 kg per caput of which 1.3 kg would be supplied by freshwater fish.

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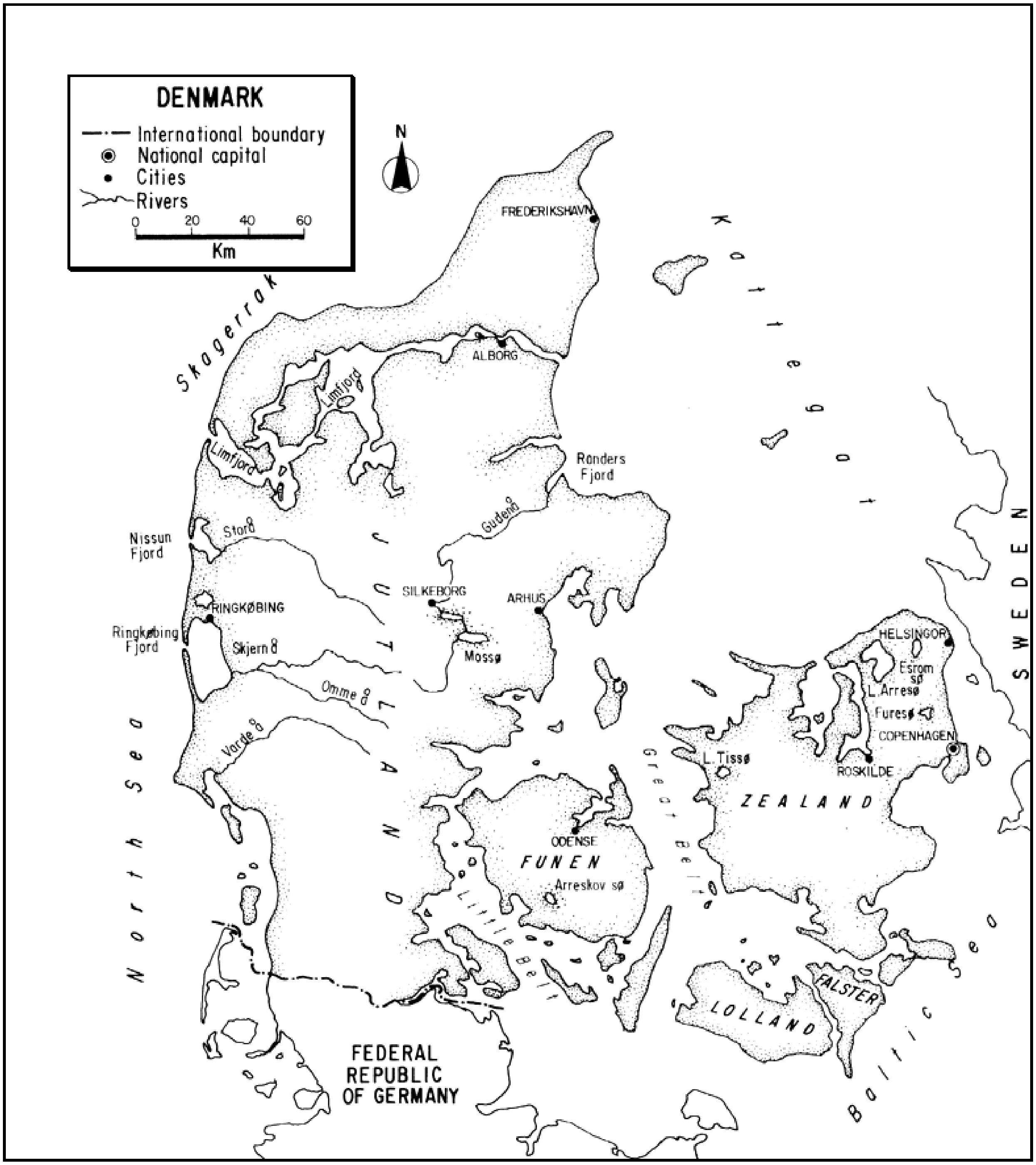

DENMARK
International boundary
National capital
Cities
Rivers
0
20
40
60
Km
N
Skagerrak
Kattegat
FREDERIKSHAVN
ALBORG
Limfjord
Limfjord
Randers
Fjord
Gudenå
Storå
Nissun
Fjord
JUTLAND
SILKEBORG
ARHUS
RINGKØBING
Ringkøbing
Fjord
Skjern å
Mossø
Omme å
Varde å
North Sea
SWEDEN
HELSINGOR
Esrom
sø
L. Arresø
Furesø
COPENHAGEN
ROSKILDE
L. Tissø
ZEALAND
Great Belt
ODENSE
FUNEN
Arreskov sø
Little Belt
LOLLAND
FALSTER
Baltic Sea
FEDERAL
REPUBLIC
OF GERMANY

DENMARK

The Kingdom of Denmark, an archipelago between the North and Baltic Seas, forms a bridge between Central Europe and the Scandinavian Peninsula. Inland from its highly dissected coast, is a low-lying area of glacial moraines, undulating plains and low hills furrowed by tunnel valleys. Primarily a land of farms and small towns, it is dominated by the metropolis of Copenhagen.

Lacking either mineral or hydroelectric resources, Denmark is intensively cultivated, has a seagoing heritage, and is increasing its industrialization.

Lacking real rivers and large lakes, the country's fisheries are largely marine. There are, however, some commercial fisheries in its shallow lakes, and recreational fishing in both lakes and streams. Trout and eel populations are dominant and cyprinids are little desired. Trout culture in fresh water has long been an outstanding development.

Heavy land and water use causes severe pollution problems and increasing eutrophication. Previously, recognition of environmental needs and the value of recreational fisheries were developing slowly, but have increased considerably during the past decades.

1. AREA: 43 092 km^2[1]

[1] In addition to continental or metropolitan Denmark, the Kingdom includes the Faeroes, a group of islands totalling 1 399 km^2 which lies north of Scotland, and Greenland, the largest island in the world, which covers 2 175 600 km^2, although only 341 700 km^2 is ice-free

2. POPULATION: 5 120 000 (est. 1990) <u>Density</u>: 119 inh/km^2

3. PHYSICAL GEOGRAPHY

Denmark, in northwestern Europe, lies between 54°34' and 57°45'N latitudes and 8°5' and 15°12'E longitudes.

Metropolitan Denmark, between the North Sea and the Baltic Sea, consists of the northern two-thirds of the Jutland Peninsula (29 775 km^2 or 69 percent of the total area) and 483 islands, most of which are in the Baltic area and of which 97 are inhabited. The largest of the islands are: Zealand (Sjaelland) (7 448 km^2), Funen (Fyn) (3 486 km^2), Lolland (1 283 km^2), Bornholm (588 km^2) and Falster (514 km^2). The N–S length is 358 km and E–W width 475 km. The glaciated surface is uniformly low, the average altitude being about 35 m with a range from -2 m to only 173 m.

Jutland's western boundary is the North Sea, its northern boundary the Skagerrak separates it from Norway, the Kattegat separates it from Sweden, and to its east lies the Baltic. Denmark has only one land boundary, a southern neck of 67.7 km, separating Jutland from the Federal Republic of Germany.

The Danish area is one of the most dissected land masses in Europe. Its coastline, ten times the shortest possible length of an island having the same area, is 7 314 km in extent. There is a considerable development of offshore bars and lagoons on the western coast of Jutland, and many open bays and long winding inlets on its east coast.

All of Denmark, except for the granitic island of Bornholm, is a low and level continuation of the North European Plain. The surface relief is characterized by deposits of glacial moraine overlying limestone, which form undulating plains alternating with gently rolling hills, interspersed with small streams, lakes and ponds.

Extending down central Jutland is a chain of hills marking the terminal moraine of the last glaciation. West and south of this line is a series of sandy outwash plains, once a vast heathland with infertile podzol soils. East of the line, the country, including the islands, is generally mantled with boulder clays or porous loams, and is more fertile, more wooded and better populated.

The original North-European deciduous forest of beech, oak, elm and lime now survives in only a few localities. Although about 10 percent of the country is forested, most of this area has been planted and includes exotic conifers such as spruce and Scots pine. Dune, heath and bog cover about 8 percent of Denmark.

4. CLIMATE

The climate is temperate with mild damp weather. Winter climates are tempered by the Gulf Stream so that the mean temperature in the coldest month is about 12°C higher than average for its latitude (56°N). Similarly, the Baltic waters which separate Denmark from the bulk of the continent generally temper its climate. The mean annual temperature is about 7.9°C. The mean temperature of the warmest month (July) is 16.6°C; that of the coldest month (February) is -0.4°C. The highest temperature recorded is 36.4°C, the lowest -31°C.

The mean annual precipitation is 664 mm, ranging from about 800 to 400 mm. Rainfall, fairly even throughout the year, is highest in August and October and lowest in winter and spring.

Snow falls between 20 and 40 days between October and May, but is usually concentrated in the January–March period.

Sea ice is rare off western Jutland, but the calm and less saline areas east of Jutland may freeze for several weeks during severe winters, creating drift and pack ice.

The growing season based on the average period with temperatures above 3°C between spring and autumn is generally between 1 April and 30 November or 240 days (Wallen, 1961).

The annual evaporation from a free water surface in Denmark is 600 mm. The evaporative rate in general is around 400 mm.

The length of day ranges between 7 and 17.5 hours throughout the year with about 1 800 sunshine hours.

5. HYDROGRAPHY AND LIMNOLOGY

The total area of inland water in Denmark is about 70 000 ha or 1.6 percent of the total area (Danmarks Statistik, 1989, and Table 1)[1]. Ovesen (1977) states that the lakes and water courses of Denmark are 1.5 percent of the total area, and Sømme (1961) states that the lake area is 1.4 percent of the total area. EIFAC (1989) gives the area of inland water in Denmark as 50 000 ha or less than 1.2 percent of the total area; a figure that appears to be too low.

[1] Danmarks Statistik (1988) lists the distribution of Denmark's inland waters as follows: Jutland (462.90 km^2), Zealand (183.45 km^2), Funen (26.44 km^2), Lolland-Falster (23.74 km^2) and Bornholm (3.15 km^2) - totalling 699.68 km^2

The approximate annual runoff from rainfall is 260 mm or 11 000 million m^3; there is no discharge from upstream countries (Van der Leeden, 1975). Most of the runoff forms ground water which later percolates into water courses. From a use standpoint, ground water is pre-eminent in Denmark (see section 6).

5.1 Rivers (Åer)

There are no long or important rivers in Denmark because of its small size, low elevation and relatively low rainfall. Only two rivers, both in Jutland, attain more than 100 km in length and only five more exceed 60 km. The longest river in Zealand is 83 km, and the longest in Funen is 53 km. All in all, there are about 15 000 km of major rivers and streams (Dahl, 1982). The area is listed as being 7 000 ha by EIFAC (1989); a figure which is, of course, a rough estimate.

The rivers of Denmark, which are primarily rainfed, generally have a maximum flow in spring, a secondary maxima during the autumn (due to precipitation) and a lower discharge in summer than in winter due to evaporation. The streams of western Jutland, where soils are poor, are relatively low in nutrients (150–300 uS/cm) and attain water temperatures of 12–15°C in summer. The streams of eastern Jutland which rise in morainic soils are rich in nutrients (200–600 uS/cm) and also influenced by biologically treated sewage. In summer they may reach temperatures above the optimum for trout (i.e., over 15°C) and even close to 25°C (Rasmussen, 1984). In general, Danish streams are small, sluggish and without falls. They are usually silty or sandy except in Bornholm, where they have a rock base. They have a high biomass of aquatic macrophytes in summer.

The principal river is the Gudenå, with a basin of 2 700 km^2. It rises in central Jutland and flows north for 158 km to Randers Fjord on the Kattegat, draining a series of lakes en route.

The Storå also originates in central Jutland and flows north for about 100 km to Nissum Fjord on the North Sea. Three other Jutland streams, the Skjernå (94 km), Omne å and Varde å flow west to the North Sea. These are trout streams as are also the Simested å, Sneum å, Konge å and Karup å (78 km).

5.2 Lakes (Søer)

There are about 500 lakes and ponds in Denmark. Denmark/EIFAC (1974) gives their total area at about 61 200 ha. Dahl (1982) says that the lake area is about 43 000 ha. EIFAC (1989) lists their total area as 42 000 ha, 120 of the lakes have areas exceeding 0.5 km^2. The lakes, which are mostly small and shallow, are found in depressions in the glacial deposits or in valleys blocked by moraines. Some are kettle lakes, others in tunnel valleys (originally cut by sub-glacial meltwater) have ribboned out into chains.

Chemically, they range from acid and clear waters (these mostly in the sandy heath or dune soils of West Jutland) to turbid, eutrophic and brackish waters. An annual gross production of about 70 g C/m^2 seems to be the maximum level for the non-culturally affected lakes in Denmark, but the majority of the Danish lakes represent a eutrophication level, which, expressed as annual primary production is close to 400$^+$ g C/m^2 (Riemann and Mathiesen, 1977). There are extremely high levels in some lakes due to heavy sewage loading.

The largest lake is Lake Arresø on the island of Zealand, joined by a canal to Roskilde Fjord. It has an area of 40.6 km^2 and is about 8 km in diameter. Arresø has a mean depth of 2.8 m and a maximum depth of 6.5 m. Nearly uniform in oxygen content and temperature, it is highly eutrophic as it receives sewage. European eel (Anguilla anguilla), pike-perch (Stizostedion lucioperca) and bream (Abramis brama) constitute 90–95 percent of the total population (Nielsen, 1977).

The second largest lake in Denmark is the dimictic temperate Lake Esrom (Esrum) also on the island of Zealand, receiving its water supply from small brooks and ditches and connected to the Kattegat by a canal. Esrom is 8–9 km long and 2–3 km wide, with an area of 17.3 km^2, mean depth of 12.3 m, maximum depth of 22 m, volume of 213 million m^3 and retention time of 8.5 years. A eutrophic lake with high calcium content and high stability, it has little or no oxygen at its greatest depth from July to November. Its ice-cover ranges from 0 to 112 days; the lake is ice-free approximately every five years. Its average fish catch over a period of 12 years consisted primarily of an assemblage of roach (Rutilus rutilus), bleak (Alburnus alburnus) and ruffe (Gymnocephalus cernua), followed by European eel, European perch (Perca fluviatilis), bream, and tench (Tinca tinca) (Jonasson, 1984). Another large lake in Zealand is the 13.3-km Lake Tisso.

The largest lake in Jutland is Lake Mossø with an area of 16.9 km^2, mean depth of 8.6 m and maximum depth of 32 m. The eutrophic Arreskov Lake with an area of 3.54 km^2, is the largest lake in Funen. The deepest lake in Denmark, 36 m, is Furesø in Zealand.

5.3 Reservoirs (Opstemningssøer)

In 1962, there were five reservoirs, totalling about 700 ha, where commercial fishing was practised (EIFAC, 1964). This amount has now increased to 1 000 ha, according to Denmark/EIFAC (1977, 1989) and EIFAC (1989).

5.4 Other Waters

Judged by their degree of penetration into the land masses, lowered salinity and type of fauna, Denmark may be said to have a large number and variety of "semi-inland" waters: "fjords", sheltered bays, estuaries, lagoons and creeks.

The term "fjords" as used in Denmark deserves explanation. First of all, they are not at all comparable to the long, steep-sided glaciated inlets of the sea common in Norway. The Danish fjords, probably better termed "fohrden", on the east coast of Jutland represent drowned tunnel valleys cut by glacial meltwater in unconsolidated material. Wide at the mouth, they narrow inland, the sides are rarely high, and they are navigable. Another type of Danish fjord found on the west coast of Jutland is merely a long spit-enclosed bay or lagoon, sometimes termed a "haff".

The largest (1 400 km^2) and most marine fjord in Denmark is the Limfjord, which cuts completely across the northern tip of Jutland to join the North Sea with the Kattegat. The second largest fjord complex is the Isefjord in northern Zealand, about 400 km^2 in extent.

These inner and coastal areas vary in their degree of salinity, e.g., that of the Kattegat is about 20–30 ppt, but in the Great Belt (between Zealand and Funen) it drops to 15 ppt. Some of these areas are open, some almost closed. They support a variety of fishes: eels and flounders (Platichthys flesus), are common in mesohaline waters while trout (Salmo trutta), whitefish (Coregonus spp.), pike (Esox lucius) and cyprinids are found in oligohaline areas.

Low winter temperatures, prolonged ice cover and low oxygen sometimes cause extensive mortalities in these waters. They are also subject to land reclamation (see section 6).

6. LAND AND WATER USE

Table 1

Pattern of land-use in Denmark, 1986

	Percent
Arable and permanent crops	60.6
Permanent pasture	5.0
Forests and woodland	11.4
Other land	21.3
Inland water	1.6
Total	100.0

Source: 1987 FAO Prod.Yearb., 41 (Publ. 1988)

About 87 percent of Denmark's population is urban, with about 25 percent of the population living in an 800 km^2 area around Copenhagen. Neverthless, with almost 70 percent of its land devoted to agriculture, Denmark has one of the highest proportions in Europe of land devoted to cultivation. The natural soils are somewhat unsuitable but they have been modified by tillage and heavy use of fertilizers (extensive use has been made of manure) in several centuries of intense cultivation. About 244 kg/ha/year of fertilizers were used in 1984. Extensive areas have also been reclaimed, sometimes with the loss of aquatic habitat. Since in the long run about 90 percent of Denmark's agricultural output is derived from animal production (livestock and dairy products), grain and root crops (especially for use as fodder) are the most important crops. Irrigation makes very little use of Denmark's surface waters, being used only supplementally and mostly with sprinklers, although overall about 9 percent of the country is irrigated (1986).

By the end of the 18th century, only 4 percent of the country was still forested but more than 10 percent is now forested - mostly through well tended plantation. Replacement must follow cutting, however, and Denmark ranks about twentieth in European roundwood production.

Mineral resources are almost lacking. There is some quarrying, production of cement, some sulphur peat and lignite, and mineral oil and gas from the North Sea. There has been river pollution from acid ferruginous wastes from lignite mines.

Despite the lack of iron, fossil fuels and hydroelectric power, and a late start in the field, industry now constitues about one-third of the GNP. Much of the industry is small. It is concentrated on industrial and construction materials, furniture, textiles, cement, brewing and food processing.

Almost all of Denmark's power production is thermal, using imported power or imported and Danish North Sea oil, some is geothermal and only a little is hydroelectric. The hydroelectric resources so abundant in other Scandinavian countries are almost lacking here due to the level terrain and small volume of stream flow. Of a total installed electrical capacity in 1987 of 8 557 000 kW, only 10 000 kW (1.2 percent) were hydroelectric. There were 120 hydroelectric plants in Denmark in 1978, but only 23 of these were operating and most are very small. The major hydroelectric power stations are on the Gudenå, Storå, Vardeå and Kolding å Rivers. They have a minor effect on fisheries. In 1980 Denmark decided not to develop nuclear power.

Denmark has a well organized system of rail (about 3 000 km), ferry and ship transport and a road density of 1.7 km/km^2. Private automobile ownership is about 301 per 1 000 (1986). The lower Gudenå is partly navigable.

Denmark has long been an important marine fishing nation, with almost 15 000 professional and occasional saltwater fishermen in 1977 and a saltwater catch of 1 671 871 t in 1987. By contrast, the commercial catch in fresh water is negligible, constituting only about 0.2 percent of the total catch (Dahl, 1982) (see section 7.1). There is, however, a thriving trout culture industry, and a fur-farming industry of about 2 400 farms which utilizes fish as food. The apparent domestic consumption of fish for food is about 40 kg per caput per year, measured in live weight (FAO, 1986).

Land reclamation through drainage has been a feature of Danish resource use for over 150 years (see section 9.2). Furthermore, according to law, land drainage and reduction in flood risk are considered the major purposes of the streams, and there are definite rules for most streams for aquatic weed removal and other maintenance work to ensure these ends. Weeds are normally cut once or twice a year by hand or by boats.

The land and water uses affecting fisheries have primarily been those causing pollution or at least the siltation and eutrophication of lakes and streams. The problems are aggravated by the intense use of the land, the slow-moving nature and small volume of the streams, and the shallowness of the lakes. Many of the polluting effluents derive from agricultural industries such as beet sugar factories, flour mills, slaughter houses, and dairies, from ensilage, and from agricultural chemicals. A good deal of industrial waste is admitted to sewers and treated with the sewage.

Fish farming is also an important source of organic pollution in Denmark's small streams (some “rivers” are only one metre wide). In Jutland, it has been estimated that 30–35 percent of the total discharged organic matter is derived from fish farms. This equals the untreated organic loading of a population of over one-half million people (see Table 2).

Table 2

Organic loading in the Simested River (t/year)

Source	BOD		Total N		Total P	
Domestic wastes	65	(20%)	44	(14%)	15	(60%)
Fish farm wastes	264	(80%)	53	(16%)	7	(28%)
Agricultural runoff	--		231	(70%)	3	(12%)
Total	329		328		25	

Source: Reproduced in Hansen (1979) and Warrer-Hansen (1982) based on Water Quality Institute (1978)

Despite pollution from fish farms, their effluents must be considered as relatively clean waste water, having concentrations much lower than those of biologically treated domestic waste water.

Of all European countries, Denmark makes by far the greatest use of its ground water, 97 percent of its total water use comes from this sources (ECE, 1978). The greatly increased extraction of ground water, especially in Zealand, has caused the disappearance of some good trout streams.

Estimates of total water use in Denmark are shown in Table 3, and somewhat similar estimates made by the Danish Pollution Council (1971) showed a total demand of 720 million m^3/year in 1970 and 1 070 million m^3/year in the year 2000[1]. It may be noted, however, that the estimates of use for the year 2000 made by both of these authorities had already been exceeded in 1982 when a total water consumption in Denmark of 1 335 million m^3 was recorded. This dropped, however, to 1 100 million m^3 in 1984 (Denmarks Statistik, 1989).

[1] Cited in Van der Leeden (1975)

The demand by thermal plants was not indicated by the Danish Pollution Council. Instead a relatively high demand was shown for fish farms: 50 million m^3/year (or 7 percent of the total demand) in 1970, and 25 million m^3/year (2.3 percent of the total demand) in the year 2000.

Table 3

Estimates of freshwater abstraction in Denmark, 1977 and 2000

Demand	1977		2000	
	Million m^3/yr	Percent	Million m^3/yr	Percent
Domestic	330	43.0	550	47.8
Industry	290	37.6	380	33.0
Agriculture	140	18.2	170	14.8
Thermal plants	10	1	50	4.4
Total demand	770	100.0	1 150	100.0

Source: Denmark, Government of (1978)

In this regard it must be realized that - compared with most manufacturing processes - trout farming requires a very large water consumption; e.g., a Danish fish farm producing 50–75 t annually uses about 500 1/sec, which equals the daily consumption of a population of 170 000 people (Warrer-Hansen, 1982).

7. FISH AND FISHERIES

The principal fishes found in the small streams and lakes of Denmark are shown in Table 4.

Of the total fish fauna in streams, eel and brown trout constitute approximately 10 and 75 percent, respectively (Larsen, 1955). Of the diadromous fishes, the eel is by far the most important in Denmark commercially, being found and caught in practically all types of Danish fishing waters as well as in the sea. Some elvers are stocked in lakes. The sea trout (Salmo trutta) is also caught in fresh waters, but mostly in the sea. Atlantic salmon (Salmo salar) is uncommon today in Denmark's fresh waters. For example, it has been extinct in the country's largest river, the Gudenå, since 1924, but a few salmon are still found each year in rivers like the Storå and Skjern å.

Table 4

Principal inland fishes of Denmark

Species	Rivers	Lakes
European eel (Anguilla anguilla)	x	x
Brown trout (Salmo trutta)	x	
Rainbow trout (Oncorhynchus mykiss)[a]	x	
American brook trout (Salvelinus fontinalis)[a]	x	
Coregonids (Coregonus sp.)		x
Pike (Esox lucius)		x
Common carp (Cyprinus carpio)		x
Bream (Abramis brama)		x
Crucian carp (Carassius carassius)		x
Minnow (Phoxinus phaxinus)	x	
Roach (Rutilus rutilus)	x	x
Rudd (Scardinius erythrophthalmus)		x
Ten-spined stickieback (Pungitius pungitius)	x	
European perch (Perca fluviatilis)	x	x
Pike-perch (Stizostedion lucioperca)[a]		x
Flounder (Platichthys flesus)	x	

[a] Introduced

At present, attempts are being made to restore sea trout populations by creating artificial spawning areas and to restock some salmon rivers. Denmark has, in fact, purchased salmon smolts for stocking from Sweden, and from 1980 onwards was to pay for the release of smolts that correspond to its catch quota (Larsson, 1980).

In recent years, the introduced pike-perch (Stizostedion lucioperca) has become of increasing importance in both the commercial and recreational catch in Denmark[1]. Since 1925, when the total yield of pike-perch in Denmark exceeded 1 000 kg for the first time, the yield increased up to 1 935 kg and then stabilized to about 5 to 8 percent of the total catch in Danish inland waters or 40 to 90 t/year. With respect to the commercial catch in Denmark's inland waters, pike-perch is today second in weight and value, being surpassed only by the catch of eel. An average yield of about 5 kg/ha/year is normal for Danish pike-perch lakes. The best yield comes from deep freshwater lakes, the lowest from shallow, brackish waters. Slow to catch on as a sport fish, the pike-perch has now become highly prized by Danish anglers. It is also increasing in value as a predator on the less-valued cyprinids, a role formerly held by pike. The increasing eutrophication and turbidity of Danish lakes makes them more suitable for pike-perch than pike.

[1] Pike-perch were first introduced from Germany into Denmark in 1879. The stocking failed and the first successful stocking, also from Germany was in 1898, followed by other plants from Sweden and Germany. It is now found in 70 Danish freshwater and brackish lakes (Dahl, 1984a)

Two other introductions in Denmark are quite recent: the results are in abeyance. The grass carp (Ctenopharyngodon idella), introduced into Denmark in 1965 from the USSR, was first stocked in Danish natural waters in 1968 with follow-up stocking from other countries to control aquatic weeds. Silver carp (Hypopthalmichthys molotrix) was first stocked in a Danish lake in 1981. In some cases, weed reduction has been considerable, in others it has been limited, and many deaths have been reported of these Chinese carps - either from cold or from asphyxiation (Markmann, 1984).

Table 5

Nominal catches in the inland waters of Denmark, 1965, 1970, 1975, 1980–87 (in tons)

	Freshwater fishes n.e.i.	European eel	Atlantic salmon	Trout	Total
1965	100	0	0	12 300	12 400
1970	0	100	0	9 300	9 400
1975	51	68	0	16 287	16 406
1980	24	113	0	18 155	18 292
1981	175	141	0	20 702	21 018
1982	348	162	0	21 055	21 565
1983	250	117	0	24 263	24 630
1984	354	126	0	22 231	22 711
1985	236	111	0	21 628	21 975
1986	291	120	0	20 764	21 175
1987	291	120	0	23 436	23 847

0 - Probably nil, negligible or insignificant; or less than 50 t during 1965–73, or less than half a ton during later years.

Source: 1965 Yearb.Fish.Stat.FAO, 36 (Publ. 1974) 1970, 1980–83 FAO Fish. Dept. Fishery Statistical Database (FISHDAB), 1984–87 Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

Table 5 illustrates the commercial "catch", as reported to FAO during the 1965–87 period for the inland waters of Denmark as does Table 6 for the freshwater and diadromous fishes reported caught by Denmark in the Northeast Atlantic.[1] It is presumed that the Atlantic-caught "freshwater fishes" are caught in oligohaline zones of the Baltic. It is obvious that the "catches" of trout shown in Table 5 are mostly cultivated rather than wild fish (see section 7.2). However, the decided discrepancies shown between the FAO report (Table 5) and the reports from Denmark made to EIFAC (Tables 7 and 8) for inland water catches during the 1973–80 period cannot be explained (see section 7.1.1).

[1] The enormous (by comparison) catch of "sea trout" by Denmark in 1986 of 3 775 t cannot be explained. It is reasonable to suspect its accuracy

7.1 Capture Fisheries

7.1.1 Commercial fishing

In Denmark, the Ministry of Fisheries considers true commercial fishing to be an activity where the product (or harvest) is offered for sale (cf. section 7.1.2)

It is obvious from Table 7 that the inland commercial capture fishery in Denmark in 1973 (a minimum reported catch of about 548 t) was dominated by the catch of cyprinids (56 percent), followed by eel (27 percent), the two percids (12 percent) and pike (4 percent). These four groups constituted 99 percent of the catch in 1973. The river catch was completely dominated by the catch of eels (96 percent). The catch in lakes was composed largely of cyprinids (56 percent), eel (25 percent), pike-perch (10 percent), perch (5 percent) and pike (4 percent). In the reservoirs, cyprinids led with 70 percent, eel followed with 28 percent and pike was third with 2 percent.

The catch statistics for 1973 in Table 7 present quite a different picture than do those in Table 5 from FAO for the same year, for example, a minimum catch of about 300 t of miscellaneous freshwater fishes as compared with Table 5's less than 50 t (at maximum) of freshwater fishes, and a minimum catch of 150 t of eel compared with FAO's 100 t.

Similarly, comparison of the FAO statistics for inland water catch in Denmark with those shown in Table 8 show decided discrepancies, e.g., the earlier catches for eel and unidentified freshwater fishes are decidedly smaller in the FAO report. Furthermore, EIFAC (1989) lists the annual commercial catch by 300 professional fishermen in Denmark's inland waters as 637 t.

Table 6

Nominal catches of freshwater and diadromous species in Marine Statistical Fishing Area 27, Northeast Atlantic by Denmark, 1965, 1970, 1975, 1980–87

Species	1965	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987
Sturgeons (Acipenseride)	0	0	0	0	0	0	0	0	0	0	0
Freshwater breams, n.e.i. (Abramis spp.)	-	-	-	-	-	1	2	3	1	1	1
Roaches (Rutilus spp.)	-	-	-	-	-	19	18	11	11	9	9
Tench (Tinca tinca)	-	-	-	-	-	1	0	0	1	0	0
Pike (Esox lucius)	-	-	-	-	9	10	5	5	8	8	17
European perch (Perca fluviatilis)	-	-	-	-	-	35	40	87	69	54	65
Pike-perch (Stizostedion lucioperca)	-	-	-	-	-	-	-	-	0	1	0
Freshwater fishes, n.e.i.	200	200	110	68	96	0	0	354	236	291	291
European eel (Anguilla anguilla)	3200	3300	3225	2141	2088	2376	2003	1745	1520	1552	1189
Pollan (Coregonus lavaretus)	-	-	-	-	-	67	11	28	16	8	26
Atlantic salmon (Salmo salar)	2000	1800	1467	1133	1177	1025	1149	1466	1490	867	976
Trouts (Salmo spp.)[a]	0	0	7	6	11	22	25	36	58	3755	36
European smelt (Osmerus eperlanus)	0	0	51	19	41	76	40	66	39	62	50
Total	5400	5300	4860	3367	3422	3632	3293	3801	3449	6607	2660

- This category not listed this year

0 - Probably nil, negligible or insignificant; or less than 50 t during 1965–73 period, or less than half a ton during later years

n.e.i. not elsewhere included

[a] Termed "sea trout" from 1984 onward

Source: 1965 Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–80 FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1984–87 Yearb.Fish.Stat. FAO, 64(Publ. 1989)

Table 7

Partial commercial catch in inland waters of Denmark, 1973 (in kg)[a]

Species	Rivers	Lakes	Reservoirs	Total
Miscellaneous freshwater spp.[b]	25	265 211	41 650	306 886
European eel (Anguilla anguilla)	13 078	120 256	16 993	150 327
Brown trout (Salmo trutta)	417	705	--	1 122
Coregonids (Coregonidae)	88	628	25	741
Pike (Esox lucius)	33	18 113	1 478	19 624
Common carp (Cyprinus carpio)	--	1 702	20	1 722
European perch (Perca fluviatilis)	--	22 063	40	22 103
Pike-perch (Stizostedion lucioperca)	10	45 375	10	45 395
Total	13 651	474 053	60 216	547 920

[a] Represents returns from 22 782 ha of lakes, 999 ha of reservoirs, and unknown river area

[b] Bream (Abramis brama), crucian carp (Carassius carassius), roach (Rutilus rutilus), rudd (Scardinius erythrophthalmus), burbot (Lota lota).

Source: Denmark/EIFAC, 1974

Such comparisons illustrate the difficulties of obtaining accurate statistics on the inland commercial catch in Denmark (or, for that matter, in many European countries) since in each case cited, the basic figures have been received from governmentally designated, although differing, sources.

Although the author's attempts (since 1976) to reconcile these differences have been unsuccessful, his feeling is that the statistics in Table 7 (even if partial) and those in Table 8 are more representative of both the quantity and composition of the Danish catch than are those of Table 5 for the same period.

Reference to Table 6 showing the catch by Denmark in Marine Statistical Area Northeast Atlantic may indicate a decline in the catch of “freshwater fishes” and also a decline in the catch of eel. With respect to eel catches, ICES/EIFAC (1976) states that Danish Baltic catches show no decrease and have been relatively constant over the last 15 years, but that the Danish catch per unit of effort in the Baltic has been decreasing for at least 30 years.

With respect to salmon catches by Denmark in the offshore fishery of the Baltic alone (Main Basin plus Gulf of Bothnia), annual catches cited by Larsson (1980) for the 1969–78 period are generally somewhat lower than those shown in Table 6 for the entire Marine Statistical Fishing Area 27. They range from a high of 1 469 t in 1969 to 810 t in 1978.

EIFAC (1989) gives the number of professional fishermen in Denmark as 300.

Commercial fishermen use a variety of gear in Denmark's inland waters: pound nets and trawls in the large lakes, fykes in lakes and streams, eel traps, longlines and beach seines. Offshore fishing in the Baltic for salmon is most important for Danish fishermen. Drifting longlines for salmon were introduced by the Danes in 1947 and dominated salmon fishing here in the 1950's. Their use continues, but in the Main Basin of the Baltic, drift nets dominate the fishery apart from November and December and are responsible for about 80 percent of the offshore salmon catch here by all participating countries (Larsson, 1980).

Table 8

Commercial catch in inland waters of Denmark, 1974–76, 1978–80, 1981–82, 1983–84, 1985–86

Species	1974 t	1974 %	1975 t	1975 %	1976 t	1976 %	1978–80 t	1978–80 %	1981–82 t	1981–82 %	1983–84 t	1983–84 %	1985–86 t	1985–86 %
Other species[a]	264.3	44	191.0	29	271	40	287	18	230	17	199	23	38	5
European eel	162.2	27	263.5	40	176	26	430	27	298	22	242	28	231	27
Salmon and trout[b]	12.0	2	13.2	2	13	2	32	2	95	7	99	11	102	12
Pike	30.1	5	32.9	5	27	4	64	4	122	9	43	5	36	4
Bream	60.1	10	59.3	9	122	18	367	23	244	18	108	13	231	27
Roach	--	--	--	--	--	--	239	15	149	11	74	9	118	14
European perch	12	2	26.3	4	20	3	48	3	54	4	35	4	44	5
Pike-perch	60.1	10	72.4	11	54	8	112	7	149	11	64	7	46	5
Total	600.8	100	658.7	100	677.9	101	1 594[c]	99	1 353[d]	99	864[e]	100	846[f]	99

[a] Mostly valueless species used for processing
[b] For 1974–80, salmon and sea trout. For 1981–82, 68 t of sea and brown trout and 27 t of rainbow trout. For 1983–84, 72 t sea and brown trout, 1 t salmon and 26 t rainbow trout. For 1985–86, 70 t sea and brown trout, 1 t salmon and 11 t rainbow trout.
[c] Total for the triennium was 1 594 t: 600 (1978), 489 (1979), and 505 (1980)
[d] Total for the biennium was 1 353 t: 637 (1981) and 716 (1982)
[e] Total for the biennium was 864 t: 412 t (1983) and 452 t (1984)
[f] Total for the biennium was 846 t: 392 t (1985) and 454 t (1986)

Source: The weight of the individual species catch through 1981–82 was calculated by the author from the total weight of each year's catch (shown in the last line of the table) and species percentages given by Dahl (1976, 1978, 1982a, and 1984). Since the sum of his percentages in the columns for 1976, 1978–80, and 1981–82 do not equal 100, the individual species weights are, of course, not exact. The figures for 1983–84 and 1985–86 are from Denmark/EIFAC (1989)

7.1.2 Sport fishing

Unfortunately, for the sake of records, the Danish Ministry of Fisheries defines "sport fishing" as including both true angling (i.e., generally fishing with hook, rod and line) and part-time (or sparetime) fishing with more professional gear (mainly small fyke nets) but only for home consumption, not sale. In Denmark, the latter type of fishing which is performed mainly by riparian owners is not, in the Ministry's sense, true "commercial fishing" where the product is offered for sale. Both FAO and the author would term this "subsistence fishing".

As late as 1980, even reasonably correct statistics on the sport or recreational fishery in Denmark were said to be lacking (Dahl, 1982), and one still cannot tell from government statistics the distinction between true angling and spare-time or subsistence fisheries (Denmark/EIFAC, 1989). Nevertheless, some past partial catch records which include those for the sport fishery will indicate the composition of the catch as well as its overall importance. Table 9 shows that in 1973 the leading species in the river catch by anglers and spare-time fishermen were: trout (46 percent), eel (40 percent) and pike (6 percent). In lakes and reservoirs the sport catch was: pike (33 percent), eel (24 percent), perch and pike-perch (23 percent) and trout (10 percent). The high percentage of eel in the catch is indicative of the effort by the spare-time fishermen rather than the sport fishermen according to Denmark/EIFAC (1989).

The total catch derived from non-commercial fishing in 1973 (using only these partial statistics) was almost one-fifth that of the reported commercial fishery in the same year (Table 7), and included a large percentage of high-value fish (salmonids and eel). In lakes and reservoirs, the catch by noncommercial fishing was only one-twentieth of the commercial catch, but in rivers it was five times that derived commercially.

Table 9

Partial fish catch by anglers and spare-time fishermen in inland waters of Denmark, 1973 (in kg)[a]

Species	Rivers	Lakes	Reservoirs	Total
Miscellaneous freshwater spp.	4 166	1 731	623	6 520
European eel (Anguilla anguilla)	28 002	6 212	438	34 652
Atlantic salmon (Salmo salar)	452	-	-	452
Rainbow trout (Oncorhynchus mykiss)	10 400	-	405	10 805
Brown trout (Salmo trutta)	22 019	1 740	448	24 207
Coregonids (Coregonidae)	70	245	-	315
Grayling (Thymallus thymallus)	62	-	-	62
Pike (Esox lucius)	4 564	7 427	1 462	13 453
Common carp (Cyprinus carpio)	-	55	-	55
European perch (Perca fluviatilis)	629	4 320	545	5 494
Pike-perch (Stizostedion lucioperca)	375	1 489	-	1 864
Total	70 739	23 219	3 921	97 879

[a] Represents returns from 5 426 ha of lakes and 200 ha of reservoirs plus unknown river area

Source: Denmark/EIFAC, 1974

Both brown and sea trout are stocked in rivers and coastal areas for recreational fishing by privately managed liberation schemes under the aegis of Fishery Control Officers (see section 8.5). At present, about 56 percent of the Danish catchment areas are managed by annual stocking of about 1.6 million trout-fry, 350 000 summerlings, 200

000 yearlings, and 130 000 two-year-old trout (Rasmussen, 1984). There are a few inns, especially in Jutland, offering angling opportunities. There are also some “put and take” fisheries in some small water areas based mainly on rainbow trout. Rainbow trout that have escaped from rearing ponds also provide fishing.

Since no general licence is required for sport fishing in Denmark, it is difficult to determine the number of anglers. About 45 000 of them are organized into clubs (Dahl, 1982), and it was estimated (Gaudet, 1977) that circa 1972 Denmark had about 300 000 sport fishermen (then 6 percent of its total population). In 1980 it was again estimated that there were about 250 000 Danish anglers and perhaps 50 000 foreign anglers (Dahl, 1982). EIFAC (1989) estimates the number as 400 000. On the assumption that each resident angler spends about D.Kr. 1 500 on his sport each year, Dahl (1982) has estimated that the Danish sport fishermen spend about D.Kr. 375 000 000 annually.

7.2 Aquaculture

Denmark's aquaculture, centred in Jutland, is primarily the production of rainbow trout, although some brown trout and common carp have also been raised, and eel farming is in its infancy.

Statistics on aquacultural production of trout in Denmark differ depending upon the source. Some of these differences are due to rounding of figures, some may originate because the reporters have not distinguished between total national production and that which is exported (about 90 percent), some figures may be preliminary and then never amended, and some simply seem to be mistakes by author or printer. Table 10 shows total trout production (most of it rainbow) in Denmark as reported by authors likely to be considered standard sources and/or who have compiled their information from sources considered to be standard[1]. The exact figures are not of as great importance as is the illustration of developmental trends.

1 Brown (1983), for example, derives material from the Danish Society for Freshwater Fisheries, and the Fédération Européene de la Salmoniculture (FES)

The first Danish trout farms were established in Jutland in about 1890. Brown trout were the major species cultivated, but they were soon replaced by rainbow trout which, generally speaking, withstands higher water temperatures and has a faster growth rate. The industry matured rapidly. By 1961–62 there were about 500–525 trout farms. The total production in 1962 was 7 781 t of which 98 percent (7 657 t) was exported. By 1975 the number of fish farms had only risen to about 530 (of these, about 150 produced only eggs, fry and fingerlings) but the Danish trout export had doubled to over 14 000 t, and (according to Edwards, 1978) the total annual production had risen to 16 770 t. By 1983, the number of farms had not increased. There were 520, but trout production had increased to 24 700 t (see Table 10). There were still only 520 operating trout farms in Denmark in 1987. As has been pointed out in section 7 above, the trout “catch” shown in Table 5 is primarily representative of the commercial production of trout in Denmark, although its figures are at variance with many of those shown in Table 10, possibly because, in some instances, of inclusion of trout from the capture fishery.

Denmark has long been one of the world's most important trout producers.[2] There have been several good reasons for this: (i) the North Sea and the Baltic have been a source of cheap “trash” fish with high convertability for feed; (ii) transport of fish feed or trout has been facilitated by the short distances to travel over level terrain on good roads; (iii) an active interest both by government and industrial concerns in promoting the industry. Another factor in developing trout culture here has been the relative simplicity of the operation - at least originally. Although fry were produced in artificial containers (using either river or ground water), the larger fish have been reared in earthen ponds using water diverted from a river, led through the ponds and released again into the same river. However, as has become evident with the growth of the industry, use of surface waters and earthen ponds has increased the incidence of disease, and disposal of the effluent (faeces and unused food) has created severe environmental problems in Danish streams. The use of relatively low stocking densities has offset the disease problem to some extent, but waste disposal into streams conflicts with both the wild fishery and other water uses (see sections 6 and 9.2)

[2] In addition to the production of trout on the Danish mainland, there is a growing production of Atlantic salmon in the Faeroes. In 1989, these islands produced 10 000 t of cultured salmon (FES, 1989)

Almost all Danish trout are raised in fresh water, but there is a growing use of the brackish water (10–30 ppt salinity) of estuaries. In 1974, Denmark produced 12 000 t of trout from an area of 500 ha of fresh water and 120 t from 5 ha of brackish water (T.V.R. Pillay, pers.comm.). Circa 1989, EIFAC (1989) listed a production of 23 000 t annually from 520 farms with an area of 400 ha.

In 1978, about 100 t of trout were raised in sea water, and in 1983 this production reached over 1 000 t, and in 1989 about 3 000 t were raised. Trout weighing 200 g are put in sea water in April and 2 to 3 kg fish taken out in November–January. Land based farms using pumped sea water are generally used for this practice in Denmark since the country lacks the deep fjords and warm Gulf Stream water found in Scotland and Norway (Fish Farm.Int., 11(5):4, publ. 1984).

Most spawning of Denmark's rainbow trout occurs during the January–March period (some earlier), and after hatching it takes one to one and a half years to grow a 200-g fish. Most fry are hatched in April, are reared in concrete tanks until June–July, and then transferred to earthern ponds until the next April or July. Marketable sizes range from 180 to 350 g. Those from 180 to 250 g, one to two-year-olds, are portion fish, and the larger trout are often smoked. The Fédération Européene de la Salmoniculture (FES) estimated the entire 1989 production of rainbow trout in Denmark of 29 500 t as consisting of 25 000 t of “portion” trout and 4 500 t of “large” trout (FES, 1989).

Up to 1985 Denmark may have been the only country in the world which fed substantial quantities of fresh wet feed to cultivated trout because of the abundance of freshly caught trash fish. That year, however, the use of wet feed was totally prohibited and today all cultivated trout are fed on dry pellets. There is intensive research on the improvement of dry fish feeds, i.e., aiming at reducing the excretion of P and N and thus lessening stream pollution. Improved feeds have already (1989) reduced the production of suspended solids from 200 g/kg to 88 g/kg of fish produced.

In addition to supplying many countries with edible rainbow trout, there are extensive exports of trout eggs. Brown (1977) states that there are probably in excess of 100 million annually. Dahl (1986) says that Denmark produces about 30 t annually and Dahl (1988) records about 23 t of rainbow trout eggs exported from Denmark in 1986.

Rainbow trout are not stocked in Danish public waters although they may appear there as escapees from fish ponds. Some rainbow are stocked in sand or gravel pits for fee fishing. Perhaps 50 t of brown trout are raised annually to restock domestic waters and for export.

Common carp were also raised in Denmark but in small numbers. In 1973, 2.7 t were produced (Denmark/EIFAC, 1974). Christensen (1978) says that there is no market for carp in Denmark and that it is difficult to get them to breed there.

Circa 1984, some Danish firms were attempting to raise eel in using warm water (Fish Farm.Int., 11(2):7, publ. 1984). OECD (1986, 1987) states that 30 t of eel were produced in 1985 and 200 t in 1986. By the end of 1987, 30 eel farms were in operation, having produced 240 t in that year (Dahl, 1988).

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership

Traditionally, fishing rights in Danish inland waters belong principally to the riparian owner. In some cases this may not be true, e.g., if special rights from ancient times can be established, or if the water is owned or administered by the State.

Fishing rights cannot be separated from the property and cannot be rented out for more than 25 consecutive years. These rights can, however, be separated from the property in case of water remaining in or coming into public possession.

Table 10

Production of cultivated trout in Denmark, 1962–89 (t)

Source	1962	1971	1972	1973	1974	1975	1976	1977	1978	1979
Brown (1977)[a]	7 781	12 600	14 600	13 950	12 945	14 764	-	-	-	-
Brown (1983)	7 781	-	-	17 500	17 950	13 950	12 945	16 700	15 100	15 450
Giorgetti and Ceschia (1982)	-	-	-	-	16 719	16 700	16 700	15 450	15 200	-
Edwards (1978)	-	-	-	-	-	16 770	-	-	-	-
Shaw, Shaw and Thomas (1981)	-	-	-	-	-	-	15 000	16 000	17 500	14 000
Fish Farm.Int., 9(10) (1982)	-	-	-	-	-	-	-	-	17 500	17 950
Fish Farm.Int., 11(7) (1984)	-	-	-	-	-	-	-	-	-	-

Source	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Brown (1977)	-	-	-	-	-	-	-	-	-	-
Brown (1983)	-	-	-	-	-	-	-	-	-	-
Giorgetti and Ceschia (1982)	-	-	-	-	-	-	-	-	-	-
Edwards (1978)	-	-	-	-	-	-	-	-	-	-
Shaw, Shaw and Thomas (1981)	17 100	18 000	-	-	-	-	-	-	-	-
Fish Farm.Int., 9(10) (1982)	17 500	21 700	20 600	-	-	-	-	-	-	-
Fish Farm.Int.,11(7) (1984)	-	-	-	24 700	-	-	-	-	-	-
OECD (1985)[b]	-	-	-	23 000	26 000	-	-	-	-	-
OECD (1986)[c]	-	-	-	-	-	27 300	-	-	-	-
Dahl (1986)[d]	-	-	-	23 800	22 500	-	-	-	-	-
FES (1986)	-	-	-	-	-	24 300	-	-	-	-
Dahl (1988)[d]	-	-	-	-	-	22 500	21 800	21 000	-	-
OECD (1989)[c]	-	-	-	-	-	27 300	27 800	26 950	-	-
FAO Fish.Info.Data Stat.Serv. (1989)	-	-	-	-	23 593	23 586	24 292	25 700	-	-
FES (1989)	-	-	-	-	-	24 300	-	-	22 500	29 500

[a] The 1962–73 figures agree in Int.Res.Devel., 1979
[b] In 1984, about 24 000 t of freshwater trout and 2 000 t raised in salt water
[c] In 1985, about 24 000 t of freshwater trout and 3 300 t raised in salt water
[d] Export plus home market; mostly rainbow trout
[e] Aquaculture production, mainly rainbow trout

The owner may exploit the water himself or he may rent it to individuals, an angling club, or to a commercial fisherman. An angling club, in turn, may sell fishing privileges. With respect to Stateowned waters such as some lakes, the fishing rights may also be leased.

8.2 Administration

Three ministeries are concerned with Danish inland fisheries: Fisheries, Environmental Protection, and Agriculture.

8.2.1 Ministry of Fisheries

This Ministry, under a permanent Under-Secretary, is responsible for governmental activity in the field of both inland and marine fisheries from both an administrative and a scientific point of view. It is organized into seven Bureaux, which deal with such matters as enforcement of the Danish Inland Fisheries Act (1965), and Danish Sea Fisheries Act (1965), advice to local authorities and water courts in inland fishery problems, the collection of fishery statistics and other data, inspection, control of fish trade and the canning industry, etc. With respect to scientific and research services, see section 8.3 below.

One of the seven Bureaux deals specifically with aquaculture, inland fisheries and fishermen's status.

8.2.2 Ministry of Environmental Protection

In relation to fisheries this Ministry deals with inland and marine waters through two agencies:

(i) The National Agency of Environmental Protection, which enforces the Danish Environmental Protection Act (1985), the Inland Water Act (1982), and the Water Supplies Act (1982);

(ii) The National Forest and Nature Agency, which enforces the Nature Conservation Act (1978).

8.2.3 Ministry of Agriculture

With respect to fisheries, this Ministry is concerned with the control of research into diseases of freshwater fish with these activities directed by the Veterinary Services (see section 8.3.3) through the Communicable Fish Diseases Control Act (1987).

8.3 Scientific and Research Services

8.3.1 The Ministry of Fisheries directs the following organizations:

(i) Danish Institute for Fisheries and Marine Research, which has: (a) an Inland Fisheries Laboratory, which conducts research on freshwater and diadromous fisheries and advises the Ministry and the public; (b) a Trout Culture Research Station (see section 8.4); (c) a Physiological Laboratory; and (d) an Ichthyopathological Laboratory.

(ii) Technological Laboratory (fish processing, etc.)

(iii) Bureau of Fisheries Statistics.

8.3.2 The Ministry of Environmental Protection directs a Freshwater Laboratory of the National Agency of Environmental Protection, which is concerned with investigation of ecological problems with respect to inland waters, including fishing waters, and advice to local authorities.

8.3.3 The Ministry of Agriculture's Veterinary Services direct: (i) a Department of Infectious Fish Diseases concerned with disease control and health certification of live fish and fish eggs; and (ii) a State Veterinary Serum Laboratory for research on fish disease.

8.3.4 Other governmental bodies concerned with studies affecting inland fisheries include the: (i) Freshwater Biological Laboratory of the University of Copenhagen, and the (ii) Botanical Institute of the University of Arhus.

8.4 Non-Governmental Bodies concerned with the inland fisheries of Denmark include: (i) Union of Danish Anglers' Associations, (ii) Danish Society for Freshwater Fisheries (mostly commercial interests, pond farmers, commercial fishermen, riparian owners), (iii) Association of Danish Trout Pond Farmers, (iv) Danish Trout Pond Farmer's Experimental Station, which is associated with the Trout Culture Research Station (section 8.3.1), (v) County Water Inspectorates, (vi) Water Quality Research Institute of the Danish Academy of Technical Sciences, (vii) Danish Aquaculture Institute of the Danish Academy for Technical Sciences, (viii) Sewage Committee of the institution of Danish Civil Engineers, and (ix) various local associations interested in angling and commercial fishing.

8.5 Management

8.5.1 Legislative Authority

The Danish Government makes the laws regulating fisheries in both marine and inland waters with respect to: ownership, protection (seasons, size limits, etc.), passage of diadromous fish, etc. Additional local regulations can be secured if approved by the Ministry of Fisheries.

8.5.2 Licensing and Revenue

There is no general fishing licence in Denmark. The commercial fishery in lakes is normally carried on under lease contracts. Angling in Danish territorial waters is free. Anyone can fish freely for sport in Danish inland waters if he pays the owner of the water for fishing rights. Local licences can be purchased from the owner, renters of the rights, or from the manager of a public water.

One way in which funds may be used for improvement of fisheries in inland waters does, however, occur through use of the “Penalty Fund”, a committee to which all penalties incurred for violating the Inland Fisheries Act accrue. Such funds are earmarked for the improvement of fisheries through fish stocking, construction of fish passes, etc.

8.5.3 Operational Management

Danish fishery laws are administered by the Ministry of Fisheries. The management and development of individual fishing waters - whether exploited commercially or for sport - are not, however, in the hands of any public agency except in the case of State-owned waters. The individual fishery manager has no obligation to follow the advice given by the Ministry except in cases where State subsidies are involved, e.g., trout liberation schemes.

Management of most State-owned lakes is in the hands of the local forestry districts. Many of these waters are used commercially and/or for sport on lease contracts, and the lessees may have to follow certain management practices.

Any manager or owner of an inland fishery, public or private, may obtain professional advice from the Inland Fisheries Laboratory. Advice for public waters is free; private interests must pay for field surveys.

Stocking of trout in rivers and coastal waters may be carried on by private enterprises under the control of Fishery Control officers. Local clubs can manage trout liberation schemes, buying fish from commercial fish farms, or in some cases securing eggs by stripping wild fish. They may also aid the fisheries through elimination of competitors, such as pike, under permission of the Ministry of Fisheries.

8.6 International Agreements

Denmark has a bilateral agreement with the Federal Republic of Germany concerning uses of their boundary streams.

[1] This section is derived from Gaudet (1974), material received by EIFAC from Denmark in 1979, Dahl (1982), and Denmark/EIFAC (1989)

9. STATE OF THE FISHERY

9.1 Yield

The fish production in seven small streams in Denmark containing primarily salmonoid populations was calculated by Mortensen (1977) as ranging from 4.7 to 27.4 g/m^2/year (equivalent to 47–274 kg/ha/year). In another small Danish stream, he calculated a production of from 6.3 to 12.8 g/m^2/year (63 to 128 kg/ha/year) of Salmo trutta (Mortensen, 1982). Another study in a small Danish stream recorded a production of about 9 g wet weight/m^2/year (90 kg/ha/year) for European eel compared with the production of salmonids in Danish streams, stated by the authors Rasmussen and Therkildsen (1979), to be about 5–40 g wet weight/m^2/year (50–400 kg/ha/year).

Actual yield to the fisherman is, of course, far less. With respect to static water fisheries, the commercial fishing catches for 1973, shown in Table 7, represent the returns from only the 22 782 ha of lakes and 999 ha of reservoirs from which catch statistics were reported. The yield from these lakes was, therefore, about 21 kg/ha/year, that from reservoirs 60 kg/ha/year. This commercial lake yield is identical with that recorded by Nielsen (1977) for Denmark's largest lake, Arresø, in 1974 (Table 11).

The potentiality of the lake is illustrated by the fact that in 1971, the bream catch alone was 140 145 kg, a yield of 34.5 kg/ha/year.

Table 11

Commercial catch and yield in Lake Arresø, 1974

	Catch in kg	Yield in kg/ha
European eel	16 458	4.05
Pike	1 323	0.32
Bream	55 110	13.57
Pike-perch	12 822	3.16
Total	85 713	21.10

With respect to non-commercial catch, those statistics shown in Table 9 represent returns from only 5 426 ha of lakes and 200 ha of reservoirs. The yield to the fisherman from these lakes was, therefore, 4.3 kg/ha/year, that from the reservoirs 20 kg/ha/year.

With respect to overall catches in Denmark's inland waters, it has already been pointed out (section 7) that the statistics - at least as reported by FAO in its Yearbook of Fishery Statistics -leave much to be desired. Although neither Table 5 nor Table 8 indicate that the commercial catch in inland water (trout not included) is declining, Denmark/EIFAC (1970) states that it is indeed decreasing (see sections 9.2 and 9.3).

The yield of cultivated trout from Danish fish farms has had a high average with respect to the quantity of water used. It required only about 5 litres/sec (range, 1.7 to 8.3 litres/sec) of water for each ton of annual production (Alabaster, 1982a).

Again, and despite any misgivings concerning its accuracy, the trend of trout production through cultivation is reasonably correct in Table 5. The table indicates some ups and downs between 1965 and 1978 with the highest production (19 100 t) in 1968 dropping to only 9 300 t in 1970, recovering to 15 000 t by 1972, and rising to over 20 000 t during the next fifteen years. Fish disease problems, markets, and other factors have influenced this production. For example, in 1969 there were no trout exports from Denmark to the U.S.A. in order to control fish disease, especially myxosomiasis. Restrictions on import of trout have also been made by Canada.

9.2 Factors Affecting the Fishery

Denmark's small size, limited amount of surface water (conditioned as it is by rainfall and dispersion over its fragmented areas) plus intensive demands upon its water courses, keep down the yield from its inland fisheries.

Although the low gradient and small flow of the streams have protected them from hydroelectric development (harmful to streams in many other countries), these same attributes have lessened their value for fisheries. None of the streams are large. They are slow-moving and thus susceptible to pollution. The cool climate makes the streams suitable for salmonoid fishes, but being sandy and muddy they lack good spawning areas for these fish. Although there are few natural falls, man-made barriers have created deterrents to migratory fish.

There are a fair number of lakes and ponds, but most are small and all are shallow. Few have remained oligotrophic, and the majority are becoming increasingly eutrophic with winter fish kills not uncommon. Pike-perch, a species adaptable to turbid waters, is becoming a more dominant part of the lake fisheries.

Drainage, straightening, culverting and canalization have reduced fish habitat. Heavy land and water use from agriculture and urbanization has increased both siltation and water pollution with subsequent fish mortality. Fortunately for the inland waters, most major towns and industries are located in coastal areas but there is localized pollution from these sources.

The low annual runoff per caput of only about 2 148 m^3 annually cannot provide much water dilution of effluents; Denmark is very deficient in this regard.

In addition to the built-in land and water uses, drainage of some areas, aided by Government subsidies, has had an adverse effect on inland fisheries; circa 1969 about 10 000 he were drained annually. This land reclamation has destroyed spawning grounds, caused discharge of acid bog waters into streams, and weirs constructed to decrease erosion have formed barriers to migrating fish. Barriers to fish migration are not, however, new in Denmark. Weirs at mills on some streams have prevented spawning since the Middle Ages.

In addition to the unfavourable environmental factors, commercial capture fisheries may decrease because of increased working expenses and low price received for the catch-especially that for cyprinids. In Lake Arresø, for example, commercially caught bream have of late been fed to the more valuable eels in the lake (Nielsen, 1977).

Aside from these factors, a very important determiner of the progress of inland fisheries in Denmark has been the much greater (quite logically) emphasis, both governmentally and industrially, on commercial marine fisheries. No spot in Denmark is more than 52 km from the sea. Production of fish from salt water is easily available, and there has been no dependence on inland fisheries for fresh supply. Governmental concern with the commercial aspects of fisheries has also lessened its interest in developing sport fisheries (cf. France).

With respect to aquaculture, Denmark had an early lead on its competitors in the field (most of its output is destined for export) because of the conditions described in section 7.2. Trout culture has been handicapped, however, by relatively slow growing conditions (including a necessity to overwinter the fish without much growth), which require about 14 to 28 months to produce a marketable product. The use and re-use of surface waters (because of absence of springs) sometimes by closely sited farms has also aggravated fish disease problems. Furthermore, the use of trash fish for feed (which produces more waste than pellets), heavy concentration of fish farms, and the use of relatively little water, have all contributed to a decline in water quality which has brought about restrictions on the establishment and enlargement of fish farms under the Danish Environmental Act. Thus, for example, the use of trash fish for feeding was prohibited from use in fish farms in 1985.

The loss of export markets, e.g., to Italy and North America is also a factor in diminishing the growth of Danish trout farms.

9.3 Prospect

As no large storage of water is possible in Denmark, and dependence on ground water sources are already extremely high, the outlook for increased freshwater fishery area is slight. On the contrary, suitable water areas will be further diminished despite efforts under the Conservation of Nature Act to diminish changes in water quality or hydrology (e.g., changes in water level) which might affect aquatic life adversely.

Demand for the low-value stocks such as cyprinids is already low and will diminish further. Little increase in inland fish production through capture fisheries can, therefore, be foreseen, and attention here will be turned toward the production of high-value fish such as eels. The Danish Aquaculture Institute (DAI) has estimated that by 1990, some 3 000 t of eels could be produced annually in Denmark from recirculation systems plus power station cooling water (Wray, 1986).

Trout culture, given Denmark's large experience, established position in the industry and vigorous policy for its development, can be expected to increase in value, but it now has heavy competition in Europe with both French and Italian trout farms. It must, therefore, be conducted under much more rigorous conditions than heretofore, and the industry cannot further develop its increasingly limited fresh water using its old extensive methods. Most of the suitable freshwater areas (almost all in Jutland) are now in use. It will require intensive methods such as greater stocking densities, employment of fast-growing strains, aeration, and re-use of water, all conditioned by the necessity to keep effluent discharge within tolerable limits. It has been noted (section 6) that the Danish Pollution Council has predicted a demand in the year 2000 for only one-half the amount of water used for Danish fish farms in 1970. If the prediction is correct and production is still to continue at its present level, it is obvious that major changes will be needed.

Edwards (1978) felt that Danish trout production would stabilize at about 15 000 t annually. Pino and Kirk (1982) also felt that Denmark's freshwater potential for trout cultivation was only about 15 000 t annually and sea water production about 3 000 t, and Brown (1983) felt that Danish trout production had peaked. But Denmark's production has already far surpassed all these prophescies. Moreover, in addition to its fresh waters, it has been estimated that about 220 000 ha of estuarine waters in Denmark are suitable for trout culture. Perhaps expansion will occur here, especially in conjunction with the use of cooling water from power plants. In fact, Anon. (1986) has prophesized that Denmark would double its farmed fish production to about 50 000 t in the next 10 years.

The rise of sport fishing, as in most European countries, will continue. It has already surpassed the yield of commercial fisheries in Danish rivers, will undoubtedly increase in lacustrine waters and provide a most valuable recreational resource to this heavily populated country. Coarse fishing, previously rather neglected by Danes, is increasing in popularity.

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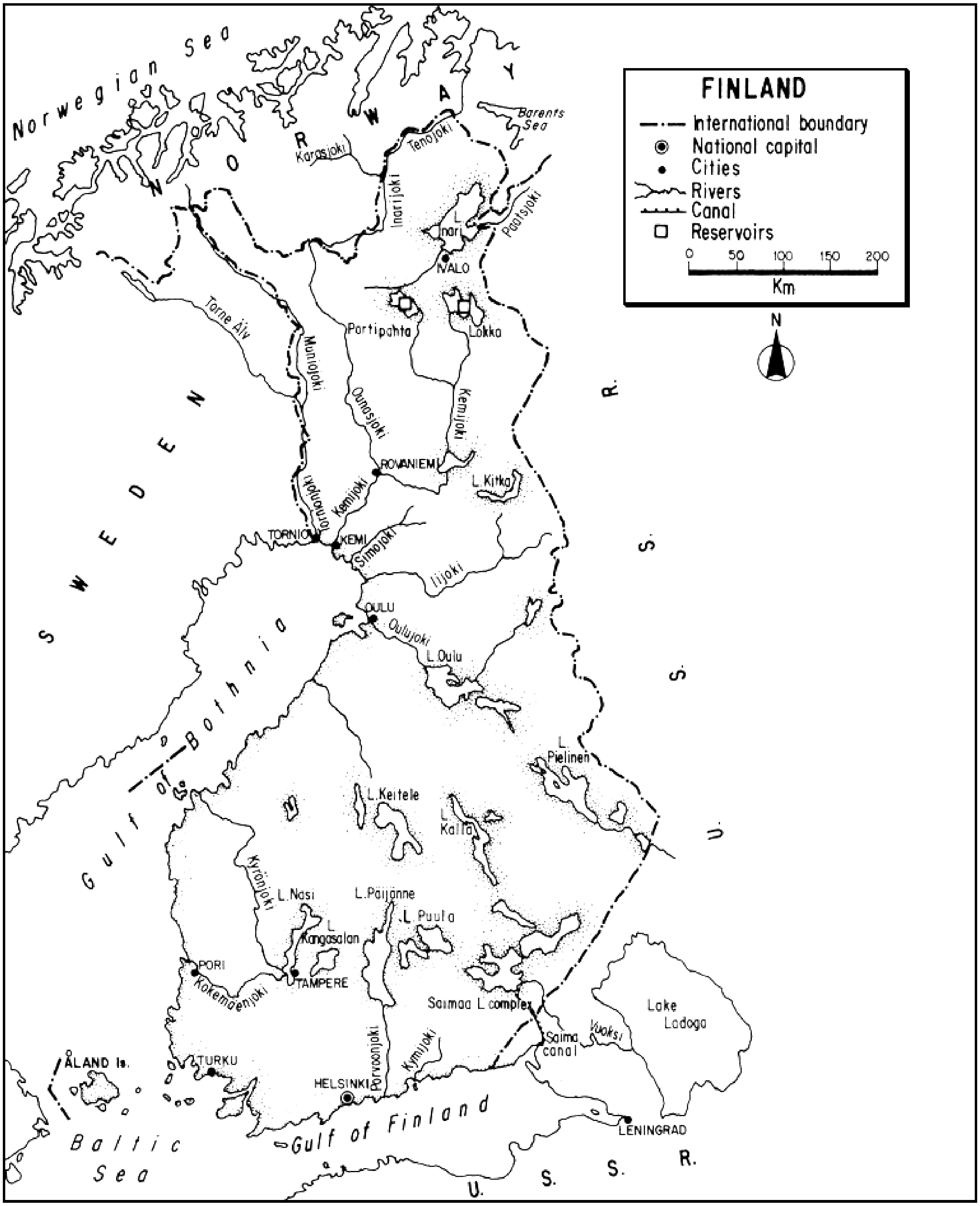
FINLAND
International boundary
National capital
Cities
Rivers
Canal
Reservoirs
0 50 100 150 200
Km
N
Norwegian Sea
NORWAY
Barents Sea
SWEDEN
U.S.S.R.
Karasjoki
Tenojoki
Inarijoki
L. Inari
Paatsjoki
IVALO
Portipahta
Lokka
Torne Älv
Muniojoki
Ounasjoki
Kemijoki
ROVANIEMI
L. Kitka
Tornionjoki
TORNIO
KEMI
Simojoki
Iijoki
OULU
Oulujoki
L. Oulu
Gulf of Bothnia
L. Pielinen
L. Keitele
L. Kalla
Kyrönjoki
L. Nasi
L. Päijänne
L. Puula
L. Kangasalan
PORI
TAMPERE
Kokemäenjoki
Saimaa L. complex
Saima canal
Vuoksi
Lake Ladoga
ÅLAND Is.
TURKU
HELSINKI
Porvoonjoki
Kymijoki
LENINGRAD
Baltic Sea
Gulf of Finland
U.S.S.R.

FINLAND

The Republic of Finland, except for Iceland, is the world's northernmost state. Low-lying and forest-clad, its labyrinth of inter-connected lakes and streams accord it the highest percentage of inland water surface of any of the European countries. Furthermore, the low salinity of the Baltic gulfs which form its coasts extend its fishery for freshwater fishes into the sea itself.

Finland's natural wealth lies in its forests which support its principal industry, the production of wood, paper and pulp. Its agricultural and mineral resources are limited, and it has a long, cold winter period. Despite its flat terrain, its hydroelectric resources have been well exploited with consequent destruction of major anadromous fish stocks.

Although its natural water quality is generally unproductive, the country's wealth of inland waters, almost 10 percent of its area, and its brackish coastal waters produce fishing for salmonids, coregonids, and cool-water fishes. Subsistence fisheries are a strong element in the use of Finnish waters, and although professional fisheries are in a decline, there is a large increase in recreational fishing. Aquaculture, primarily confined to trout production, is growing steadily in both fresh and brackish waters and has well surpassed the commercial catch in inland waters.

1. AREA: 338 145 km^2

2. POPULATION: 4 966 000 (est. 1990) <u>Density</u>: 15 inh/km^2

3. PHYSICAL GEOGRAPHY

Finland lies between 59°30'10" and 70°5'30"N latitudes and 19°7'3" and 31°35'20"E longitudes. About one-third of the country is above the Arctic Circle.

Its extreme length (N–S) is 1 160 km, its extreme width (E–W) is 540 km. Its narrowest dimension is 195 km. About three-quarters of the country is flat, ranging from 60 to 180 m, with only a few hills which rarely exceed 300 m and a mean altitude of about 150 m. The altitude, which increases gradually from southwest and south to northeast and north, has an extreme range from sea level to 1 328 m.

Finland is partially surrounded by the Baltic Sea and its gulfs, the Gulf of Bothnia on its west and the Gulf of Finland on its south. It has a boundary of 586 km on the west with Sweden, a boundary of 716 km on the north with Norway and one of 1 269 km on the east with the USSR[1].

[1] Boundary lengths after <u>Suomen Tilastollinen Vuosikirja</u> (Statistical Yearbook of Finland) 1988

In straight line, the coast is about 1 100 km in length, with curves it is about 4 680 km long, and if one includes the shoreline of its archipelago in the southwest with about 80 000 small islands, it totals about 27 000 km in length.

A part of the peneplained Fenno-Scandian shield, Finland was once covered by glaciers which, during the ice-age, scarred and gouged the surface, rounding its hills and filling in most of its depressions. Eskers or low ridges of stony-sandy material, laid down sub-glacially, cover much of the country. Many valleys were dammed by glaciers to create lakes and disrupt rivers causing falls and rapids. Inter-connected lakes now cover about 9 percent of the land and as a result of small differences in altitude over large areas, form long chains with equal water level over distances of 100 km or more.

The underlying rocks are mostly gneisses and schists and intruded bosses of granite blanketed by infertile morainic drift and peat. About 30 percent of the land area (bogs and fens) is organic soil (peat), low in plant nutrients, and generally deficient in phosphorus. Other soils are thin, almost exclusively pedzols, with a low rate of drainage following summer snowmelt which leaches them. There are some clays and silts in littoral areas, and some poor forest soils.

About 70 percent of the country is forested. Finland is situated almost wholly in the northern zone of coniferous forest. As one proceeds north, the vegetation changes from conifers and deciduous trees (oak, maple, linden) to purer stands of conifers, then stunted birches, and finally tundra. Pine, spruce and birch are 98 percent of the forest.

Physiographically, Finland can be divided into three main areas:

(i) the northern lands extending into Lapland;
(ii) a central lake plateau in the south and southeast, and
(iii) the coastal plains in the south and west.

Northern Finland is a thinly settled area of forests, bogs and barren fells (fjells). Lakes occupy only 3–5 percent of the area and rivers are the predominant waters. The central lake plateau is an undulating peneplain with some round granite hillocks, and a confused immature drainage. It is dominated by large river basins with chains of lakes covering 10–20 percent of the area. Largely forested, it supports some agriculture, and the lower portion is more thickly settled. The third area of the country, the greatly indented coastal plains which extend inland for about 80 km, has some good soils: clays, sand and gravel. Its rivers are relatively small and there are few lakes. This area has the most extensive farmlands, the most continuous settlements, and the largest number of urban centres.

4. CLIMATE

The climate of Finland is intermediate between the maritime type of climate of western Europe (with the Gulf Stream as a source of heat) and the dry continental type of the east which dominates it.

The mean annual temperature in the southern part is 6°C, to -0.4°C in the far north. The winter range is about -3° to -21°C; the summer range, 12.8° to 17.2°C.

The average annual precipitation in Finland is 630 mm, ranging from about 700 mm in the south to 400 mm in the north. Summer precipitation is two to three times as much as that in winter. One-third of the total precipitation in the south is snow; it equals two-thirds of the precipitation in the north. Snow-cover lasts from 80 to 140 days in the southwest to 220–250 days in the far north. Inland waters are frozen from about five months in the south to seven and a half months in the north (extremes, three to nine), and the less saline waters of the coast may also freeze (see section 5).

The growing season, based on the number of days on which the average air temperature exceeds 5°C, is about 170–180 days on the south and southwest coast, 150 days in the central lake district, and about 110–120 days in the far north (Lapland).

Annual evaporation is 350 mm in the south and 100 mm in the north. Since the annual rainfall on the south coast is about 700 mm and that in the north 400 mm, the runoff is almost equal in all parts of the country (see section 5).

In the far north the sun does not set for two months in the summer, and during winter there are two months without sun.

5. HYDROGRAPHY AND LIMNOLOGY

The land surface of Finland has a distinct fracture pattern, forming an irregular fault-mosaic. This is the basic factor in its intricate network of land and water.

Finland has a very large area of inland waters[1]. Table 8 indicates that its inland waters total 31 560 km^2 or 9.3 percent of the country's total area. Mustonen (1977) states that the total lake area of Finland is 31 600 km^2, which is 9.3 percent of the entire area of the country. Munne (1982) agrees generally with this, saying that the lake area of Finland is 31 500 km^2 or 9.3 percent of the total area. Westman et al. (1984) say that the inland waters of Finland cover 31 613 km^2 or 9.3 percent of the total area. Heikinheimo-Schmid, et al. (1988) say they cover 33 520 km^2 or about 10 percent of the total area. The Statistical Yearbook of Finland, 1988, gives the inland water area as 33 522 km^2 or 9.9 percent of the total area of the country. Europa (1988), Paxton (1984) and Worldmark (1984) also indicate that the area of inland water in Finland constitutes 9.9 percent of the total area. This percentage ranks above that of all other countries in Europe, surpassing both the Netherlands and Sweden in this respect.

[1] In addition to these waters which are fresh, Finland has some large brackishwater areas which support several species of freshwater fishes (see sections 5.5 and 7)

Based on an average precipitation of 630 mm/year (20 litres/sec/km^2), the approximate annual runoff from rainfall in Finland is 300 mm or 100 000 million m^3. Upstream countries contribute 4 000 million m^3 so that total annual river discharge leaving Finland is 104 000 million m^3 (Van der Leeden, 1975; ECE, 1978). About one-half of the runoff from precipitation runs off through the water courses and as ground water into the sea, and slightly over one-half is evaporated. Thus about 3 100 m^3/sec from this source is discharged.

The “natural state” of Finland's surface waters is as follows: suspended solids, 1–5 mg/litre; phosphorus, 8–25 mg/m^3 P; nitrogen, 200–500 mg/m^3 N (Mustonen, 1977). The larger northern Finnish rivers are close to this state, but water quality has been altered through man's activities as wll be seen in sections 6 and 9.

The major drainage basins of Finland are listed in Table 1 together with their areas and the percentage of each occupied by lakes. Rivers are the predominant inland waters in northern Finland; lakes are predominant in the south.

Table 1

Major drainage basins of Finland

Name of drainage basin Finnish/Swedish	Area within Finland 1 000 km²	% occupied by lakes Percent
Arctic Ocean		
Tenojoki/Tana älv	4.5 [a]	2.5
Paatsjoki/Pasvikälv	14.6	12.2
Koutajoki/Koutajoki älv	5.0	--
Baltic Sea		
Tornionjoki/Torne älv	14.0 [b]	4.6
Kemijoki/Kemi älv	49.3 [c]	2.9
Iijoki/Ijo älv	14.3	5.7
Oulujoki/Ule älv	22.3	11.5
Siikajoki/Siikajoki älv	4.3	1.5
Kalajoki/Kalajoki älv	4.3	1.8
Lapuanjoki Lappo a	2.4	2.4
Kyrönjoki/Kyro älv	4.9	0.8
Kokemäenjoki/Kumo älv	27.0	11.1
Kymijoki/Kymmene älv	37.2	19.1
Vuoksi/Vuoksen	52.4 [d]	21.3

[a] Total area (× 1 000 km^2) - 14.8
[b] Total area (× 1 000 km^2) - 40.0
[c] Total area (× 1 000 km^2) - 50.9
[d] Total area (× 1 000 km^2) - 61.6

Source: Suomen Tilastollinen Vuosikirja, 1982

5.1 Rivers (Joki/Älv)[1]

Munne (1982), following Finland's National Board of Waters, says that the total length of Finland's rivers exceeds 20 000 km. Several other Finnish authors, such as Westman et al. (1984), and Heikinheimo-Schmid et al. (1988) agree.

[1] Finland has two official languages: Finnish (over 90 percent) and Swedish. In Finnish, the term “joki” (river) is usually included with the basic name of the stream, e.g., “Kemijoki”. The Swedish term for river is “älv”

The major rivers of Finland are listed in Table 2, together with their discharge characteristics.

Table 2

Principal rivers of Finland and discharge characteristics

	Monthly discharge, m^3/sec				
	Maximum flow			Minimum flow	
	Extreme	Mean	Mean flow	Mean	Extreme
Arctic Ocean					
Tenojoki/Tana älv	--	--	--	--	--
Paatsjoki/Pasvikälv	499	288	152	54.0	17.0
Gulf of Bothnia					
Tornionjoki/Torne älv	3 180	2 128	376	71.0	53.0
Kemijoki/Kemi älv	4 400	2 945	536	136.0	62.0
Simojoki	636	417	49	4.8	1.0
Iijoki/Ijo älv	1 397	880	171	43.0	14.0
Kiiminki	660	377	44	5.6	1.7
Oulujoki/Ule älv	889	473	248	91.0	0.1
Siikajoki/Siikajoki älv	686	404	34	2.1	0.1
Pyhäjoki	425	240	32	6.8	0.9
Kaläjoki/Kalajoki älv	518	326	35	1.8	0.1
Perhonjoki	385	252	22	3.7	2.0
Ahtavanjoki	67	39	16	6.9	0.1
Lapuanjoki/Lappo å	326	197	31	3.3	1.0
Kyrönjoki/Kyro älv	507	307	44	3.7	1.0
Kokemäenjoki/Kumo älv	881	583	215	72.0	9.4
Gulf of Finland					
Karjaanjoki	95	45	19	5.0	0.1
Kymijoki/Kymmene älv	671	421	288	178.0	66.0
Lake Ladoga					
Vuoksi/Vuoksen	1 142	700	556	349.0	56.0

Source: Van der Leeden (1975) after Jaatinen, Aqua Fennica, 1971

Arctic Ocean drainage. The Tenojoki (Tana in Norway), a continuation of the border river the Inarijoki (Anarjokka of Norway), after its junction with the Karasjoki, forms a portion of the border between Finland and Norway. The most important salmon river in both Finland and Norway, it flows north into Norway to enter the Tana Fjord on the Barents Sea. The total length of the Tenojoki is about 360 km. Another Barents Sea river is the Näätätämönjoki, originating in Finland and travelling through Norway to its mouth. The Paatsjoki is another international river, which flows north from Lake Inari for 142 km to the Barents Sea in Norway, first forming a border between Finland and the USSR (known there as the Paz) and then a border between Norway and the USSR. There is also a drainage from Finland's eastern uplands, the Koutajoki or Kovda River drainage, which flows through the lake system of the Soviet Karelia to the White Sea.

Baltic Sea drainage. The other principal Finnish rivers are all in the Baltic drainage. In Table 2, those from the Tornionjoki through the Kokemäenjoki are listed in the order they enter the Gulf of Bothnia from north to south.

Of these Bothnian rivers, the Tornionjoki is distinguished by being another of the country's international rivers, a border between Finland and Sweden. The lower portion is formed by the junction of the Torne Älv, flowing southeasterly through Sweden from Lake Torneträsk to the border, and the Muoniojoki/Muonioälv which rises in Lapland close to the Norwegian/Swedish/Finnish border and then flows southerly forming a Finnish/Swedish border en route. The border river is about 400 km long. Also in this Bothnian drainage is Finland's longest river, the 552-km Kemijoki, and its 338-km tributary, the Ounasjoki, and the Kokemäenjoki, Finland's best source of crayfish until the crayfish plague broke out here in 1907.

The Karjaanjoki and Kymijoki enter the Gulf of Finland directly, but the Vuoksi (the largest drainage basin in Finland) drains from Finland's largest lake, the Saimaa, southeast into Lake Ladoga in the USSR. Ladoga itself drains into the Neva River which has its mouth in the Gulf of Finland.

The annual runoff in the rivers does not vary much from place to place in the country or from year to year, but seasonal changes are quite large, depending to a large extent upon the size and percentage of lakes in the river basin. Thus, in the north where lakes are fewer, high water or even floods occur during the melt period of early summer. The balancing effect of the lakes is clearly shown in the Vuoksi which passes through many lakes. Its normal discharge during the month does not deviate from the mean monthly volume by more than 10 percent. On the other hand, the flow of the Kemi which passes through few lakes varies widely. The annual discharge pattern of these two rivers and that of the Kymi is shown in Table 3.

The five chief river systems (Kemijoki, Oulujoki, Kokemäenjoki, Kymijoki and Vuoksi), which drain almost 60 percent of the country and include most of the lakes, range from fast to slow-flowing. The rest of the country is drained by many smaller rivers, chiefly to the west and south coasts. Passing through flatlands, they are slow-moving and sometimes turbid with clay. Most of the rivers in Finland are short. Many of them are dammed and have lost their former runs of anadromous fishes. They are by no means as important as the lakes.

Table 3

Discharge of three principal rivers in Finland, 1930–40 and 1945–65

	Mean discharge, m³/sec												
River, station	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
Kemijoki, Petäjäkoski	204	175	159	232	1 557	1 093	563	488	518	513	426	274	517
Kymijoki, Kuusankoski	270	260	250	270	334	353	322	283	252	247	252	269	280
Vuoksi, Imatra	606	594	525	564	539	531	512	514	559	569	596	600	567

Source: Van der Leeden (1975) after ECE (1970)

5.2 Lakes (Järvet/Sjöar)

Depending upon the size of a static water body which one considers to be a "lake", estimates of the number of lakes in Finland range upwards to about 188 000. Suomen Til. Vuosikirja (1988) says that "lakes with an area of at least 500 m^2 total about 188 000", but most references credit Finland with about 70 000 "lakes". The total number of lakes in Finland with a diameter over 200 m is estimated to be about 55 000 (Mustonen, 1977; Suomen Til. Vuosikirja, 1982, 1985/86). Of these lakes, 17 have an area of more than 200 km^2 and the total lake area has been estimated at about 31 500–

31 600 km^2 (see section 5 above). The five lakes in Table 5 have a combined area (8 294 km^2) over one-quarter the total surface area of all the lakes. Another classification of distribution of lake sizes in Finland is given in Table 4, and the largest lakes in Finland are shown in Table 5.

Table 4

Finnish lakes classified according to size

Area	Number	Percent of total lake area
Large (over 2 000 ha)	158	62
Medium (100 to 2 000 ha)	3 000	25–30
Small (less than 100 ha)	50–70 000	10

Source: Finland/EIFAC (1974)

Table 5

Principal lakes of Finland

Lake	Area (km^2)
Suur-Saimaa/Stor-Saimen	4 377
Inari/Enare	1 102
Päijänne	1 054
Oulujärvi/Ule träsk	893
Pielinen	868

Source: Suomen Tilastollinen Vuosikirja, 1988

The total shore length is above 160 000 km, and the lakes have highly irregular shorelines. Their coefficient of irregularity lies between 10 and 20 in most cases, and they are full of islands. The deepest lake, Kallavesi, is 120 m deep, followed by Päijänne (104 m) and Saimaa (82 m). However, the lakes are generally shallow with an average depth of only 7 m. Consequently, despite their large extent their total volume is only about 220 km^3 which increases their susceptibility to pollution. In fact, the rainfall of one year would be almost sufficient to fill all the lake basins, and the total volume of the 17 biggest Finnish lakes is roughly equal to that of the 5 585-km^2 Lake Vänern of Sweden.

The geological development of Finnish lakes began after the last (Weichselian) glaciation. In eastern and northern Finland their basins were formed immediately after this glaciation, but in the submerged coastal areas of southern, western, and central Finland the lakes were isolated from the various stages of the Baltic Sea as a result of isostatic uplift and tilting of the land. Some new lakes are still emerging on the coasts (Alhonen, 1983). Most of the glacial lakes lie in depressions formed by ice-scouring of fractures in bedrock shatter belts which have been excavated or filled with drift. Some are dammed by moraines. Some, such as Lake Päijänne, are partly tectonic.

Westman et al. (1984) state that most of the Finnish lakes (86 percent) are oligotrophic, and that the eutrophic lakes (14 percent) are generally located in the south and southwest in clay-soil areas. Some of the earlier authors, however, consider that a large number of the Finnish lakes are dystrophic. Thus, Kajosaari (1968) says that the dystrophic lake is the most common with eutrophic lakes predominant in some southern areas and oligotrophic in the north, while Lind (1977) states that most of the lakes in central Finland are dystrophic, whereas those in the southwest are eutrophic with oligotrophic lakes occurring in the southeast and north. Whatever one terms them, they are generally unproductive and poor in species.

The special quality of Finnish lakes is due in large part to low fertility of the soil and large amounts of peatland. About 90 percent of the lakes have low primary productivity and some 60 percent of the lake water is brown, coloured by humus from the peat and thus subject to a heavy natural load. The average lake water colour value of the whole country is 91 mg Pt 1 (Alhonen, 1983).

Surface water temperatures in the lakes of southern Finland are about as follows: June (15°C), July (19°C), August (17°C). The deep open lakes of the Central Plateau only become frozen permanently by mid-December. Ice breakup occurs in these lakes by mid-May and in the southern lakes by early May, but in Lapland the lakes freeze earlier and ice may not break up until June.

Some limnological data for Finnish lakes are shown in Tables 6 and 7.

In addition, some notes on Lake Päijänne, situated near the industrial centres of the south, and the second largest lake in Finland, may illustrate the importance of changes in the environment that have made a change in the fisheries of Finnish lakes. Päijänne, in the Kymi River drainage, has a volume of 18.3 km^3, a maximum depth of 104 m, a mean depth of 17 m, shoreline of 2 450 m, a discharge of 209 m^3/sec, an ice-cover of 147–169 days, and a theoretical retention time of 1 013 days. Naturally oligotrophic and oligohumous in its natural state, the average catches of professional and nonprofessional fishermen in Northern and Central Päijänne varied between 22 and 40 kg/ha/year providing total catches of about 2 million kg annually. Pollution and eutrophication began about 35 years ago, and with loading the catch has varied with reduction of planktonivorous fishes (coregonids) and an increase in perch (Perca fluviatilis), roach (Rutilus rutilus) and bream (Abramis brama). In its natural state the fishermen's catch was about 60 percent coregonid or 17 kg/ha/year, but with loading the coregonid catch declined to only about 7 percent of the total or less than 1 kg/ha/year (Nyrönen, 1978; Hakkari and Granberg, 1977; Harjula and Granberg, 1978).

Table 6

Limnological data for characteristic Finnish lakes, rivers and brackish waters

Lakes	Area (km^2)	Max.depth (m)	Conductivity ($uS.cm^{-1}$)	Colour (Pt mgl^{-1})	pH	Oxygen ($mg.1^{-1}$)
Lakes						
Inari	1 085	95	29	15	7.1	12.9
Oulujärvi	900	35	28	60	6.3	11.7
Saimaa[a]	1 460	82	34	45	6.7	12.6
Av. 11 smaller lakes	95	26	58	37	6.7	10.9
Rivers						
Kokemäenjoki, Rautavesi	30	40	98	65	6.1	4.1
Kokemäenjoki, Liekovesi	4.5	>5	98	65	6.1	4.1
Paimionjoki		>3	123	90	7.2	11.7
Brackish water						
Gulf of Bothnia, Oulu	117 000	291	4 300	30	7.1	11.8
Gulf of Finland, Porvoo	29 500	116	9 000	15	7.4	10.5
Gulf of Finland, Helsinki			7 700	20	7.6	11.2

[a] Part of the Great Saimaa system of about 120 connecting lakes (see Table 5)

Source: Modified from Lind (1977); Most samples analysed during winter

Table 7

Some limnological data for small and large Finnish lakes

	Small lakes	Great lakes
pH	6.3	6.6
Alkalinity (m mol/1)	0.08	0.17
Conductivity (mS/m)	3.1	4.6
Colour (mg Pt/1)	100	50
Total N (µg/1)	450	500
Total P (µg/1)	15	19

Source: Rask and Ruuhijärvi (1990) after Kortelainen et al. (1989) and Laaksonnen (1972)

It should be noted that there are some international lakes in Finland such as the Karelian, Lake Pyhäjärvi (Ozera Pjuhajarvi) with 200.9 km^2 in Finland and 54.1 km^2 in the USSR[1]. Discharge from these lakes may affect the waters of border states (see section 8).

[1] Finnish and Soviet studies on Lake Pyhäjärvi are the subject of a special issue of Finnish Fisheries Research, 8 (1987)

It should also be emphasized that many Finnish lakes have not only been affected by wastewater (as has Lake Päijänne), but have been regulated for hydropower and thus taken on some of the aspects of reservoirs, e.g., Lake Inari fluctuates 2.36 m causing erosion and a decrease in vegetation and benthos (see sections 6 and 9.2).

5.3 Reservoirs (Tekoaltaat/Sjöar, Konstgjorda bassänger)

The first artificial lake in Finland was built at the end of the 1950s, and by 1974 there were about 900 km^2 of reservoirs in the country. Among the large reservoirs are Lokka (417–216 km^2 in area) and Porttipahta (214–43 km^2) in Lapland, which have become remarkable commercial fishing areas for whitefish (Coregonus lavaretus) and pike (Esox lucius). Generally, however, Finnish reservoirs are small, about 6.5 km^2 in area.

Some of the earlier ones were built on marshy lands, and oxygen concentrations were low for some years. Although Finnish watercourses were first dammed to create hydroelectric power and for flow regulation, most reservoirs built today are multipurpose in nature.

5.4 Canals (Kanavat/Kanaler)

There are about 40 major canals in Finland. One of these is the Saimaa Canal, 32 km long with a draught of over 4 m, leading through nine locks from the Gulf of Finland to Lake Saimaa to rise 76 m. Many small canals connect lakes and rivers and most are navigable.

5.5 Coastal Areas

The Baltic Sea proper (or Main Basin) occupies an area to the south of Finland, i.e., below the Åland Islands. Its largest arm, the Gulf of Bothnia extends along the eastern coast of Sweden and western coast of Finland; the northern part of this Gulf is called the Bay of Bothnia, the southern portion the Bothnian Sea. A smaller arm of the Baltic, the Gulf of Finland extends along the southern coast of Finland.

Tidal movements in the Baltic Sea are insignificant. The Sea is characterized by a positive freshwater balance and the water is brackish. The salinity off Finland rarely exceeds 6 ppt, and at the very ends of the Gulfs decreases to about 3 ppt. In fact, the northern part of the Gulf of Bothnia may be frozen from 110 to 210 days/year, and the Gulf of Finland closed by ice for about 150 days[2]. Separate freshwater areas form at the mouths of rivers and extend out to sea. (See Table 6 and section 5.4 in the review of Sweden.)

[2] The freezing point of sea water = -0.054 × salt content in ppt

These major brackishwater areas, the 117 000 km^2 Gulf of Bothnia, and 29 500 km^2 Gulf of Finland, support populations of freshwater or fluvial fishes which have good growth rates and make a considerable contribution to the fishery (see section 7).

6. LAND AND WATER USE

Table 8

Pattern of land use in Finland, 1986

	Percent
Arable and permanent crops	7.1
Permanent pasture	0.4
Forests and woodland	69.0
Other land	14.2
Inland water	9.3
Total	100.0

Source: 1987 FAO Prod.Yearb., 41 (Publ. 1988)

Finland is considered to be 68 percent urban and 32 percent rural (1990). Its industry or use of land and water is largely determined by the fact that 70 percent of the country is forest, there is a lack of fossil fuels and minerals, the terrain is generally flat, the soil is poor, the country has a long winter period, and lies at the upper end of the grain growing area. Over 50 percent of the population lives in the south and southwest which represents only about 15 percent of the country's area.

Grass is the main crop and only about 7 percent of the land is cultivated. About 35 percent of the people, however, live by farming, which may also include some fishing (since most waters are privately owned) and forestry. Cattle are important agriculturally, especially for dairy use, some grains, beets, and potatoes are also raised. Less than 0.02 percent of the country was irrigated in 1986, and water for its use is normally not drawn from streams. Quite a bit of fertilizer is used and cultural eutrophication of some of the lakes began many years ago. Both swamps and forests have been ditched and drained to improve production. In fact, the Finns are experts in this subject. In response to the need for agricultural land, during the first part of this century, at least 500 lakes were drained and over 500 km^2 of former lake beds made suitable for cultivation (Smeds, 1961).

Finland is the most forest-clad country in the world and its main industries are production of wood, paper, and pulp in which it ranks among the top two or three countries. Dredging of rivers was first carried out by manpower in order to promote boat traffic, but since the end of the Nineteenth Century the dredging has been carried out mainly for timber-floating. It was not extensive until the 1950s when bulldozers were brought into general use and many of the rivers and large brooks, especially in northern and eastern Finland, were thoroughly dredged in the 1950s and early 1960s. Some 40 000 km of water routes have been used for floating logs and about half of the 20 000 km of rivers included in these routes were dredged by bulldozers. Such dredging has been very injurious to fisheries, especially salmonoid stocks. Log-floating occupies from a few weeks to several months a year. Trees are generally cut in the winter and floated during the early summer when streams are high. Bundle-floating is replacing raft- and loose-floating systems, and road haulage is gradually taking the place of water transit. As long ago as 1974, canal traffic in Finland (waterways connecting lakes) carried 22 130 timber rafts, but by 1979 only 16 459 timber rafts were in transit. After the 1960s, timber floating ceased in most rivers, except for the largest. As in other northern countries, some of the Finnish streams have been canalized and their bends straightened to permit log transport and prevent log jamsalbeit at the expense of fish populations.

The forest products industry consumes about 70 percent of the total amount of water abstracted daily from Finnish watercourses (Nilsen, 1974). Its largely decentralized pulp and paper industries produce considerable quantities of polluting effluents, particularly waste liquor from the sulphite process which has a high BOD, and waste fibre which causes slime blankets in the streams. Slimecides which are discharged with the effluent may also aggravate the problem.

In addition to Finland's principal forest industries, other industries, particularly in the southwest, include food processing, textiles, chemicals, machinery and shipbuilding. Some of these also cause water pollution, and by far the greater portion of Finland's water use is by industry.

Finland's major minerals are zinc, copper, a little iron, some vanadium, manganese and asbestos. There is no coal, oil or natural gas, thus placing more dependence upon hydropower for electrical generation. Finland does, however, have one of the largest peat reserves in the world.

The potential for hydroelectricity in Finland is relatively low as compared with that of its neighbours, e.g., its water flow per unit area is about half that of Sweden and one-tenth that of Norway. Furthermore, gradients are low, most of its lakes with high volume lie at low altitudes, and the rapids are usually long and gently flowing. Nevertheless, there has been a considerable development of hydroelectricity, and all of the main rapids have been harnessed. The option has been for power rather than for fish. Most of the development is on the Kemi River in the north, the Oulu Basin, and the Vironkoski River in the southeast. There are also many stations in the south where streams which leave the plateau have low heads, but are sustained by headwater lakes. By 1974, there were more than 150 hydroelectric plants in Finland and from 1 000 to 1 500 other man-made obstructions to the passage of migratory fish. By now, plants have been built on the principal sites, and dependence on future energy needs will depend largely upon thermal, nuclear, or imported power. The first nuclear plants were installed in 1976 and 1978, and by 1987 the installed electrical capacity in Finland was 11 661 000 kW, of which only 2 586 000 kW (22 percent) was hydroelectric. The remainder was thermal (6 725 000 kW or 58 percent) and nuclear (2 350 000 kW or 20 percent).

In fact, Finland has less hydroelectric power now than a few years ago, but the damage to its rivers has been great. As an example, within the Oulujoki watershed, with the fifth largest drainage basin in Finland, about 60 percent of the water area is regulated for hydroelectric purposes, 17 hydroplants have been constructed, and 77 percent of the rivers dredged so that most of the rapids have disappeared (Salojärvi, Auvinen and Ikonen, 1982).

Finland's 8 936 km of railroad (1988) link it with Sweden and the USSR. In 1987 it had 76 233 km of public automobile road giving it a road density of only 0.22 km/km^2, one of the lowest in Europe, and a passenger car ownership of 330 per 1 000 people. Inland waterways navigable by ship total about 6 675 km, excluding some 40 000 km for timber-floating. However, the major way of moving goods is by truck.

Ground water is preferably used for water supply, and most private domestic water supplies are from underground sources. However, these reserves are scanty, so more than 80 percent of distributed or public supply now comes from surface sources and the amount is increasing.

Water usability in Finland has been classified, taking into account varied uses such as for domestic supply, fishing, or recreation. A classification given by Mustonen (1977) is shown in Table 9. Another study made by the National Board of Waters and Environment shows very similar results, namely, that in the “early 1980s”, with respect to water quality, almost 80 percent of Finland's lake area was considered excellent or good, almost 19 percent was satisfactory and only 2 percent was poor or bad (Tilastokeskus, 1988). As has been shown, a high percentage of the water was suitable for fisheries. There is, however, under Finnish law no mode of use which is preferred over another with the possible exception of obtaining water for domestic purposes, and in cases where water is to be used for a community, industry has the lowest priority.

In overall terms of wastes generated in Finland (1984) the following were largely responsible: agricultural straw and manure (28 percent), mining and quarrying (23 percent), tree felling (18 percent), and industrial woodwastes (12 percent) (Tilastokeskus, 1988).

Inland water is, of course, used for disposal. Public sewerage is high in urban areas, is spreading to rural areas, and piped water supply rapidly being extended. Municipal wastes account for only 3.6 percent of all Finland's wastes (1984).

Traditionally, many summer vacations in Finland are spent on lakes, and the erection of summer homes has been increasing at a rate of about 5 percent/year. With the growth of these homes comes increased water use, more pollution, more fishing, and more possible conflicts with fishing through use of boats, water skiing, etc.

Fishing both on a private and subsistence level is common throughout the country. The per caput supply for human consumption (1982–84) is 34.3 kg annually, and large amounts of fish are used for mink feed in the fur industry; both marine fish and some undesired or under-sized inland fish are used for this purpose. In 1987, about one-half of the total commercial catch in Finland was used for human consumption; the other half was used as feed on fur farms (OECD, 1989). See Table 12 for the source of Finland's capture fish supply.

Finland attracts tourism, especially in the summer, but although there has been interest in promoting recreational fishing, the opportunities for catching the most highly desirable fish (trout and salmon) are limited. Sport fishing for foreigners on the Tenojoki cost Fmk 80 or about US$ 20/day in 1980.

Table 9

A classification of water (by use) in Finland

	Class	Suitability	Extent
1.	Excellent	For all purposes requiring high-water quality	= 78 percent
2.	Good	For all purposes, but because of high humus content may require treatment for domestic supply	
3.	Satisfactory	Requires treatment for domestic supply. Not always safe for swimming	19 percent (10–15 percent slightly polluted)
4.	Fair	Only for cooling water	3 percent highly polluted
5.	Bad	Not for any conventional use	

Source: Mustonen (1977)

7. FISH AND FISHERIES

Finland has a limited fish fauna: about 60 species including marine forms, and only about four of these are exclusively freshwater fish. About 33 species live in both fresh water and in the brackish Baltic, most of them close to shore and seldom found in the open Sea. It is somewhat difficult, therefore, to speak of a Finnish “inland fish fauna”, because in some cases the catch of certain freshwater fishes in Baltic coastal waters is equal to or even exceeds that in strictly fresh water (see section 7.1). However, if we consider as “inland” not only strictly fluvial fishes, but diadromous fishes and those also capable of living in brackish water, then Finland has an inland fish fauna close to the number of species found in Sweden and Norway.

The inland native fishes of Finland include the following important species: lampern or river lamprey (Lampetra fluviatilis), European eel (Anguilla anguilla), Atlantic (Baltic) salmon (Salmo salar), brown trout and sea trout (S. trutta), the muikku/siklöja

(Coregonus albula) which termed "European whitefish" in FAO statistics, but is commonly called "vendace" in Finnish fishery literature written in English, another coregonid (C. lavaretus) the siika/sik of the Finns, but known to them in English as the "whitefish", grayling (Thymallus thymallus), smelt (Osmerus eperlanus), pike (Esox lucius), bream (Abramis brama), orfe or ide (Leuciscus idus), roach (Rutilus rutilus), burbot (Lota lota), European perch (Perca fluviatilis), and pike-perch (Stizostedion lucioperca).

The landlocked salmon (Salmo salar sebago) and char (Salvelinus alpinus) are also found in Finland, but are considered rarities (Pironen, 1990).

Fifteen new species of fish have also been introduced into Finnish waters since the middle of the Nineteenth Century. Of those species which have persisted, the following are of the greatest importance in open waters: Siberian whitefish (Coregonus peled), lake trout (Salvelinus namaycush), American brook trout (S. fontinalis), common carp (Cyprinus carpio), and tench (Tinca tinca). The rainbow trout (Oncorhyncus mykiss), first introduced in 1897, has not been successful in Finnish open waters, but is used for "put and take" fisheries, and is the preeminent aquacultural species (see section 7.2). Other exotic salmonids in Finland are the Pacific pink salmon (Oncorhynchus gorbuscha) and chum salmon (O. keta), products of stocking by the USSR, which enter Finland's Arctic rivers and have been found in the Baltic. (See Westman and Tuunainen, 1984, for an account of exotic fish introductions into Finland.)

In addition to finfishes, one species of crayfish, Astacus astacus, is endemic to Finland. Formerly very abundant, it has undergone a strong decline in this century since introduction of the crayfish plague (Aphanomyces astaci) in 1893, and habitat changes occasioned by dam construction, drainage, and dredging. Circa 1984, only 20 of 74 major watercourses of Finland, which formerly held crayfish, remained unaffected by the plague. At its peak, the Finnish catch amounted to about 20 million crayfish. In 1900, exportation reached its height of about 15.5 million, making Finland Europe's most important exporter of this crustacean. But in recent years the catch has amounted to only a few million, and in 1973, exports dropped to 21 300 crayfish, a severe economic loss. Meanwhile, imports of crayfish for consumption, which commenced in 1967, have increased and now exceed exportation. In 1982, importation totalled 1.78 million individuals while exports were only 155 000. (Most of the imports are from Turkey.) In 1984, the native crayfish catch in Finland was estimated at about 1.5 million individuals with a value of Fmk 10.5 million (US$ 1.7 million). The extent of the littoral zone, the primary habitat of crayfish, is very large in Finland, and many studies have been conducted to counteract the loss.

Attempts to restore the native populations through restocking have not been very successful, and since 1967, Finland has imported the plague-resistant American signal crayfish (Pacifastacus leniusculus) to augment its stocks. This crayfish has developed self-supporting stocks in some Finnish lakes, and attempts have been made to produce juveniles for stocking.

7.1 Capture Fisheries

Finland's official catch record statistics are segregated as follows: (i) professional fishermen; (ii) semi-professional fishermen, and (iii) non-professional fishermen[1].

1 Official catch record statistics for Finland, compiled by the Finnish Game and Fisheries Research Institute, appear in Suomen Kalatalous and Suomen Tilastollinen Vuosikirja. They have been collected since 1962 using basically the same methods: primary data are collected by the fisherman and surveys made by the Government (Rantala, 1983). A decided change in the sampling frame was, however, made in 1986. See section 7.1.2

Using another and more detailed classification by Munne (1982), his classes are further defined as follows:

(i) Professional fishermen.

(a) Full-time fishermen (the "professional" of the official statistics) who fish the year round and obtain over 50 percent of their income from fishing;

(b) Part-time fishermen (the "semi-professional" of the official statistics) whose fishing is usually seasonal and who merely supplement their income through fishing;

(ii) Non-professional fishermen (same category as in the official statistics) who sell their catches only occasionally, if at all.

(a) Subsistence fishermen who fish for domestic use and whose fish catches may be an important contribution to their food supply. They fish with gillnets, seines, traps and weirs, ice-fish and angle;

(b) Recreational fishermen (the "sport fishermen" of most classifications) who fish in their leisure time, are not concerned with the economic value of their catch, and whose fishing expenses exceed the value of their catches. They mostly angle (fly included), or fish with weirs or gillnets. Their fishing is usually based on ownership of an estate, especially if they fish with weirs or nets.

Putting it in another way, or to use more universal terms, the "professional and semi-professional" (whether full-time or part-time) fishermen of Finland constitute what are generally known as "commercial" fishermen, while the finnish term "non-professional" lumps two categories which are often separated: "subsistence" and "recreational or sport" fishermen. Table 12 shows the statistical separation of the three classes in Finland in 1986: 4 639 commercial fishermen in the Baltic Sea and 2 245 commercial fishermen in fresh water, 328 758 non-professionals in the Sea and 1 195 387 in fresh water.

Despite the afore-mentioned criteria of Munne (1982) for distinguishing between subsistence and recreational fishermen, Salojärvi and Lehtonen (1982) have pointed out that in practise it is very difficult to separate these two classes. Furthermore, although Finland's system of tabulating catch records lumps the catches of subsistence and recreational fishermen, the statistics in FAO's Fishery Yearbooks theoretically include commercial and subsistence catches, but exclude recreational or sport catches. This makes it difficult to use either Finnish or FAO Yearbook catch statistics when comparing Finland's catch with that of many other European countries.

Although the most accurate presentations of the Finnish "inland" catch are the tables appearing in Suomen Kalatalous or in Finland's Statistical Yearbook, Suomen Tilastollinen Vuosikirja, their wealth of detail does not permit reproducing all of them to show the Finnish catch during the 1965–87 period. I have, therefore, continued the practise of using FAO compilations for this period (see Tables 10 and 11). Table 10 shows the catches in the inland waters of Finland and - as has been necessary - with some of the other countries in this review - Table 11 shows the catch as compiled by FAO in a marine statistical area (here one that includes the Baltic) in order to cover the catch of freshwater, brackish, and diadromous fishes whose life cycle may include residence in both a freshwater and marine milieu. The addition of the marine table makes a decided difference in the total catch of Finnish waters of species generally considered to be fluvial. For example, in 1986 (the last year in which Table 11 has complete figures), over one-third of the catch of bream and orfe and about one-fourth of the catch of roach was made in the sea, the catch of Coregonus lavaretus in the sea exceeded that in fresh water, and the catch of pike-perch in the sea was over twice that in fresh water. (See also Table 12 for somewhat similar figures.)

While such facts are useful, the reader must clearly understand that these tables derived from FAO usually seem to include the entire catch of inland (freshwater and brackish) fishes in Finland, i.e., commercial, subsistence and sport, plus from 1978 on the production of food fish through aquaculture. For example, as will be seen below, in 1975 and 1977, FAO recorded only the catch of wild trout. In support of this statement, note that FAO (Tables 10 and 11) show that a total of 368 t of trout were caught in Finland in 1975, 272 t in inland waters and 96 t in the sea. The printed FAO Yearbooks of Fishery Statistics call these fish “trouts” although FISHDAB calls them “rainbow trout”. The tonnage of trout caught in Finland in 1975 in both fresh water and in the sea, as recorded by official Finnish sources (Suomen Kalatalous (48) published 1978), agrees with the FAO statistics, except that the catch was specified as brown trout, and made by all classes of fishermen. Furthermore, in addition to these fish in the capture fishery, Finland/EIFAC (1977) states that 1 800 t of cultivated rainbow trout (150 t from brackish water) were produced in Finland in 1975. A similar picture is noted in 1977 where FAO (Tables 10 and 11) records a catch of only 361 t of trout (FISHDAB again calling them “rainbow”) from both fresh and salt water, with Suomen Kalatalous (48) agreeing as to the amount of catch, but specifying that it includes the catch of sport fishermen and terming the fish brown trout. Moreover, the FAO statistics for 1977 again fail to list Finland's aquacultural production of trout, which amounted to over 2 400 t of rainbow trout according to Westman and Tuunainen (1978).

Starting in 1978, FAO's statistical report on the total trout “catch” of all species seemed for a while to agree with official Finnish statistics in including both the catch from the capture fishery and aquacultural production. For example, in 1978, FAO listed a catch of 2 646 t of rainbow trout from inland waters and 930 t of rainbow trout from the sea for a total of 3 576 t. Suomen Kalatalous (49) listed capture fishery catches of 253 t of trout from fresh waters and 121 t of trout from the sea plus an aquacultural production of 2 396 t from fresh water and 809 t from brackish water or a grand total of 3 579 t, very close to FAO's total for 1978. However, the FAO statistics were still incorrect in lumping the so-called “catch” of two quite different species, rainbow trout (aquacultural production), and brown trout (capture fishery) and terming this “catch” as rainbow.

Table 10

Nominal catches in the inland waters of Finland, 1965, 1970, 1975, 1980–87 (in tons)

Species	1965	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987F
Freshwater bream (Abramis brama)	1 700	1 300	1 481	1 976	1 651	1 662	1 656	1 307	1 303	1 296	1 300
Roaches (Rutilus spp.)	-	0	0	4 168	3 791	3 727	3 710	3 024	3 024	3 055	3 050
Orfe/Ide (Leuciscus idus)	-	-	-	207	157	183	181	226	224	308	310
Pike (Esox lucius)	2 900	3 300	4 734	5 311	5 923	5 987	6 062	6 463	6 467	6 461	6 450
Burbot (Lota lota)	-	-	-	1 282	1 135	1 164	1 190	1 220	1 240	1 212	1 210
European perch (Perca fluviatilis)	3 600	4 400	5 221	8 172	7 869	7 904	7 909	7 326	7 324	7 312	7 310
Pike-perch (Stizostedion lucioperca)	400	400	332	337	276	270	290	303	300	288	290
Freshwater fishes, n.e.i.	2 700	2 800	4 489	523	716	814	724	551	584	526	530
European eel (Anguilla anguilla)	...	0	0	63	30	29	29	23	23	24	25
Pollan/whitefish (Coregonus lavaretus)[a]	900	700	1 116	1 325	1 608	1 557	1 505	1 518	1 649	1 735	1 730
European whitefish/vendace (C. albula)[a]	3 100	5 000	4 923	5 905	5 853	5 945	6 007	6 480	6 254	6 349	6 350
Atlantic salmon (Salmo salar)	100	100	55	37	47	57	62	93	92	93	90
Rainbow trout (Oncorhynchus mykiss)[b]	-	-	-	2 977	3 593	3 522	4 026	4 112	3 427	3 773	3 894
Trouts (Salmo spp.)[b]	...	0	272	-	-	-	-	288	287	288	290
European smelt (Osmerus eperlanus)	100	100	118	137	243	180	340	163	190	193	190
Total	15 500	18 100	22 741	32 420	32 892	33 001	33 691	33 097	32 388	32 913	33 019

[a] The first common name is that used by FAO in its Yearbook of Fishery Statistics, the second is that generally used in Finish Governmental publications where English is employed. The catch statistics for these two species of coregonids for 1965–69 were listed incorrectly by FAO (see below): those for C. albula being listed for those of C. lavaretus and vice versa. They have been corrected here

[b] FISHDAB lists this catch as “rainbow trout” in the inland waters of Finland for the period 1977–83, and does not list “trouts” during this period. However, some of the FAO Yearbooks of Fishery Statistics list only “trouts” as an inland “catch” in Finland from 1965 at least through 1982

- : This category not listed this year
... : Not available
0 : Probably nil, negligible or insignificant; or less than 50 t during 1965–73; or less than half a ton during later years
F : FAO estimate, except for rainbow trout

Source: 1965–69 Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–83 FAO Fish.Dept.Fishery Statistics Database (FISHDAB)
1984–87 Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

Table 11

Nominal catches of freshwater and diadromous species in Marine Statistical Fishing Area 27 - Northeast Atlantic, by Finland, 1965, 1970, 1975, 1980–87 (in tons)

Species	1965	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987F
Freshwater bream (Abramis brama)	900	1 300	938	939	885	880	824	798	758	747	750
Roaches (Rutilus spp.)	-	0	0	1 555	1 296	1 122	997	936	877	923	900
Orfe/Ide (Leuciscus idus)	-	-	-	202	161	145	131	111	112	107	110
Pike (Esox lucius)	1 800	1 600	2 074	1 704	1 700	1 683	1 620	1 496	1 442	1 424	1 400
Burbot (Lota lota)	-	-	-	595	520	494	490	368	310	334	330
European perch(Perca fluviatilis)	2 300	1 900	3 038	2 759	2 590	2 208	2 121	1 957	1 977	1 824	1 800
Pike-perch (Stizostedion lucioperca)	400	300	632	787	568	448	386	526	521	608	600
Freshwater fishes, n.e.i.	1 300	1 000	2 118	351	273	262	271	334	184	263	260
European eel (Anguilla anguilla)	-	0	0	16	9	9	9	5	5	5	5
Pollan/whitefish (Coregonus lavaretus)[a]	1 200	1 200	2 019	2 177	2 371	2 410	2 305	1 784	1 672	1 873	1 800
European whitefish/vendace (C. albula)[a]	600	1 100	795	499	335	290	272	206	156	273	270
Atlantic salmon (Salmo salar)	300	500	697	668	715	681	758	1 297	1 107	1 146	1 140
Sea trout (S. trutta)[b]	-	-	-	-	-	-	-	357	326	392	390
Rainbow trout (Oncorhynchus mykiss)[b]	-	-	-	2 252	2 475	3 251	4 217	5 381	6 647	7 140	8 764
Trouts (Salmo spp.)[b]	...	0	96	-	-	-	-	-	-	-	-
European smelt (Osmerus eperlanus)	700	400	729	559	204	317	465	658	571	530	530
Total	9 500	9 300	13 136	15 063	14 102	14 470	14 866	16 214	16 675	17 589	19 049

[a] The first common name is that used by FAO in its Yearbook of Fishery Statistics, the second is that generally used in Finish Governmental publications where English is employed. The catch statistics for these two species of coregonids for 1965–69 were listed incorrectly by FAO (see below): those for C. albula being listed for those of C. lavaretus and vice versa. They have been corrected here

[b] FISHDAB lists the "catch" as "rainbow trout" for the period 1977–83, as does Yearb.Fish.Stat.FAO, 64 for the period of 1984–87, although the earlier FAO Yearbooks of Fishery Statistics list only "trouts" from 1965 at least through 1976. The term "sea trout" for Finland's catch in Statistical Fishing Area 27 does not appear in the early FAO Yearbooks

- : This category not listed this year
... : Not available
0 : Probably nil, negligible or insignificant; or less than 50 t during 1965–73; or less than half a ton during later years
F : FAO estimate, except for rainbow trout

Source: 1965–69 Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–83 FAO Fish.Dept.Fishery Statistics Database (FISHDAB)
1984–87 Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

Again, comparison of the total FAO statistics for the catch of all trout (including sea trout) in Finland for 1986 (Tables 10 and 11) which add up to 11 593 t, show reasonably close agreement with the official Finnish statistics (Tables 12 and 15) which include a capture fishery catch of 889 t of brown trout and an aquacultural production of 10 913 t of rainbow trout totalling 11 802 t. Again, however, one should note that the so-called total "catch" of all trouts recorded by FAO confused two species of trout and included the sport fishing catch.

Such examples can be multiplied, and further reasons for surmising lacks in the FAO fishery statistics for Finland were given in Dill (1976) and need not be repeated here[1]. It is hoped that such discrepancies in the statistics can eventually be resolved. However, in the meantime, it is strongly advised that one seek out original statistical data emanating directly from Finland in order to follow the course of its fisheries. These will provide much more accurate and easily interpretable data on: the origin of the catch, its distribution among different classes of fishermen, and its exact species composition. Tables 12, 13, 14, 15 and 16 represent recent original and official Finnish fishery statistics.

1 Excessive rounding of figures during 1965–73 is another fault of the FAO tables for Finland

Table 12 shows the catch both from the sea and fresh water in 1986, derived from one of the latest tables prepared by the Finnish Government. Unlike the tabulations derived from FAO, this table relates only to the capture fishery and does not contain production from Finnish aquaculture (see section 7.2).

With respect to the origin of the catch of freshwater and diadromous fish, it is obvious from Table 12 that the great majority of this group were caught in fresh water, and still within this group it was only in the commercial fishery that the catch at sea exceeded (and then only barely) that in fresh waters[2].

2 In 1986, the total catch of freshwater and diadromous fish amounted to 39 650 t in fresh water and 13 367 t in the sea. The commercial catch of this group was 5 536 t in fresh water and 5 680 t in the sea. (The marine fish excluded from these calculations are: herring, sprat, cod and flounder.)

With respect to the distribution of the catch among classes of fishermen, the table shows that in fresh water an overwhelming part of the catch (86 percent) was made by non-professional fishermen, and even in the sea, 57 percent of the catch of freshwater and diadromous fishes was made by nonprofessionals.

In 1986, of the total catch of freshwater and diadromous fish in fresh waters, 65 percent of the catch was composed of three species in this order: European perch, pike and vendace (Coregonus albula). By adding the catch of roach, freshwater bream, whitefish (C. lavaretus), and burbot to the list, we find that seven species (of five families) provided almost 93 percent of the total inland catch of 39 650 t. Within the Finnish sea fisheries for the same period, 52 percent of the catch of "inland" fish were perch, whitefish and pike, in that order. By adding the catch of the next four species in descending order of catch (Atlantic salmon, roach, bream and pike-perch), we find that seven species of five families make up 83 percent of the total sea catch of 13 367 t of freshwater and diadromous fishes.

As in most European countries, much attention in Finland has been directed toward its Atlantic salmon fishery, but today the stock is sparse and the catch is low. Baltic salmon, a geographically isolated stock of Atlantic salmon (Salmo salar) are not taxonomically discriminated, and the salmon in the Gulf of Finland appear to from a stock with little migration into the Baltic proper. The Finnish salmon from the streams entering the Arctic Ocean from another group. Fluctuation in the Finnish populations in the Baltic rivers were similar to those in other Baltic streams: catches were high at the end of the Nineteenth Century, low in the 1900–45 period, high in 1945–50, and low again thereafter (Lind, 1982a).

Table 12

Capture fishery (total catches) in Finland, 1986[a] (in tons)

	Sea fisheries				Freshwater fisheries				
	Prof.	Semi-prof.	Non-prof.	Total	Prof.	Semi-prof.	Non-prof.	Total	Grand total
Number of fishermen	1 722	2 917	328 758	333 397	350	1 895	1 195 387	1 197 632	1 531 029
Baltic herring (Clupea harengus)	82 843	11 214	1 285	95 342	-	-	-	-	95 342
Sprat (C. sprattus)	3 220	5	56	3 281	-	-	-	-	3 281
Cod (Gadus morhua)	3 776	1 055	732	5 563	-	-	-	-	5 563
Flounder (Platichthys flesus)	72	33	426	531	-	-	-	-	531
Freshwater bream (Abramis brama)	171	266	656	1 093	12	37	1 896	1 945	3 038
Roach (Rutilus rutilus)	137	102	923	1 162	174	63	4 467	4 704	5 866
Orfe/Ide (Leuciscus idus)	11	32	117	160	96	5	199	300	460
Pike (Esox lucius)	143	262	1 656	2 061	133	186	8 244	8 563	10 624
European perch (Perca fluviatilis)	141	232	2 206	2 579	29	102	10 501	10 632	13 211
Pike-perch (Stizostedion lucioperca)	229	152	353	734	13	32	467	512	1 246
Burbot (Lota lota)	94	113	192	399	89	101	1 364	1 554	1 953
European eel (Anguilla anguilla)	0	1	4	5	0	2	49	51	56
Whitefish (Coregonus lavaretus)	680	790	817	2 287	280	246	2 163	2 689	4 976
Vendace (Coregonus albula)	167	69	79	315	1 826	1 859	3 088	6 773	7 088
Atlantic salmon (Salmo salar)	839	164	234	1 237	2	11	97	110	1 347
Brown trout (Salmo trutta)	111	69	259	439	10	6	434	450	889
European smelt (Osmerus eperlanus)	285	191	70	546	80	76	237	393	939
Others	146	83	121	350	58	8	908	974	1 324
Total	93 065	14 833	10 186	118 084	2 802	2 734	34 114	39 650	157 734

[a] The data are based on the answers to inquiries concerning 1986 made by the Finnish Game and Fisheries Research Institute.

Source: Finland/EIFAC (1989). This or a similar table will be published in Suomen Kalatalous (57) as: Leinonen, K., H. Lehtonen and M. Hildén (1990), Virkistys - ja Kotitarvekalastus Suomessa vuonna 1986 (Recreational and subsistence fisheries in Finland in 1986)

At one time, Finland had a considerable number of salmon streams extending along its entire coast, but only a few are left now. A survey of 47 of Finland's salmon and trout rivers (Hurme, 1966) found that natural salmon and trout stock had died off in 15 rivers by damming, drainage, flood control, timber-floating and over-fishing. Lind (1982a) shows the major salmon streams of Finland to be only the Tornionjoki (shared with Sweden), Kemijoki, Iijoki, Oulujoki, Kokemäenjoki and Kymijoki in the Baltic drainage, and the Tenojoki (shared with Norway) in the Arctic drainage. However, only the Tornionjoki and Tenojoki were unaffected by hydroelectric use as late as 1980, and there is little production in the other streams. Toivonen (1983) said that only two out of 20 Finnish salmon streams on the Baltic still produce natural smolts, and his Figure 1 shows only the following as "current" Finnish salmon rivers: the Tornionjoki and Simojaki in the Baltic, and the Tenojoki and Näätätämönjoki in the Arctic. Virtanen (1988) confirms the statement that only the first two rivers still produce Baltic salmon smolts, and Jutila (1990) states that the last river within Finnish borders which retains its original naturally spawning stock is the Simijoki.

The Tenojoki is the best salmon stream in both Finland and Norway. During the 1972–77 period, the total salmon catch from the Finnish and Norwegian sides of this boundary river varied between 117 t and 250 t, being highest in 1975. Finland's average share of the total salmon catch has been about a third. Landowner families on the Finnish side can fish with nets. Visiting sport fishermen can fish only by angling, and in 1977 took more than half of the Finnish salmon catch (Toivonen and Heikinheimo-Schmid, 1979)[1].

[1] See section 7.1 in the review on Norway for more information on the Tenojoki (Tana)

Up to about the end of the Nineteenth Century, Baltic salmon were traditionally taken in the rivers as they ascended to spawn, but only about five percent of them are now taken here. Coastal fishing using fixed gear was dominant in the Baltic up to the middle of the Century, but offshore fishing using drifting gear for feeding salmon is dominant today, accounting for about 80 percent of the catch. The Finnish offshore catch in the Baltic and its Gulfs has varied between 291 t and 502 t during 1969 and 1978 (Larsson, 1980). In 1987, the Finnish commercial salmon catch in the sea was only 817 t and the commercial inland catch was 11 t. The overall value of the salmon catch was high, however, running about third highest in the sea fishery and sixth in the total fishery. Longlines and drift nets are used in the Baltic, and in the few salmon rivers that are left, short bank weirs, floating gillnets, seines and brails are used. The majority of the salmon harvested in the Baltic in their growing areas are at a size of 3–4 kg, i.e., before the size or age of maturity. There is some evidence that in addition to damage done through destruction of their spawning grounds, that the salmon have been affected by fluctuations in the humic quality of the Baltic waters and move to more saline waters. The freeflowing rivers of the Arctic, with good water quality and low exploitation in the growing areas, still produce good catches.

It has been estimated that the salmon rivers flowing to the Baltic Sea and Gulf of Bothnia once produced about 7 million salmon smolts (Ikonen and Pruuki, 1990). Larsson (1980) estimated that this natural production had fallen to 350 000 in 1970, the same figure being reiterated in various Finnish publications through 1984, e.g., Westman et al. (1984). Ikonen and Pruuki (1990) say that the production is now less than one-half million. Finland now rears salmon smolts for stocking the Baltic. Reared Finnish salmon smolt and fingerling production was 672 000 individuals in 1980, and 922,000 in 1981 (Eskelinen, 1983). In 1983, stockings of salmon were initiated in the Kemijoki and Iijoki to compensate for losses caused by damming these rivers. Five to six million artificially raised salmon smolts are now released in the mouths of the rivers entering the Baltic (Ikonen and Pruuki, 1990). The salmon stocking is augmented by stocking other fishes harmed by river development: sea and brown trout, whitefish and grayling. (For additional information on Baltic salmon, see the review on Sweden.)

Sea trout (Salmo trutta) were once found in about 50 Finnish rivers flowing into the Baltic, but as a result of powerplant construction and pollution have also declined (Hurme, 1966). Today, smolts are released in an effort to compensate for the loss. Observations indicate that sea trout favour the less saline parts of the sea and are not as home-oriented as salmon.

The smelt (Osmerus eperlanus) is caught in small quantities in both the sea and in fresh waters. Most of the Finnish commercial catch is taken from the Bothnian Gulf.

Coregonids are caught in much larger numbers in Finland than either salmonids or osmerids, and their catch is much more valuable monetarily. Of the two principal coregonids, the highly important vendace (Coregonus albula)) has the highest overall catch, as well as the highest in inland waters. Studies on this species and its status have been summarized by Auvinen et al. (1990).

The other principal coregonid, the whitefish (C. lavaretus) has the highest catch in the sea[1]. The two species ranked fourth and third in value in the entire catch of both marine and inland fishes in 1981. In the Baltic, vendace inhabit areas of low salinity usually near the mouths of rivers. Gillnets are the most important gear for whitefish, while vendace are captured mainly by trawl and trapnet.

[1] According to Svärdson (1957) there are five different coregonids in Finland, and Lehtonen (1981) says that there are three coregonids in the Finnish Baltic: sea-spawning whitefish (Coregonus widegreni), river-spawning whitefish (C. lavaretus), and the vendace (C. albula). He also says that the sea-spawning form is also called C. nasus. Various other coregonid species are listed by other authors as resident in Finland, and a recently completed stock registry for Finnish coregonids contains information on 181 coregonid stocks (Kallio-Nyberg and Koljonen, 1988). However, the official Finnish catch record statistics distinguish only between C. lavaretus and C. albula

European eel (Anguilla anguilla) populations have never been dense in Finland, probably because of its northerly location and distance from the Atlantic. There was, however, a small eel fishery in Baltic rivers until the main rivers were closed in the 1930s. Unprofitable to obtain eels from Baltic river mouths because of the small numbers available, both elvers and young yellow eels have been obtained from abroad and stocked in Finland. During the 1960–79 period there was a mean annual stocking of 830 000 individuals, 94 percent elvers and 6 percent small yellow eels. Denmark, Germany, Sweden and Scotland have been sources, and the Finnish eel fishery has been almost totally dependent upon these introduced fish because dams on the larger rivers have prevented natural migration into lakes. Since 1976, the eel catch has been included in official Finnish catch statistics. In that year, the total catch of eels was 28 t; about 19 t from the Baltic coast and 9 t from inland waters. About 22 t were taken by non-professional fishermen and 6 t by commercial fishermen. The Finnish eel catch reached a total of 79 t in 1980 (63 t in inland waters), but has since descended to only 29 t in 1982, 38 t in 1983 and 56 t in 1986. Since 1979, stocking has been low because of the risk of spreading a communicable viral disease through elvers, and undersized yellow eels cannot be introduced due to new legislation by exporting countries (see Pursianen and Toivonen, 1984).

There is also a small fishery for the lampern (Lampetra fluviatilis), the last remaining anadromous species in Finland which it is possible to catch in large numbers running up rivers. Thirty-three rivers are known to support spawning populations. At the beginning of the 1970s, the lampern catch was estimated at 2.7–3.0 million individuals or 130 t. In 1983, the lampern catch was about 100 t, consisting of 2.3–2.4 million individuals. The value of the 1983, catch was estimated at Fmk 4.3 million (US$ 800 000). Environmental changes in rivers have caused damage to the lampern fishery, but successful attempts have been made to transport spawners over dams (Ikonen et al., 1983).

Aside from the fishes mentioned above, the European perch and pike deserve special attention as the species generally ranking as highest in tonnage caught in inland waters. The perch is found throughout Finland especially in small lakes and ponds, where it is the most abundant species. The pike, second in abundance in small lakes, is overwhelmingly the most valuable fish monetarily in total freshwater catch, being challenged only by the value of the vendace catch. The pike-perch is also an important fish, occurring in both fresh water and in more or less separate populations along the Finnish coast. The species, which favours turbid water, is both a good food and game fish. Finnish trends in its research and status are described by Lehtonen (1990).

7.1.1 Commercial fishing

As has been pointed out above, commercial fishing in Finland includes both "professional" and "semi-professional" (part-time) fishermen who catch fish for sale and profit.

Table 13 is a review of the catch in the freshwater commercial fishery in Finland during the 1964–85 period. The statistics in Table 12 show the freshwater commercial catch in Finland in 1986, and Table 14 shows the freshwater commercial fishery catch in Finland in 1987.

With respect to freshwater alone in Finland in 1986, about 2 245 commercial fishermen took about 5 336 t or 13 percent of the entire freshwater catch of 39 650 t, the latter being about onequarter of the entire catch by the capture fishery in that year. The total commercial catch from Finnish inland waters in 1986 was valued at about Fmk 43 million or US$ 8.5 million (Heikinheimo-Schmid, et al., 1988). About 67 percent of this was due to the vendace catch. The commercial catch of freshwater and diadromous fish in the sea in 1986 amounted to 5 680 t and the total commercial catch of these fish in Finland in 1986 amounted to 11 016 t or almost 10 percent of the entire commercial catch in Finland in 1986.

Table 13

Inland (freshwater) commercial fishery in Finland, 1964, 1970, 1975, 1980–85 (in tons)

	1964	1970	1975	1980	1981	1982	1983	1984	1985
Freshwater bream (Abramis brama)	152	256	137	103	59	70	64	60	56
Roach (Rutilus rutilus)	...	...	...	300	329	265	248	200	206
Orfe/Ide (Leuciscus idus)	...	8	17	13	6	32	30	19	17
Pike (Esox lucius)	150	204	398	168	196	260	335	321	325
European perch (Perca fluviatilis)	171	30	275	188	186	221	226	145	143
Pike-perch (Stizostedion lucioperca)	62	82	63	45	34	28	48	54	51
Burbot (Lota lota)	93	276	254	115	104	133	159	198	218
European eel (Anguilla anguilla)	...	...	...	3	2	1	1	1	1
Whitefish (Coregonus lavaretus)	142	128	417	253	327	276	224	309	440
Vendace (Coregonus albula)	1 747	4 045	3 712	3 882	3 719	3 811	3 873	3 816	3 590
Atlantic salmon (Salmo salar)	10	48	5	9	7	13	16	13	12
Brown trout (Salmo trutta)			28	23	17	19	21	16	15
European smelt (Osmerus eperlanus)	33	45	86	78	169	106	266	126	153
Others	279	133	359	81	146	244	148	91	124
Total	2 830	3 255	5 751	5 261	5 301	5 479	5 659	5 369	5 351

Source: Suomen Kalatalous 1989 (55)

According to OECD (1989), all commercial species of fish in Finland are now fully exploited.

7.1.2 Recreational (sport) and subsistence fishing

As has been emphasized, it is difficult to erect firm lines between recreational and subsistence fishermen in Finland, and their catches are grouped together in official Finnish statistics as “nonprofessional”.

True subsistence fishing in Finland is greatest in northern Lapland where about one-third of the people are directly dependent upon natural resources for a livelihood: keeping reindeer, gathering berries, hunting, and fishing. But, throughout the country an early aim was to establish self-supporting households. Most farmers owned fields and forests and had fishing rights owned jointly by the landowners of a village. Consequently, subsistence fisheries have traditionally had a strong position in Finland and completely full-time fishermen are comparatively rare in inland waters. (In 1986, there were only 350 full-time fishermen in Finnish fresh waters, taking only about seven percent of the total freshwater catch.) However, the role of subsistence fishing is now declining. The fishing activity of inhabitants of large communes is less than that of those living in small communes, and people who own summer homes may fish more recreationally than for subsistence. Urban development, decrease in the number of people earning their living from agriculture and forestry, and migration to the cities has changed the picture.

Concommitantly there has been a rise in the number of recreational fishermen who own no fishing waters or fishing rights.

Table 14

Commercial fishery in Finland, 1987 (in tons)[a]

	Sea fisheries			Freshwater fisheries	
	Professional fishermen	Semi-prof. fishermen	Total	Total	Grand total
Baltic herring (Clupea harengus)	73 285	9 236	82 521	-	82 521
Sprat (Clupea sprattus)	287	0	287	-	287
Cod (Gadus morhua)	1 731	577	2 308	-	2 308
Flounder (Platichthys flesus)	43	15	58	-	58
Freshwater bream (Abramis brama)	74	96	170	47	217
Roach (Rutilus rutilus)	56	25	81	193	274
Orfe/Ide (Leuciscus idus)	4	8	12	9	21
Pike (Esox lucius)	77	98	175	309	484
European perch (Perca fluviatilis)	64	100	164	151	315
Pike-perch (Stizostedion lucioperca)	117	53	170	44	214
Burbot (Lota lota)	58	63	121	211	332
European eel (Anguilla anguilla)	0	0	0	1	1
Whitefish (Coregonus lavaretus)	599	587	1 186	379	1 565
Vendace (Coregonus albula)	75	41	116	2 934	3 050
Atlantic salmon (Salmo salar)	720	97	817	11	828
Brown trout (Salmo trutta)	72	43	115	18	133
Char (Salvelinus spp.)	-	-	-	10	10
Grayling (Thymallus thymallus)	-	-	-	1	1
European smelt (Osmerus eperlanus)	273	130	403	234	637
Others	123	88	211	151	362
Total	77 658	11 257	88 915	4 703	93 618

[a] The data are based mainly on the reports of professional fishermen to the Finnish Game and Fisheries Research Institute

Source: Finland/EIFAC (1989) - this or a similar table will be published in Suomen Kalatalous

One of the important duties of Finnish fishing organizations is to obtain fishing facilities for their members and to advertise accessible fishing waters. The organizations have, therefore, published guidebooks to the fishing waters offered by private owners. They have also tried to expand fishing rights, feeling that people who live in an industrialized society should have free access to the recreation offered by woods, the countryside, and fishing waters. These attempts to expand such opportunities have, however, been hampered by private ownership and the uneven distribution of fishing waters. For example, a survey of 1978 indicated that 35 percent of the non-professional fishermen owned fishing waters (Lehtonen and Salojärvi, 1983). Circa 1982, less than 10 percent of the Finnish recreational fishermen belonged to a fishing organization (Munne, 1982). See section 8 on ownership of fishing areas and fishing organizations.

By 1978 the number of subsistence and recreational fishermen in Finland numbered about 810 000, and if one takes into consideration the number who did not need a fishing card (general fishing licence), the number can be estimated at one million or about one-fifth of the country's population (Lehtonen and Salojärvi, 1983). Earlier estimates have boosted this number to two million at times (Salojärvi and Lehtonen, 1982).

It must be noted that up to 1986, the sampling frame consisted only of those households which purchased a general fishing license sold by the State. However, as Finnish fishing law permits certain groups to fish without this license, the old frame was not complete, and estimates of the total number of recreational and subsistence fishermen were biased[1]. Therefore, starting in 1986, the central register of population was used as the sampling frame. This consists of every Finn who lives permanently in Finland and the Finnish Game and Fisheries Research Institute is now sure that the 1986 estimate (Table 12) represents all fishermen who fished in that year. Previous results are not directly comparable (personal communication from M. Hildén and K. Leionen, 20 April 1990).

[1] A person under 16 years of age and an angler fishing with natural bait within his own municipality or commune does not require this licence (see section 8). In 1978, the total number of general fishing licences purchased by Finnish households was 481 603 (Lehtonen and Salojärvi, 1983)

Questionnaires indicated that by 1970, about 68 percent of the fishermen were fishing for recreation. Subsistence fishing further declined by 1975 when the number of recreational fishermen rose to about 80 percent. Recreational or sport fishing is now considered to be the most popular leisure time activity in Finland. Among the sport and subsistence fishermen, anglers were the largest group of fishermen in 1982, but the number of gillnets in use exceeded the number of rods and more than half the total catch by this group was taken with gillnets. As in Sweden, unlike a good many countries, “sport fishing” in Finland is not synonymous with “angling”.

The general trend in the subsistence and recreational catch in Finland has been upward. In fresh water during the 1959–77 period, this annual catch averaged 14 943 t (range, 12 205 t in 1965 to 18 070 t in 1962), constituting 63–88 percent of the total freshwater catch during this period. In brackish water, the catch of subsistence and recreational fishermen increased from 1 643 t in 1953 to 8 754 t in 1981 (see Salojärvi and Lehtonen, 1982).

In the latest detailed account of this fishery (Lehtonen, et al., 1988) it was noted that although 21 percent of the fishermen in 1981 fished solely with rods, over 70 percent of the catch was taken with nets and traps. It was also noted that the total catch of recreational and subsistence fishermen in 1981 was 33 137 t, the inland catch being three-quarters of the total. The mean catch per household in 1981 amounted to 75.5 kg. About 30 000 t of the catch was eaten, 882 t was used as animal feed, 1 465 t was thrown away, and 1 029 t was used in some other way.

If the economic value of the recreational and subsistence fishery of Finland were calculated according to the value of the commercial catch, the total value of this fishery in 1975 would have been Fmk 85.5 million (US$ 21.3 million) or 45 percent of the value of the entire Finnish catch of Fmk 188 million (US$ 46.8 million). However, the recreational and subsistence fishermen of Finland spent about Fmk 144 million (US$ 36 million) pursuing their fishery, exceeding the value of the Finnish commercial catch in that year of Fmk 103.4 million or US$ 25.8 million. In 1978, the money spent on subsistence and recreational fisheries in Finland was about Fmk 350 million, well exceeding the estimated value of the entire catch (Fmk 281.5 million) by all classes of fishermen.

Using later figures (Table 12), and in summation, in 1986, about 1.2 million Finns (or one-quarter of the entire population) were so-called recreational and subsistence fishermen in inland waters. Perch and pike were by far the most important species (by weight) in their catch. Heikinheimo-Schmid, et al., (1988), probably using incomplete figures, stated that the 1986 recreational and subsistence catch in inland waters was 23 600 t, estimated in value as Fmk 161 million or US$ 32 million. Accepting the figures in Table 12 as being more accurate, the inland recreational and subsistence catch in inland waters in that year was closer to 34 114 t or 86 percent of the total inland catch. If the value of the catch per kilogramme remained constant, then the recreational and subsistence catch in inland waters had a value of about Fmk 232.7 million or about US$ 46 million.

The value of the total catch of 39 650 t in 1986 in inland waters by all classes of fishermen was about Fmk 280 million or US$ 55.2 million of the value of the total catch made in Finland that year.

7.2 Aquaculture

Aquaculture in Finland, for either consumption or stocking in open waters, is limited to cold or cool water species. The only fish species really cultivated for consumption is rainbow trout (Oncorhynchus mykiss) and its cultivation is a relatively new development. (A few attempts have been made to develop the farming of Baltic salmon in brackishwater net cages.) In 1973, there were about 50–60 commercial fish farms in Finland which cultivated rainbow trout for food, and the total amount marketed annually was about 1 500 t. Cage farming of rainbow trout in brackish water produced over 100 t in Finland in 1974. By 1977, more than 2 400 t of rainbow trout were raised at 50–60 farms with 300 t raised in brackish water (Westman and Tuunainen, 1978). The production in later years (1978–87) is shown in Table 15. It reached 12 678 t in 1987, about one-third fresh water and two-thirds in brackish (see also section 9.3 for FES figures).

Although net-cage farms have become more numerous in Finland in recent years, about 90 percent are run in brackish coastal waters and in 1988 there were only 19 inland net-cage units, the largest being situated on large rivers rather than on lakes. Freshwater cages occupied only 140 ha, compared with 380 ha of coastal cages, and in 1988 their annual production was less than 700 t.

Table 15

Production of cultivated trout in Finland, 1978–87[a]

	Number of farms and hatcheries			
	Brackishwater[b] cage farms	Freshwater[b] farms	Natural rearing pond farms	Total
1978	32	138	154	324
1980	78	164	180	422
1982	98	296	203	597
1984	151	302	222	675
1986	179	339	248	766
1987	181	318	248	747

	Food fish (ungutted) production (t)		
	Brackishwater cage fish	Freshwater[c] fish	Total fish
1978	809	2 396	3 205
1980	1 958	2 712	4 670
1982	3 226	3 099	6 325
1984	5 381	4 112	9 493
1986	7 140	3 773	10 913
1987	8 784	3 894	12 678

	Value of food fish (millions)	
	Fmk	US$
1978	54.4	14.3
1980	95.7	22.0
1982	128.4	27.0
1984	204.0	-
1986	246	48
1987	304	-

[a] Over 99 percent of the production was rainbow trout; the rest was salmon, brown trout, coregonids, bream and pike

[b] Same owners separate farms counted as separate entities

[c] Farms represented: 76 (1978), 108 (1980), 293 (1982), 335 (1984), 361 (1986), and 381 (1987)

Source: Suomen Kalatalous (49), Publ. 1980, Suomen Kalatalous (50), Publ. 1983, and Suomen Kalatalous (53), Publ. 1988, for 1978, 1980 and 1982 data. Heikinheimo-Schmid, et al., (1986, 1988) for 1984 and 1986 data. Finland/EIFAC (1989) for 1987 data

Domestic dry feeds for both rainbow trout and other salmonids have been available in Finland for some years. They are compounded of imported fish meals and oil and local cereals. Low value fish such as roach, smelt, or Baltic herring are also used as feed, especially in net ponds in brackish water, but the use of herring is decreasing because of the possibility of transferring disease. There is a regular Governmental inspection for disease. Rainbow trout are marketed in Finland mainly as three-summerolds at a weight of 0.5–1 kg.

It will be noted that the value of the 1986 production of trout (Fmk 246 million or US$ 48 million, according to Heikinheimo-Schmid, et al., 1988) was about six times the value of the entire commercial catch from inland waters. FAO Fish. Info. Data and Stat.

Serv. (1989), which agrees generally with this value for the aquacultural production of Finnish trout in 1986, estimates the value of the 1987 production to be US$ 66.4 million.

Fish are also cultivated in Finland for stocking. In fact, extensive fish stocking programmes form the main part of the management of economically important fish stocks, and is increasing because of compensation stocking in the largest dammed salmonid rivers and in lakes where the water level is regulated. State-owned fish farms and farms owned by fishery societies direct their efforts chiefly to the production of salmonid smolts and coregonids, but in recent years, 21 species (15 native and 6 exotic) have been stocked in Finland, primarily Baltic and land-locked salmon, sea trout and brown trout, rainbow trout, grayling, several species of coregonids, pike, pike-perch, perch, bream, orfe, carp and crayfish. Eels have also been stocked, and there has been some transfer stocking of lampern and crayfish. Fish for stocking are produced intensively in land-based fish farms (mostly salmonids) or extensively in large ponds with a natural food supply (mostly coregonids, grayling, pike, pike-perch, and some cyprinids). Since 1951, it has been customary to raise brown trout to two years and coregonids to one summer and some fish are even raised for a longer period before stocking. Some of the newer farms use heated water from power plants.

Table 16 provides a summary of recent stocking (1987) showing that 48 523 000 finfish (excluding newly hatched larvae) were produced for this purpose. Of these, it will be seen that (roughly) whitefish constituted 60 percent of the total, followed by Atlantic salmon (10 percent), brown and sea trout (9 percent), pike-perch (6 percent), Coregonus peled (4 percent), and grayling (4 percent). The stocking is obviously dominated by coregonids.

The value of the stocked fish production in 1987 is unknown to the author, but Heikinheimo-Schmid, et al. (1988) states that a production in Finland of 52 million (excluding newly hatched juveniles) in 1986 had a value of Fmk 80 million (US$ 16 million).

Indications are that such stocking is profitable in areas where natural reproduction has been destroyed, and - in some cases - when exotic species are used. In waters where species are already reproducing well, stocking is not significantly important. As in other countries, the size of the fish stocked is increasing.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership of Waters

Finnish laws distinguishes the right of ownership of a water-area from the right of ownership of the water itself. (Water-areas are areas permanently covered by water.) The surface water of a waterarea is, in principle, res communis. However, the owner of the area has a priority for the use of the water, e.g., for domestic supply or power. In the use of man-made reservoir, the water is owned by the owner of the installation.

Currently, about 85 percent of all inland fishing areas are privately owned. Most often this means that water-areas inside village boundaries belong to the village, and are jointly owned by the landowners. However, the owner may also be the State, a private person, or an organization. This applies to both inland waters and to Finnish territorial waters. Water-areas outside village boundaries at sea and in the middle of large lakes are owned by the State and are known as public water-areas. A collectively owned water-area may also be parcelled and divided among the owners according to their shares. In each case, the proprietary rights are connected with the ownership of land;

consequently Government-owned water-areas exist only where the Government owns land, primarily in eastern and northern Finland.

The extent of the village water-areas in the lakes and coastal waters has been fixed as follows. If the expanse of water is 8 km or more in width and length, a village shall control an area extending no farther than 500 m from the point where a depth of 2 m begins. Water beyond the 500 m limit is a public water-area. Small amounts of water on the coast or in the archipelagos as well as in the lakes belong to the village.

[1] Based primarily on material sent by Finland to EIFAC in 1979, Munne (1982), Enäjàrvi (1983), and Finland/EIFAC (1989)

Table 16

Production for stocking purposes in Finland, 1987 (number of fish)[a]

	Number
Cyprinids	936 000
Pike	1 900 000
Pike-perch	2 760 000
Whitefish (Coregonus lavaretus)	29 017 000
Siberian whitefish (C. peled)	2 131 000
Atlantic salmon	5 039 000
Brown and sea trout	4 263 000
Other salmonids	451 000
Grayling	2 026 000
Total finfish	48 523 000
Crayfish (Astacus astacus)	71 000
American signal crayfish (Pacifastacus leniusculus)	4 000
Total crayfish	75 000

[a] Excluding newly-hatched larvae

Source: Modified from Finland/EIFAC (1989)

Fishing rights. The basic legal provision in the use of waters is that the rights and obligations concerning a water-area belong to its owner. That is why, with minor exceptions, fishing rights in Finland belong to the owners of the respective water-areas. The ownership unit is primarily the village, and each landowner has his share in the jointly owned water-area and fishing rights according to the size of his estate.

According to the Fisheries Act, the fishery management of water-areas under joint ownership has to be organized by the owners who shall agree on a policy and define the extent of fishing rights for different shares. The owners are also responsible for conservation of fish stocks and management of the area.

The Government is the sole or joint owner of water-areas exceeding 0.5 million hectares which are administered by the National Board of Foresty. In granting fishing permits and leases for fishing rights, the Forestry Administration must give preferential treatment to the local inhabitants, especially to those who do not have fishing rights of their own. This especially concerns fisheries for subsistence and recreation. Permits may be given for short periods, e.g., one year, and leases are made from 2 to 25 years. When leasing rights, the authorities may impose management and conservation obligations on the lessee. These Government-owned areas include special sport fishing areas with permit fees and the Forestry Board also grants permits for angling.

There are also fishing rights which are not connected with the ownership of a water-area:

(i) All citizens may fish in coastal off-shore areas outside the village boundary (i.e., in the public water-area). This also applies to recreational fishing by citizens of all the Scandanavian countries;

(ii) Inhabitants of a commune by a large lake may angle and do other hook-fishing outside the village boundary, and the commune may decide whether other methods may be allowed;

(iii) Inhabitants of a commune may angle (with minor restrictions) without permits issued by the landowner, or a general licence issued by the Government. In the outer archipelago and in an area facing the open sea they may net fish for Baltic herring, sprat and vendace; and

(iv) Inhabitants of a village are entitled, upon making a reasonable payment, to obtain a permit for subsistence and recreational fishing in jointly owned water-areas.

A personal fishing license and the permission of the water owner are generally required for every kind of fishing, but district licenses enable angling with natural bait and ice fishing with rods without the permission of the water owner.

Irrespective of the ownership conditions, owing to the jus regale, the Government monopolizes salmon and sea trout fishing in the Gulf of Bothnia and its rivers. Anyone who wishes to fish there for these species (except with rod and line) has to pay an annual assessment.

The Åland Islands have their own Provincial Government and can pass their own laws in the field of fisheries.

8.2 Administration and Management

In Finland, the Ministry of Agriculture and Forestry is responsible for both the inland and sea fisheries.

(i) The Department of Fisheries and Game, within the Ministry, is the principal administrative agency for fisheries. It manages fishery policy, draws up the budget, prepares laws, deals with foreign states, safeguards the public interest concerning fisheries during stages of administrative measures and judicial proceedings concerning the use of waters, supervises management and research on fishing waters and fisheries, promotes fisheries, plans resource development, etc. (see section 8.3 concerning research).

In 1983, a new fishery law came into effect which expanded fisheries administration to include 11 districts each headed by a fishery biologist (Heikinheimo-Schmid et al., 1984).

(ii) The Department of Veterinary Medicine, also within the Ministry, is responsible for the control of fish diseases;

(iii) The National Board of Waters, under the Ministry, is the public supervisory authority (excluding fisheries) responsible for the protection, general planning, research and control of water resources;

(iv) The National Board of Forestry, also under the Ministry, administers more than 0.5 million hectares of different kinds of water-areas. The major part of these waters are used for subsistence and recreational fishing under a permit system of the Ministry of Agriculture and Forestry. The fund from the permits are used for management and surveillance of fishing waters.

8.3 Investigation

The Governmental fishery research body under the Ministry is the Finnish Game and Fisheries Research Institute which has a Fisheries Division. This Division carries out research on both inland and sea fisheries and on fish culture, prepares fishery statistics, and has charge of inland fish culture and research stations. Fishery research is also carried out at Finnish Universities such as, Helsinki, Kuopio, Oulu and Turko. For a review of Finnish fishery research, see Tuunainen (1983).

8.4 Other Concerned Agencies

8.4.1 Ministry of the Environment. This new Ministry has directed water pollution control measures in Finland since October 1983 (Heikinheimo-Schmid et al., 1984).

8.4.2 The Department of Fisheries and Game in the Ministry of Agriculture and Forestry has no official field organization. It therefore makes use of Government-sponsored organizations as unofficial field organizations. The following exist in the field of fisheries:

(i) Federation of Finnish Fisheries Associations, the central organization for regional associations of professional fishermen and owners of fishing waters. Its programmes include the management and use of fishing waters, fishery technology, fish farming, fish handling and processing, and assistance to the Fisheries Administration;

(ii) Federation of Finnish Recreational Fishermen's Associations, the central organization for recreational fishermen, composed of more than 500 angling clubs and about 60 000 members circa 1982. Its programme includes promotion of fishing for recreation and subsistence, and management of fish stocks and fishing water; and

(iii) Finnish Fish and Game Association, a central organization for recreational fishermen and hunters, with a membership of about 6 000 circa 1982.

8.5 <u>International Agreements</u>[1]

Bilateral agreement exists between Finland and Norway concerning their fisheries in boundary waters. Special conventions have been made concerning fishing in the Tenojoki, and in the Näätämönjoki, a salmon river which travels through both countries.

Finland and Sweden established a joint Finnish-Swedish Boundary-River Commission for the drainage basin of the Tornionjoki in 1971, including monitoring and joint salmon cultivation. There is also an agreement between Finland and Sweden on water quality in the Gulf of Bothnia.

A trilaterial agreement concerning water regulation in Lake Inari exists between Finland, Norway and the USSR.

Finland and the USSR established a joint Finnish-Soviet Boundary Water Commission on the use of bundary watercourses in 1964. Its work is chiefly in Lake Inari and Lake Phyäjärvi (Karelia). They also have an agreement concerning water quality in the Gulf of Finland.

1 See Enäjàrvi (1983) for details of the functions and powers of the international bodies mentioned here

9. STATE OF THE FISHERY

9.1 Yield

The total reported catch of freshwater, brackish and diadromous fishes in Finland by all classes of fishermen has increased from 25 000 t in 1965 to 53 017 t in 1986. The total catch in 1986 in fresh water alone was 39 650 t.

All of the inland waters are, of course, not used for fishing, but if we use a rough estimate of 30 000 km^2 as the area of fresh water in Finland, its total yield in 1965 was about 5.2 kg/ha/year, in 1972 it was about 6 kg/ha/year, in 1978 it was 10 kg/ha/year, in 1981 was 9.9 kg/ha/year, and in 1986 was 13$_2$2 kg/ha/year. Lind (1982) found a yield of about 10 kg/ha/year in a Finnish lake area of 580 km^2.

In 1978, the yield from the fresh waters of Finland as a whole by non-professional (subsistence and recreational) fishermen alone was 8.1 kg/ha/year. Studies by Lehtonen and Salojärvi (1983) show that in that year the catches of these fishermen ranged from 4.4 to 28.5 kg/ha/year in different Finnish Fishery Statistical Areas. The highest yield came from the inland waters along the southern coast, the next highest (12.7 kg/ha/year) came from southeastern Finland along the Bothnian Sea, and the lowest of 4.4 kg/ha/year from northern Finland in Lapland. All of these yields were higher than those registered in 1975 by Lehtonen and Salojärvi (1978): the highest for a district in that year was 15.2 kg/ha/year and the lowest 4.4 kg/ha/year.

With respect to yields from all types of fishing, Salojärvi, Auvinen and Ikonen (1982) indicate that the yields from about 3 303 lakes with a combined area of 2 558 km^2 in the Oulujoki Basin were 5.38 kg/ha/year in 1973 and 3.6 kg/ha/year in 1976. Another yield from all types of fishing for vendace whitefish, roach, pike, perch and burbot, was the 6.4 kg/ha/year in 1977 from the 188-km^2 oligotrophic/oligohumic Lake Konnevesi (Toivonen, Auvinen and Valkeajärvi, 1982). Auvinen, et al. (1983) stated that the average catch for the lakes of the Vuoksi river drainage was 8.6 kg/ha/year. Lake Phyäjärvi, which lies within this drainage had a catch of 14.2 kg/ha in 1979 in its Finnish zone. This was due largely to the high catches of vendace, 9.9 kg/ha (Auvinen, 1987). Pitkanen (1975) said that the yield in most parts of Finland was from 5 to 10 kg/ha/year.

Lehtonen (1979) cited yields of pike-perch in the brackish waters of the Helsinki area of 1.67 kg/ha/year in 1970 and 1.48 kg/ha/year in 1971.

An exceptionally high production for a Finnish lake is that of another Lake Pyhäjärvi, a 154-km^2 lake with a mean depth of 5.4 m in southwestern Finland. Sarvala, et al. (1984) states that its fish production is about 63 kg/ha/year, of which vendace forms 40 percent and whitefish 16 percent. This fish yield is considered to be almost one order of magnitude higher than the average for Finnish lakes.

With respect to yield in general, a study by Lind (1982), based on the period of 1953–77, found (as would be expected) positive correlations in Finnish lakes between yield and the rate of exploitation, growing season, alkalinity and conductivity. He found a negative correlation between yield and water colour, and presence of a predator (pike).

9.2 Factors Affecting the Fishery

The extent of water available for freshwater fisheries in Finland is much greater and should continue greater than in most other countries of Europe. This is due not only to the original wealth of inland waters (almost 10 percent of the country's area), but the extension of low salinity areas into the Baltic Sea so that freshwater fishes are also caught here. Furthermore, with its very low population density, Finland's water resources are ample and evenly distributed except for the southern and southwestern coastal area where most of the population and industries are located.

Although drainage has diminished some lake areas, the limited agricultural use in Finland has been generally kind to its inland waters. There has, for example, been little withdrawal from streams for irrigation, and a high (although admittedly lessening) dependence upon public water supply from underground rather than surface sources has minimized demands on fishable water. The use of inland water for navigation or timber transport has diminished because of better land transportation, again a favourable factor in preserving environment.

The inland fish fauna is rather limited, it is true, but the fishes it contains are mostly desirable either for food or sport, e.g., the salmonids and coregonids, as well as coolwater species such as pike and pike-perch.

There is, further, a traditional interest in subsistence fishing which has linked the act of fishing with other uses of land and water such as farming and forestry, and has promoted a rational use of the aquatic resource.

There are, however, some elements (both natural and man-made) that have constrained the inland fishery. One of these is the natural water quality; another is its alteration by man.

As shown in sections 5 and 6 (see also Table 9), most of the water courses in Finland are as yet in almost natural condition, with unpolluted water satisfactory for the support of fisheries. Their mineral content is, however, low giving them weak buffering properties and making them subject to many quality changes.

Furthermore, the ice-cover of four to seven months prevents reaeration and self-purification and therefore weakens their resistance to pollution. A survey of 1962–68 on a drainage basin basis showed the following water quality: pH - 6.6; electrical conductivity - uS 69; suspended solids (mg/litre) - 13; $KMn0_4$ (mg/litre 0_2) - 56; total phosphorus (mg/m^3P) - 58; total nitrogen (mg/m^3N) - 800 (Mustonen, 1977).[4]

Alteration of the natural state of Finland's waters has been due in large part to the forest industry. According to Nilsen (1974), the share of the forest products industry in the load in Finnish water courses by man in 1970 was as follows: effluent quantity - 74 percent; BOD - 84 percent; phosphorus - 22 percent; nitrogen - 25 percent. Since that time, determined efforts have been made to reduce this load.

Eutrophication of waters has been one of Finland's aquatic problems. Interestingly enough, circa 1988 the discharges from Finnish fish farms contributed 55 t of phosphorous and 300 t of nitrogen to the environment annually. This represented less than 4 percent of the phosphorus and 2 percent of the nitrogen from all sources in the country.

As in many countries, the bioaccumulation of toxic substances in fish is also a problem. A national programme to monitor concentrations of chlorinated hydrocarbons and heavy metals has been in progress for some time, and although the mercury content in fish is still a severe problem (e.g., it may enter the water because of its use in slimecides), the direct release of mercury into water has been greatly reduced (Lodenius, 1988).

In brackishwater areas, the Gulf of Finland for example, the chief pollutants are from population centres, wood-processing, and oil-based industries. Slight eutrophication from sewage has increased the stock of some cyprinids and pike-perch, while stocks of coregonids, burbot, and pike have decreased. Sewage has also fouled fishing gear and lowered oxygen. Wood-processing industries have produced effluents which have had a mechanical effect on adult fish, affected the spawning grounds in rivers, and harmed bottom organisms. Oily effluents, toxic substances such as chlorinated hydrocarbons, cadmium, and mercury have also affected fish stocks both in the Baltic and its entering rivers (see Lehtonen and Hildén, 1980).

In a paper presented in early 1982, Westman et al. (1984) stated that some 20 percent of the total surface area of Finnish lakes was significantly affected by wastewater, that about 1 400 km^2 of the coastal waters had been changed from their natural state, and that the major portion of the largest Finnish rivers, about 9 000 km combined length, was at best only in satisfactory condition from the point of view of fisheries. Two years later, Heikinheimo-Schmid et al. (1984) considered that only 700 km^2 (2.2 percent) of the lake area in Finland were badly polluted, some 10–15 percent of the lake area was polluted to some extent, and about 2 200 km of the rivers were polluted.

Due to extensive water protection measures, Heikinheimo-Schmid et al. (1988) found that water pollution had even more strongly diminished in Finland. They stated that about 80 percent of the lake area could be classified as good or excellent, that 18 percent of the lake area was satisfactory and that in only about 2 percent of the lake area the water quality was either passible or heavily polluted by industry or sewage.

On the credit side, the level of oxygen is still generally high in Finnish lakes and rivers due to large areas of water surface, and the long coastline and concentration of cities on the coast further diminishes the effects of pollution. Furthermore, the volume of surface water available in Finland is about 20 940 m^3 per caput, which provides for a very large dilution of effluent discharge. Such a figure is, of course, somewhat misleading in that the volume per caput is much less in the most populated areas of the country where industrialization as well as the demand for dilution of sewage water is high.

The fisheries of Finland have suffered severe losses not only from pollution but from physical damage to the rivers. During the first half of the century, most of the rapids in large Baltic rivers were cleared for timber-floating, diminishing spawning and nursery areas. Narrow channels were cut through some rapids, other areas were left dry, and erosion has caused pools to silt up (see especially Jutila, 1985).

The production of hydroelectric power has also devastated stocks. Dams have barred access to spawning grounds, and severe regulation of water levels by power stations has dried out rivers or frozen their shallows. The Kymijoki, for example (once Finland's most important salmon river flowing into the Gulf of Finland), enters through five outlets, all of them dammed. Some fish ladders are in use, but not only have the stocks of Baltic salmon been greatly reduced, but important strains from some of the rivers are now extinct. Other migratory fishes have also been affected, e.g., the lampern, eel, sea trout, and river-spawning whitefish.

Transportation from the fishing areas to the markets is one of the chief factors limiting the use of fish from inland waters.

Fluctuation of water level in regulated lakes (such as Inari) has also been cited in several publications as causing damage to fisheries.

Aside from the man-made influences listed above, a number of natural factors also limit the yield from Finland's fisheries. Despite the wealth of lake and stream complexes, the short growing season and deficiency of nutrients in the water will keep fish production low even under the best of circumstances. The yield from fishing is further limited by the long periods of darkness, and because both lakes and coastal waters are generally frozen for many months.

Private ownership of most waters tends to minimize commercial fishing - fishing normally being the work or sport of riparian owners who control the fishing rights. Furthermore, the number of commercial fishermen has fallen off decidedly, being less than half of what it was in the early 1950s[1]. Many have moved into other types of work and have left the lake districts, and few young people now choose fishing as an occupation. However, even though the number of commercial fishermen has decreased in Finland, better gear is now being used and their individual catch has improved (see section 9.3). Furthermore, there is a continual demand for fish by man, consumption in Finland being about 34 kg <u>per caput</u> annually, a total amount which exceeds the entire Finnish domestic catch in both inland and marine waters.

[1] This was already apparent in 1977. In a study based on a lake area 9 percent of Finland's total freshwater area, Lind (1982) found that between 1953 and 1977, the number of professional fishermen decreased from 1 000 to 300 and the number of semi-professional fishermen decreased from 9 000 to 3 000. During the same period, the number of non-professionals more than doubled, from 160 000 to 340 000

9.3 Prospect

Although there has been damage to the inland aquatic environment in Finland, particularly through log-transport, erection of hydroelectric installations, and pollution, a considerable effort has and will continue to be made to offset these unfavourable factors. For example, attention has been paid to improving areas damaged by dam construction or timber floating, e.g., the Simojoki considered one of the largest rivers in Europe to be restored to natural condition. There has also been a nationwide pollution control programme. The latter has included a wastewater charge which has decelerated the rate of growth in water consumption. Finland does have hundreds of acidifying lakes in the south, and although their roach populations (and to a lesser extent perch) have been affected, acidification of inland waters has not yet caused the drastic alterations in fish stocks apparent in Norway and Sweden. Crayfish populations have also been affected by acidification.

In addition to improvements in the environment itself, intensive efforts have been made to increase the stock of Baltic salmon through release of smolts. By rearing brood fish of valuable threatened strains and releasing their young into the original waters, it is hoped that economically viable populations can be at least partially restored. Effective regulation of offshore salmon fishing, at both national and international levels, will also be necessary to improve the fishery.

It has been considered that many Finnish inland waters are still underfished, and that they could be exploited to a greater degree, especially during the winter. Over fifteen years ago it was estimated that the annual fish catch (including domestic sea catch) could be almost doubled without harm to the stocks (Bank of Finland, 1974). As has been shown, the total Finnish fish catch has increased decidedly, in 1981 it was already seven times that reported in 1974. Although the number of professional fishermen has declined, their use of improved gear and methods has tripled their catch in inland waters and quadupled it in the sea. In 1983, it was estimated that fishing of a larger number of stocks could be continued at the current rate in certain areas, and even increased in certain other areas. However, recommendations were also made by the same author (Sjöblom, 1983) for reduction in fishing for several stocks, and the state of the vendace (Coregonus albula) stock in the Bothnian Bay has become a matter of concern in Finland. The catch shows a rapid and almost continuous decline, variously attributed to intensification of Swedish trawling during the vendace's spawning period, or recruitment overfishing in the Finnish parts of the Bay (Hildén, Lehtonen and Böhling, 1984). Careful attention to desirable fishing effort for individual fish stocks is a noteworthy part of Finland's management programme.

Aquaculture was slow to develop in Finland, but the production of rainbow trout for food more than tripled between 1978 and 1986. FES (1989) which stated that the production for food of trout in Finland was 15 000 t in 1988 and 18 000 t in 1989 has forecasted a production of 19 000 t in 1990 or about six times the production in 1978. It can certainly be increased both for domestic use and export, especially by using brackish water and cooling water from power stations. It can also be increased by improving the quality of aquacultural effluent water which has been the most serious factor in limiting the expansion of aquaculture. Finish water authorities have strict regulations and have limited fish farm production. An important programme is to reduce the phosphorus content of dry fish feeds and remove effluent solids.

There will, of course, be continued water demands which will be detrimental to Finnish fisheries. At present, extensive desalinization has been rejected as a means to increase the supply of fresh water, so there may eventually be conveyance of raw surface water to other areas, accompanied by the usual dangers to fish.

Fishery management in Finland is primarily financed by fishing communes (privately owned waters), hydroelectric power companies and other groups who have been ordered by Water Courts to repair damage they have caused by fish stocks, and the State. It should be noted that public spending by the State for the management of fisheries exceeds the income it receives from that sector of the economy, be it commercial or recreational. It is considered, however, that the Government has an obligation to those who own no fishing waters (recreational fishermen), and should also aid in compensating for stresses in stocks engendered as a result of damage to watercourses incurred for so-called “public benefit”. Preservation of native fish stocks, improvement of benefits from employment, and maintenance of social infrastructure are also considered Governmental obligations (Salojärvi, 1984).

Generally speaking, the Finn's traditional interest in fisheries, coupled with their industry and scientific direction augur well for continued development.

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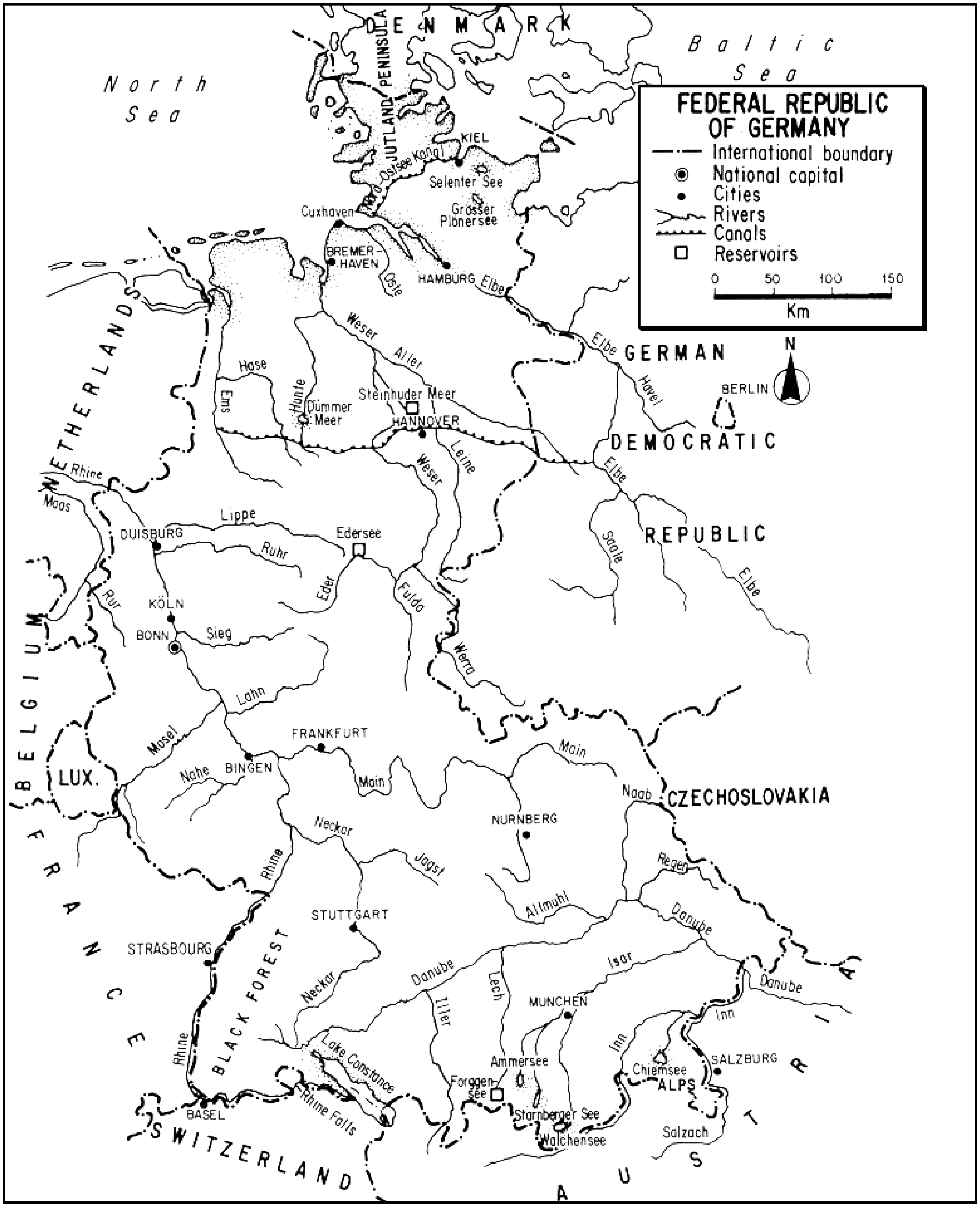

N.B. The borders are those of the sub-division of Germany up until 2 October 1990

FEDERAL REPUBLIC OF GERMANY[1]

The Federal Republic of Germany is the heartland of north-central Europe. Bordered by nine countries, it extends from the North and Baltic seas across a series of plains and medley of hills and plateaux south to the Bavarian Alps.

Rich in coal resources and served by well organized river, canal, rail, and highway transport, it is one of the most industrialized nations in the world. Nevertheless, both agriculture and forestry remain important in its economy and it still maintains a considerable amount of productive inland water.

Within the Federal Republic of Germany, the streams range from great rivers such as the Rhine to small mountain brooks, and the lakes from large glaciated basins to high mountain tarns, but generally speaking the country is deficient in standing waters.

The discharge of effluent and the manifold uses of its resources of surface waters have played a heavy toll on several of its formerly extensive inland fisheries. Although the freshwater commercial capture fishery has declined severely, aquaculture especially for trout has made decided strides in both quantity and quality of production. Meanwhile as in most European countries, recreational fishing is assuming a greater importance.

[1] Data given in this section refer to the Federal Republic of Germany up until 2 October 1990

1. AREA: 248 692 km^2 [2]

[2] Includes the area of West Berlin

2. POPULATION: 60 332 000 (est. 1990) Density: 243 inh/km^2

3. PHYSICAL GEOGRAPHY

The Federal Republic of Germany lies in north-central Europe between 47°16' and 55°04'N latitudes and 5°52' and 13°51'E longitudes.

Its greatest length (N–S) is about 876 km and its greatest direct E–W width is about 450 km. (The greatest distance between its extreme eastern and western points is, however, 627 km.) Its highest point, the Zugspitze, is 2 962 m; its lowest point is somewhat below sea level.

Bordered by nine countries, the Federal Republic of Germany (proceeding clockwise) is bounded: on the north by Denmark for 67 km, on the east by the German Democratic Republic for 1 378 km and by Czechoslovakia for 356 km, on the southeast and east by Austria for 784 km, on the south by Switzerland for 334 km, on the southwest by France for 446 km, and on the west by Luxembourg for 135 km, Belgium for 155 km, and the Netherlands for 576 km[3]. In addition to these national boundaries, the Federal Republic of Germany fronts for about 570 km (about 1 500 km considering indentations) on the North Sea, which lies west of the lower Jutland Peninsula (Schleswig-Holstein) and the Baltic Sea which lies east of this Peninsula.

[3] The lengths of these boundaries are taken from Statistiches Jahrbuch, 1989 für die Bundesrepublik Deutschland (1989)

The Federal Republic of Germany cuts across three of Europe's major east-west trending regions: the Great European Plain, the Central Uplands, and the Alps in the south. Thus, it encompasses areas ranging from its north coastal dunes, mudflats, polders and marshes which bound a great glaciated plain, south to a central area of low mountains, forests and basins which merges into a foreland plateau and culminates in the high-montane Alps of the extreme south.

Topographically, the Federal Republic of Germany can be divided into three (or four) great zones. Using the tripartite division, the sub-parallel-zones, each constituting about one-third of the country, are arranged from north to south as follows:

(i) North German Lowland or Plain. This is part of the Great North European Plain continuing into the low countries and southwest France on the west and extending east through Poland into the USSR.

Formed by glacial action, and mostly under 150 m in elevation, the northern Plain is gently rolling moraine with long low ridges and old glacial coastal valleys. Much of the area is sandy, health and moorland. Much has been converted into agricultural land; some is lakeland. It has a southern border (the Börde) of fertile loess.

Its embayed coast bordering the North Sea is flat and alluvial, protected by dikes, and fringed by lines of low sandy islands, the Frisians. The mud and sand are constantly shifting and channels require constant maintenance. The Baltic coast of the Jutland Peninsula is also flat, has sandy beaches, and a number of large islands. Unlike the North Sea it has almost no tide. It is characterized by long, deep winding inlets or drowned sub-glacial melt-water channels called Förden. The Peninsula also has some large lakes.

(ii) Central Uplands. South of the Plain is this central section or Mittelland. Topographically complex (a part of the old eroded Herycnian Massif), it includes low mountains dissected upland plateaux, down-faulted basins, and wooded areas. Extending south to the Danube, it varies in altitude from about 300 to 1 500 m. Its rocks are mostly ancient schists and sandstones with some volcanics, and its soils are thin and poor.

(iii) Bavarian Foreland and Alps. The Danube River flows easterly across southern Germany to its junction with the Inn where it enters Austria. South of the Danube is the Bavarian Foreland, a continuation of the Central Swiss Plateau. This area of plains and ridges, with beds of limestone, sandstone, and clay, which averages 300 to 900 m in elevation, rises to merge into the Allgau Mountains (west) and Bavarian Alps (east).

This Alpine chain, at most 40 km wide, stretches across the country between Lake Constance (the Bodensee) and the Austrian border (Salzburg) for about 240 km with a mean height of 1 830 m. In the west there are only low sandstone ridges, but the mountains south of München represent the northern or outer fringe of the limestone Alps.

The Alps here do not have glaciers, but contain mountain lakes. The forelands contain even larger moraine-dammed lakes, such as the Chiemsee.

(iv) Rhine Valley and Western Highlands. Although often included topographically with the Central Uplands, this portion of the Federal Republic of Germany, occupying most of the western and southwestern area of the country from Switzerland to the Netherlands, is sometimes considered a separate unit. As the Rhine proceeds north as the greatest unifying feature of the country, its landscape has many aspects: the dense Black Forest in the southwest, next the wide terraced rift valley of the upper Rhine, a narrow gorge between Bingen and Bonn, and finally its downstream lowlands. Meanwhile, as the river proceeds north, it increases in industrialization, river traffic and effluent content.

The Federal Republic of Germany lies in the mixed forest belt, but its once great deciduous forests (oak, linden, beech and birch) are largely gone. On the poor sandy soils of the north, the original forest has been replaced by heath and bog, and planted with Scots pine. The uplands contain beech and spruce, and cover in the mountains ranges from spruce, fir and pines to mosses and lichens at high altitudes.

The soils of the country are varied but generally not very fertile. They have been improved through drainage, tillage and fertilization. Those of the cold and damp Northern Lowland are badly leached soils, sands, acid podsols and peat bogs. Those of the Central Uplands are more varied: acid brown forest soils, podsols, and rendzinas. The Alpine soils tend to be thin, stony, and leached.

4. CLIMATE

The climate is temperate and mostly oceanic, affected favourably by the Gulf Stream. There is, however, some conflict between the western oceanic and the polar and continental air currents to achieve a range between the milder west European and the more extreme continental climates.

The average annual temperature, around 9°C, is almost constant throughout the country. In January, the coldest month of the year, temperatures average around freezing point in the lowlands, and about -6°C in the mountains. The average July temperature is 17–18°C in the northern lowlands, and reaches 20°C in the upper Rhine area.

The average annual rainfall is 800 mm, ranging from 500 to 700 mm in the northern lowlands to 700–1 500 mm in the central uplands, and to over 2 000 mm in the Alps. Rainfall is fairly uniform throughout the year although concentrated in the summer in the south.

The frost period lasts from 70 days a year in the west to 150 days in the east. Considerable snow falls in the winter: the northwest coast may receive 9 m and parts of Bavaria 16 m. The higher mountains are usually snowbound from January to March, and there is a permanent snowline at about 2 450 m in the Alps. During a low presure system, the Föhn (a warm dry wind) may melt snow in the spring.

The Baltic Sea which is only brackish may be frozen at times so that its German ports are closed. On the Rhine the area near Cologne may be frozen over for 20 days, and Lake Constance, at 395 m, has frozen over 30 times since the year 1000.

5. HYDROGRAPHY AND LIMNOLOGY

The Federal Republic of Germany has about 4 600 km^2 of inland water according to Gallus (1979). This estimate, which equals about 1.8 percent of the area of the country, should be one of the best available. An earlier estimate (also based on information from the Federal Republic of Germany) was that in EIFAC (1960) and in Framji and Mahajan (1969) which listed the inland water area of the Federal Republic of Germany as 4 203 km^2 or 1.7 percent of the total area. Another is that derived from Table 7 where inland water constitutes 4 300 km^2 or 1.7 percent of the Federal Republic of Germany[1].

[1] FAO (1980) presents a rather confusing statement on this matter, saying that: "Germany possesses nearly 80 000 ha of inland waters where capture fisheries is possible. These include the Rhine and its tributaries and the lake regions of Schleswig Holstein and Bavaria where the largest lake-Constanz (the Boden Sea) is found". Incidentally, the Bodensee is in Baden-Württemberg - not Bavaria

The average annual runoff from rainfall in the Republic is 307 mm or 77 000 million m^3. About 85 000 million m^3 is received annually from upstream countries, resulting in a total annual river discharge of 162 000 million m^3 leaving the country (Van der Leeden, 1975; ECE, 1978).

The greater part of the country drains to the North Sea via the Rhine, Ems, Weser, Elbe, and some minor streams in the northwest. (A very small portion of the country drains easterly through the Rur to enter the Mass system outside the Federal Republic of Germany and also proceed to the North Sea.) The Baltic Sea is fed by a few streams originating in Schleswig-Holstein. The southern portion of the Republic is drained primarily by the Danube which proceeds eventually to the Black Sea.

5.1 Rivers (Flüsse)

The major rivers of the Federal Republic of Germany are shown in Table 1, and the discharges of some of the principal rivers are listed in Table 2.

The regimes of the Federal Republic of Germany rivers fall generally into two groups: (i) those of the Alpine rivers, and (ii) those of middle and northern Germany.

Table 1

Principal (navigable) rivers of the Federal Republic of Germany

River	Length (km) Within the country	Length (km) Navigable	Basin area (km^2)
Danube (Donau)	647	386	56 215
Rhine (Rhein)	865	778	102 111
Neckar	367	203	13 958
Main	524	396	26 507
Regnitz	58	5	7 540
Lahn	245	148	5 947
Mosel	242	242	9 387
Saar	120	120	3 575
Ruhr	213	41	4 489
Ems	371	238	12 649
Leda	75	27	1 917
Weser	440	440	41 094
Fulda	218	109	6 947
Werra[a]	292	89	1 417
Aller[a]	211	117	14 446
Leine[a]	241	112	6 006
Lesum/Wümme	128	29	2 225
Hunte	189	26	2 785
Geeste	43	29	337
Oste	160	82	1 714
Elbe	227	227	14 945
Ilmenau	107	29	2 869
Este	50	13	361
Luhe	55	13	204
Schwinge	35	5	199
Pinnau	44	20	358
Krückau	37	11	247
Stör	88	51	1 800
Eider	188	112	1 891
Trave	118	53	1 854

[a] Including share of the German Democratic Republic

Source: Statisches Jahrbuch 1989 für die Bundesrepublik Deutschland (1989)

(i) Alpine rivers. The streams rising in the Alps, such as the Danube and its southern tributaries, have their lowest flow in the winter and highest in May–June following snowmelt. The upper Rhine above Basel is also an Alpine stream. Although regularized by Lake Constance (the Bodensee) its flow is increased below the lake by receiving that of the Aar from Switzerland and continues with high volume and rapid current during June–July, subsiding to its low flow in February[1].

[1] Over 90 percent of the rock detritus transported by the Rhine is deposited in the Lake (Muller, 1966)

Table 2

Discharge of seven rivers in the Federal Republic of Germany

River and station	Basin area (km^2)	Mean monthly discharge, m^3/sec Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Danube, Hofkirchen	47 496	605	687	779	731	678	724	737	605
Rhine, Rees	159 680	2 560	2 840	2 660	2 450	2 050	2 200	2 170	1 900
Main, Kleinheubach	21 505	134	193	197	190	136	148	81.7	70.1
Mosel, Cochem	27 100	535	555	429	324	201	158	135	125
Ems, Versen	8 469	136	139	114	79.5	44.7	28.8	35.8	33.6
Weser, Intschede	37 788	450	498	478	379	246	206	210	185
Elbe, Neu-Darchau	131 951	725	843	1 100	1 130	766	591	571	486

River and station	Sept.	Oct.	Nov.	Dec.	Year	Daily discharge m^3/sec Max.	Min.	Period of record
Danube, Hofkirchen	534	516	543	530	639	3 830	193	1931–60
Rhine, Rees	1 700	1 650	1 970	2 390	2 210	9 440	590	1936–65
Main, Kleinheubach	60.9	72.2	115	196	133	857	13.8	1960–65
Mosel, Cochem	124	168	314	427	291	3 730	22	1931–60
Ems, Versen	35.5	49.8	77.6	105	73.5	1 200	5.2	1931–60
Weser, Intschede	171	199	277	357	305	3 300	59.2	1931–60
Elbe, Neu-Darchau	448	478	597	652	700	3 620	145	1931–60

Source: Van der Leeden (1975) after Bundesanstalt für Gewasserkunde und Deutsche Forschungsgemeinschaft, 1972

(ii) Central and northern rivers. As opposed to the Alpine rivers, these lowland streams have their strongest flow in winter and spring (December to April) and their lowest flow from June to October. Despite summer rains in their catchments, there is also a high evaporative rate during this period, and winter rains fall on saturated or frozen soil and reach the rivers quickly. Differences do exist between middle and northern rivers in the Federal Republic of Germany due to differences in terrain, declivity, and evaporative rate. The ratio between high and low flows may also differ considerably (e.g., it is 40 to 1 for the Lahn and 18 to 1 for the Main), and on the northern plain the rivers are more constant and slower. Nevertheless, the regimes are similar.

As has been customary in several parts of the world, early attempts were made in Germany to classify river zones on the basis of their dominant fishes. Thienemann (1925), for example, outlined six successive zones as one descends a German river:

(i) Spring and spring brooks
(ii) Trout zone

(iii) Grayling zone
(iv) Barbel zone
(v) Bream zone
(vi) Brackishwater zone - ruffe (<u>Gymnocephalus cernua</u>) and flounder (<u>Pleuronectes flesus</u>)

An even more elaborate classification is that of Illies (see Ladiges and Vogt, 1979) shown below:

(i) Rithon

Epirithron	- Upper salmonid region: upper trout zone
Metarithron	- Middle salmonid region: middle trout zone
Hyporithron	- Lower salmonid region: grayling zone

(ii) Potamon

Epipotamon	- Upper cyprinid region: barbel zone
Metapotamon	- Lower cyprinid region: bream zone
Hypopotamon	- Ruffe - flounder region

Similarities between these zones and those described by other scientists are obvious (see, for example, section 5 for Belgium, France, and the UK).

The major river systems of the Federal Republic of Germany are described below.

Rhine (Rhein in German/Rhin in French). The Rhine with a total drainage area of about 160 000 km^2 and length of 1 350 km, is the most important waterway in Europe. Once a great salmon river, and one which supplies drinking water to about 20 million people, it has also been termed the “cloaca” or “sewer” of Europe. In its use, it typifies western Germany. Originating in Switzerland, it forms a partial border between it and the Federal Republic of Germany below Lake Constance. Upon leaving Switzerland at Basel, it turns northeast through a 30–50 km rift valley, forms a German/French border downstream to the Lauter River, passes through a series of gorges and flanking coalfields, and finally flattens out to continue through Germany and the Netherlands to its deltaic mouth in the North Sea[1].

[1] For 121 km between Basel and Strasbourg, the Grand Canal d'Alsace with nine locks, runs parallel to the Rhine on the French side, and the river bed is virtually dry

Flow in the Rhine is rather neatly balanced by a summer maximum from snowmelt in the Alps and a winter maximum from the lower tributaries, mainly from the Central Uplands. The latter flow comes at a time of year when the lower stream is more responsive to precipitation to maintain its level. The result is a river with powerful and sustained flow well suiting it for navigation.

As the Rhine leaves Basel, it has an average discharge of 1 040 m^3/sec. As it enters the Netherlands from the Federal Republic of Germany, it has an average discharge of about 2 200 m^3/sec, a maximum of about 12 200 m^3/sec, and a minimum of 590 m^3/sec. Its average flow has doubled with the inflow of the pluvia-nival rivers of the Mittelland.

The Rhine is a great river upstream to the Rheinfalls (see Switzerland), being navigable for 778 km of its 865 m course in the Federal Republic of Germany. An international waterway since the Treaty of Vienna in 1815, it supports a heavy traffic of cargo ships, barges, and passenger vessels, and serves as a giant effluent channel for central Europe[2]. Duisberg is the largest inland port on the Rhine.

[2] Die Zeit once termed the Rhine: “a navigable canal filled with industrial wastewater”

Neckar. Proceeding downstream, the first important German tributary of the Rhine is the 367-km Neckar which rises in the Black Forest close to the headwaters of the Danube. Draining the southwest of the Federal Republic of Germany, it proceeds northerly to join the Rhine from the right at Mannheim. During the 1960–65 period, it had an average discharge of 124 m^3/sec and estimated maximum of 2 500 m^3/sec at Rockenau.

Main. The Main, which flows almost completely across the Federal Republic of Germany from the east, for 524 km between the Central Uplands and Alpine Foreland, to join the Rhine at Mainz, is its most important right bank tributary. Navigable for 396 km, it connects with the Danube through the Main-Donau Canal.

Continuing downstream, other right bank tributaries of the Rhine, are the 245-km Lahn, 130-km Sieg, the 213-km Ruhr, and the 237-km Lippe, in that order.

Mosel (Moselle in French). The 505-km Mosel is the most important left bank tributary of the Rhine in Germany. Rising in the Vosges in France, it flows between Luxembourg and the Federal Republic of Germany for 40 km, leaves Luxembourg after its confluence with the Sûre at Coblenz, and continues through Germany to the Rhine. Its course in the Federal Republic of Germany is 242 km, all of which is navigable. The Mosel has a low gradient and has been canalized and levelled to permit cargo traffic. The most important tributary of the Mosel in the Federal Republic of Germany is the 120-km Saar from the south.

Another important left bank tributary of the Rhine in the Federal Republic of Germany is the 97-km Nahe, entering at Bingen above the mouth of the Mosel. The Ruhr basin is highly industrialized, furnishing most of the country's coal, steel, and smelting metals, and using industrial power from coal.

Ems. A large part of the North German Lowland is drained by the slow-flowing 371-km Ems, which flows northward from the Central Uplands to parallel the Dutch border and debouch through a 32 km estuary, the Dollart, in the North Sea. Canalized, it is navigable for 238 km.

Weser. Formed by the junction of the north-flowing Fulda and the Werra, the 440-km Weser flows north to drain part of the lower Central Uplands and central portion of the Northern Lowlands. It enters the North Sea at Bremenhaven between the Ems (to its west) and the Elbe (to its east), and is connected with each river by the Mittelland Canal.

Elbe. Last of the large north-flowing rivers of the Federal Republic of Germany is the Elbe which rises in Czechoslovakia and flows for 1 137 km, through the Democratic Republic of Germany and then through the Federal Republic of Germany to the North Sea at Cuxhaven. Only 227 km of the Elbe are in the Federal Republic of Germany, but the important city of Hamburg, with 64 km of quays, is situated at the upper end of its 110-km estuary.

Danube (Donau) or Black Sea Drainage. The line between the Rhine and Danube basins extends across southern Germany, so that the Danube River receives its drainage from the Black Forest on the west as well as from the Bavarian Foreland and Alps. The Danube itself flows generally easterly across the country for 647 km to enter Austria at Passau, and continue its course (a total of 2 848 km) within the eight Danube countries) to the Black Sea. The seasonal flow of the Danube varies greatly: its southern tributaries (from the Alps) are torrential in spring and early summer but contribute little water in autumn and winter, and its northern tributaries are minor.

Its major tributaries from the south are the: 146-km Iller, 282-km Lech, and 262-km Isar. Major northern tributaries are the: Altmuhl, 165-km Naab and 108-km Regen.

Other drainages. A small area north and northeast of Hamburg drains to the Baltic. These rivers are generally short but have deep inlets called Förden. There is also a small area west of the Rhine, the Rur, which drains west to the Maas and thence to the North Sea.

5.2 Lakes (Seen)

Table 3 lists the major lakes, in eight groups, in the Federal Republic of Germany.

Most of the lakes have been formed by glacial excavation or moraine dams (e.g., Chiemsee). A few, such as the Laachersee in the Eifel district north of the Mosel, are "maar" lakes, formed in a volcanic crater, and some in this area were formed by lava-flows across streams. Although the Federal Republic of Germany has some large sub-Alpine or foreland lakes, it is deficient in having the large number of lakes and lake groups found in the continuation of the Great European Plain to its east (see Poland, section 5).

The largest lake in the Federal Republic of Germany is Lake Constance (Bodensee/Konstanz) in the southwest Alpine Foreland. The third largest lake in Central Europe, it is shared with Switzerland and Austria. The German portion of the lake is 305 km^2 or 56 percent of the total area. Fed by the Rhine entering from Switzerland, the lake is divided into a main body called the Obersee, a northwest arm the Überlingersee, and a southwest extension below the city of Konstanz called the Untersee. Some characteristics of the two major lake bodies are shown in Table 4. The entire lake, with an area of about 540 km^2, is 62 km long and 13 km wide. Fluctuation in water level is about 160 cm. Its summer surface water temperature is about 22°C, its minimum temperature about 3.7°C. It can be considered as just dimictic. The German and Swiss Untersee is connected with the rest of the lake by a 3.2 km stretch of the Rhine. This 62-km^2 portion is about 16 km long and 4.8 km wide. Once oligotrophic, there has been a progressive eutrophication of the lake since 1950, due primarily to untreated municipal waste containing sewage and detergents. About one-third of the eutrophication derives from agricultural practices. The main basin is now considered to be between meso- and eutrophic. Annual fish yields have increased with eutrophication, but the composition of the major stocks in the Obersee has shifted from coregonids to cyprinids and perch (Hartman and Nümann, 1977). The fish catch in the Obersee during the 1970–74 period was divided as follows: the Federal Republic of Germany, 41 percent; Switzerland, 41 percent, and Austria, 18 percent (Deufel, 1975). According to Milway (1970) it has an annual yield of about 4 000 t of fish.

The next largest West German lakes also lie in the Alpine Foreland: the Chiemsee (82 km^2), Starnberger See or Wurmsee (57.2 km^2), and the Ammersee (47.5 km^2). In the southern Federal Republic of Germany, they are rivalled in size only by the 16.1 km^2 Alpine Walchensee.

All of the other large lakes of the Federal Republic of Germany lie at low elevations on the Northern Plain (see Table 3).

5.3 Reservoirs (Talsperren)

Table 5 lists the major reservoirs in the Federal Republic of Germany, those with a volume of about 10 million m^3, according to their drainage basins. Their primary uses are to provide water for the creation of electrical energy and for domestic and industrial use, and for flood control and the regulation of navigation.

Table 3

Principal natural lakes of the Federal Republic of Germany[a]

Lake	Total area km^2	Altitude m	Depth Max m	Depth Mean m
Alpine				
Walchensee	16.1	802	192	92
Tegernsee	8.9	725	72	36
Königsee	5.2	603	189	93
Schliersee	2.2	777	39	24
Eibsee	1.8	973	32	14
Alpsee (near Füssen)	0.9	814	59	27
Alpine Foreland				
Constance (Bodensee)	538.5 [b]	395	252	90
Chiemsee	82.0	518	73	29
Starnberger See	57.2	584	128	54
Ammersee	47.5	533	83	38
Waginger and Tachinger See	9.0	442	27	16
Staffelsee	7.7	649	38	10
Simssee	6.5	470	23	13
Kochelsee	6.0	599	66	31
Wörthsee	4.5	560	33	14
Alpsee (near Immenstadt)	2.5	724	23	14
Bannwaldsee	2.3	786	12	6
Hopfensee	1.9	785	10	5
Black Forest				
Schluchsee	5.1	900	61	15
Titisee	1.1	846	40	21
Feldsee	0.1	1 109	32	19
Eifel area				
Laacher See	3.2	275	51	33
Pulvermaar	0.4	411	74	38
Northwest Lowland				
Steinhuder Meer	29.4	37	3	2
Dümmer	16.0	37	3	2
Zwischenahner Meer	5.2	6	5	3
Grosses Meer	4.2	0	2	1
Holstein Lake Area				
Grosser Plöner See	29.0	21	60	14
Selenter See	22.4	37	34	17
Wittensee	10.1	4	27	-
Westensee	8.2	6	20	-
Kellersee	5.6	24	28	13
Grosser Binnensee	5.0	0	3	2

Hemmelsdorfer See	4.4	0	45	-
Dieksee	3.9	22	39	-
Mecklenburg Lake Area				
Schaalsee	23.3	35	72	17
Ratzeburger See	14.1	4	24	12
Märkische Lake Area				
Tegeler See	4.1	31	16	7
Wannsee	2.7	30	9	4

[a] All natural lakes over 10 km^2 in area as well as some of the best known smaller lakes

[b] The area within the Federal Republic of Germany is 305 km^2

[c] Including the part in the German Democratic Republic

Source: Statistisches Jahrbuch 1989 für die Bundesrepublik Deutschland (1989)

Table 4

Characteristics of Lake Constance (Bodensee)

Parameter	Unit	Obersee	Untersee
Elevation	M	395	395
Total area	km^2	476	63
Area with 0–10 m depth	percent	14	48
Basin area	km^2	11 000	--
Mean depth	M	100	13
Maximum depth	M	252	46
Volume	km^3	48	1
Shoreline length	Km	171	90
Discharge of tributaries	m^3/year	10^9	--
Retention time	Years	4.3	0.1

Source: Hartman and Nümann (1977)

5.4 Canals (Kanale)

The Federal Republic of Germany is well supplied with canals which are used principally for navigation, but which may also function as drainage channels. The major canals are shown in Table 6.

In addition to artificial canals, the major rivers have been canalized to provide better navigability (see Table 1). Thus, the Rhine is navigable upstream to Basel, and the Mosel has been canalized throughout its entire course in the Federal Republic of Germany. When ultimate construction of the Rhein-Main-Donau Kanal is completed (expected in 1992, but actually proposed by Charlemagne in 793), it will be possible for total passage of cargo between the North Sea and Black Sea.

Canals have facilitated the spread of fish stocks from one river system to another, and provide some fishing, although heavy use and pollution handicap this activity.

6. LAND AND WATER USE

The economy of the Federal Republic of Germany is now about 86 percent urban and 14 percent rural, but agriculture remains an important use of the land, mainly on small family and mixed farms. Nearly two-thirds of the total land is mountainous, thus much of the agriculture is determined by altitude. In general, the soils are not fertile, but they have been improved through centuries of use, and heavy applications of fertilizer. The country ranks third or fourth in Europe on its use of fertilizer per hectare of agricultural land or about twice the European average. Fertilization has contributed to eutrophication. Major crops are cereals (wheat, barley and rye), potatoes, beets and fruits, but emphasis is placed on livestock raising. Irrigation is a minor use of water in the Federal Republic of Germany being used primarily to prevent frost damage and increase yields. Only about 1.3 percent of the land is irrigated (1986), and only about 3 percent of the total water use is for agriculture. Agriculture is well supported governmentally to increase its sufficiency, and at times or places this may have an adverse effect on inland fisheries.

Forestry is an important occupation in the Federal Republic of Germany which ranks fourth in roundwood production in Europe. Spruce is the principal forest tree and pulpwood accounts for about one-third of the output. In recent years, what is believed to be acid rain had affected about 10 percent of the forest area by 1984. The Federal Republic of Germany is well known for good forestry practices with an aim for the annual cut not to exceed the increment. Forestry practice is also closely linked to recreational use, including maintenance to insure good hunting and fishing.

Mining is also an important industry. The Federal Republic of Germany's great coal production - a major basis for its industrial wealth - has dropped but lignite remains as one of the world's great resources. Deposits of potash (used mostly as fertilizer), petroleum, iron, salt and other minerals add to the resource.

The Federal Republic of Germany is the greatest producer of power in Europe. In 1987, its installed capacity for electrical production was 84 100 000 kW. About 67 percent of this is thermal, 8 percent (6 760 000 kW) is hydroelectric, and the remainder nuclear. Most of the hydro plants use Alpine water.

One of the most highly industrialized countries in the world, the Federal Republic of Germany has a wide variety of major industries, such as: metallurgy, chemicals, shipbuilding, auto manufacturing, and textiles. Considerable effluent is produced by these industries, as well as sugar factories, paper mills, and breweries. Manufacturing is widely distributed throughout the Republic, but heavy industry is concentrated at sea and river ports.

The marine commercial fisheries in the Federal Republic of Germany have been important and marine sport fishing is increasing in importance. Per caput fish consumption is about 11.8 kg annually (1983). The commercial inland fisheries have declined as the waters have deteriorated, but aquaculture, a traditional occupation in Germany, is continuing in importance, as is the use of inland waters for sport fishing. Tiews (1988a) has estimated the total annual value of production by West German inland fisheries, including fish eggs and fish for stocking, as DM 180 million or about two-thirds of the total value of the Federal Republic of Germany sea fisheries. Tourism (12.6 million tourists in 1985) is important in the Federal Republic of Germany, but angling is not one of its major attractions.

The Federal Republic of Germany has a well-organized system of railways, (about 27 500 km in 1984), good roads, and canals enabling easy access to all of the country. Its 491 240 km of auto roads has a density of 1.9 km/km^2 (1985) and passenger car ownership (1988) was about 428 per 1 000 people, the highest of any large country in Europe. Its inland waterways totalled about 4 300 km circa 1988 and considerable pollution is produced by the large fleets which use them.

Table 5

Principal reservoirs of the Federal Republic of Germany[a]

Name (watercourse)	Volume mill m^3	Max.area km^2	Max. waterlevel m	Age
Danube Basin				
Forggensee (Lech)	165.0	15.3	40	1953
Sylvensteinsee (Isar)	104.0	3.9	41	1959
Eixendorf (Schwarzach-Naab)	20.8	1.8	25	1976
Frauenau (Kleiner Regen-Schwarzen Regen)	20.0		75	1984
Dornau (Lech)	18.0	2.1	22	1959
Grüntensee (Wertach Lech)	16.0	2.5	16	1961
Rhine Basin				
Bigge (Bigge-Lenne-Ruhr)	171.8	7.1	52	1965
Möhne (Möhne-Ruhr)	134.5	10.4	35	1913
Schluchsee (Schwarza-Wutach)	108.0	5.1	35	1932
Grosse Dhünn (Dhünn)	81.0	4.6	54	1974
Sorpe (Sorpe-Rohr-Ruhr)	70.0	3.3	60	1935
Wahnbach (Wahnbach-Sieg)	41.3	2.2	46	1958
Henne (Henne-Ruhr)	38.4	2.1	57	1955
Verse (Verse-Lenne-Ruhr)	32.8	1.7	52	1952
Wupper (Wupper)	25.9	2.2	35	1968
Wiehl (Wiehl-Agger-Sieg)	31.5	2.0	50	1973
Bever (Bever-Wipper-Wupper)	23.7	2.0	33	1939
Lister (Bigge-Lenne-Ruhr)	22.0	1.7	35	1912
Mauthaus (Nurner Ködel, Rodach-Main)	21.7	0.9	56	1972
Nonnweiler (Prims-Saar)	19.2	1.3	60	1975
Agger (Agger-Sieg)	19.3	1.2	40	1929
Kerspe (Kerspe-Wipper-Wupper)	15.5	1.6	28	1912
Obernau (Obernaubach-Sieg)	14.9	0.9	44	1972
Halterner Stausee (Stever-Lippe)	20.5	2.2	4	1971
Aabach (Aabach-Alte-Aime-Liwe)	20.0	1.3	41	1972
Schwarzenbach (Schwarzenbach-Murg)	14.3	0.7	44	1926
Kleine Kinzig (Kleine Kinzig-Kinzig)	13.0	0.6	61	1985
Ennepe (Ennepe-Volme-Ruhr)	12.6	1.0	45	1904
Maas Basin				
Schwammenauel (Rur)	205.0	7.8	68	1959
Urft (Urft-Rur)	45.5	2.2	54	1905
Olef (Olef-Urft-Rur)	19.3	1.1	54	1961
Wehebach (Wehebach-Inde-Rut)	25.0	2.1	46	1983

Weser Basin				
Edersee (Eder-Fulda)	202.0	12.0	42	1914
Oker (Oker-Aller)	47.4	2.2	66	1956
Grane (Grane-Innerste-Leine-Aller)	45.0	2.1	61	1969
Oder (Oder-Rhume-Leine-Aller)	30.6	1.4	51	1934
Söse (Söse-Rhume-Leine-Aller)	25.5	1.2	56	1932
Diemel (Diemel)	20.5	1.7	34	1923
Innerste (Leine-Aller)	20.0	1.5	35	1966
Ecker (Ecker-Oker-Aller)	13.3	0.7	57	1942
Elbe Basin				
Formitz (Formitz-Säch Saale)	11.4	1.0	31	1979

[a] Reservoirs with a capacity of about 10 million m^3

Source: Statistiches Jahrbuch 1989 für Bundesrepublik Deutschland (1989)

Table 6

Major navigational canals of the Federal Republic of Germany[a]

Name	Connections	Year opened	Length km	Locks no.	Max.capacity tons
Mittellandkanal	Bergeshovede-Rothensee bei Magdeburg	1938	258.7[b]	2	1 000
Dortmund-Ems-Kanal	Dortmund-Emden, Borsumer Schleuse	1899	266.0	16	1 500
Elbeseitenkanal (Nord-Sud-Kanal)	Artlenburg-Edesbuttel	1976	112.5	1	1 500
Nord-Ostsee-Kanal	Brunsbuttel-Kiel-Holtenau	1895	98.7	2	Oceanship
Main-Donau-Kanal	Bamberg-Nurnberg	1972	72.0	7	1 500
Kustenkanal	Dorpen (Ems) Oldenburg (Oldenburg)	1935	69.6	2	1 500
Elbe-Lübeck-Kanal	Lauenburg/Elbe-Lübeck	1900	62.0	7	1 000
Wesel-Datteln-Kanal	Wesel-Datteln	1929	60.2	7	1 500
Datteln-Hamm-Kanal	Datteln-ostlich Hamm	1915	47.1	2	1 000
Rhein-Herne-Kanal	Duisburg-Ruhrort-Henrichenburg	1914	45.6	6	1 500

[a] Navigational canals with a length over 40 km and capacity of at least 650 t

[b] Length within the Federal Republic of Germany; total length 321.3 km

Source: Statistiches Jahrbuch 1989 für die Bundesrepublik Deutschland (1989)

Table 7

Pattern of land use in the Federal Republic of Germany, 1986

	Percent
Arable and permanent crops	30.0
Permanent pasture	18.3
Forests and woodlands	29.5
Other land	20.5
Inland water	1.7
Total	100.0

Source: 1987 FAO Prod.Yearb., 41 (Publ. 1988)

Air pollution in Germany is a formidable problem, and water pollution has long been a major offender with respect to inland fisheries. The Rhine, especially, contains dissolved salt from mines, water pumped from coal mines, and sewage, and is considered more polluted than it was 35 years ago. In fact, Worldmark (1988) says that it is 20 times as polluted as in 1949. In some industrial rivers, such as the Emscher, fishing has been completely destroyed and some smaller streams have been deoxygenated. Sewerage is increasing rapidly, but sewage remains an important source of pollution, and thermal pollution is growing. Oxygen deficiences due to disposal of silage waters and manure also cause fish deaths in Germany.

With respect to total water use in the Federal Republic of Germany (1972), surface water constitutes 64 percent and ground water 36 percent. Industry uses 86 percent of all water used or 58 percent of the surface water (ECE, 1978).

7. FISH AND FISHERIES

About 70 species of native and seven species of introduced freshwater, brackish, and diadromous fishes are listed for Germany by Ladiges and Vogt (1979), but the fishes actually dominant in the inland fishery catch of the Federal Republic of Germany are essentially the same species normally caught in neighbouring countries. Among the most important are: European eel (Anguilla anguilla), brown trout (Salmo trutta), the introduced rainbow trout (Oncorhynchus mykiss), the scarce but coveted huchen (Hucho hucho), char (Salvelinus alpinus), whitefishes (Coregonus spp.), grayling (Thymallus thymallus), European smelt (Osmerus eperlanus), pike (Esox lucius), common carp (Cyprinus carpio), bream (Abramis brama), barbel (Barbus spp.), roach (Rutilus rutilus), tench (Tinca tinca), burbot (Lota lota), European perch (Perca fluviatilis), and pike-perch (Stizostedion lucioperca). In addition, the Federal Republic of Germany supports crayfish populations including the widespread American Orconectes limosus.

The Rhine was once the greatest Atlantic salmon (Salmo salar) stream in Europe. Similarly, the Main, Neckar, Ems, Weser, and Elbe were once good salmon streams. However, the salmon's decline due especially to a combination of dams and water pollution both in the main streams and their tributaries was virtually complete circa 1939. There is, however, a German fishery for salmon in the Baltic (see Table 9). Germany lacks opportunities to rear salmon, but has purchased salmon smolts from Sweden for stocking.

Eel fishing continues as a “staple” of inland fisheries in the Federal Republic of Germany because it is one of the species affected least by eutrophication and water pollution. Circa 1971, eel production in the Federal Republic of Germany was about 1 500 t, half from inland waters and half from the sea according to Tiews (1971). As eel is a very popular fish in Germany, large numbers of elvers are imported annually from France, the Netherlands, and England to stock inland waters.

Table 8

Nominal catches in the inland waters of the Federal Republic of Germany, 1965–87 (in tons)

	1965	1966	1967	1968	1969	1970	1971	1972
Freshwater fishes, n.e.i.	10 000	10 000	10 000	10 000	10 000	15 000	15 000	15 000
	1973	1974	1975	1976	1977	1978	1979	1980
	15 000	15 000	15 000	15 000	15 600	15 100	15 600	18 200
	1981	1982	1983	1984	1985	1986	1987	
	20 500	22 326	22 927	23 800	24 000	24 200	24 000	

Source: 1965–69 Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–81 FAO Fish.Dept. Fishery Statistical Database (FISHDAB)
1982–87 Yearb. Fish.Stat.FAO, 64 (1989)

The nominal "catches" in the inland waters of the Federal Republic of Germany for the 1965–87 period as compiled by FAO from data received from the Federal Republic of Germany, are shown in Table 8. No distinction is made in these statistics between those fish derived from capture fisheries and those that are the product of aquaculture, and there is no breakdown into species. It is known that the catches for 1971–73 were estimates by the Federal Republic of Germany and it seems obvious that all the other figures are also very rough (as well as rounded) estimates. A statement emanating from the Federal Republic of Germany's Ministry of Food, Agriculture and Fisheries (Gallus, 1979) said that the inland commercial fishery of the country produced about 3 000 t of "table fish" annually, and that the trout and carp pond fisheries (i.e., aquaculture) produced another 10 000 t. This total of 13 000 t is close to the 15 000 t annually which were recorded during the 1970–76 period in the FAO statistics and indicates that the capture fishery was about one-third that of the aquacultural production. Riedel (1982) states that the capture fishery in Germany was about four-fifths of the total inland fishery of 1909, declining to only one-fifth of the total in 1978.

Table 9 illustrates, as reported to FAO, the commercial catch in the Federal Republic of Germany's marine waters of freshwater fishes and those found in both fresh and marine waters. Quantitatively, it is not very useful, but it does demonstrate that some freshwater fishes are taken in the sea (undoubtedly the brackish waters of the Baltic), and the importance of the eel and smelt fisheries in the Federal Republic of Germany. It may be noted that the figures in this table on salmon catch do not agree exactly with those of Larsson (1980) for the 1969–78 offshore catches by the Federal Republic of Germany in the Main Baltic Basin who cited salmon catches here ranging from 134 t in 1969 to only 16 in 1978. Since the figures in Table 9 pertain to the Federal Republic of Germany's catch in the entire Northeast Atlantic fishing area, and FAO statistics are sometimes rounded, discrepancies might be expected. However, in some cases Larsson (1980) has cited catch figures which exceed those of FAO for the wider area, e.g., 77 t in 1977 instead of 36 t.

Table 9

Nominal catches of freshwater and diadromous species in Marine Statistical Fishing area 27, Northeast Atlantic, by the Federal Republic of Germany, 1965–87 (in tons)

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Freshwater fishes, nei	-	-	-	-	-	100	100	100	100	51	43	57
Sturgeons (Acipenseridae)	0	0	0	0	0	0	0	0	0	77	0	0
European eel (Anguilla anguilla)	400	500	600	600	500	500	500	400	400	351	382	386
Atlantic salmon (Salmo salar)	200	200	200	200	200	200	100	100	100	53	81	65
Trouts (Salmo spp.)	0	0	0	0	0	0	0	0	0	0	-	-
European smelt (Osmerus eperlanus)	300	300	300	300	200	200	400	200	500	166	384	228
Salmonids (Salmonidei)	0	0	0	0	0	0	0	200	800	462	274	0
Allis shad and Twaite shad (Alosa spp.)	0	0	0	0	0	0	0	0	0	0	0	1

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Freshwater fishes, nei	56	29	15	23	78	126	127	69	49	88	88
Sturgeons (Acipenseridae)	0	0	0	0	0	0	0	0	0	0	0
European eel	382	319	348	330	316	354	304	255	217	212	154
Atlantic salmon	36	17	33	47	21	16	21	34	34	63	35
Trouts (Salmo spp.)	-	-	-	-	-	-	-	-	-	-	-
European smelt	276	440	332	293	281	255	133	172	88	131	149
Salmonids (Salmonidei)	0	0	0	0	0	0	0	0	0	0	0
Allis shad and Twaite shad	1	7	1	0	1	0	0	0	0	0	0

0 = Probably nil, negligible, or insignificant; or less than 50 t during 1965–73, or less than half a ton during later years.

- = This category not listed this year

Source: 1965–69 Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–83 FAO Fish. Dept. Fishery Statistical Database (FISHDAB)
1984–87 Yearb.Fish.Stat. FAO, 64 (Publ. 1989)

The last detailed statistics on both the catch by capture fisheries and aquacultural production in inland waters obtained by the author from the Federal Republic of Germany are those for 1971 and 1981. They are listed below in sections 7.1 and 7.2[1].

[1] Official Federal Republic of Germany statistics based on census may not be readily available except at infrequent intervals, and it is often necessary to use rather old statistics. The last inland fishery statistics derived by census are those for 1971/72 and 1981/82

7.1 Capture Fisheries

7.1.1 Commercial fishing

Table 10 breaks down the inland commercial fish catch for 1971 and 1981. Referring only to the latter figures (for 1981), note that the total catch amounts to only 2 495 t compared with the "catch" statistics cited in Table 8 and that for "edible fish" is even less. It is a useful table, however, in demonstrating the relative importance of the lake and river fisheries and the composition of their stocks. As might be expected, the lake the fishery exceeds the river fishery both in total weight of catch and in the percentage of valuable fishes (e.g., coregonids as opposed to cyprinids). In relative importance overall by weight of the edible fish, the major specified groups ranked as follows in 1981: cyprinids (35 percent), coregonids (20 percent), trouts (17 percent), and eel (15 percent). Although the statistics for 1971 have been included in Table 10, they are not readily comparable with those of 1981 because neither tench nor trouts were represented separately. One assumes that their catch was included elsewhere.

Considering the above figures and the statement of Gallus (1979), it might appear that the commercial catch of inland fishes in the Federal Republic of Germany is indeed around 3 000 t annually. However, rough estimates made by the German Fisheries Association indicate a catch of about 4 000 t in 1983 and about 4 000 t in 1985 (Tiews, 1986, 1988).

Another measure of the importance of the inland commercial fishery in the Federal Republic of Germany and the changes that have occurred in its use are evidenced in statistics on the number of commercial fishery enterprises and the extent of the areas they have exploited. These are shown in Table 11. During the entire period of 1962–81, the number of river fisheries declined by 61 percent, the number of lake fisheries decreased by only about 1.5 percent. There was an overall decline in the number of fisheries (enterprises) of 43 percent. There was also an overall decline in the number of hectares fished (24 percent). As again might be expected, there was a greater stability in the lake fisheries than in the river fisheries. Thus, although river fisheries fished 43 percent less area in 1981 than in 1962, the lake fisheries fished only 18 percent less area.

The number of commercial fishermen on inland waters in the Federal Republic of Germany has also declined decidedly[2]. Circa 1957, it was estimated that they numbered about 30 000 (EIFAC, 1964), but by 1972 these had been reduced to only 1 669 (Federal Republic of Germany/EIFAC, 1977), and to only 1 022 in 1981 (Statistiches Bundesamt Wiesbaden, 1984).

With respect to the catch of food fish in the different Länder, in 1981 the bulk of its catch was made in Bavaria (33 percent), Schleswig-Holstein (25.5 percent) and Lower Saxony (21.5 percent) (Statistiches Bundesamt Wiesbaden, 1984).

Gillnets are used to catch coregonids in German inland waters. Stow nets, trawls, longlines, permanent barriers, traps and electric gear are used for eel fishing in rivers and lakes, while trawls, traps, and hooks are used to catch eels in coastal waters. Germany uses drift nets and longlines to catch salmon in the Baltic.

[2] A "commercial fisherman" is defined as one who earns more than 50 percent of his livelihood by fishing, or in some states (Länder) those who spend more than 50 percent of their working time fishing (Kühlmann, 1982). A large number of the inland commercial fishermen in Germany are part-time workers, e.g., 75 percent of them in 1972. In 1981, more than one-half of them worked under 50 days each as commercial fishermen (Statistiches Bundesamt Wiesbaden, 1984)

Table 10

Inland commercial capture fishery in the Federal Republic of Germany, 1971 and 1981 (in tons)

Species	River fishery		Lake fishery[a]		Total inland fishery	
	1971	1981	1971	1981	1971	1981
Edible fish						
European eel (Anguilla anguilla)	121.4	160.8	124.5	151.3	245.9	312.1
Coregonids (Coregonidae)	1.7	0.0	379.6	429.0	381.3	429.0
Trouts (Salmonidae)	-	38.6	-	311.4	-	350.0
Pike (Esox lucius)	34.5	20.8	56.4	36.2	90.9	57.0
Common carp (Cyprinus carpio)	18.7	17.0	43.3	48.0	62.0	65.0
Tench (Tinca tinca)	-	11.8	-	9.8	-	21.6
Other cyprinids (Cyprinidae)	362.3	214.4	291.1	410.8	653.4	652.2
European perch (Perca fluviatills)	8.2	4.8	44.7	38.3	52.9	43.1
Pike-perch (Stizostedion lucioperca)	19.7	24.4	27.3	18.6	47.0	43.0
Other fishes	266.0	132.3	21.2	28.0	287.2	160.3
Total	832.5	624.9	988.1	1 481.4	1 820.6	2 106.3
Other categories						
Fingerlings	46.1	69.5	55.9	11.3	102.0	80.8
Forage fish	115.5	106.0	89.2	201.0	204.6	307.0
Crustaceans	2.5	0.5	1.9	0.4	4.4	0.9
Total	164.0	176.0	147.0	212.7	311.0	388.7
Total commercial capture fishery	996.5	800.9	1 135.1	1 694.1	2 131.6	2 495.0

[a] Does not include the catch from Lake Constance

Source: Federal Republic of Germany/EIFAC (1974, 1989) based on the official German census (see Statistisches Bundesamt Wiesbaden)

Table 11

Number of enterprises and area fished in the inland capture fishery of the Federal Republic of Germany 1962, 1972, 1981[a]

Fishery	Year	Under 10	10–50	50–100	100–500	500+	Total
Number of Enterprises							
River	1962	500	212	144	226	19	1 101
	1972	269	215	79	67	5	635
	1981	205	124	42	53		424
Lake	1962	32	52	14	52	119	269
	1972	73	50	24	126	20	293
	1981	63	47	21	134		265
Totals	1962	532	264	158	279	138	1 370
	1972	342	265	103	193	25	928
	1981	270	183	64	200		717
Areas Fished (ha)							
River	1962	1 182	4 581	8 762	32 553	7 758	54 835
	1972	1 055	5 020	5 230	12 532	2 900	26 737
	1981	850	4 020	2 952	23 329		31 151
Lake	1962	114	1 330	1 033	12 547	42 353	57 377
	1972	180	1 125	1 796	28 239	20 737	52 078
	1981	275	1 088	1 508	44 283		47 154
Totals	1962	1 295	5 911	9 795	45 100	50 111	112 212
	1972	1 235	6 146	7 026	40 771	23 637	78 814
	1981	1 144	5 444	4 541	73 693		84 822

[a] Does not include the commercial fishery on Lake Constance

Source: Statistiches Jahrbuch über Ernährung, Landwirtschaft und Forsten der Bundesrepublik Deutschland (1982), and Statistiches Bundesamt Wiesbaden (1984)

7.1.2 Sport fishing

Sport fishing in the Federal Republic of Germany is practiced in all types of inland waters: rivers, small brooks, natural lakes, reservoirs, gravel extraction pits, canals, and artificial ponds. Almost all fishes sought by sport fishermen are edible and are eaten. Sport fishermen are not allowed to sell their catch.

The Federal Republic of Germany had about 622 000 sport fishermen (1.1 percent of its population) circa 1973 according to Gaudet (1973), and using the same figure, Federal Republic of Germany/EIFAC (1977) estimated that each of these anglers caught at least 18 kg of fish a year or about 11 200 t collectively. Circa 1978, the number of anglers had risen to about 800 000 (Gallus, 1979), but this still constituted only about 1.5 percent of the country's total population. The number is, however, increasing at a rate of 2–5 percent annually according to Kühlmann (1982), who points out that the area which can be fished by these anglers is rather constant. He also lowered the estimate of the annual angler catch (which is believed to include ocean-caught fish) to about 8 000 t. Although this was only about 2 percent of the country's entire fishery catch, he pointed out that this sport-catch figure exceeded that for the entire commercial catch in the same area.

As in most European countries, many of the anglers are organized into societies which provide fishing possibilities not only for their members, but to non-members to whom licences are sold.

Sport fishing receives governmental approval as a healthful activity which contributes to the economy and aids in the protection of the aquatic environment.

7.2 Aquaculture

The two principal fishes cultivated for food in the Federal Republic of Germany are rainbow trout and common carp. Others are: brown trout, European eel, tench, pike, and pike-perch.

Table 12 shows the number of fish farms and ponds, as well as the pond and water areas of these farms in the Federal Republic of Germany, as revealed by a census in 1981. Table 13 shows the production through aquaculture of carp and salmonids (primarily trout) in the Federal Republic of Germany as revealed in censuses of 1971 and 1981. The production figures are undoubtedly minimal-as will be seen below - and the tables are of interest primarily in showing the disposition of the various elements of pond culture as well as (in the case of production) the trend. Ackefors (1989) estimation differs somewhat from that in Table 12, saying that in 1988 there were 16 262 ha of fish ponds in the Federal Republic of Germany.

Trout. The major areas of high production of trout in the Federal Republic of Germany are the southern Länder of Bavaria with 28 percent of total production and Baden-Württemberg with 19 percent in 1981 (Statistiches Bundesamt Wiesbaden, 1984).

Although some farms use concrete raceways, most of the trout are still produced in earthern ponds using running water. Brown (1983) says that the usual calculation in the Federal Republic of Germany for water flow is 10 litres/sec for 1 t of fish, but Alabaster (1982) shows a range of 65.8–175.8 litres/sec/t for surveyed ponds in the Federal Republic of Germany. There is also some cage culture in the Federal Republic of Germany, usually in gravel pits with cages from 50 to 70 m^3. In 1988, about 3 000 t were produced in cages according to the EIFAC Working Party on Fish Farm Effluents.

Less than one-half of the rainbow trout eggs are produced domestically during the September-May period. Most of the others are imported from Denmark. Live trout less than 250 g in size are also imported and fed to attain marketable size, which is about 250–300 g. Most of the fish are sold for cooking, some sold at about 300–500 g for smoking, and some sold to fish-out ponds at two-summer size. Of the 15 500 t of cultivable trout produced in Germany in 1989, 97 percent were “portion” sized according to the Fédération Européenne de la Salmonidae (FES, 1989).

Table 12 shows the number of trout farms in the Federal Republic of Germany and their size in 1981. Table 13 shows the production in 1971 and 1981 of different size/age classes. Of the total production in 1981 of 5 297.7 t, 4 011.6 were food fish and the remainder large fingerlings. Of the 4 011.6 t of “food fish”, 3 894 t or 97 percent were rainbow trout.

Although these are the latest “official” statistics on German production, it is obvious that they are in no way representative of today's production. Table 14 is included to illustrate this point. It also demonstrates that as is customary for many European countries, statistics for aquacultural production in the Federal Republic of Germany differ depending upon the source. However, as is similar for other countries (see for example, section 7.2 for Denmark), it is the development trend rather than the accuracy of specific figures which is most important.

EIFAC (1989) provides figures on aquaculture in the Federal Republic of Germany which differ in many respects from the ones listed in this chapter. They are not reproduced here, however, because their exact source is not indicated and some of them appear confusing.

It is obvious that since 1961 there has been a large development in the Federal Republic of Germany's trout industry. The number of trout farms tripled during the 1962–72 period (Gallus, 1979) and total production of trout also tripled during this period. With a production in 1989 of about 15 500 t annually, the Federal Republic of Germany now ranks about fourth in European trout production, but still well behind France, Denmark and Italy in this regard.

Although most domesticated trout in the Federal Republic of Germany are rainbow, brown trout and other salmonids are used to restock fishing waters. Rainbow trout are also imported as food from about 10 countries including Denmark and Italy.

Table 12

Number of fish farms and ponds, pond area and water area, Federal Republic of Germany, 1981

	Pond area (ha)							
	Under 1	1–2	2–5	5–10	10–20	20–40	50+	Total
Total[a]								
No. of fish farms	5 830	1 449	1 042	323	168	90	63	8 961
No. of ponds	14 620	6 426	7 417	3 502	2 229	1 788	2 029	38 011
Pond area (ha)	1 913	1 888	3 046	2 172	2 307	2 675	5 636	19 637
Water area (ha)	1 267	1 236	2 064	1 517	1 740	2 107	4 381	14 312
Carp farms[b]								
No. of carp farms	3 330	993	731	233	133	70	46	5 536
No. of carp ponds	5 523	2 748	3 270	1 678	1 252	1 063	1 220	16 754
Pond area (ha)	1 228	1 263	2 153	1 555	1 814	2 108	3 528	13 669
Water area (ha)	882	903	1 574	1 152	1 415	1 662	2 706	10 294
Trout farms								
No. of trout farms	1 583	197	114	28	10	-	-	1 932
No. of trout ponds	5 813	2 027	2 162	793	451	-	-	11 246
Pond area (ha)	349	259	309	179	131	-	-	1 227
Water area (ha)	174	116	135	79	63	-	-	567

[a] Includes enterprises having both carp and trout ponds

[b] “Carp ponds” include ponds which also raise other fishes, e.g., tench

Source: Statistisches Bundesamt Wiesbaden (1984)

In the last few years there has been a decided increase in the Federal Republic of Germany - as in Austria - in the number of “hobby pond farmers”. Kühlmann (1982) said that they then produced about 25 percent of the country's cultivated trout crop.

Common carp. Carp have been raised commercially in the Federal Republic of Germany for many years, with about four-fifths of the production in Bavaria.

As in Czechoslovakia, production of the desired size of carp generally takes three years as compared to only two years in more southern countries. Furthermore, many carp farms in the Federal Republic of Germany are very extensive with little fertilization or artificial feeding, i.e., they still carry out the old traditional “natural” cultivation.

Generally speaking, first-summer carp weigh 35–50 g, second-summer fish 350 g, and third-summer fish 1.25 kg (900–1 400 g). Most are harvested at 1–2 kg as family-sized fish. Carp are used both for food, particularly at Christmas, and the smaller (younger) fish are also sold to stock angling waters.

The number of carp farms increased by nearly 30 percent during the 1962–72 period (Gallus, 1979). In 1981 there were about 5 500 carp farms in the Federal Republic of Germany, totalling 13 669 ha (see Table 12). The average number of ponds per farm was 3 and the average pond size (water area) was 0.61 ha. It will be seen that 60 percent of the farms had ponds that did not exceed 1 ha in size.

In 1961, the carp production in the Federal Republic of Germany was 1 537 t, rising to 3 368 t in 1971, and 3 602 t in 1979 (Kühlmann, 1976; Brown, 1983). Production in 1981 of carp for consumption and 3-summer fingerlings from 5 336 farms was 3 061.9 t (see Table 13). Estimates of production by the German Fisheries Association for “consumption carps” are 6 800 t in 1983 and 6 200 t in 1985 (Tiews, 1986, 1988). Other estimates of carp (Cyprinus) production in the country are: 5 800 t (1984), 6 200 t (1985), 5 900 t (1986) and 5 400 t (1987) (FAO Fish.Info.Data and Stat.Serv., 1989).

Table 13

Aquacultural production of carp and salmonids in the Federal Republic of Germany, 1971 and 1981

	1971	1981
Carp production		
No. of fish farms	4 015	5 336
No. of 1-summer fingerlings	19 461 000	11 203 000
2-summer fingerlings	6 300 000 (no.)	1 342.8 (tons)
3-summer fingerlings (tons)	-	420.7
Fish for human consumption (tons)	-	2 641.2
Fish for human consumption plus 3-summer fingerlings (tons)	3 368	3 061.9
Salmonid production		
No. of fish farms	1 386	1 932
No. of eggs	139 630 000	143 867 000
No. of 1-summer fingerlings	32 092 000	37 337 000
2-summer fingerlings (tons)	-	1 060.9
3-summer fingerlings (tons)	-	225.2
Fish for human consumption (tons)	-	4 011.6
Fish for human consumption plus 2- and 3-summer fingerlings (tons)[a]	3 445	5 297.7

[a] Large fingerlings are commonly sold to stock fee fish-out ponds and other angling waters

Source: Federal Republic of Germany/EIFAC (1974, 1989), based on Statistiches Bundesamt Wiesbaden (1972, 1984). Some additions and slight modifications have been made by the author using Statistiches Bundesamt Wiesbaden (1984).

Brown (1983) derives an annual yield of 421 kg/ha for 1971, but he uses only the area of pond water “devoted to third-summer fish for food”, and on page 136 of his book he gives the average annual production of three-summer fish as 263 kg/ha. Kühlmann (1976) states that the annual yields of carp per hectare in the Federal Republic of Germany were 169 kg in 1961, 312 kg in 1971, and 270 kg in 1973. Gallus (1979) says that the average annual yield in the Federal Republic of Germany's carp ponds has risen from 170 kg/ha to 370 kg/ha, but judging from Tables 12 and 13, as well as the statement of Federal Republic of Germany/EIFAC (1989) it is closer to 300 kg/ha/year. The low yields, even the highest quoted, are undoubtedly a product of climate, cold water, and the extensive type of culture usually practised.

Demand for carp in the Federal Republic of Germany has slackened somewhat, but there is still an evident demand for this fish since it has been imported from at least eight countries including Yugoslavia, Hungary and Poland.

European eel. Eel is a very popular fish in Germany, but water temperatures are generally too cold for good growth. Attempts have been made to culture them using warm water from electric plants and a farm has been set up on the Mosel. Although Kühlmann (1976) did not list eel as one of the fishes cultivated in the Federal Republic of Germany, Brown (1983) states that in 1975 there was a total cultivated production in the Federal Republic of Germany of about 10 t. In 1981 this had increased to at least 70 t (Federal Republic of Germany/EIFAC, 1989). In a report to EIFAC in 1989, the Federal Republic of Germany said that the country had 26 eel farms, using recirculated water, with a scheduled production of 300 t, and planned 25 more such farms with a scheduled production of 138 t. Ackefors (1989) says that the country has two fish farms for eel.

Table 14

Estimated production of cultivated trout, 1961, 1971–89 (in tons)

Source	1961	1971	1972	1973	1974	1975	1976
Kühlmann (1976)	1 089	3 445	--	5 300	5 500	--	--
Riedel (1982)	1 066	3 445	--	--	--	--	--
Fed.Rep.Germany/EIFAC (1974)	--	3 445	--	--	--	--	--
Brown (1983)	--	--	3 642	--	--	5 300	--
Giorgetti and Ceschia (1982)	--	--	--	--	5 000	5 000	5 400
Shaw, Shaw and Thomas (1981)	--	--	--	--	--	--	10 000
Pinot and Kirk (1982)	--	--	--	--	--	--	--
Lewis (1981)	--	--	--	--	--	--	--
Fish Farm.Inter., 9(10)(1982)	--	--	--	--	--	--	--
Fish Farm.Inter., 11(7)(1984)	--	--	--	--	--	--	--

	1977	1978	1979	1980	1981	1982	1983
Kühlmann (1976)	--	--	--	--	--	--	--
Riedel (1982)	8 000	8 000	--	--	--	--	--
Fed.Rep.Germany/EIFAC (1974)	--	--	--	--	--	--	--
Brown (1983)	--	--	8 000	--	--	--	--
Giorgetti and Ceschia (1982)	6 000	6 000	--	--	--	--	--
Shaw, Shaw and Thomas (1981)	7 500	7 500	7 000	11 300	12 000	--	--
Pinot and Kirk (1982)	8 000	--	--	--	--	--	--
Lewis (1981)	--	7 500	7 000	--	--	--	--
Fish Farm.Inter., 9(10)(1982)	--	7 500	8 000	8 800	12 000	13 000	--
Fish Farm.Inter., 11(7)(1984)	--	--	--	--	--	--	14 000
Stat.Bund.Wies. (1984)	--	--	--	--	5 300	--	--

	1984	1985	1986	1987	1988	1989
FAO Fish.Info.Data and Stat.Serv. (1989)	14 000	14 000	14 000	14 500	--	--
FES (1986)	--	13 500	--	--	--	--
Ackefors (1989)	--	--	7 900	--	--	--
FES (1989)	--	--	--	--	14 400	15 500

Other species. Tench, perch, and pike-perch are also cultivated in the Federal Republic of Germany, mainly for stocking purposes. Brown (1983) says that about 300 t of tench are produced there annually. However, the official governmental statistics state that the production of tench as food fish in 1981 was 69.4 t. With the addition to this crop of three-summer or more fingerlings, the 1981 production amounted to 120.2 t. These same statistics record a production of about 35 t of other pond fishes in 1981. Pike are also raised in carp ponds as “police” fish, for stocking and to some extent as food.

A recent manual of freshwater aquaculture with particular reference to the Federal Republic of Germany is that edited by Bohl (1982).

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership and Availability

Fisheries are owned either by the Federal Government, the State (Länder) Governments or communities, sport fishing associations, and private individuals. Owners of fisheries are often organized into associations.

The owner of a fishery is free to decide who can use the fishery and at what price. There are only a few places in the Federal Republic of Germany where angling is "free", i.e., without being a member of a sport fishing association.

In most Länder, a precondition for angling is possession of an official sport fishing license.

8.2 Administration

The Federal Ministry of Food, Agriculture and Forestry, Underdepartment Fishery Politics is responsible in the field of freshwater fisheries only in matters of inter-territorial importance.

Legislative and other special problems of freshwater fisheries are the responsibility of the Länder. Within these states, the Ministry of Food and Agriculture or corresponding authorities deal with matters of freshwater fisheries, both sport and commercial, within their respective Länder and organization differs within them. In some Länder, Central Fishery Offices are established; in others freshwater fisheries are administered by regional bodies. There may be subordinated offices at district or community level. Direct supervision is by police or public fishery inspectors. Sport fishing clubs may have regulations in addition to those of the State. As far as there are Chambers of Agriculture (public bodies) in the Länder, they are responsible for both promotion of production and vocational training.

8.3 Education and Investigation

Training in inland fisheries is offered at various institutions, colleges, and schools throughout the Federal Republic of Germany which offer courses in subjects such as river and lake fisheries, carp and trout pond management, fishery economics, electrical fishing, and fish production. In addition to these schools, some Länder have established other courses on the subject.

8.3.1 Research Institutes

(i) Federal Research Centre for Fisheries, Institute for Coastal and Freshwater Fisheries at Hamburg, dealing with fishery biology and management, pollution, aquaculture, fish diseases, etc.;

(ii) Federal Research Centre for Fisheries, Institute for Fishing Techniques at Hamburg, development and research on fishing gear;

(iii) Federal Institute of Hydrography, including research on fish passage;

(iv) Federal Sanitary Board.

8.3.2 Länder Freshwater Fishery Institutes

There are several institutes in different Länder dealing with fish, fishery biology, pond management, limnology, etc. Included is an Institute for Lake Research and Lake Management at Lake Constance.

8.3.3 Other Institutes

(i) Hydrobiological Institute of the Max-Planck Society;
(ii) Federal Institute for Hydrology and Water Protection;
(iii) Limnological Institute of the University of Freiburg.

8.3.4 Institutes and University courses dealing with freshwater fisheries

(i) Institute of Hydrobiology and Fishery Biology of the University of Hamburg;
(ii) Institute of Marine Science of the University of Kiel;
(iii) University of Göttingen (fishery science);
(iv) University of Freiburg (hydrobiology, pathology, management);
(v) University of München: Bavarian biological station Demoll-Hofer Institute München with fish management branch, Wielenbach, biology of waste waters, fish disease, fish breeding, etc.;
(vi) University of Tübingen: freshwater fisheries and management.

8.4 Other Agencies

Both the organizations of the commercial fishermen and the associations of sport fishermen of the individual states are represented in the German Fisheries Association (Deutscher Fishereiverband E.V. Union der Berufs-und Sport-fisher).

8.5 International Agreements

The Federal Republic of Germany has bilateral agreements on the use of boundary streams with Austria and Denmark.

With respect to the Netherlands, a Permanent Boundary Water Commission was set up in 1963 under the aegis of the German-Dutch Border Treaty to deal with mutual interests in water management such as the hydrological regime of the rivers.

The Federal Republic of Germany has a trilateral agreement with Austria and Switzerland on water quality in Lake Constance, belonging to the Internationale Gewässerschutz Kommission für den Bodensee. Since 1893, fish management of Lake Constance (Bodensee) has been regulated by the Internationale Bevollmächtigen Konferenz für die Bodenseefischerei.

It belongs to another international commission with France and Luxembourg concerning water quality of the Mosel and Saar rivers. It is a member of the International Commission for the Protection of the Rhine against pollution given legal authority by a treaty together with France, Luxembourg, the Netherlands, Switzerland, and the European Economic Community (EEC). This Commission is charged with drawing up permit and discharge standards and will fix the maximum tolerable levels of pollution in the Rhine.

The Federal Republic of Germany also belongs to the Central Commission for Navigation on the Rhine to guarantee freedom of navigation on this river and signed by interested countries in 1868. Other members include France, the Netherlands, Switzerland and the UK.

It is a member of the Danube Commission concerning navigation and related problems on the Danube River with the other Danube countries.

[1] Based largely on Gaudet (1974), material from the Federal Republic of Germany sent to EIFAC in 1979, Europa (1982), Kühlmann (1982), and updated by Federal Republic of Germany/EIFAC (1989)

9. STATE OF THE FISHERY

9.1 Yield

The statistics appearing in the FAO Yearbook of Fishery Statistics (see Table 8) indicate that the nominal catch rose from 10 000 t per year in 1965 to 15 000 t in 1970 continued at about this level through 1979, and then started to rise, to achieve an annual catch of 24 000 t in 1985. On the other hand, such a wide discrepancy exists between these figures and those furnished by Federal Republic of Germany/EIFAC (1974) for 1971, that one simply cannot draw any conclusions concerning sustained yield with only these data at hand. Federal Republic of Germany/EIFAC (1974) states that the harvest from the inland commercial capture fishery of the Federal Republic of Germany in 1971 totalled 2 132 t, and even if one adds to this figure their total reported production from aquaculture in the same year of 6 813 t, one still has a catch/production figure of only 8 945 t instead of the 15 000 t reported in Table 8 for that year. Clearly, the data must be more specific and more refined to allow appraisals, and one assumes that all of the figures in Table 8 are very gross estimates.

Yields (kg/ha/year) from natural waters are not available in the material at hand. The average yield from cultivated carp ponds appears to be only about 300 kg/ha/year which is very low (see section 7.2).

9.2 Factors Affecting the Fishery

Although the Federal Republic of Germany is well threaded with large rivers and small streams, it is generally deficient in a good supply of standing waters throughout the country. The composition of native stocks ranges from the fish in cold, oligotrophic waters (salmonids and coregonids) to a wide variety of cyprinids, pike, percids, some brackishwater fishes, and the especially important eel in both inland and marine waters.

The soil conditions are not conducive to very fertile waters, and climatic conditions do not ensure a long growing season.

As is shown in section 6, the inland waters of the Federal Republic of Germany have and continue to be subjected to heavy impact by man's use - almost all of it unfavourable to fisheries. Such use has resulted in the demise of stocks of valuable fishes, such as the Atlantic salmon, and has shifted the composition of lake stocks from coregonids to cyprinids. Drainage, barriers to migration, and especially water pollution from manufacturing, inland shipping, mining, sewage, and agriculture have all contributed to this degradation of the Federal Republic of Germany's inland waters.

In 1984, Germany passed new clean air standards to reduce sulphur emissions. Its high nitrogen emissions, another cause of acid rain, also require more attention. In recent years the Federal Republic of Germany has also enlarged the number of its water purification facilities, provided incentives to reduce pollution, adopted some water utilization standards, and supported the concept that water should be free of all pollution to the extent that can be attained by current technology and economics. Still, the annual runoff per caput of 2 685 m^3 is somewhat below the European average, and despite improvements in pollution control, the prospect of continued alleviation is not bright.

On the credit side, the hilly or mountainous terrain of the country does further water protection and thus protects fisheries, and future demands for water for either hydroelectric or irrigation are relatively small.

9.3 Prospect

Aquaculture has long been traditional in the Federal Republic of Germany and its growth can be expected, especially with modernization in the trout industry and in eel production. The use of warm water to produce fish is increasing as are efforts to develop closed systems using both fresh and sea water.

On the other hand, the traditional river and lake commercial fisheries are on the decline as suitable waters are diminished and as desirable fish stocks decline as a consequence. Eel fisheries provide some supplementation. There is also a growing emphasis on recreational fishing.

If goals for pollution control can be strengthened beyond present short-term objectives - no further deterioration in water quality and improvement of the regions worst affected - the prospect for inland fisheries in the Federal Republic of Germany will be decidedly improved.

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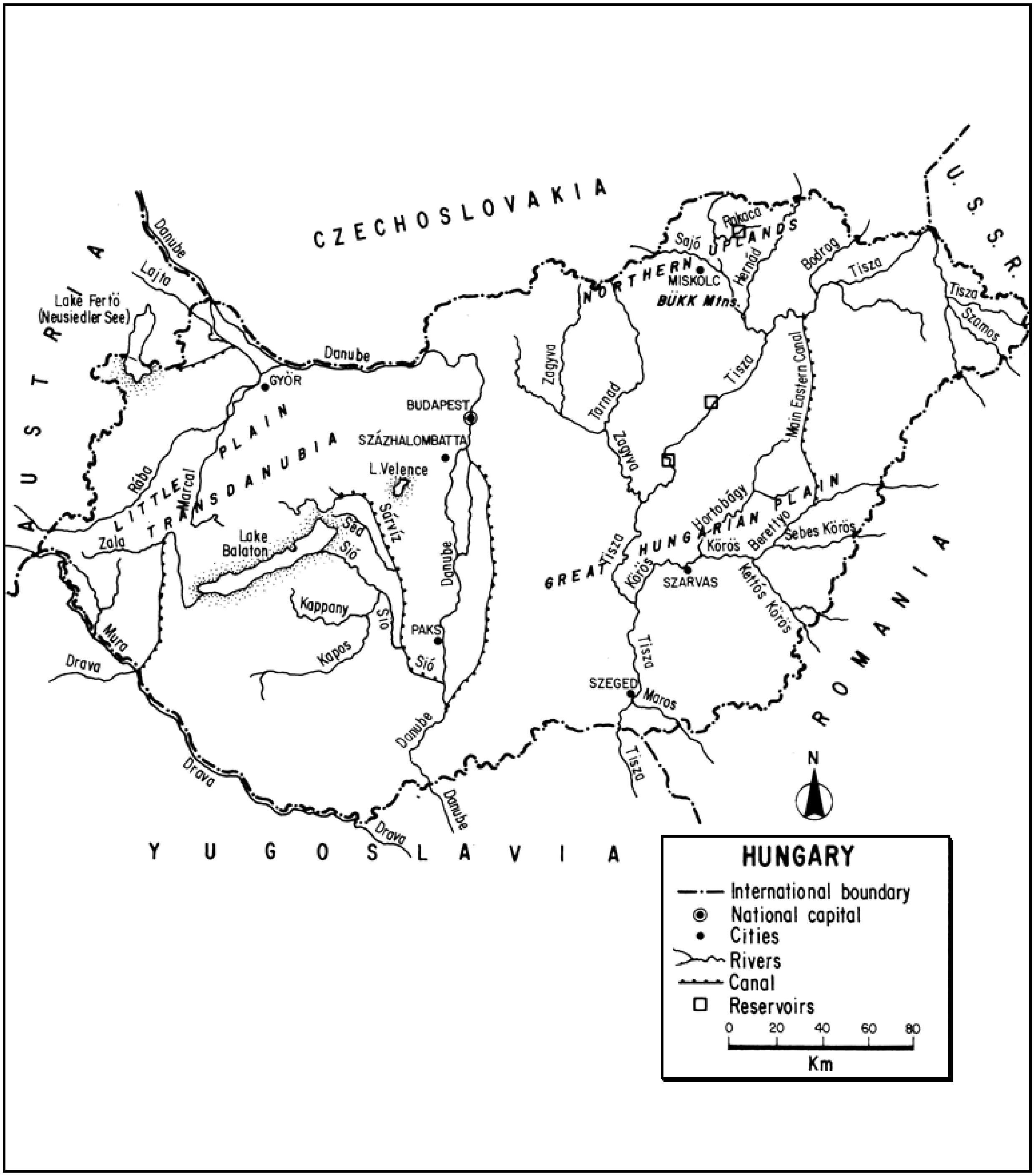

CZECHOSLOVAKIA
AUSTRIA
U.S.S.R.
ROMANIA
YUGOSLAVIA
Danube
Lajta
Lake Fertö (Neusiedler See)
GYÖR
LITTLE PLAIN
TRANSDANUBIA
Rába
Marcal
Zala
Lake Balaton
Sed
Sió
Sárvíz
L.Velence
BUDAPEST
SZÁZHALOMBATTA
Kappany
Kapos
PAKS
Mura
Drava
NORTHERN UPLANDS
MISKOLC
BÜKK Mtns.
Sajó
Rakaca
Hernád
Bodrog
Tisza
Szamos
Zagyva
Tarnad
Main Eastern Canal
Hortobágy
GREAT HUNGARIAN PLAIN
Berettyo
Sebes Körös
Körös
SZARVAS
Kettös Körös
SZEGED
Maros
N
HUNGARY
International boundary
National capital
Cities
Rivers
Canal
Reservoirs
0 20 40 60 80
Km

HUNGARY

Landlocked in central Europe, the Republic of Hungary is largely an area of fertile plains with lesser hilly and low mountainous areas. Its lowlands are dominated by the once intricate courses of the Danube and Tisza Rivers, now so well regulated that their former extensive floodplain fisheries have long been in decline. There are only three major lakes and relatively little reservoir area within the country.

Although primarily an agricultural land, increases in both industrial and domestic pollution have affected fisheries adversely. Furthermore, the quantity of water available for fisheries is severely restricted not only because of internal use, but because Hungary is largely dependent upon upstream countries for its supply. As a result, intensive warmwater pond fish culture provides by far the bulk of Hungary's fish production, and sport fishing is beginning to compete with commercial fishing.

1. AREA: 93 030 km^2

2. POPULATION: 10 658 000 (est. 1990) Density: 115 inh/km^2

3. PHYSICAL GEOGRAPHY

Hungary is situated in central Europe between 45°48' and 48°40'N latitudes and 16°23'E longitudes.

Its extreme length (E–W) is 528 km; its extreme width (N–S) is 268 km. Its altitudinal range is from 78 to 1 015 m, but two thirds of the country is below 200 m in elevation and only two percent rises above 400 m.

Hungary is bounded on the north by Czechoslovakia for 608 km, on the northeast by the USSR for 215 km, on the east and southeast by Romania for 432 km, on the south and southwest by Yugoslavia for 631 km, and on the west by Austria for 356 km[1]

[1] The lengths of these boundaries are taken from Worldmark (1984)

Lying largely within the middle Danubian or Pannonian Basin, Hungary is ringed on the west by the Alps and on the north and east by the Carpathians. The Danube, flowing from north to south, bisects the country into two major regions: (i) the Great Plain or Alföld, a lowland to the east of the Danube and south of the Northern Upland, occupying about 55 percent of the total area, and (ii) Transdanubia, a hillier region west of the Danube, occupying about 40 percent of the country. The Great Plain, a generally level and fertile series of hillocks and sand dunes, the chief agricultural area of Hungary, has a mean elevation of about 90 m. It, in turn, is bisected by the Tisza River which also runs from north to south across the country. Bounded on the west by Alpine foothills, Transdanubia is occupied by hills, low mountains, flatlands and the Lake Balaton Basin. Two other (minor) regions complete the picture: (i) the Little Plain, drained by the Rába and other rivers from Austria, an area of agriculture and swampland in the extreme northwest, and (ii) the Northern Upland, a well-forested volcanic fringe of the Carpathians ranging for 225 km along the Czechoslovakian border, east of the Danube and north of the Great Plain.

Originally much of the higher land was forested, especially with deciduous trees such as oaks and beeches, and with some conifers at heights. The eastern lowlands supported steppe and riparian grasses, shrubs and reeds. Much of the natural vegetation has been replaced as over half of the land is now cultivated for annual crops.

Soils in Hungary are distributed about as follows: forest soils (41 percent), skeletal in waterlogged fields and inundated areas (26 percent), chernozems (25 percent), alkali (6 percent), kotus and peat in the marshlands (2 percent). There are large areas of alkaline soils, covering about one million hectares in the eastern region. Some of these can be reclaimed for use as rice fields or for fish ponds, but a distinction must be made between two major types. Sodic alkali soils (solonchak), which are mostly in Danube deposits, can be found only where soils contain lime in their surface deposits. Tisza deposits (to the east) are solonetz and do not contain lime. In using lakes on alkaline soils for fish farm production, solonchak soils may produce a very high pH and free ammonia which may be dangerous especially when aquatic plants are decomposing in summer. On solonetz soils, there may be danger due to the release of hydrogen sulphide which may kill fish. This has occurred in backwaters and barrage ponds (Vámos and Tasnádi, 1975).

4. CLIMATE

Continental, but so strongly influenced by air currents from the Atlantic and Mediterranean that weather conditions vary greatly both seasonally and from year to year. Sometimes, one or the other of the three climatic types predominates.

The mean annual temperature is 11°C with an average range of -4° to 23°C and an absolute range of -34° to 41°C. January is the coldest month with a mean temperature of 0° to 4°C; July is the warmest month with a mean temperature of 20° to 22°C. The country is generally frost-free from mid-April to October.

The average annual precipitation is about 640 mm: 500–550 mm on the plains and 600–800 mm in the western hilly area. The heaviest rainfall occurs in May–July and in October. Only eight percent of the precipitation is in the form of snow. Most Hungarian rivers freeze over from late December to mid-February, and there is ice-cover on the lakes. Severe droughts may occur, increasing the need for irrigation and affecting fisheries adversely.

The total hours of sunshine are high for this latitude: 1 950–2 050 h per year or a total annual insolation of between 80 and 110 kcal/cm^2. The evaporative rate is also high. The average value of potential evapotranspiration on the Great Plain is about 700 mm; in a warm year, evaporation from water surfaces may reach 1 000 to 1 500 mm.

5. HYDROGRAPHY AND LIMNOLOGY

The total area of inland water in Hungary according to Table 4 is 0.74 percent of the country's total area or 690 km^2. This figure is equivalent to only the area of Lake Balaton and the Hungarian portion of Lake Fertö and therefore, must be too low. Hungary/EIFAC (1977) states that Hungary's inland waters total 1 450 km^2 or 1.6 percent of the country's area. Dobrai, Thuránszky and Pékh (1981) state that the water areas in fish production constitute 195.7 km^2 of pond farms and 1 299 km^2 of natural waters. Collectively, this constitutes 1 495 km^2 or 1.6 percent of the country's total area. A similar figure, 1 500 km^2 of surface waters is given by Fish Farm.Inter., 11 (11) (1984). According to FAO (1988) the inland water area of Hungary is 1 400 km^2 or 1.5 percent of the country's area.

The approximate annual run-off from rainfall on Hungarian territory is only 64 mm or 6 000 million m^3. Added to this is 114 000 million m^3 received from upstream countries, resulting in a total annual river discharge leaving the country of 120 000 million m^3 (Van der Leeden, 1975; ECE, 1978).

5.1 Rivers(Folyam)

All of the rivers of Hungary flow into the Danube, which with its tributary the Tisza constitute the two great river basins of Hungary. A third basin, the Drava is of importance only along the country's southwestern boundary. Hydrological data, including discharge, on these and other principal Hungarian rivers will be found in Tables 1 and 2.

Danube River. The greatest river in Hungary, the Danube or Duna, has a total length within the country of 417 km. Entering from Czechoslovakia (just below the border with Austria), it then flows along the Hungarian-Czechoslovakian boundary for 140 km before turning south to cross the country and finally enter Yugoslavia.

It is a great river throughout its extent, averaging about 450 m in width with a depth of 3 m, a drop of 40 – 5 cm/km, and a velocity of 0.6 – 2.5 m/sec. The range for minimum, maximum and average discharges, respectively are as follows: 570–620, 7 700–9 500 and 2 100 – 2 400 m^3/sec.[1]

[1] As is characteristic of many of the measurements provided in this review, these sometimes vary decidedly depending on the source. Those cited above are primarily from Dvihally-Tamás (1975); see Table 1

Table 1

Hydrologic data on the principal rivers of Hungary

River	Length		Drainage basin area		Mean width, depth slope of rivers in Hungary			Discharge at mouth m^3/s		
	within the country	Total	within the country	Total	width		depth slope			
	km	km	km^2	km^2	m	m	cm/km	Max.	Mean	Min.
Tisza	763	804	44 619	139 078	150	5.5	6	3 360	190.0	29.00
Danube	417	1 457	38 936	209 379	450	4.5	15	9 600	2 025.0	570.00
Dráva	225	695	6 242	40 490	150	2.5	23	2 100	600.0	200.00
Ipoly	193	257	1 518	5 108	20	2.0	30	360	16.2	0.20
Rába	182	283	5 564	10 113	45	3.0	50	560	36.4	6.50
Zagyva	174	174	5 672	5 577	30	3.0	30	150	1.4	0.04
Zala	134	139	2 578	2 578	40	2.0	20	137	5.8	0.25
Sajó	125	229	9 487	12 708	60	2.0	51	520	32.4	2.40
Sió	123	123	8 954	8 954	20	2.5	14	224	21.0	0.60
Hernód	112	282	1 134	5 436	60	2.0	60	552	29.9	2.40
Sárviz	111	111	3 449	3 449	12	1.5	21	45	5.0	1.40
Kapos	111	111	3 242	3 242	25	2.0	30	130	5.1	0.22
Tarna	101	101	2 112	2 116	15	2.0	120	860	2.6	0.015
Marcal	100	100	3 076	3 076	15	2.0	27	122	73.0	0.33
Hármas Körös	91	363	12 931	27 537	70	3.0	4	1 322	119.0	4.30
Berettyó	78	204	2 649	6 095	40	2.0	18	270	7.9	0.20
Sebes Körös	59	209	3 156	9 199	20	1.5	24	600	25.0	1.90
Szamos	50	415	602	15 881	100	2.5	10	1 350	120.0	15.00
Bodrog	50	267	1 382	13 579	50	3.0	3	1 300	120.0	4.00
Maros	49	754	1 385	30 332	90	3.5	26	1 800	150.0	22.00
Kraszna	46	193	389	3 142	15	1.5	13	83	3.5	0.01
Mura	37	454	1 750	14 138	80	2.0	65	1 050	150.0	50.00
Kettös Körös	37	273	1 744	10 386	40	2.0	10	687	68.0	0.5
Tur	28	95	112	1 262	30	1.5	26	234	18.0	0.22
Fekete Körös	21	168	151	4 645	20	1.5	14	572	29.0	0.4
Fehér Körös	11	236	352	4 275	20	1.5	16	605	23.6	0.001

Source: Van der Leeden (1975) after Ballo (Hungarian National Water Authority) (1973)

Table 2

Discharge of the Danube and Tisza rivers in Hungary

River Station	Basin area km^2	Mean monthly discharge, m^3/s Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Danube, Nagymaros	183 533	1 880	2 220	2 700	2 950	2 920	3 120	2 920	2 460
Tisza, Polgár	62 723	463	485	808	1 010	682	489	405	294
Tisza, Szeged	138 408	669	747	1 285	1 465	1 235	885	673	451
	Sep.	Oct.	Nov.	Dec.	Year	Period			
Nagymaros	1 920	1 690	1 810	1 770	2 360	1931–65			
Tisza, Polgár	301	267	428	441	506	1931–65			
Tisza, Szeged	384	379	628	683	790	1931–65			

Source: Van der Leeden (1975) after Unesco (1971)

Table 3

Characteristics of Lake Balaton

Basin area (km^2)	5 774
Elevation (m)	104
Area (km^2)	596
Length (km)	77
Width (km)	1.5–15
Volume (km^3)	1.8
Depth, mean (m)	3
Depth, maximum (m)	11.2
Retention time (years)	2.2
Water temperature, mean annual (°C)	10
Water temperature, summer (°C)	21.7–24.7
pH	7.8–8.8
Total dissolved solids (TDS)(mg/l)	400
Morphoedaphic index (MEI)[a]	133.3
Conductivity (20°C)($us.cm^{-1}$)	409–471
Evaporation ($m^3.s^{-1}$)	17.2

[a] $MEI = \frac{TDS}{\text{Mean depth}}$

Source: Biró (1977) and Dévai and Moldován (1983)

The Danube's total fall within Hungary is from 134 to 85 m, but most of this occurs in its upper portion. The average gradient as the river arrives from Austria is 30–40 cm/km, but it soon drops to 8–12 cm/km, and on the Great Plain it is a true “plains river” with a declination of only 9 km to the km. This slight fall, in addition to the irregularity of flow, accounts for great floods which markedly affect land use and its characteristically cyprinid fishery.

There are two regular floods a year. The early “white flood” (April–May) results from the thawing of snow in the Alps while the Carpathian rivers are still frozen and the Danube is ice-covered. The Alpine torrents break up the ice into floes which pile up and augment the floods. The later “green flood” involves more water - not just from the Alps but from ample June rains. For protection against these floods, over 1 100 km of dikes had been installed by 1968 to protect over 1 265 000 ha of land. With subsidence, the Danube normally reaches its lowest level at the end of summer. It may be frozen over for a month or so during severe winters.

According to Dvihally-Tamás (1975) the water of the Hungarian Danube is characterized by Ca^{++} and HCO_3 ions in excess, and its total amount of dissolved salts averages 200 mg/l. Its gross primary production (in $g/0_2/m^2/day$) averages 3.9 with a maximum of 15. He considers it to be contaminated at a low to medium level as compared to rivers in European industrial areas. Two of its principal sources of pollution are the city of Budapest and the Vág, which brings in waste-water from Czechoslovakia.

Major direct or indirect right bank affluents of the Danube are the Lajta and Rába (both originating in Austria), the Marcal and the Sió Canal (outlet of Lake Balaton) joined with the Kapos and Sárviz. Major left bank affluents of the Danube stem from the mountains of Slovakia: the Vág (Vah), Nyitra (Nitra), Garam (Hren) and Ipoly (Ipelv). The Ipoly, originating in Czechoslovakia, forms part of the Czech-Hungarian boundary before entering the Danube. There are almost no tributaries to the Danube entering from the Great Plain within Hungary.

Despite river training and diking, islands and side branches have not been eliminated in the upper section of the Hungarian Danuble. A rich water network still persists along much of the Hungarian/Czechoslovakian border and constitutes a good fishing section. Another good fish-producing section on the Danube is the stretch below Paks (about 100 km below Budapest) where old meander curves provide rich fishing areas.

<u>Tisza River</u>. The second largest river system within Hungary is the Tisza whose catchment is in the eastern half of the Carpathian Basin. With headwaters in the USSR and Romania, it enters Hungary from the north and proceeds southerly to enter Yugoslavia where it joins the Danube as its second largest tributary. Table 1 shows its length within Hungary as 763 km, its mean width as 150 m and its mean depth as 5.5 m[1].

[1] Erdei (1968) states, however, that the Tisza's full course in Hungary is only 579 km, shortened by regulation during the last century from its original 955 km within the country, and Dobrai, Thuránszky and Pékh (1981) say that its Hungarian course is 600 km

Primarily a “plains river” throughout its Hungarian course, with a fall of only 6 cm/km, it meanders sluggishly over its floodplain of dunes and oxbow marshes. Like the capricious Danube, it is subject to floods and 4 000 km of dikes have been installed. Floods occur in early spring, early summer (“green flood”) and autumn. The Tisza's flow is lowest in winter and it may freeze over.

Its major Hungarian affluents from the right are the Bodrog and Sajó (both from Czechoslovakia), the Eger and Zagyva. From the left it is joined by the Körös (Cris), Szamos (Somes) and Maros (Mures) from Romania.

<u>Dráva River</u>. The third largest river system in Hungary is the Dráva with a mean width of 150 m and mean depth of 2.5 m. With most of its volume originating in Austria (where it is called the <u>Drau</u>), it flows across the northern tip of Yugoslavia, forms 95 km of the Hungarian-Yugoslavian border, and then turns back into Yugoslavia for about 64 km before joining the Danube. The Dráva also has three annual floods.

Market fishing is conducted, primarily by fishery cooperatives, on the Danube, Tisza and their tributaries. The average annual professional catch during the last decade has been about 1 000 t on the Danube and 800 t on the Tisza (Dobrai, Thuránszky and Pékh, 1981). Catches are primarily of cyprinids. The rivers are also used by anglers.

5.2 Lakes (Tó)

There are only three lakes of consequence in Hungary, all in Transdanubia.

Lake Balaton. Fringed by the Bakony Mountains on its northern shore, Lake Balaton lies in the western half of the country at an elevation of 104 m. Formed in a tectonic rift, it is the largest lake in central Europe, its area of 596 $km^2{}_3$ exceeding that of either Lake Geneva or Constance. Fed by the Zala River with a flow of 12–15 m^3/sec., 32 small streams and 11 canals, it debouches via the Sió Canal which proceeds to the Danube. With an average depth of only 3 m, its surface water attains a temperature of 24°C (occasionally 30°C). Ice cover averages 44 days and the lake may freeze to a depth of 40 cm. About 25 percent of its shore is covered with Phragmites. This slightly alkaline lake (400 kg/1) of Ca and Mg bicardonates according to Biró (1984) is very rich, saturated with oxygen, and can be considered hypereutrophic (see Table 3 for other characteristics).

Balaton has been fished since 5000 B.C. Gillnets and seines were used here in 1230 A.D., and in 1880 about 20 000 gillnets were in use (Biró, 1977). Ice fishing with long nets was abandoned in 1957. Most of the commercial fishing today is pursued using long surrounding nets which were introduced here in the 1920s. Of a total of perhaps 47 fish species in Lake Balaton, about 15 are of economic significance. The most valuable indigenous fish is the pike-perch (Stizostedion lucioperca), but common bream (Abramis brama) together with the garda (Pelecus cultratus), a shoaling cyprinid, accounts for about 80 percent of the net catch. Following large introductions of European eel (Anguilla anguilla), the eel catch had attained 32.8 t by 1969 of which anglers took 22 percent (Kovary, 1971). The overall catch by professional fishermen is about 1 000–1 200 t of fish per year, although declining in 1985 and 1986, and anglers' catches were 347.9 t in 1977 (Dobrai, Thuránszky and Pékh, 1981). (See also Tables 7 and 9.)

One of the principal vacation areas in Hungary, sometimes visited by over half a million people on a week-end, Lake Balaton has a shoreline which is a continuous chain of summer resorts and lodges. As a resort area, both commercial fishing and angling must complete with other water uses such as swimming, boating and water-skiing, and the high tourist population now exceeds that estimated to tax the capacity of the lake.

Lake Fertö[1]. The second largest lake in Hungary is Lake Fertö in the extreme northwest, where it is shared with Austria, known in that country as the Neusiedler See. About 32 km in length (N–S) and 4–10 km wide (E–W), it is a steppe lake which has almost dried up at times. Its reported area varies both with the year and the author consulted. It is assumed here that Löffler (1979) is close to the mark. He says that at an elevation of 115.5 m above sea level, the total area of the lake approaches 300 km^2, of which about 200 km^2 are covered by the reed, Phragmites, and that at its deepest the present basin is about 113.5 m above sea level. In the same publication, Hacker (1979) indicates that the Hungarian portion of the lake is about one-fifth of the total area, i.e., about 60 km^2 at 115.5 m elevation. Kusel-Fetzmann (1979) also states that the total area is about 300 km^2, about 50 percent is covered with reeds and that its depth is 0.5–2 m, maintained since 1965 at 1.75 m through an agreement between Hungary and Austria. Wurzer et al (1982) agree that the total area of the lake is 300 km^2 but that the area of open water is about 150 km^2. One of the latest estimates indicates that the total area of

Lake Fertö without its reed belt is 152 km^2, of which the Hungarian portion is only 20 km^2 (Republik Osterreich, 1983).[2]

[1] This is essentially the same description that is used in section 5.2 of the review for Austria and the full citations for Republik Österreich (1983) and Wurzer et al. (1983) will be found there

[2] Some estimates in addition to those cited in the main text follow. Erdei (1968) says that Lake Fertö has a total area of 335 km^2 of which one-fourth is in Hungary, i.e., its Hungarian area would be about 84 km^2. Kovary (1971) gives its total area as 320 km^2 and its Hungarian area as 52 km^2. Hungary/EIFAC (1977) and Biró (1984) state that its total area is 280 km^2 of which 82 km^2 is Hungarian. Fodor (1984) gives its total area as 335 km^2 of which 87 km^2 is Hungarian

Fed by mountain water, including one tributary of consequence, the Wulka, this high-silicate water is mixed with soda-containing ground water from old sediments. The lake water has a high salt content which has ranged from about 1.8 g/1 depending upon the year and the depth of the water. Biró (1984) says that it has more than 5 000 mg/1 of Na_2SO_4. Its volume varies from 180 to 250 million m^3. Its theoretical water retention time is about one year and its discharge is only about 0.5 to 2.0 m^3/sec. (Wurzer et al., 1982). Normally, its only outlet (artificial) is the Hanság Canal which proceeds to the Moson Danube. The lake is turbid and contains many water weeds in addition to its reed belts. Summer water temperatures are high; they reach 25–30°C. Ice cover lasts 10 to 97 days and in 1928/29 the lake froze to the bottom with severe effects upon its fish population.

The lake now contains about 23 species of fish, including introductions, according to Hacker (1979). Fourteen of these are cyprinids, including the exotic silver carp (Hypophthalmichthys molotrix) and grass carp (Ctenopharyngodon idella). The lake also contains pike (Esox lucius), three percids and the introduced European eel. In 1975 Austria and Hungary signed an international agreement concerning the management of the lake's fisheries especially with respect to stocking. Both countries have stocked the Fertö with elvers. Hungary's commercial eel catch in 1970 was 7.8 t with anglers accounting for 20 percent of the catch.

For many years there have been plans to drain the lake and convert it into agricultural land (despite its poor soil). It now appears that the lake will continue as a unique resource, including its wealth of bird life as well as its highly fluctuating fishery.

Lake Velence. Known as the Velencei-tó in Hungary, this lake lies at an elevation of 106 m, northwest of Balaton toward Budapest. The third largest lake in Hungary, it has an area of about 26 km^2 but only about 17 km^2 of open water. The remainder is reeds and meadow, worked artificially to maintain depths for bathing and fishing. It is fed by only a few small streams and has a depth of 0.9 m (Andrikovics, 1975). It is classed by Biró (1984) as a “sodic” lake, containing 2 000–3 000 mg/l of Na and Mg bicarbonates. Stocked with elvers, its eel catch in 1969 was 9.9 t (Kovary, 1971).

5.3 Reservoirs (Rezervoár)

Despite a considerable dependence on the use of small reservoirs for both water resource management and inland fishery development (as also in countries such as Bulgaria and Spain), the total number of sizeable reservoirs has not been large in Hungary. Circa 1972, the total number of lakes and reservoirs in the country surpassing 100 ha was only 34. There were, however, 300 reservoirs of 10 ha or over and more than 1 200 of 0.5 ha or over (SCOPE, 1972).

Reservoir construction, mainly for agricultural purposes has increased in recent years. Hungary/EIFAC (1977) stated that the total area of all types of Hungarian reservoirs was 8 540 ha and by the end of 1978, agricultural reservoirs with a total surface area of 8 000 ha average volume of 640 000 m^3, and total capacity of 125 million

m^3 had been built. Not yet in operation at the time was the newest and largest reservoir, one constructed on the Tisza River, reported to have an area of over 12 000 ha, one-fifth the area of Lake Balaton (Dobrai, Thuránszky and Pékh, 1981).

The primary function of a Hungarian reservoir (storage for agriculture, drinking water or industry) is considered paramount, and many are seasonal in nature and subject to severe fluctuations in water level. Nevertheless, reservoirs are considered to be “natural waters” and capable of being used for at least semi-intensive fish and water-fowl production.

5.4 Canals (Osatorna)

Hungary has many canals. Some function partly as artificial waterways for transport and partly as irrigation or drainage channels. Examples include the 97-km Main Eastern Canal connecting the Tisza with the Berettyó (a tributary of the Körös), the 100-km Sió Canal connecting Lake Balaton with the Danube, and the Hanság between Lake Fertö. and the Moson Danube.

6. LAND AND WATER USE

Table 4

Pattern of land use in Hungary, 1986[1]

	Percent
Arable and permanent crops	56.85
Permanent pasture	13.30
Forests and woodland	17.80
Other land	11.30
Inland water	0.74
Total	100.00-

[1] The Statistical Yearbook of Hungary (Statisztikai Évkönyv, 1981) uses a different classification for land use which does not permit one to distinguish between land and water areas. It does, however, list 384 km^2 of the country as reeds (nádas) and 252 km^2 as fish ponds (halastó). The Statistical Yearbook for 1987 lists reeds and fish ponds as 630 km^2 in 1980 or almost the same total as in 1981

Source: 1987 FAO Prod.Yearb., 41, Publ. 1988

Although agriculture accounts for only about 20 percent of the national income, Hungary is fundamentally an agricultural country. Its proportion of arable land to its total area (51 percent) is one of the highest in Europe and the country as a whole is about 59 percent urban and 41 percent rural. Most of the arable land lies in the Great Plain, but there are pastures, vineyards and orchards in the hills. Cereals are the predominant crop followed by livestock production. A large portion of the land is devoted to fodder. Most of the agricultural land is controlled by collective and State farms.

In order to achieve its present agricultural staus, there have been profound changes in the original land and water areas. Until the middle of the last century, over a million hectares along the banks of the Danube and more than two million hectares on both sides of the Tisza were marshland and bog -almost useless for farming. During the second half of the century, these great expanses were drained and reclaimed with marked effect on the fisheries (see section 9). Similarly, elimination of marshy areas of Lake Balaton in the last century reduced much of the natural spawning area. Shortening of Hungary's rivers has already been mentioned in section 5.1. Biró (1984) says that the river lengths in Hungary had been reduced from 6 014 km to 3 589 km by about 1967.

By 1967, 105 curves on the Tisza alone had been straightened and by 2050 it is expected to be completely regulated.

In years of average and normally distributed precipitation, most of the crops in Hungary can provide medium yields without irrigation. In the not infrequent dry years, however, irrigation is a necessity, as it also is for crops such as rice. In 1976, 320 000 ha were under irrigation, decreasing however by 1986 to 163 000 ha or only 1.8 percent of the country's area. Not all of these demands are made on surface waters. Ground water supplies are good and have a considerable place in irrigation. Fertilizer use is well above the European average and well above that of other lower Danube countries. Herbicides are widely used for weed control and vines and orchards may be sprayed eight times a season.

Forest resources are very small. Hungary ranks about fifteenth in European forest production. Mineral resources are also small aside from high supplies of bauxite, some uranium, some poor grade coal and some oil and natural gas.

Industry, which accounts for over half of the economy, is increasing, with emphasis on the machine industry, electronics and chemicals. Virtually all industry is state-owned and highly concentrated in Budapest, Györ and Miskolc. In 1970, less than one third of the industrial effluent was treated adequately and only 35 percent of the domestic sewage was treated properly (Johnson and Brown, 1976).

Most power is thermally generated. In 1985, only 46 000 kW or less than one percent, of the installed electrical capacity of 5 815 000 kW was hydroelectric, and there is little potential for its increase. The most important hydroelectric development is the Nagymaros-Gabcikovo barrage on the Danube with Hungarian and Czechoslovakian operation of a 850 mW plant, the first high capacity hydrostation in Hungary. Installed nuclear and geothermal power totalled 829 000 kW in 1985.

Automobile road density in Hungary was about 1 km/km^2 in 1986. Railway density is low, about 0.14 km/km^2 (1987). Passenger car ownership is low, only 156/1 000 people (1987). Navigable waterways totalled 1 622 km in 1987. Of these, 417 km were on the Danube (which also had about 105 km of alternate routes), 443 km on the Tisza and lesser amounts on the Körös (about 124 km), Sió (100 km) and Dráva.

Landlocked and distant from an oceanic supply, demand for fish in the Hungarian diet has been rather low. It has increased to four times the demand of 1950 but (in 1987) the annual fish consumption was still only 2 kg per caput including imports and angler catches as opposed to a total meat consumption of 74 kg per caput. As in other central European countries, the demand for freshwater fish is quite seasonal. The amount of fish sold during the first few days before Christmas is about equal to the amount sold in two normal months. Still, with its large river systems and with ponds, reeds and marshes occupying much of the Great Plain until the middle of the last century, fishing has been a traditional occupation in Hungary. Commercial capture fisheries are still holding up rather well, although in competition with other water uses and undergoing gradual replacement by pond fish culture and intensive production (almost pondfish culture) in backwater areas. Angling by residents is increasing but - with its emphasis on warmwater fishes - is not a real attraction to tourists from other countries. (Including those in transit, Hungary had about 16 million tourists in 1986.)

With respect to complete use of surface water, the percentages of use in 1972 were as follows: agriculture (32.1 percent) industry (23.4 percent), population (2.5 percent), other uses (42 percent) according to ECE (1978)[1]. Hungary is one of the few

European countries in which agricultural water use still exceeds that of industry (others are Cyprus, Greece, Malta, Portugal and Spain).

[1] Ambroggi (1980) gives somewhat different figures for Hungarian water use: agriculture (about 45 percent), industry (about 45 percent) and domestic use (about 10 percent)

7. FISH AND FISHERIES

There are about 70 species of fish in Hungary. About 55 species belonging to 15 families are resident in the Danube, about 47 species are found in Lake Balaton, and about 23 species are found in Lake Fertö. Thirty-two species have value as food or sport fish; they are listed taxonomically in Table 5 under categories used in "Fisheries in Hungary".

The common carp (Cyprinus carpio) is by far the most important species in Hungary, accounting for about 70 percent of the pondfish production, 33 percent of the commercial catch in natural waters and 41 percent of the catch by anglers in 1978. The common bream (Abramis brama) is also of outstanding importance commercially, commanding an annual catch of about 1 500 t.

Among the native predatory fish in natural waters, those of most importance are the pike-perch (Stizostedion lucioperca), the pike (Esox lucius), European catfish or wels (Silurus glanis) and asp (Aspius aspius).

The European eel (Anguilla anguilla), which most authors consider is not native to Hungary, was planted in Lake Fertö in 1913. Elvers obtained through import from France and Ireland have been stocked in the lakes since 1961 and eels have now achieved importance in the capture fishery. Three other imports, carps introduced from China in 1963 as pondfish, have also achieved some prominence in natural waters. The bighead (Aristichthys nobilis) and silver carp (Hypophthalmichthys molitrix) are still primarily pondfish but the grass carp (Ctenopharyngodon idella) constituted three percent of the angler's catch in 1978. Both it and the silver carp apparently propagate naturally in Hungarian waters (Pintér, 1980).

Table 5

Commonest exploited fishes of Hungary [a]

(i) PRIMARY MARKET FISHES

Sterlet	Acipenser ruthenus
European eel	Anguilla anguilla[b]
Rainbow trout	Oncorhynchus mykiss[b]
Pike	Esox lucius
Common carp	Cyprinus carpio
Asp or Ragadozó ön	Aspius aspius
Barbel	Barbus barbus
Tench	Tinca tinca
Bighead	Aristichthys nobilis[b]
Grass carp	Ctenopharyngodon idella[b]
Silver carp	Hypophthalmichthys molitrix[b]
European catfish (Wels)	Silurus glanis
Pike-perch	Stizostedion lucioperca
Volga pike-perch (Kösüllö)	S. volgensis
Largemouth black bass	Micropterus salmoides[b]

(ii) LESS IMPORTANT MARKET FISHES

Common bream	Abramis brama
White bream	Blicca bjoerkna
Giebel, silver crucian (Ezüst kárász)	Carassius auratus gibelio
Orfe	Leuciscus idus
Chub	L. cephalus
Roach	Rutilus rutilus
Brown bullhead	Ictalurus nebulosus[b]

(iii) MINOR MARKET FISHES

Brown trout	Salmo trutta
Lapos keszeg	Abramis ballerus
Bagoly keszeg	A. sapa
Bleak	Alburnus alburnus
Crucian carp	Carassius carassius
Nase Paduc	Chondrostoma nasus
Siege or Garda	Pelecus cultratus
Rudd	Scardinius erythrophthalmus
Silver bream Éva keszeg	Vimba vimba
European perch	Perca fluviatilis[c]

[a] These three divisions are those made in Dobrai, Thuránszky and Pékh (1981); the term "market" applies even to fish taken primarily for sport; (i) the capture of primary fishes is controlled by legal divisions for each species. Most are dealt with by pond farms and are stocked in natural waters; (ii) capture not controlled by separate species provisions, and artificial propagation and introduction not undertaken; (iii) their number is unappreciable on a national scale although they may have local importance

[b] Not native to Hungary

[c] FAO (1988) mistakenly states that this species (together with carp) is a most important market fish

Of other introduced species, the American largemouth black bass (Micropterus salmoides), which became established in the Dráva years ago, occurs sporadically in other areas and is taken by anglers in the cooling water reservoirs of power plants. The rainbow trout (Oncorhynchus mykiss), first introduced in Hungary in 1885 is raised in trout farms and also found in some natural waters. Two other North American fishes, neither considered desirable, are the brown bullhead (Ictalurus nebulosus), introduced in 1902 and the pumpkinseed (Lepomis gibbosus) which are both abundant in some areas of the Danube, Tisza and Körös rivers. The subspecies of the goldfish, the giebel, or silver crucian (Carassius auratus gibelio) was introduced from Bulgaria in 1954. As in Romania, it has become an abundant species but forms stunted populations and is sometimes considered a pest[1].

[1] Tóth and Biró (1984) discuss 18 exotic fish species which have been introduced into Hungary since the turn of the century. They differ from most authors in saying that the European eel is a native member of the Hungarian fish fauna

With respect to native fishes, the once abundant runs of several species of sturgeons (Acipenseridae) are gone, blocked by dams on the Danube. Only the sterlet (Acipenser ruthenus) still remains in the Hungarian rivers. The native brown trout (Salmo trutta) is confined to mountain areas such as the Bükk Mountains in the north. Crayfish are native to Hungary and furnish a small fishery.

Determination of the individual species or species groups and the relative amounts taken, either individually or collectively, by commercial fishermen or by anglers or produced in pond farms is not a simple one using easily available "standard" statistics such as those in Tables 6 and 7.

Table 6 shows the nominal "catch" for the inland waters of Hungary as compiled by FAO for the period of 1965–87. As with similar tables for other countries, it is included both for uniformity and as (another) illustration of the difficulties of obtaining meaningful information from these second-hand compilations. The statistics shown in Table 6 were sent to FAO by Hungary, but their presentation simply does not permit one to distinguish between the species involved, those cultured in ponds and those taken by capture, whether commercially or for sport[2].

[2] By definition, in the FAO Yearbooks of Fishery Statistics, nominal catch data exclude all quantities caught by sports fishermen but they have been included at times for several countries, including Hungary, as has been shown in this review.

Furthermore, as will be shown later, at least some of the "catches" (from fish ponds) were then used as "stocking material" and do not represent marketable or consumable yield for food. For example, in 1973, 9 000 t of the total catch of 29 100 t shown in Table 6 were actually used to restock ponds, according to Hungary/EIFAC (1974) (see also section 7.2).

Turning now to Table 7, compiled from the official statistics in Hungary's statistical yearbooks, we find that for the years 1960, 1970, and the period of 1975–79, Hungary's own figures for its total fish catch are almost identical with those that appear in the FAO Yearbooks. However, here they are not arranged by species groups as is done by FAO but in three columns: total catch, fish from fish farms and fish from Lake Balaton[3]. From this table, we can determine which fish originate from aquaculture in fish farms and which from capture fisheries but from this table alone we cannot determine the species groups caught, nor whether sport as well as commercial catches are included. Thus, for example, Table 7 shows that in 1978 of a total of 32 584 t of fish "caught" in Hungary, 23 579 t derived from fish farms, and 1 159 t from Lake Balaton - leaving 7 846 t to be accounted for from unknown sources. One might assume that the latter amount comes from areas such as the Danube, Tisza and Hungarian reservoirs but one would still not know whether it represented recreational as well as commercial fisheries.

3 The catch from fish farms listed in the Hungarian statistical yearbooks under “tógazdasági” is translated there as “fish hatcheries” but “fish farms” (including both pond farms and trout farms) is the correct term (Pintér, 1985, pers.comm.)

Luckily, Anon./Hungary (1982) contains some figures which will at least answer the latter question which has been raised concerning the statistics in Table 7. He states that in 1978 the gross production of fish farms was 23 600 t and that the “total catches from natural waters (commercial and recreational)” were 9 005 t of which 5 919.6 (5 920) t were from the commercial fishery and 3 085 t from the sport catch. If then, we refer back to the 1978 catch shown in Table 7 and subtract the 23 579 t (23 600 t) shown there as derived from fish farms from the total Hungarian catch of 32 584 t, we obtain a figure of 9 005 t. Other things then being equal, we arrive at the following breakdown of the 1978 production/catch in Hungary: 23 579 t from fish farms and 9 005 t from capture fisheries of which 5 920 t are from commercial fisheries and 3 085 t from the sport catch. It appears, therefore, that proportionally, the 1978 “catch” in Hungary was derived as follows: 72 percent from aquaculture, 18 percent from commercial capture fishing and almost 10 percent from sport fishing. Other earlier information from Hungary corroborates the thesis that the harvest from recreational fisheries has been incorporated into the overall “catch” statistics recorded by Hungary and later reproduced in modified form by FAO.[1]

1 One finds the same type of error in Europa (1988) and Worldmark (1988) where the total Hungarian fishing “catch” actually includes: commercial catch, angler's catch, and aquacultural production

<u>Table 6</u>

Nominal catches by species in the water of Hungary,
1965, 1970, 1975, 1980–87 (tons)

Species	1965	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987
Common carp (<u>Cyprinus carpio</u>)	...	...	...	...	...	...	...	...	10 113	9 713	11 406
Tench (<u>Tinca tinca</u>)	...	...	...	...	...	...	...	...	0	13	0
Grass carp (<u>Ctenopharyngodon idella</u>)	...	...	...	...	...	...	...	...	349	482	468
Silver carp (<u>Hypophthalmichthys molotrix</u>)	...	...	...	...	...	...	...	...	4 350	3 207	3 674
Bighead (<u>Aristichthys nobilis</u>)	...	...	...	...	...	...	...	...	2 543	1 020	1 877
Cyprinids n.e.i.[a]	24 800	21 800	22 981	23 812	27 724	27 487	29 105	26 003	17 552	19 457	16 789
Pike (<u>Esox lucius</u>)	...	...	...	...	...	...	...	...	0	10	0
European catfish (<u>Silurus glanis</u>)	...	...	...	...	...	...	...	...	80	85	69
Pike-perch (<u>Stizostedion lucioperca</u>)	...	...	...	...	...	...	...	...	7	20	18
Freshwater fishes, n.e.i.	...	4 200	7 807	9 901	11 545	14 555	14 752	12 973	1 696	1 789	2 074
European eel (<u>Anguilla anguilla</u>)	...	...	...	...	...	...	...	...	0	0	115
Rainbow trout (<u>Oncorhynchus mykiss</u>)	...	...	...	...	...	...	...	...	237	266	269
Total finfish	24 800	26 000	30 788	33 713	39 269	42 042	43 857	38 976	36 927	36 062	36 759
Misc. freshwater crustaceans	0	0	0	0	0	0	0	0	0	0	0
Grand Total	24 800	26 000	30 788	33 713	39 269	42 042	43 857	38 976	36 927	36 062	36 759

[a] 1965 includes "Miscellaneous freshwater fishes…quantities n.e.i."
0 - probably nil, negligible, or insignificant; or less than 50 t during the 1965–70 period, or less than half a ton during later years.
... - not available

Source: 1965 <u>Yearb.Fish.Stat.FAO</u>, 36 (Publ. 1974)
1970–81 FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1982–87 Yearb.Fish.Stat.FAO. 64 (Publ. 1989)

For example, communications sent directly to EIFAC by Hungary (Hungary/EIFAC, 1974, 1977) state that in 1974 the total fish catch was 30 161 t of which 23 606 t (78 percent) came from fish farms and 6 555 t from capture fisheries in natural waters of which 4 805 t (16 percent) were commercial and 1 750 t (6 percent) were from the sport catch.[2]

From such examples, it appears very likely that the reports of Hungarian catch data for other years follow the same pattern. And if so, it would then appear that since the FAO figures for total catch in Table 6 agree with the official Hungarian figures for total catch shown in Table 7, that FAO has mistakenly included the catches by Hungarian anglers in its statistics[3]. This conclusion appears to be corroborated by the statement by Dobrai, Thuránszky and Pékh (1981) that anglers account for about 10 percent of the total fish harvest in Hungary.

2 The FAO Yearbook's figure for Hungary's total catch in 1974 was 30 159 t

3 This type of error is, however, readily understandable. Reference to publications such as Anon./Hungary (1982) and Dobrai, Thuránszky and Pékh (1981) show that the Hungarian authorities constantly stress that the catch by anglers is part of a “planned” system of fishery management in which commercial and recreational fishing work hand in hand, complementing each other to produce a full utilization of the aquatic resource. This concept is not followed by all countries or by all angler and commercial fishermen and has obviously not been understood by FAO

Finally, a figure in a paper by Pintér (1983) sheds some additional light on the subject of the sometimes confusing Hungarian fishery statistics, especially as to the composition of the harvest from aquaculture (see Table 8). The figure for total fish production in Table 8 for 1960, 1970, 1975 and 1979 agree almost exactly with the total catch figures for the same years shown in official Hungarian statistics (Table 7). However, in several instances, Pintér's breakdown of these total figures (Table 8) does not agree with the listings used in other sources used in this review. In some cases the reasons for the differences are obvious. For example, Pintér distinguishes the result of special aquaculture activities such as intensive utilization of backwaters and reservoirs from the traditional capture fisheries in natural waters. Thus, the fish taken from these intensively used waters may be included with the production from fish farms and construed as constituting “food fish from fish farming”. (It may be noted that several Hungarian publications assert that reservoirs are considered to be “natural waters”. This is, however, only from the point of view of legal fishing regulations.) We see, therefore, that matters of definition underline the interpretation of many of these statistics. There are also some small differences between figures which cannot be explained but these are not considered to be of real importance. What Pintér has shown - and is of most importance - is the clear distinction between “production of stocking material” and production of marketable or consumable food fish as two quite different components of aquacultural production (often called “catch”). Thus, in the years 1960, 1970, 1975 and 1979 the production of stocking material constituted about one quarter of Hungary's entire fish catch (see also section 7.2).

The preceding explanation demonstrates the ease with which fishery statistics can be misinterpreted without a full array of data. But, rather than continue a tedious analysis, it may be more fruitful to elicit a picture of Hungarian fisheries and aquaculture by presenting a few more recent statistics obtained directly from Hungarian sources. (See Tables 9–11.)

Table 7

Fish catch in Hungary, 1960, 1970, 1975–79 (tons)

Year	Total catch	Source of catch		
		Fish farms	Lake Balaton[a] (commercial)	Unaccounted[b]
1960	14 953	11 191	1 442	2 321
1970	25 988	19 697	1 464	4 827
1975	30 788	23 545	1 095	6 148
1976	31 855	24 520	1 041	6 294
1977	34 661	26 356	889	7 416
1978	32 584	23 579	1 159	7 846
1979	32 827	22 892	1 163	8 772

[a] Pintér (pers.comm. 1985) states that this catch in Governmental statistics is entirely commercial

[b] This column, not included in the original publications, was derived by the author by subtracting the sum of the "catch" from fish farms and Lake Balaton from the "total catch".

Source: Statisztikai Évkönyv, 1980 (Statistical Yearbook, Hungary)

Table 8

A recent version of the origin of fish production/catch in Hungary 1950, 1960, 1970, 1975, 1979 [a]

	1950		1960		1970		1975		1979	
	t	%	t	%	t	%	t	%	t	%
1. "Catches from natural waters"	2 579	49	3 289	22	4 418	17	4 991	16	6 237	19
2. "Food fish from reservoirs and intensively utilized backwaters"	---	--	449	3	2 079	8	2 149	7	3 611	11
3. "Food fish from pond farms and trout farms"	1 896	36	7 776	52	12 734	49	15 347	50	14 116	43
4. "Production of stocking material"	790	15	3 439	23	6 757	26	8 287	27	8 864	27
5. "Food fish from fish farming"	1 896	--	8 334	--	14 953	--	17 384	--	17 716	--
6. "Total fish production"	5 264	100	14 953	100	25 988	100	30 694	100	32 828	100

[a] The percentages on lines 1–4 and the number of tons on lines 5–6 are taken from the original author (Pintér, 1983). The number of tons appearing on lines 1–4 have been calculated using Pintér's percentages times line 6. It is assumed that the figures on line 5 represent the sum of the tonnages taken from the origins specified in lines 2 and 3. In actuality, Pintér's figures on line 5 differ somewhat from summations of the calculated figures on those lines. The reasons for the discrepancies are unknown, but the major conclusions are not invalidated by the small differences

Source: Figure 20.1 (p. 280) in Pintér (1983)

7.1 Capture Fisheries

The capture fishery in Hungary is practised in natural waters: the major rivers and their tributaries, overflow areas, oxbows and static water such as the largest lakes and some reservoirs. (As has been pointed out, in Hungary, with respect to fisheries, reservoirs other than fish ponds are legally considered to be "natural waters".) In recent years the area of these waters seems to have varied from about 1 250 km^2 to 1 390 km^2, depending upon the year, their use, and construction of new ones.

In some years cyprinids constitute about 80 percent of the capture fishery in natural waterways. Common carp alone form about one-third of the catch and bream also contribute a significant quantity. Fish such as pike-perch, eel, sterlet and European catfish (wels), although caught in much smaller quantities, are considered "high-value" fish and are in demand because of their quality.

7.1.1 Commercial fishing

The difficulties of obtaining accurate figures for the Hungarian commercial catch from readily available references have already been discussed. In 1971, the total commercial catch in Hungary was 4 903 t and in 1978 it totalled 5 920 t (Anon./Hungary, 1982). Table 9 shows total commercial catch figures ranging from 7 398 t to 8 685 t during the 1983–86 period.

The fishing methods range from use of old traditional Danubian gear such as reed and willow traps to quite modern ones. On Lake Balaton, for example, 1 000 × 5 m surrounding nets are used together with 25-m trawlers. Small and giant fish traps, lift nets, seines and electric trawls are used in a variety of situations and eel traps in conjunction with drainage are used at the outlets of Balaton and Velence.

Table 9

Capture fishery in Hungary, 1981–86

	1981[a]	1982[a]	1983	1984	1985	1986
Area utilized (km^2)	1 270	1 280	1 360	1 370	1 380	1 390
Commercial fisheries						
Lake Balaton (t)	-	-	1 022	1 521	887	692
Other water bodies (t)	-	-	7 663	7 009	7 302	7 246
Total (t)	-	-	8 685	8 530	8 189	7 938
Angler's catch (t)	-	-	4 520	4 428	4 635	4 964
Total capture fishery (t)	11 104	12 551	13 205	12 950	12 824	12 902

[a] It will be noted that the addition of the gross production derived from fish farming in 1981 and 1982 (derived from the same source and shown in Table 10), results in a total harvest from capture fishing and fish culture of: 39 145 t in 1981 and 42 042 t in 1982. See the totals for the same years shown in Table 6; close agreement for 1981, exact agreement for 1982

Source: Anon./Hungary (1984) for 1981–82
Pintér (1986, 1988) for 1983–86

7.1.2 Sport fishing

Many of the warmwater fish represented in the commercial fishery are also caught by sport fishermen. Anon./Hungary (1982) lists the 1978 rod catches of different species in Hungary in this order: common carp (41 percent), "bream" (38 percent), pike, pike-perch, grass carp (3 percent), wels, asp, eel, barbel, kösüllö[1]. Coldwater fishes are scarce in Hungary but there are a number of trout streams in the uplands, some of which are relatively unexploited by anglers, where brown trout can be taken. There are also some rainbow trout in wild waters and the largemouth black bass is fished in some reservoirs.

1 The “bream” catch included species of low market value such as: common bream, white bream, roach, orfe, crucian carp and giebel or silver crucian

In 1971 the reported catch by 94 600 Hungarian anglers averaged 14.3 kg annually for a total take of 1 357 t or 22 percent of the entire capture fishery. In 1978 the reported annual catch by 204 942 anglers averaged almost 15.1 kg for a total of 3 085 t or 34 percent of the capture fishery (Anon./Hungary, 1982). Table 9 shows the angling catch to have ranged from 4 478 t to 4 964 t during the 1983–86 period.

Although the number of anglers in Hungary is still very small compared with the number in many western countries, it is increasing rapidly. In 1960, the total number of licensed resident anglers in the country was 51 800 or only 0.5 percent of the total population. By 1970, it had risen to 92 800 or 0.9 percent of the population, and by 1980 to over 250 000 anglers or 2.3 percent of the population (Thuránszky, 1982). FAO (1988) states that there were 316 000 licensed anglers in Hungary in 1986.

As has been emphasized above, Hungary considers sport fishing to be an integral part of full utilization of the aquatic resources as well as part of a social goal to secure recreational possibilities for everyone. The State has enunciated various principles concerning its development: (i) recreational fisheries have to be developed without losses in commercial fishing; (ii) natural waters must be managed to secure harvest of fish species not produced economically in fish farms; (iii) catches from natural waters should cover the gap in marketing during summer when fish farms are not selling their products; (iv) full utilization of natural waters demands the improvement of its stock of fish through selective commercial fishing; (v) a good bag should be developed for sport fisherman (since its possession is the main motive of the sport) but the angler should not sell his catch, and the number of anglers should not be limited. In furtherance of such ends: (i) commercial and recreational fisheries are carried on simultaneously in the majority of the country's natural waters; (ii) some waters are used exclusively for recreational fishing (e.g., the Government has granted angling associations large tracts of water around cities and important recreational areas); and, conversely, (iii) there are some waters where no anglers are admitted and fishfarm-like management is carried out. Circa 1980, 0.45 ha were available for each angler in type (i) waters and 0.09 ha in type (ii) waters[1].

1 Based on Pintér (1978) and Anon./Hungary (1982)

The basic condition for angling in Hungary is membership in one of the angler's societies but foreign tourists as well as Hungarians who take out licences for only a two-week period are excepted. Admission to a society involves payment of a tax-like fee which is the price of the State-issued fishing licence. The angler may then purchase an areal permission for a selected water section with the competent water-utilizing body. Although the permission may be valid for most areas of the country, the general practice is that the angler obtains permission for only one water area, usually near his residence and then buys on-the-spot area licences for one day or a week. There are various limits and seasons according to angling law and anglers must pass an examination on basic knowledge of the regulations and fish fauna. They are not permitted to sell their catch.

7.2 Aquaculture

The first modern carp farm in Hungary (covering 75 ha) was established in 1984. Definite plans for expansion of the industry commenced in 1950, large-scale construction of ponds commenced in 1953, and by 1954 production was up to 4 556 t. By 1980 there were 21 151 ha fish ponds with a total production of 23 996 t.

Common carp is the principal species cultivated, representing about 65 percent of the production (1983–86). Production is usually a three-year cycle. The first year produces fingerlings of 25–35 g, the second-year fish of 200–300 g, and the third-year food fish of over 1 kg. In less common usage is a two-year system in which fingerlings of 80–100 g are produced during the first year and food fish somewhat under 1 kg the second year. Carp above 1 kg in weight are a first-class commodity and are usually sold alive. Their most important export market is the Federal Republic of Germany. Some supplementary fish may also be raised with the carp: pike-perch, tench and wels.

In general, the principle in Hungary is to allow the ponds themselves (through fertilization) to provide the nutriment needed. Wheat, maize, lupine and peas may, however, also be added, and the highest yields at pond farms originate from application of feeds.

The herbivorous Chinese carps (grass, silver and bighead) constitute about 33 percent (1983–86) of warmwater pondfish production, using various polycultural combinations together with common carp. At present the Chinese carps have less market demand than does the traditional common carp.

There is also some cultivation of sterlet, pike, asp, barbel and black bass primarily for stocking natural waters. There is also a market demand for such fish; the consumer's price for the predatory fish is about 2.5 times the price of common carp. Eel farming using geothermal water was set up during the 1979–81 period.

Trout are raised in only a few areas in Hungary because of the absence of suitable water. The largest trout farm at Ódörögd, north of Lake Balaton, uses karstic water with a temperature of 10–14°C. Rainbow trout are reared here in raceways using artificial feeds. Rearing fingerlings to 30 g takes 100–160 days and trout reach the market weight of 250 g in 180–300 days. The farm which has been operating at full capacity since 1978, produced 200 t in that year and the total production of rainbow trout in Hungary was 280 t in 1979 and 409 t in 1986. Part of these trout are sold locally and part are exported. A small number of brown trout (<u>Salmo trutta</u>) are raised to stock recreational water.

With water temperatures usually reaching at least 20°C in September, the major pondfish production in Hungary is, however, of warmwater fishes. These pond areas vary around 20 000 ha in total extent. FAO (1988) states that the pond area in 1986 was 20 925 ha. Circa 1980 when the pond fish areas in Hungary totalled 19 586 ha, they were distributed approximately as follows: 13 962 ha on 22 state farms (which carry on mixed farming); 3 991 ha on about 200 agricultural cooperatives; 1 352 ha on 17 fishery cooperatives; and 263 ha used by the Hungarian National Angling Union (Dobrai, Thuránszky and Pékh, 1981). In 1978, the state farm fisheries produced 15 920 t of warmwater pond fish and 295 t of trout[1]. Of the 22 state farms, 11 possess pond farm areas of over 200 ha, e.g., the state farm of Hortobágy is 5 000 ha, and the fish farm of Balaton is 1 800 ha. Some individual fish ponds in Hungary reach 600 ha in extent.

1 The state farms also controlled the Lake Balaton capture fishery with a gross harvest of 1 159 t and collectively produced over 50 percent of the annual production/catch of fish. The cooperatives which operated on about 5 300 ha of pond area and about 46 000 ha of natural waters, produced about one-third of the country's production/catch

Unfortunately, most of the farm ponds in Hungary have been constructed on infertile alkaline areas because central guidelines did not permit their construction on higher quality lands. The yields from ponds on poor ground or of such large size that intensive cultivation is difficult are relatively low.

Overall yields from farm ponds have not risen much in recent years.[2] Thus, Rabanal (1971) cited an average total yield of about 1 000 kg/ha/year and about ten years later Dobrai, Thuránszky and Pékh (1981) said that the national average indicated 1 000 kg/ha/year. Some yields for the intermediate and later years follow.

2 However, even at a lower level of production, the profitability of pond farming during the last few years is said to have improved (Pintér, 1988)

Year	kg/ha	Source
1974	1 133	Anon./Hungary (1976)
1975	1 180	Anon./Hungary (1976)
1976	1 284	Thuránszky (1978)
1977	1 306	Thuránszky (1978)
1979	1 186	Thuránszky (1982)
1980	1 130	Thuránszky (1982)
1981	1 273	Anon./Hungary (1984)
1982	1 329	Anon./Hungary (1984)

In citing such yields, one must distinguish, however, between the total amount caught or harvested from a pond and that portion of the take which is actually marketable or consumable. Table 10 illustrates this difference. The marketable yields (net production per unit area) shown there are far lower than the gross yields.

Another table (Table 11) is also shown as an example of the current presentation to EIFAC of aquacultural production in Hungary. From such a table, one gains a better concept of the entire process.

Table 10

Hungarian fish ponds: size and yields, 1974, 1975, 1981, 1982

	1974	1975	1981	1982
Pond area in production (ha)	20 839	19 948	22 021	22 192
Gross production (t)	23 606	23 545	28 041	24 491
Gross yield (kg/ha)	1 133	1 180	1 273	1 329
Net production (t)	16 292	16 800	-	-
Net yield (kg/ha)	782	842	841	899

Source: Anon./Hungary, 1976 and 1984

Table 11

Aquacultural production in Hungary, 1983–86

	1983	1984	1985	1986
Pond area in production (ha)	21 668	23 253	21 659	20 925
Stocking (t)	10 837	10 333	9 008	8 055
Harvest (t)				
Common carp (t)	18 346	16 272	15 465	15 412
Chinese carp (t)	11 178	9 129	7 577	6 592
Predatory species (t)	414	170	161	185
Trout (t)	320	191	370	412
Other species (t)	394	256	530	559
Total harvest (t)	30 652	26 018	24 103	23 160
Of which:				
edible (consumptive) fish (t)	19 413	16 838	16 121	13 862
stocking material (t)	11 239	9 180	7 982	9 298

Source: Pintér (1986, 1988)

A more recent presentation of aquacultural production in Hungary is that found in Table 12. It would appear, however, that the FAO-compiled statistics in this table suffer from some of the same inaccuracies which have been pointed out before. For example, compare the production for the Chinese carps in 1984 with that shown in Table 11, and the differences shown between the statistics for 1985 and 1986. Regardless of such differences, the Source states that the aquacultural production in Hungary during the 1984–87 period had an annual value ranging from US$ 14 028 million (1985) to US$ 22 686 million in 1987.

Offsetting such problems as poor land and sometimes limited water is the development of superior technology in the operation of Hungarian pond farms, with emphasis on use of better feeds and feeding methods, water supply of controlled temperature, aeration and increased mechanization, induced breeding and cage culture. An outstanding example in this development is the Warmwater Fish Hatchery at Százhalombatta (TEHAG) near Budapest, inaugurated in 1974, which uses ponds with water from a thermal power plant and hormonally-induced artificial fertilization. Considered to be the largest unit of its kind in Europe, it supplies about 30 percent of the country's requirements for fish fry and 30 percent of one-summer fingerlings. As further evidence of advancement, some ponds at Bikal have attained yields about 2.5 t/ha/year and some experimental ponds using a combination of common and Chinese carps with supplemental feedings have yielded 4 t/ha/year. The use of ducks in pond culture may also increase yield (see, especially, Balogh, Kozma and Mosonyi (1975) and Woynarovich (1979).)

Table 12

Aquacultural production in Hungary, 1984–87 (in tons)

Species	1984	1985	1986	1987
Common carp	16 272	10 113	9 713	11 406
Grass carp	...	349	482	422
Silver carp	...	4 350	4 797F	3 674
Bighead	...	2 543	2 520	1 877
Osteichtheys	...	636	691	98
European eel	...	...	...	115
Rainbow trout	191	237	266	269
European catfish (wels)	10	80	85	69

... - Data unavailable

F - FAO estimate

Source: FAO Fish.Info.Data and Stat.Serv. (1989)

Further fish pond development in Hungary depends mainly on the economic possibilities of pond farming intensification. Table 8 shows that the line between capture fisheries and pond fish production is in Hungary, as in several other countries, not always a clear one. Pintér, source of the material in this table says (in a personal communication, 1985) that his criteria of aquaculture are the use of feeding and/or fertilization. In addition to standard aquaculture in closed (pond) systems, almost all Hungarian natural waters and reservoirs are systematically stocked. Thus at Lake Balaton pike-perch production is augmented by annual fry stocking, 160 t of two-summer carp are stocked annually and elvers are also stocked each year. Backwaters adjacent to flood control embankment, oxbows and other waters also receive stocking - sometimes resulting in such production that it may be considered aquaculture.

Currently about 1 100 ha of backwaters are under intensive fish production in Hungary. On over approximately 90 percent of this area the food fish are produced through polycultural stocking with two-year fish and on about 10 percent of the area, two-year fish are produced through fingerling stocking (Pintér, 1983). There are apparently a considerable number of reservoirs in Hungary which store water for only a year. Many of these seem to have been adapted to fishery production through a combination of the same type of features used in standard farm ponds, e.g., drainage, fishing pits and fish screens. Most of them, however, are used for traditional natural water fishing and for angling.

Cage culture has also been used in Hungary, of late in deep gravel pits. Since it requires the use of complete feeds it seems most suitable for fish which have a special need in domestic or export market, e.g., high-value fish. Good results have been obtained with wels and the hybrid of sterlet x beluga (Huso huso).

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership

All fish in natural waters and man-made reservoirs in Hungary are State-owned. The law decree on fisheries (decree of legal force No. 30 of 1977) states that with few exceptions the right of fishing is the legal due of the State. The State transfers this right to State-owned companies, agricultural and fishery cooperatives and to the Hungarian National Angling Union (HNAU).

To ensure planned utilization of the water areas, the beneficiary of the fishing right must prepare a working plan for the approval of the competent technical body (Fishery Inspector) of the local County Council (see section 8.2.2) for a five-year period. Interim modifications can be made. The fishing right can be cancelled or withdrawn if the beneficiary fails to observe prescription of the plan, or if justified in the interest of the national economy. In the latter case, there may be idemnification.

The beneficiary must also pay the State for the fishing right. These payments raise a Fund for Fisheries Development used to develop the fishery sector, especially the fisheries of natural waters, but which may also be used for hatcheries, research, technological developments, etc.

[1] Based largely on material from Hungary sent to EIFAC in 1979, Dobrai, Thuránszky and Pékh (1981) and Anon./Hungary (1982) and updated by Hungary/EIFAC (1989)

8.2 Administration and Management

8.2.1 The sector of fishing and fish farming is under the supervision of the Ministry of Agriculture and Food.

The Department for Fisheries and Wildlife of this Ministry is responsible for central management of the fisheries, including: elaboration of fishery policy, State management of the fisheries and elaboration of long and middle-term plans.

8.2.2 The regional administration of fisheries is carried out by the Fishery Inspectors of the 20 County Councils of Hungary. They have as their functions: State management of fisheries at the first level, supervision of the fishery activities prescribed in the management plans for each water area, issue of licences to fishermen, etc.

8.2.3 In addition to these administrative units, there are the following:

(i) National Centre of State Farms, responsible among others for control of all State-owned farms and at the same time their business federation;

(ii) Association of Fishery Cooperatives, a business federation established by the fishery cooperatives and which grants vocational and legal assistance to members. Any agricultural cooperative which needs assistance from the central apparatus of the Association for better fishery management, regular supply of breeding material or for marketing may join the Association.

(iii) A fish marketing sector which belongs only partly to the productive sector. The domestic wholesale trading company for fish and fish products is controlled by the Ministry for Internal Trade, and the TERIMPEX Foreign Trade Company by the Ministry for Foreign Trade.

(iv) Hungarian National Angling Union (HNAU), the central organ of the angling associations (about 600 in number). The HNAU cares for the professional and ethical education of anglers and helps the associations in management matters. Both the Ministry of Agriculture and Food and the County Councils consult with the HNAU in matters concerning angling.

8.3 Investigation

(i) The Fisheries Research Institute at Szarvas (HAKI) has been in charge of coordinating all fish-related research work in Hungary since 1975. Both biological and technological aspects are stressed.

(ii) The Institute cooperates with various Hungarian scientific institutes, stations and training institutes and coordinates their work: (a) Hungarian Academy of Sciences (Veterinary Research Institute in Budapest, Balaton Limnological Institute at Tihany, Danube Research Station at Göd and Genetics Station at Göd), National Veterinary Institute (Budapest), University of Sciences “József Attila” (Szeged), University of Agricultural Sciences (Debrecen), High School for Agriculture (Kaposvár), University of Rural Sciences (Keszthely) and TEHAG (Százhalombatta). It is also the Interregional Centre of the FAO/ADCP Network of Regional Aquaculture Centres.

8.4 Training

(i) There is no university in Hungary especially designed for training in fish farming or breeding but the basis as well as special courses in high-level fishery education is offered at a number of universities.

(ii) The training of high level specialists in fish-farming science is undertaken at: Kaposvár and Szarvas for production engineers, and at Debrecen, Gödöllö, and Keszthely for general agronomist-engineers. Post graduate training is available at Debrecen.

(iii) Special training and continuing education in fish farm production is offered at Százhalombatta not only for Hungarians but for foreign students;

(iv) The Skilled Workers' School at Tata provides training for skilled workers in fish farming at low and medium levels.

8.5 International Agreements

Hungary has bilateral agreements concerning the use of boundary waters with: Austria, Czechoslovakia, and Yugoslavia. It belongs to the Danube Commission along with the other Danube countries concerning navigation and related problems. It adheres to the Convention on Fisheries of the Danube, together with Bulgaria, Czechoslovakia, Romania, the USSR and Yugoslavia, to take joint action to protect the river's fish stocks.

9. STATE OF THE FISHERY

9.1 Yield

Reference to early statistics shows that there was a great overall rise in "catch" during the 1938–64 period: the average annual catch of 6 200 t during 1934–38 doubled to 13 000 t in 1958 and attained 22 700 t by 1964 (FAO Yearbook of Fishery Statistics, 26; Iyengar, 1974). Since that time (see Table 6), the overall yield from Hungarian capture fisheries and aquaculture has been comparatively even, rising decidedly only during the last few years.

One must bear in mind, of course, that the statistics throughout this entire time may not be uniform. The catch for angling (which should not have included by FAO in its Yearbook) has been represented in at least some of its records. Furthermore, the true picture of marketable or "consumable" production of Hungarian fish farms has been masked in the generally available statistics through inclusion of the quantity of fish used for restocking.

Nonetheless, the total yield from capture fisheries has - surprisingly enough - not only held its own for many years but has been seen to increase, even when using such constraints as have been imposed upon it by its representation in Table 8. Secondly, the total or gross production of fish farms has also increased. Table 13, which presents a record of some of the statistics that definitely distinguish between the catch in natural waters by the capture fishery and the production of fish farms illustrates these two points. Nevertheless, recalling the differences in total production from fish ponds and marketable production (sections 7 and 7.2) the summation of FAO/UNDP (1979) is pertinent: "It is … clear that both annual production and total pond surface area have remained relatively unchanged from 1960 to 1980 at about 12 000 to 16 000 tonnes of market fish and 21 000 hectares respectively"[1].

[1] These net yields of market fish (stocking material **not** included) range from 571 to 762 kg/ha/year (see also Table 10)

There are a considerable number of figures on yield per unit area from Lake Balaton. The figures through 1975 that follow are from Biro (1977, 1978, 1979). From 1902 to 1975 (when the total commercial catch from the lake varied between 300 and 1 963 t), the commercial yield varied from 5 to 33 kg/ha/year. During the 1950–75 period, the yield by commercial fishermen averaged 24 kg/ha/year. During the 1976–79 period, the yield as derived from Table 7 ranged from 14.9 to 19.5 kg/ha/year. With respect to the commercial yields of individual fish species from Lake Balaton, Biró (1978) states that between 1902 and 1976 bream (Abramis brama) constituted 70–80 percent of the annual catch with a yield of 89–106.8 kg/ha/year; pike-perch (Stizostedion lucioperca) constituted 6–12 percent of the catch with a yield of 1–3 kg/ha/year; and asp (Aspius aspius) constituted 0.4–1.5 percent of the catch with a yield of 0.007–0.5 kg/ha/year. He further stated that the present yield of these species from Lake Balaton was as follows: bream (16.8 kg/ha/year), pike-perch (2 kg/ha/year), and asp (0.18 kg/ha/year).

Table 13

Some annual returns in Hungary from fish farms and natural waters (tons)[1]

Year	Total	Fish Farms	Natural Waters	Source
1958	12 976	9 152	3 824	Rabanal (1971) Iyengar (1974)
1968	29 878	23 884	5 994	Rabanal (1971) Iyengar (1974)
1969	27 560	22 130	5 430	Rabanal (1971) Iyengar (1974)
1970	25 998	19 697	6 301	Iyengar (1974)
1971	-	-	6 260	Anon./Hungary (1982)
1973	29 000	23 000	6 000	Hungary/EIFAC (1974)
1974	30 159	23 606	6 553	Anon./Hungary (1976) Hungary/EIFAC (1977)
1975	30 789	23 545	7 244	Anon./Hungary (1976)
1976	32 428	25 093	7 335	Hungary/EIFAC (1977)
1977	34 661	26 356	8 305	Thuránszky (1978)
1978	-	-	9 005	Anon./Hungary (1982)

There do not appear to be many figures for the yield from capture fisheries from other areas. Holčik and Bastl (1976) state that during the 1961–72 period, the 142-km section of the Danube River from the mouth of the Ipoly downstream to Dunaföldvár yielded 21.6 kg/ha/year[2]. The Hungarian yield from natural waters was 55.7 kg/ha/year in 1976 and 66 kg/ha/year in 1977 (Thuránszky, 1978).

[1] In all these cases, the source positively distinguished between “catch” from “fish farms” and “natural waters”. It is also known that the catches from natural waters in 1971, 1974 and 1978 include both commercial and sport fishing. Slight differences in these figures and those in other tables (such as Tables 6 and 7) are not considered important: initially reported figures are often subject to revision in later publications and errors of transcription are common

[2] The area studied occupied 9 171 ha of river plus 195 ha of adjacent river arms (see Czechoslovakia for reference)

As previously related, the overall or gross aquacultural yield in Hungary now appears to be somewhat above 1 t/ha/year (see section 7.2).

9.2 Factors Affecting the Fishery

Drainage and the use of former bottom lands for agriculture have reduced habitat, including the once nutrient-rich spawning and feeding areas, for fish. Nevertheless, the most important factor limiting fishery production in Hungary is simply the quantity and quality of water available for both wild and cultivated stocks. Hungary has a limited supply of usable water, agreements with downstream countries limit the amount of water that can be diverted from its international rivers, and due to its topography, water storage potentials are relatively restricted[3].

[3] The practicable storages (Framji and Mahajan, 1969) are of the order of 90 million m^3 in the dead reaches of the rivers, 700 million m^3 in the live reaches upstream of weirs, 400–500 million m^3 in small hillside ponds and reservoirs in mountainous areas, and about 600 million m^3 in the plains

About 95 percent of Hungary's surface water originates outside the country, and aside from that in the Danube, much of it is of poor quality. For example, some of the most seriously polluted water in Hungary, that of the Sajó River, originates in Czechoslovakia. Total annual water demand in Hungary was 5.30 km^3 in 1970, and it was considered that it would rise to 12.5 km^3 by 1985 (Alföldi, Almássy, and Major, 1978). The latter amount would be more than twice the annual runoff from rainfall alone on Hungarian soil.

Competitive demands upon water are great. There are few for development of hydroelectric power or for the development of mineral or forest products, but demands by agriculture for irrigation are high. In fact, fish ponds themselves use a high percentage of the available water. Elekes (1972) says that the water supplied for 37 000 ha of fish ponds is 400 million m^3 annually or almost 50 percent of the total water requirements for agriculture[1]. Figures furnished by Benedek and Simo (1978) differ, but stress the same general point. They say that “present” annual water demands in Hungary for animal breeding are 370 million m^3 of which fish ponds use about 70 percent (i.e., 259 million m^3).

[1] Note that this figure for 37 000 ha of fish ponds is far greater than the various official figures previously cited

The advent of modern agriculture with its emphasis on the use of chemical fertilizers and pesticides and the intensification of animal production with an increase in liquid manure have increased water pollution in Hungary. There have been some severe fish kills at Lake Balaton (500 t in one year), and eutrophication has altered its fish fauna. Its European perch have almost disappeared, and pikeperch are declining. It has been estimated that by 1985, Hungary's industrial waste discharge would be three times what it was in 1972, and that its domestic wastes would be doubled (Johnson and Brown, 1976). In 1972, 800 km of stream were said to be fishless because of pollution, and without strict control the potential for damage to fisheries is large (Holden and Lloyd, 1972). “Extreme meteorological conditions” (perhaps coupled with pollution) have also caused severe losses. In 1987, Pintér (1988) recorded known fish kills in Hungary as reaching 919 t or 2.5% of the total catch/production.

The total annual discharge leaving the country is 11 259 m^3 <u>per caput,</u> but the average annual runoff <u>per caput</u> for rainfall only on Hungarian territory is only 563 m^3. Were it not for the Danube, the amount of water available for waste dilution would be very small indeed.

Factors important to the continued development of aquaculture in Hungary include the following:

(i) extension of irrigation to areas previously lacking water but otherwse having favourable soil and topographic conditions for fish farming;
(ii) the use of sodic or saline areas otherwise unfavourable for agriculture (about 200 000 ha of sodic soils cannot be used for agriculture, but the addition of water and organic matter makes some of them suitable for fish culture);
(iii) rehabilitation of the existing pond systems. Many of these, constructed years ago, do not meet the requirements for efficient production of the size and type of fish crop it is now possible to produce. They are too large for intensive cultivation and harvest is difficult;
(iv) greater use of phytophagous fish such as the Chinese carp, and substitution of intensive polyculture for extensive monoculture;
(v) use of ducks on ponds;
(vi) development of better supplementary feeds than the unmilled cereals generally fed in the past;
(vii) disease problems associated with intensive culture;
(viii) genetic changes and improvement in stocks, and
(ix) the use of cooling water from thermal power stations, as well as the use of more ground water, including warm artesian supplies.

It may be noted that the supply of broodstock and fry to be used throughout the country is adequate, and in a country as small as Hungary, distribution from hatcheries to rearing ponds is relatively easy.

9.3 Prospect

The yield from capture fisheries seems to be holding up well. Eventually, however, one can only visualize a decline especially in the river fisheries as stream regulation and drainage continue and if pollution cannot be abated. An optomistic statement by Hungary/EIFAC (1974) said that although pollution of natural waters was increasing, the production from capture fisheries was not decreasing because new reservoirs were being built. There are also plans to construct dams exclusively for recreational purposes. However, as has been indicated, storage capacity in Hungary is relatively small, and the quality of its surface water is unduly determined by effluent discharge from upstream countries.

Similarly, it is difficult to foresee an increase in commercial yield from Hungary's few natural lakes, with their ever-increasing multiple use, unless eel stocking raises the output. At Lake Balaton, for example, its water quality started to deteriorate at the beginning of the century with modifications in the shoreline and water levels. Undisturbed shoreline now constitutes only 60 percent of the lake, and reeds, which are natural filters, are perishing (Dévai and Moldovan, 1983). With increased nutrient loading it is now almost hypereutrophic, and being a large resort area the lake is subject to many activities incompatible with fishing.

The growth of angling in Hungary, aided by the activity of the angling associations and the HNAU, and with support by the Government, is significant. With angler-catch already exceeding that of commercial fishermen in some waters, there is growing conflict between the two groups, despite the governmental policy of their integration. Stocking waters intensively with commercial-size fish and development of fee-fishing is one measure to offset the increase in angling intensity.

All in all, the greatest possibility of sustained and increased fishery yield-in-Hungary lies in the field of intensive aquaculture of warmwater species. Aside from technical problems in rearing these fish, there are some difficulties in obtaining consumer acceptance of the Chinese carps and lessened demand for the traditional common carp. Improvements in processing will alter demand, especially as more "kitchen-ready" fish are placed on the market. Sales of live fish will decrease. Meanwhile, a very high demand for the so-called "high-value" fish such as eel, European catfish, pike-perch and sturgeon and efforts to produce these species easily will increase.

The fifth Hungarian National Five-Year Plan (1976–80) called for a 45 percent increase in fishery production, i.e., to about 44 500 t in 1980. An even more optamistic prediction was made by Amir (1986) who expected the production in Hungary to reach about 60 000 t in 1986 and who spoke of a target for 1990 of 80 000 t. However, as is shown in Table 6, the increase by 1980 was only slight, because of "unfavourable conditions", and as shown in Table 11, the prediction by Amir (1986) was altogether too high. Continuation of efforts to increase the catch will be based on a threefold system: intensification of pond production; reconstruction of old fish ponds and establishment of new ones; and more intensive management of natural waters.

It should also be noted that Hungary has established various incentives to improve the quality of its waters, and taken many measures to prevent adverse damage to the surface waters that support all of its fisheries.

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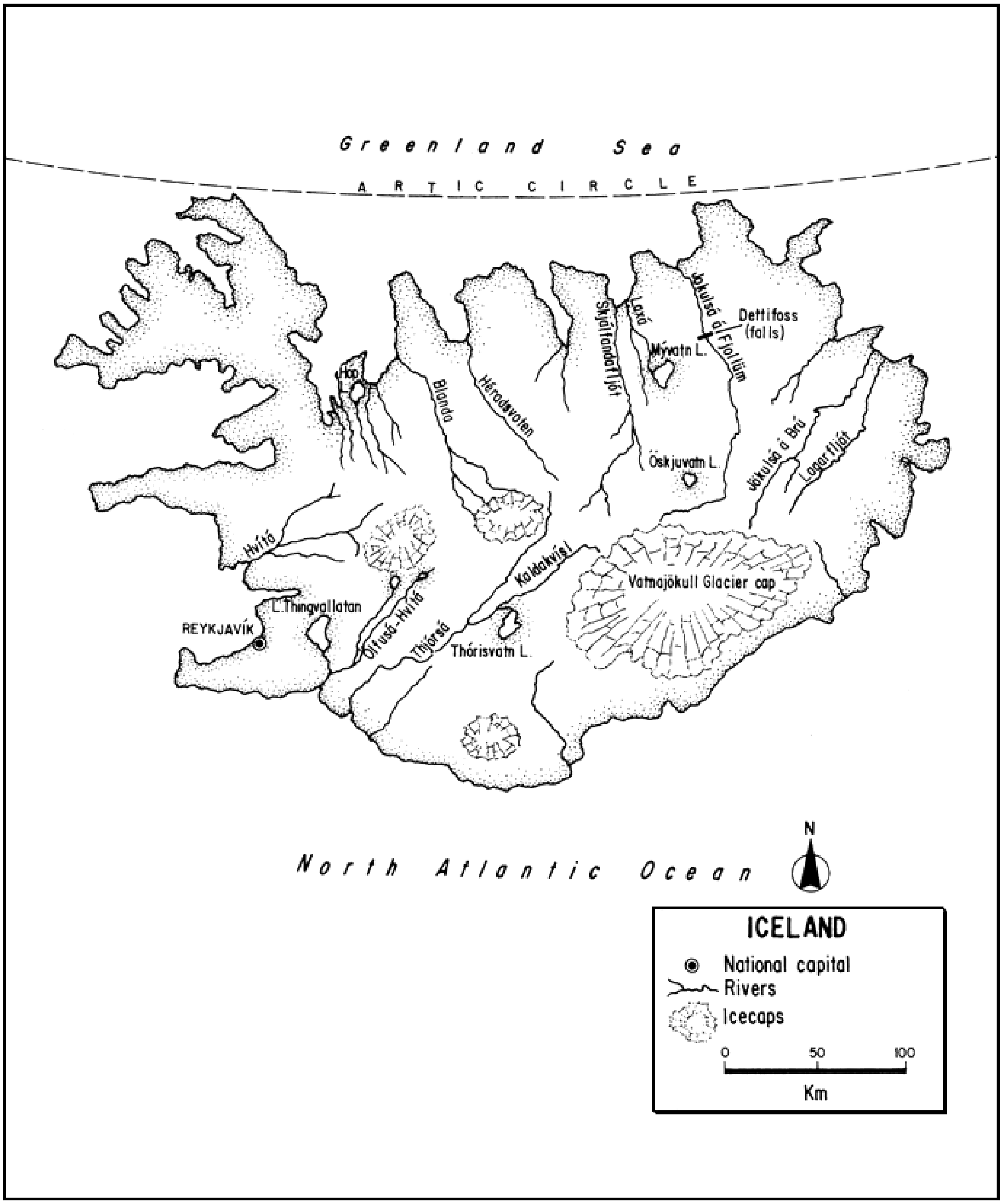
[1] Although this reference should have been credited to K. Pintér in the original publication, I have retained the citation Anon. (1982) in order to facilitate literature search



Greenland Sea
ARTIC CIRCLE
Hop
Blanda
Héradsvoten
Skjálfandafljót
Laxá
Jökulsá á Fjöllum
Dettifoss
(falls)
Mývatn L.
Öskjuvatn L.
Jökulsá á Brú
Lagarfljót
Hvítá
Kaldakvísl
Vatnajökull Glacier cap
L. Thingvallatan
REYKJAVÍK
Ölfusá-Hvítá
Thjórsá
Thórisvatn L.
North Atlantic Ocean
N
ICELAND
National capital
Rivers
Icecaps
0
50
100
Km

ICELAND

The Republic of Iceland, northwesterly outpost of Europe, lies in the North Atlantic close to the Arctic Circle. Famed scenically for volcanoes, glaciers, hot springs and geysers, it has little soil, few mineral resources, and only a low cover of vegetation. With such unproductive, and often uninhabitable land, Iceland has the lowest population density of any European country, and much of its economy is based on rich sea fisheries.

Its freshwater resources are also abundant. From a central core of plateaux and mountains, its rivers radiate in all directions to reach the sea, and it has numerous small lakes. Low population and the absence of harmful industrial practices keep its waters virtually without pollution. Iceland has only five native species of fluvial and diadromous fishes, but three of these are valuable salmonids and its Atlantic salmon now provides one of the world's leading sport fisheries for this species.

Its recreational fisheries, the development of ocean ranching for salmon and a growth in aquaculture indicate a bright future.

1. AREA: 103 000 km^2

2. POPULATION: 254 000 (est. 1990) Density: 2.5 inh/km^2

3. PHYSICAL GEOGRAPHY

Iceland, the fourth largest island in the North Atlantic, lies between 63°24' and 66°32'N latitudes and 13°30' and 24°32'W longitudes. Its northern coast just touches the Arctic Circle. Its nearest European neighbours are Scotland, 837 km to the southeast, and Norway, 1 000 km to the east. Iceland is 490 km long and 312 km wide. Its coastline is estimated to be from 5 000 to 7 000 km in extent.

Iceland is largely a plateau of volcanic rocks between 600 and 800 m high, broken by faults, and moulded by erosion, abrasion, frost, and other denuding activities. It is indented by fjords and has extensive table lands and mountains. Twenty-seven percent of the country lies below 200 m, 36 percent between 200 and 800 m, and 37 percent over 800 m. The highest point is 2 120 m; the lowest, sea level.

Almost 15 percent of the total area is covered with snowfields and glaciers. The 120 glaciers range from those of cirque type to the large glacier cap of Vatnajökull with an area of 8 400 km^2 and depth of 1 000 m. There are about 200 postglacial volcanoes, and more hot springs (some geysers) and solfataras than in any other country in the world. Some of the volcanoes are still active, and at least in one case ash from eruptions has killed salmon parr and smolts. Earthquakes are common. The eastern and western parts of the island (about one-half of the country) consist of basalt separated by a zone of newer, more porous volcanics. The little soil that is present is partly mineral (loess) with a pH of 6–7, and partly organic or bog soil with a pH of 5–6, rich in minerals, but deficient in calcium carbonate. Although suitable for agriculture, the soils generally require heavy fertilization.

With respect to flora, Iceland lies on the border of tundra (treeless plains) and coniferous forest. About one-third of the vascular plants in Iceland are Arctic-Alpine; the remainder are boreal. Only about one quarter of the country has a continuous carpet of vegetation, especially mosses, lichens, and grasses. Its upper level is at about 700 m, while tree line is at about 300 m. The only tree of importance is the birch (Betula). There are extensive moors and bogs.

Indented, except in the southwest, most of the coast varies from large bays and fjords (the result of glacial deepening and widening of eroded river valleys) to the sandy south coast which is backed by shallow lagoons and outwash areas. There are a few small islands or groups of skerries.

4. CLIMATE

The climate of Iceland is cool temperate oceanic - warmer than might be expected because of the proximity of the Gulf Stream - but unsettled from year to year and day to day. Winters are generally long and mild; summers are short and cool.

The mean annual temperature varies from about 3.9° in the north to 5.7°C in the south, with mean monthly ranges of -1.5° to 10.9°C in the north to 1.2° to 11.3° in the south. The warmest month is July with an average of about 11°C; the coldest month is February with an average temperature below 0°C.

The annual precipitation averages 1 400 mm, ranging from an average of 300–400 in the north to 1 500 in the southern lowlands. It is much heavier, about 2 000 mm in the mountains to over 4 000 on the glaciers. The snowline varies from 400 to 1 300 m.

The growing season, based on the average period with temperatures above 3°C between spring and autumn, is about 180 days (1 May–30 October) in the south, and 150 days (15 May–15 October) in the north (Wallen, 1961).

Ice cover is of long duration, e.g., it lasts from October to May or 190 days at Lake Mývatn in northeastern Iceland, where it reaches 70–80 cm in thickness. The southern coasts are rarely frozen but polar ice sometimes piles up against the northern and eastern coasts.

From the end of May until the beginning of August there is perpetual daylight for 24 hours.

5. HYDROGRAPHY AND LIMNOLOGY

The total area of inland water in Iceland is 2 750 km^2 or 2.7 percent of the country's area according to Table 2.

Originating from glaciers, direct surface drainage, and springs, the rivers flow in all directions from the interior into the sea. Their average annual run-off is about 1 750 mm or 170 000 million m^3 (Van der Leeden, 1975; ECE, 1978).

5.1 Rivers

There are about 250 large and small rivers in Iceland, ranging from 60 to 237 km in length and with flows of about 50–400 m^3/s each. The discharges of four of the principal rivers are shown in Table 1.

Icelandic rivers are of three general types. The glacial-fed rivers (Ĭokulár) carry large quantities of fine silt (2 000 ppm) and are typically brown in colour. Their runoff, being conditioned by icemelt, is high in the summer and low in the winter, reaching a peak in July–August with daily variations during the warm weather. Glacial rivers are close to freezing at source but warm up considerably in lowland areas. They may freeze over in winter. They typically divide into many interlinked distributaries which constantly change course and pendulate over the outwash plain below the glaciers. Skeiŏará is a prototype.

The direct runoff rivers (dragár), which are relatively clear (e.g., the Grímsá), are characteristic of old basaltic areas where the bedrock is relatively impermeable. They have their greatest flows in the spring during snowmelt and in autumn following heavy rains. The smallest discharge is during winter but there is a secondary minimum during the summer. Floods may occur at any season, and their erosive power is high. Water temperature in these streams generally follows the air temperature. Below the freezing point, anchor ice forms which drifts to the surface and the flow diminishes. Drifting snow may also affect the flow of small streams.

The third type of Icelandic river is the spring-fed stream (lindár) which drains areas covered by permeable postglacial lava fields. In these neo-volcanic zones where the ground is more porous, subsurface drainage is common and the water emerges in springs at lower levels to supply the rivers with an almost constant flow of generally clear water. These spring-fed rivers have a water temperature of 3–5°C at source and never freeze over at that point. Their beds and banks are usually stable.

In general, the rivers, which may be composites of the three basic types (Rist, 1956, 1979), are fast flowing, deep, rugged, and have many natural falls. Europe's largest falls, the 44-m Dettifoss on the glacial Jökulsá á Fjöllum is an example. The streams usually have good spawning areas for salmonids. Icelandic rivers are characterized by low conductivity; the annual average in 10 rivers (listed by Kristinsson and Alexandersdóttir, 1978) ranged from 53.6 to 91.5 micromho/cm at 25°C.

The longest rivers in Iceland are the Thjórsá (237 km), Jökulsá á Fjöllum (206 km), Ölfusá - Hvítá (185 km), and Skjálfandafljót (178 km). Other large rivers are the Jökulsá á Bru, Lagarfljót, Skeiðrá, and Kúðafljót.

Table 1

Discharge of four major Icelandic rivers

River and station	Basin area km^2	Mean monthly discharge, m^3/s Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Thjórsá, Urridafoss	7 200	245	288	311	302	536	545	509	448	368
Jökulsá, Dettifoss	7 000	105	110	122	144	218	213	325	345	249
Ölfusá, Selfoss	5 760	386	417	392	394	401	372	358	340	339
Lagarfljót, Lagarfoss	2 800	70	87	79	94	189	316	215	145	136
		Oct.	Nov.	Dec.	Year	Period of record				
Thjórsá, Urridafoss		338	295	263	371	1947–66				
Jökulsá, Dettifoss		163	128	111	186	1939–66				
Ölfusá, Selfoss		387	397	367	379	1950–66				
Lagarfljót, Lagarfoss		138	122	106	141	1949–66				

Source: Unesco (1969)

5.2 Lakes (Vatn)

Iceland has numerous lakes, all relatively small. Fifteen lakes exceed 10 km^2 in area and 68 others have an area of from 1 to 10 km^2. About 1 200 lakes have a linear extent of 300 m or more (Kristjansson, 1978).

Their origins are diverse. A large number are chiefly tectonic, e.g., the two largest Icelandic lakes: Thingvallatan (84 km^2) and Thorisvatn (70 km^2). Some lakes have been formed by the deepening of valleys by glacial erosion, e.g., Skorradalsvatn and Lögurinn (53 km^2). The well known Lake Mývatn (37 km^2) is a basin formed in a collapsed lava flow. Glacier or ice dams have formed some of the lakes, e.g., Graenalón, and such lakes are occasionally emptied beneath the damming ice. Other Icelandic lakes have been formed by rock slides or glacial deposits. Small crater or maar lakes are common in explosion craters. Lagoon lakes are common on the sandy shores, Hóp (45 km^2) being the largest of this type and the fourth largest lake in Iceland.

The largest lake in Iceland is Lake Thingvallavatn, 40 km west of the capital, Reykjavík. It has an area of 84 km^2, a mean depth of 34.1 m, a maximum depth of 114 m, and a retention time of 290 days. The deepest lake in Iceland is Lake Öskjuvatn, lying in a caldera at an elevation of 1 050 m, and formed after an eruption in 1875. With an area of 10.7 km^2, it has a maximum depth of 217 m, a mean depth of 115 m, and a volume of 1 230 × 10^6 m^3. It is probably ice-free for only half the year. One of the best known Icelandic lakes is the fifth largest and highly eutrophic Lake Mývatn, lying at 278 m in the northeast. With an area of 37 km^2, this productive lake has a maximum depth of only 4.2 m, a retention time of about 24 days, and an ice-cover of 190 days. Retention times of up to 1 000 days have been calculated for some Icelandic lakes.

In southwest Iceland (aside from Thingvallavatn), there are about 20 good fishing lakes including: Apavatn, Hlióărvatn, Kleifarvatn, Hvalvatn, Reyŏarvatn, Langavatn, Hítarvatn, and Oddastaŏavatn. In the northwest, the best fishing lakes are in the Húnavatnsśyslur districts. In the same area as Hóp are Vesturhópsvatn, Svińavatn and Laxáevatn. The Veioivötn lakes in the southeast contain only brown trout.

The chemistry of lake (and river) waters differs somewhat between the basaltic and neo-volcanic zones. In the old basalt areas where water is drained off rapidly it has little chance to react with the mineral phases and is poor in nutrients. In the volcanic zone, groundwater circulation is more effective, is sometimes affected by geothermal activity, and the load of dissolved solids is increased, e.g., at Öskjuvatn there are 850 mg/1.

Both brown trout (Salmo trutta) and char (Salvelinus alpinus) are found in many of the lakes, but some are barren, e.g., Thorisvatn, the second largest Icelandic lake contains no fish (see section 7.1).

5.3 Reservoirs

Although a number of streams and natural lakes have been regulated to produce hydroelectric power, there has been no extensive development of reservoirs in Iceland.

6. LAND AND WATER USE

Table 2

Pattern of land use in Iceland, 1986

	Percent
Arable and permanent crops	0.8
Permanent pasture	22.1
Forests and woodland	1.2
Other land	74.0
Inland water	2.7
Total	100.0

Source: 1987 FAO Prod.Yearb., 41 (Publ. 1988)

About 75 percent of the country is simply unproductive and virtually uninhabitable, being cold and high and consisting of barren snowy mountains, glaciers, lava desert, sands, and other waste lands. As a consequence, habitation is almost limited to lowland coastal areas. Iceland is about 90 percent urban and 10 percent rural. About 40 percent of the people live in the capital and almost all the others in towns and villages around the periphery of the island.

About one quarter of the country is used for grazing and cultivation, but only about one percent of the land is under crops. Hay is the principal and staple crop followed by potatoes and root crops. Grass grows for only four months (May–September), but raising livestock, mostly sheep, and dairy farming based on grass cultivation are the primary land-based industries. A very small amount of water is used for irrigation. Fertilization is necessary in this climate and with Iceland's soils. Artificial fertilization has been increasing rapidly since 1950. The consumption is about 115 kg/ha/year of N and 30 kg/ha/year of P (Olaffson, 1979).

There are no real forests in Iceland. Through wood-cutting, fires, and the advent of grazing livestock, the once extensive birch woods were devastated and destruction of the weak soils followed. Forest practices are primarily to combat erosion rather than to maintain an industry.

Mineral resources are also slight: there is some sulphur, diatomite, pumice, lignite and peat. Effluent from diatomite mining has affected the nutrient chemistry at Lake Myvatn.

The rivers with swift and irregular flow and waterfalls are unsuited for navigation. There are no railroads in Iceland. Automobile road building is increasing. The density of auto roads is 0.12 km/km^2, and private automobile ownership is high, about 425 per 1 000 people in 1985. Heavy reliance is placed on internal travel by aircraft.

In 1987, 79 percent (756 000 kW) of Iceland's total installed power capacity of 951 000 kW was hydroelectric. The total hydroelectric potential of the country was estimated by Worldmark (1988) at 7 million kW, of which half would be derived from the five principal glacial rivers. A number of recent authors say that only 6–10 percent of the potential has been tapped. In addition to its abundant hydroelectric resources, Iceland has considerable geothermal resources; in 1987 these accounted for 42 000 kW (4 percent) of installed capacity.

Situated on a platform on the continental shelf, with favourable conditions, such as presence of the Gulf Stream and upwelling, Iceland has rich fishing banks, and for many years marine fishing and fish processing has been its principal industry. About 18 percent of the labour force is engaged in these sectors which account for about one-quarter of the GNP. The per caput consumption of fish is very high, about 88 kg/year (1984).

Any possible decline in the marine fishing industry is now somewhat countered by development of power-intensive industries, such as aluminium smelting and manufacture of ferro-alloys which are assuming a greater portion of the island's economy.

The inland fisheries for salmon, trout and char have always been important to the economy of farmers and have now become an additional source of income through the growth of sport fishing[1].

Most of the public water supply comes from underground, primarily from springs. As most of the population is concentrated in coastal areas, most sewage discharges are to the sea rather than into rivers.

With respect to total consumptive water use, it was estimated in 1966 that about 50 million m^3 (an amount equivalent to only 0.03 percent of the surface run-off) was withdrawn annually. Of this amount, 80 percent was used municipally and 20 percent for agriculture. The total consumptive use is still very small.

Tourism (about 114 000 in 1986), including special trips for sport fishing, is increasing rapidly.

[1] In Iceland, with its small population and northern location, farmers have relied on nature for a subsidiary income, e.g., salmon and trout fishing, egg and eiderdown taking, and seal hunting. All of these activities except fishing have declined

7. FISH AND FISHERIES

Only five species of fluvial and diadromous fishes are native to Iceland: Atlantic salmon (Salmo salar), brown and sea trout (S. trutta), char (Salvelinus alpinus), European eel (Anguilla anguilla), and threespine stickleback (Gasterosteus aculeatus). A few Pacific pink salmon (Oncorhynchus gorbuscha) which were planted in the USSR have strayed into Icelandic streams, and rainbow trout (Oncorhynchus mykiss) have been introduced into the Icelandic hatchery system from Denmark.

The Atlantic salmon ascend about 80 rivers in Iceland, the maximum migration being 100 km. They are found in the rivers having the warmest waters during the summers, being found in the greatest abundance in western and southern rivers. Their runs extend from May to October, peaking in July, and spawning occurs from September to December. Most Icelandic salmon migrate into the sea after three years in the rivers (range one to five years), and remain there for one to two years, some for three. A 20 percent oceanic survival of wild smolts to grilse size has been ascertained in some streams, and about 50–60 percent return as grilse, i.e., one-sea-winter fish. Average growth is from 30 g to 2.5 kg in one year and to 6 kg in two years. The largest net-caught salmon was 22 kg, captured in the ocean in 1957. The largest rod-caught (fly) salmon was 17.5 kg from the Hvítá River in 1946. The highest average weight is reached in the river Laxa in Adaldalur in northern Iceland.

Resident brown trout are found in every Icelandic lake containing suitable spawning grounds, and the sea-run form of brown trout is found especially in the southern and southwestern part of the country. Sea trout run from about 0.5 to 2 kg and have been taken to 9 kg in the Skafta River.

Char also have resident and anadromous forms. Resident forms occupy all trout lakes except a group in south-central Iceland; a pelagic form is found in the largest lakes. Sea-run char are found throughout the country, but are most numerous in the colder waters of the north and east. Sea char attain weights of 0.5 to 1 kg and upward to 5.5 kg.

The European eel is found primarily in rivers where sea trout are abundant.

The threespine stickleback is widespread, but has no economic value.

7.1 Capture Fisheries

Table 3 illustrates the catch from Iceland's inland waters for the period 1965–87 as reported in rounded form by FAO (on the original basis of Governmental statistics) and as modified by the author. The modification was necessary because the early FAO Yearbooks of Fishery Statistics (see, for example, Volumes 36 and 40) incorrectly accredited the Icelandic catch of Atlantic salmon and trouts to Marine Statistical Fishing Area 27, the Northeast Atlantic[1]. This is an obvious error because the salmon fishery of

Iceland is limited to rivers. Since 1932 the country has banned fishing for salmon in estuaries and in the sea, even in its territorial waters[2]. Therefore, in this report both the salmon and trout catch in Iceland have been attributed to the inland fishery just as is now being done in the FAO Fishery Yearbooks and in FISHDAB. (The author is suspicious of the reported "catches" of all trouts - for obvious reasons.)

1 The catch of "freshwater fishes, n.e.i." in Iceland was listed correctly in these Yearbooks as coming from inland waters. However, as shown in these statistics (and considering its fish fauna) it is obviously small

2 A few farms that had fished in the sea traditionally, mostly by land-connected gillnets, were excepted. However, these farms account for only about one percent of the total Icelandic salmon catch (Isaakson, 1980). Fishing for sea trout and sea char is allowed in the sea, but it is believed that the catch is small

Table 3

Nominal catches in the inland waters of Iceland, 1965–87[a] (in tons)

Species	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Altantic salmon (Salmo salar)	0	0	100	100	100	200	200	200	300	225	266	225
Rainbow trout (Oncorhynchus mykiss)	-	-	-	-	-	-	-	-	-	-	-	-
Trouts, n.e.i. (Salmo spp.)	0	0	300	300	300	300	300	300	200	250	250	250
Freshwater fishes n.e.i.	...	...	...	...	...	...	0	0	0	0	0	0
Total	-	-	400	400	400	500	500	500	500	475	516	475

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Altantic salmon	230	291	225	248	163	147	198	160	217	296	220
Rainbow trout	-	-	-	-	-	-	-	30	12	150	139
Trouts	250	250	250	250	250	250	250	250	250	250	250
Freshwater fishes	0	0	0	0	0	0	0	0	0	0	0
Total	480	541	475	498	413	397	448	440	479	696	609

a The Icelandic catches of both Atlantic salmon and trouts during the 1965–75 period were listed incorrectly in Yearb.Fish.Stat.FAO, Vol.36 (1965–73) and Vol.40 (1970–75) as derived from marine statistical fishing area 27, the Northeast Atlantic

0 - Probably nil, negligible or insignificant; or less than 50 t during the 1965–73 period, or less than half a ton during later years.

... not available

Source: 1965–69 Yearb.Fish.Stat.FAO, 36 (Publ.1974)
1970–83 FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1984–87 Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

It should be noted that the line between "capture fisheries" and "aquaculture" may be somewhat blurred in the secondary references available for Iceland. Thus, for example, salmon smolts may be reared either for stocking rivers (with a hope of return from the sea) or for direct sale, and the disposition or use of the 4.6 million smolts produced by 38 companies in Iceland in 1987 is not made clear by Ackefors (1989). Furthermore, it is obvious that some of the "catches" (e.g., the salmon catch for 1987) recorded by FAO and reproduced in Table 3 are less than those for aquacultural production alone recorded by FAO in Fisheries Circular No. 815, Revision 1 (see below), despite the fact that the records in Table 3 are supposed to include this production. For such reasons, it is probably more important to be concerned with the general trends of Iceland's inland fisheries rather than with some of the details.

Table 4 illustrates the complete catch (in unrounded figures) of Atlantic salmon in Iceland for the period 1963–77 as furnished directly to EIFAC by the Government, supplemented by round figures for the period 1978–87 from FAO.

Table 4

Catch of Atlantic salmon in Iceland, 1963–87

Year	Number	Weight (kg)
1963	38 698	143 970
1964	36 832	134 605
1965	35 707	131 597
1966	28 744	105 241
1967	40 503	143 918
1968	40 785	161 368
1969	35 038	133 027
1970	55 971	194 742
1971	58 874	203 704
1972	65 726	249 921
1973	66 162	255 904
1974	55 913	225 069
1975	74 004	265 679
1976	59 633	224 695
1977	64 575	229 747
1978	-	291 000
1979	-	225 000
1980	-	248 500
1981	-	163 000
1982	-	147 000
1983	-	198 000
1984	-	160 000
1985	-	217 000
1986	-	296 000
1987	-	220 000

Source: 1963–77 - Institute of Freshwater Fisheries, Iceland, April 1979
1978–83 - FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1984–87 - Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

Iceland's 80 salmon streams have now replaced those of Norway as the finest in the world (see section 9.2 for a listing of some of Iceland's unique advantages with respect to the salmon fishery). The salmon catch is divided between commercial operators (about 30 percent) and sport fishermen (about 70 percent). The commercial fishing with stake nets and gillnets is almost exclusively confined to the three principal watersheds in the southwest which carry such milky silt that sport fishing would be poor.

During the period of 1973–77, the number of salmon caught in the rivers by all fishermen ranged from 55 913 to 74 004 annually. The average annual catch for the period was 64 057 salmon totalling 240 t. The average individual weight of these fish was 3.75 kg. Ísaakson (1980) says that the 50–60 percent of the fish which are grilse average 2.5 kg apiece.

Scarnecchia (1989) states that the average annual angling catch from 1971 to 1980 was 41 700 fish and that the commercial gillnet catch from rivers during the same period averaged 21 500 fish. The total catch in 1987, excluding salmon ranching, was about 45 000 fish. About 34 000 of these were caught by rods; the rest by nets (Isaakson, 1988; Gudbergsson, 1988). During 1987, cage and tank culture produced 490 t of salmon. Note that this is about twice the amount of all the true capture catch in rivers, both recreational and commercial (Scarnecchia, 1989).

Although the streams are relatively limited - runs are often blocked a short distance above the mouth - they are remarkably productive and are supplemented by smolt-planting. As an example, in the Elidaár, a stream within the capital city which is less than 6 m in width and only 6 km long, annually produces about 1 800 salmon weighing as much as 4 t. Fifteen of the 80 rivers produce between 1 500 and 3 500 rod-caught fish each season, and the most productive, the Laxá in Adaldalur produces about 3 000 salmon annually totalling 15 t. Among other major salmon rivers in Iceland are the: Vididalsa, Vatnsdalsá, Nordurá, Thverá, Sog, Langá, Laxá in Laxardalur, Laxá in Leirásveit, Laxá, in Kjós, Grímsa, Haffjardará, Hrutafjardará and Midfjardará.

Circa 1982, the total number of anglers allowed to fish each day for salmon was only about 400 in the entire country; the number of rods per stream is severely restricted. Flies, other artificial lures and bait are permitted. A high percentage of the angling permits go to foreigners, and rates for salmon beats on peak streams at peak season have become very high. Circa 1974, some of them cost US$ 200–300/day. Prices have steadily gone up. Hubert (1982), addressing himself to the North American angler, says: “Salmon fishing in Iceland is expensive. Expect to spend US$ 5 000–6 000 for a week's fishing, airfare and sundry expenses”. In 1988, a lodge on the Laxá in Adaldalur leasing about 11 km of river restricted to seven rods, charged over US$ 5 000 for a week of salmon fishing including guide service and accommodation.

As Mathieson and Gudjonsson (1978) have said: “The salmon fishery in Iceland is predominantly a sport fishery. As such, the prime task of management is not to maximize the yield, as in other fisheries, but to achieve the greatest satisfaction of the angling public…Improved fishing can be achieved by releases of smolts in the naturally producing streams, or in previously barren streams. But the greatest expansion is seen in ocean ranching when the products are in addition to meat also eyed eggs or juvenile salmon and smolts…a recreational fishery for salmon…is economically more rewarding than a direct commercial fishery…” “Ocean” or “sea-ranching” is, of course, dependent upon the release of smolts which will return to the streams as grilse or adults for capture (McNeil, 1973, 1975).

Sport fishing for trout (especially large browns) and char is practiced in both rivers and lakes, but commercial fishing for these species is of minor importance, being carried on in only three lakes. Lake Thingvallavatn has an annual catch (circa 1978) of 3–5 t of benthic char and up to 70 t of pelagic char. Lake Mývatn yields from 10 000 to 100 000 fish/year, an estimated catch of 20 t/year, about 10–15 percent being trout, the remainder char (Jónasson, 1979). Lake Apavatn yields 5–12 t of trout and char annually. Winter fishing through the ice is practiced in some places.

Although most of the other lakes in Iceland are used by their owners to produce fish for home consumption, there is a tendency to lease them for recreational fishing, both to Icelanders and foreigners.

7.2 Aquaculture

Although Iceland is particularly interested in developing its Atlantic salmon fishery to build a larger sports-angler industry and to produce adult fish for commercial sale, development along such lines is primarily a form of “ocean-ranching” - rather than traditional aquaculture where one has complete (or almost complete) control of the “product” from egg to consumable or marketable production. There are now 15 registered ranching stations in Iceland, and in 1988 a total of 180 t of salmon returned to the release sites (Ackefors, 1989).

Although the first hatchery in Iceland (for salmon) was built at Kjós in 1885, and the first rearing station (for sea trout) in 1944, sustained aquacultural production using modern methods is a much more recent endeavour. In fact, interest in true aquaculture did not develop in Iceland until 1984 and it was not until then that the government took a decided interest in its development (Ackefors, 1989). The growth of Iceland's salmon aquaculture can be followed in Gudjonsson (1978) and by reading such journals as Fish Farming International. Suffice it to say that the industry in Iceland employs about 182 persons, working on 106 salmon farms, 19 trout farms, and a mussel farm. Thirty-eight companies produced 4.6 million smolts in 1987 and the production capacity in 1988 was 21.5 million smolts (Ackefors, 1989).

According to FAO Fish.Inf.Data and Stat.Serv. (1989), the production from aquaculture in Iceland during the 1984–87 period ranged from 91 t to 490 t (1987) of Atlantic salmon, and 12 t to 150 t (1976) of rainbow trout, as well as 11 t of brown trout and 3 t of char in 1987. According to FES (1989), in 1988 Iceland raised 1 000 t of salmon, 50 t of large trout, and 100 t of portion trout. This production had increased in 1989 to 8 000 t of salmon, 200 t of large trout, and 200 t of portion trout.

The use of Iceland's warm springs for salmonid rearing is a distinct advantage. In some cases, springs with a water temperature of 10–18°C are used directly; in other cases warm thermal water is used to elevate the temperature of cold springs. Use of heated water permits a one-year rearing cycle through the smolt stage of salmon instead of the two or three years usually required under natural conditions. (Smoltification in Iceland takes from one to five years.)

Aside from geothermal water as an aid to aquaculture, many of the Icelandic fish farms have large outdoor tanks with a continuous flow of water. Seawater is pumped from wells close to shore and filtered through sand and gravel to eliminate bacteria and toxic algae. The productive capacity of landbased farms in Iceland in 1989 was about 2 100 t compared to offshore farms with a production of about 5 500 t (Ackefors, 1989).

Iceland has many other advantages for the development of salmonoid aquaculture (not only salmon but rainbow trout, brown trout, and char are also raised). It has an abundance of unpolluted river water, spring water of good quality and bacteria-free, large areas of land available for producing fish, small protected bays for cages, dissipation of wave-force by offshore skerries, and areas with relatively constant salinities. Tidal ranges indicate that cages rather than sub-littoral enclosures are better in coastal waters.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT AND INVESTIGATION

8.1 Ownership

Fishing rights in Iceland go with the land that adjoins rivers and lakes, i.e., they are privately owned, generally by farmers.

The fishing rights may be leased for use by angling clubs, other groups, or individuals.

8.2 Administration

Although the oceanic fishery stocks are under the jurisdiction of the Ministry of Fisheries, salmon are administered under the Ministry of Agriculture.

"In 1934 a law was passed which created fishery associations on every river or river system, with the function of managing the local fishery. All holders of the fishing rights on a river became members of the association."

"The freshwater fisheries law of 1932 provided for a governmental authority for promulgation of regulations of the fisheries…an Advisory Freshwater Fisheries Council…was established in 1933. In 1946 the Institute of Freshwater Fisheries…was appointed. In addition to management of freshwater fisheries at a governmental level, the work of the Institute includes the collection of fisheries statistics, distribution of information and consultation on fisheries matters, besides research on freshwater fishes and their environment, and research on fish cultural techniques." (Gudjónsson, 1978).

An experimental fish cultural station at Kollafjördur is also operated by the Government under the Director of Freshwater Fisheries.

Aquacultural production licenses are approved by both the Institute of Freshwater Fisheries and the National Centre for Hygiene, Food Control and Environmental Protection.

8.3 Management

The number of rods on each salmon river is determined by the Directorate of Freshwater Fisheries and kept within a reasonable limit to ensure quality fishing. However, on many salmon rivers there is no bag limit and anglers are allowed to retain their catch.

Other methods of management include: establishment of seasonal fishing periods, daily fishing times and number of fishing hours, removal of waterfalls and erection of fishways as an aid to migration, and fish stocking, including its extension to barren waters.

9. STATE OF THE FISHERY

9.1 Yield

The unrefined statistics in Table 3 cannot be usefully employed to determine changes in the state of the several Icelandic inland fisheries. However, with respect to Atlantic salmon the record from other sources (Table 4) clearly shows that perhaps until recently the fishery has not only been sustained, but has increased in total harvest.

Iceland has had official records of salmon catches since 1897. During the period 1887–1909, the average annual catch was 5 168 fish, and from 1910 to 1950 the average annual catch was about 15 000 fish. After that time, the reported catches began to increase to reach about 64 000 fish annually during the years 1970–75. The trend which was upward and generally uniform in most parts of the country was ascribed by Gudjónsson (1978a) to improved catch records and management practices (see section 8.3). In 1981, the catch went down decidedly and was even less in 1982 (see Table 4).

There are few statistics with respect to yield per unit area of either Icelandic streams or lakes. Catch statistics for Lake Stóra Fossvatn show a very high yield of brown trout for a northern country: 20–30 kg/ha/year; and the estimated yield of char from a shallow (average depth 0.8 m), 2.36 km^2 lake, East Fridmundarvatn, in 1977 was 16 kg/ha/year[1]. The average annual yield of salmonids at Lake Mývatn is estimated at 5.36 kg/ha (Jónasson, 1979).

[1] Kristjánsson (1978), from whom these figures are derived, cites a comparative yield of 5–7 kg/ha/year of brown trout from Norwegian lakes

Densities of juvenile salmon are considered high as compared with those in other countries; good Icelandic salmon streams produce about 1 000 smolts/ha of nursery area (Isaksson, Rasch and Poe, 1978).

9.2 Factors Affecting the Fishery

Despite its far northern location and limited fauna, Iceland has many advantages over most European countries with respect to inland fishery production. For example, its isolation preserves it from actions by other countries, such as the release of pollutants or erection of barriers to fish migration, which might affect its fisheries[2]. Secondly, its low population density, relative absence of harmful industrial practices, and abundance of water renders its streams and lakes almost pollutionfree. The average annual runoff per caput amounts to almost 670 000 m^3 - an almost unbelievable figure as compared to that in heavily populated and industrial countries. Thirdly, with respect to anadromous stocks, hydroelectric dams have apparently not cut off their spawning grounds or otherwise affected them adversely (T. Gudjónsson, pers.comm., 1979).

[2] Fishing equipment and river gear must be sterilized before it is brought into the country by foreign anglers in order to prevent the entry of fish diseases

With specific reference to the maintenance of Atlantic salmon stocks, Iceland has several advantages over most of the other salmon-producing countries:

(i) "The insular position of Iceland and the nature of the surrounding ocean currents effectively…isolate Icelandic salmon stocks against intermingling with foreign stocks" (Mathisen and Gudjónsson, 1978);

(ii) the Government does not permit commercial fishing for salmon within its territorial seas which permits assignment of the catch to each individual river;

(iii) stream rights belong to individuals or groups who, with the aid of the Government, can control fishing within them;

(iv) 50–60 percent of Icelandic salmon return to their rivers as grilse (one-sea-winter fish). These grilse do not migrate as far as two- and three-sea-winter fish, and consequently are not caught in foreign waters. Under such circumstances control of about half of the stocks is primarily in the hands of Iceland. In 1970, it was estimated that escaping salmon, regulated by a closed season as well as a limit on catch and effort, constituted about 50 percent of the returning stock, and

(v) there are a great number of suitable food organisms in Iceland's sea, e.g., capelin (*Mallotus villosus*), lance fish (*Paralepsis* sp.), crustacea, and squid.

There are, of course, some unfavourable factors. A number of streams, especially in the northwest, are too short, steep, and cold to promote salmon propagation, and others are too silty for good fish production. There have been deterrents to fish migration on some waters. Cooling down of the sea by drift ice from the Arctic Ocean, and even fall of volcanic ash are other factors which at times have been blamed for diminished salmon production.

9.3 Prospect

As has been emphasized above, several rather unique geographical, political, economic and biological factors contribute to the maintenance of good salmonoid stocks in Iceland. Given continuance of these advantages, as well as perennial recognition that the inland waters should be preserved from the adverse effects of development, the inland fisheries should continue to prosper.

For over a thousand years, Iceland has placed heavy dependence upon both its marine and freshwater fisheries for food - it has the world's highest per caput consumption of fish - and profit. If its marine fisheries decline, greater emphasis will be placed on the development of power-intensive industries, such as aluminium smelting. This will, of course, lead to more hydroelectric installations (there are at least 90 potential sites for these in Iceland) whose effects on fisheries necessitate ecological considerations to minimize their extent. (In this regard it is of interest to note demands by the local population for ecological investigations of Lake Mývatn and the River Laxá area in view of plans to convert the upper 50 km of the river into reservoirs (Jónasson, 1979).

Future developments in inland fisheries in Iceland also embrace: greater emphasis on both commercial and sport fishing in lakes, carefully designed management to ensure high quality recreational fishing for salmon and greatly augmented production through ocean ranching, as well as increased rearing of cultivated salmonids. In fact, with respect to Icelandic exports in 1987, the National Economic Institute, Reykavik (1988) said that the largest growth was recorded in aquaculture.

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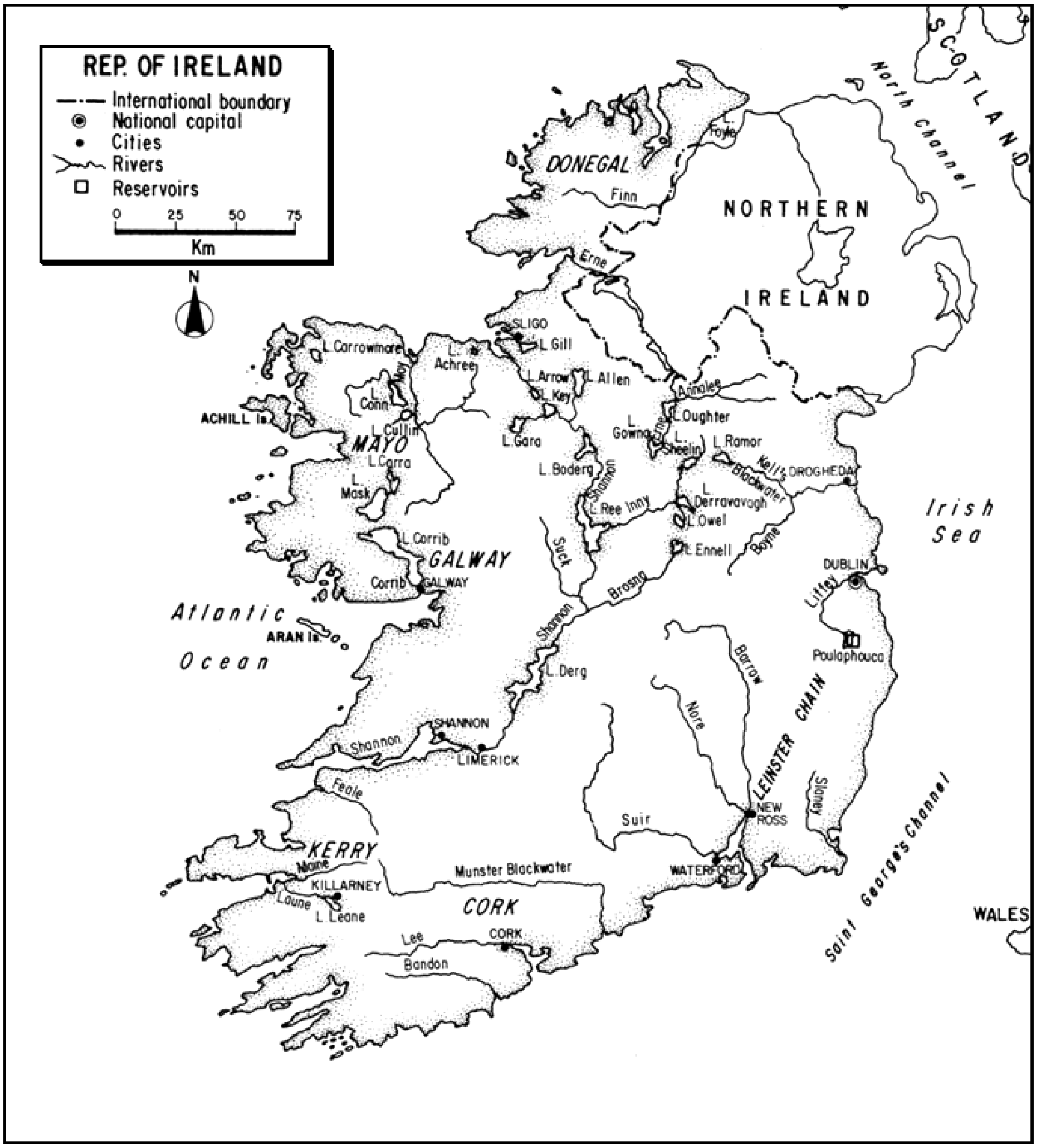
REP. OF IRELAND
International boundary
National capital
Cities
Rivers
Reservoirs
0 25 50 75
Km
N
SCOTLAND
North Channel
DONEGAL
L. Foyle
Finn
NORTHERN
IRELAND
Erne
SLIGO
L. Gill
L. Carrowmore
L. Achree
Moy
L. Conn
L. Arrow
L. Allen
L. Key
Annalee
ACHILL Is.
L. Cullin
MAYO
L. Gara
L. Gowna
L. Oughter
L. Sheelin
L. Ramor
Kells
DROGHEDA
L. Carra
L. Boderg
Shannon
Blackwater
L. Mask
L. Ree
Inny
L. Derravaragh
L. Owel
L. Ennell
Irish Sea
L. Corrib
GALWAY
Suck
Boyne
DUBLIN
Corrib
GALWAY
Brosna
Liffey
Atlantic
Ocean
ARAN Is.
Shannon
Poulaphouca
Barrow
L. Derg
Nore
LEINSTER CHAIN
SHANNON
Shannon
LIMERICK
Feale
Slaney
Saint George's Channel
NEW ROSS
Suir
KERRY
Maine
WATERFORD
KILLARNEY
Munster Blackwater
Laune
L. Leane
CORK
WALES
Lee
CORK
Bandon

IRELAND

The Republic of Ireland (Eire) occupies four-fifths of the island of Ireland, second largest of the British Isles, lying just west of Great Britain.

A limestone-based lowland, rimmed by coastal uplands, its central plain contains many bogs, lakes and slow-moving rivers. Streams on the seaward side of the coastal fringe are usually short and rapid. With a cool, rainy climate, Ireland is primarily an agricultural or pastoral country with a rural aspect. Industrial development, less than that in Great Britain or on the continent, has been generally kind to its waters.

Good fish populations of Atlantic salmon and sea trout occupy most of Ireland's rivers, and provide both inland and offshore fishing. Eels also constitute a fishery resource. Its streams and lakes provide excellent angling for resident brown trout, and cyprinid and pike fishing are also important. Cold-water aquaculture is developing.

Provided that overfishing for the anadromous stocks can be curtailed, and that management can cope with the exigencies of industrial and agricultural development, the prospect is good for commercial and recreational fishing and for aquaculture.

1. AREA: 70 285 km^2
2. POPULATION: 3 843 000 (est. 1990) Density: 55 inh/km^2
3. PHYSICAL GEOGRAPHY

The Republic of Ireland is situated between 51°30' and 55°30'N latitudes and 5°30' and 10°30'W longitudes. It occupies 83 percent of the island of Ireland, second largest of the British Isles.

It has a boundary of 412 km with Northern Ireland, which is part of the United Kingdom, along its northeastern and northern borders. Otherwise, it is surrounded by the Atlantic Ocean with a coastline of about 3 200 km, separated from Great Britain to its east across the Irish Sea and St. George's Channel, but about 80 km at the narrowest point. Donegal, the northernmost extension of the Republic, is separated from Scotland by the North Channel.

The main body of the country has a length (N–S) of about 330 km and a width (E–W) of about 275 km, although it has an extreme length (SW-NE) of about 475 km. Its altitudinal range is from sea level to 1 025 m, with a central lowland averaging about 90 m. Only small areas exceed 360 m, while less than 0.25 percent top 610 m.

Essentially, Ireland is a rolling drift country, lying mainly at 60–90 m and rising gently to 120 m, and varied by a number of low hills about 180–300 m in height. Around the lowland is a discontinuous rim of coastal highlands which are mainly granitoid. These hilly or mountainous groups, rarely exceeding 900 m, more or less surround the country on the north, west and south opening more widely to the east on the Irish Sea. Major groups include: the rocky, hilly region of the extreme northwest (Donegal); some ice-worn masses in the west (Mayo and Galway); a large area in the southwest (Kerry and Cork) where parallel ribs of land separate the long narrow coastal rias or drowned river channels; some scattered groups through the south, southeast and east; and the moorlands and uplands of the Leinster Chain running south from the capital city of Dublin.

Enclosed by this girdle of highlands, most with gentle gradients, is the large central peneplain. It stretches from its northern boundary, the River Erne, through the midlands south to the Munster Blackwater Valley. Basically, limestone or karstic, the plain is covered by deposits of sand and gravel, especially in the east. This glacial drift may be 60 m thick. The River Shannon flows through this entire plain from north to south and then westward to the sea. To its west are large areas of limestone; to its east is an area of limestone and boulder clays, shallow lakes, and peat bogs. Since Ireland is somewhat saucer-shaped, it is difficult for its central rivers to wend their ways to the sea except through constant meanders. It is characterized by its "difficult" drainage: many oddly shaped lakes, both large and small, and streams flowing in all directions. It has many marshes, peat bogs, and pasture lands, and is subject to frequent flooding.

The drift-clad east coast is comparatively smooth, but the west coast is deeply penetrated by bays, fjords and rias, and in many places fringed by great sea cliffs. Wave attack is high, especially in the west, and lagoons are absent. There are many small coastal islands. The largest islands are Achill (148 km^2), and the three Aran islands (47 km^2), all on the west coast.

The basic rocks in Ireland's mountains very from granite to slate, sandstone and volcanic. Most soils originate from drift. Some of the older rocks weather into unproductive soil, but ice-borne drift is often limestone-bearing and fertile. In general, high saturation makes many soils acid and lacking in phosphate. High precipitation and poor drainage have made the central lowland conspicuous for its bogs, and about one-seventh of the country is covered with peat.

Ireland has always had a poor indigenous flora, impoverished because of glaciation and the early breakdown of land connection with the mainland. Oak, birch, ash, juniper and yew are among the native trees, but the dampness and acidity of many Irish soils have not been conducive to forest growth in historic times. Furthermore, there was a general deforestation between 300 and 1700 A.D. due not only to climatic conditions, but through pastoral activity and the exploitation of timber which left an almost treeless landscape. There is still comparatively little forest in Ireland today, although there has been a partial afforestation including the planting of many species of exotic conifers[1].

[1] The appearance of tree cover in Ireland is, however, deceptive due to presence of shelter-belts, copses, and even single trees

4. CLIMATE

The "mild, moist and changeable" climate of Ireland is western maritime, temperate, mild and wet, strongly affected by warm moist air from the Atlantic. Only the southeast has warm summers; the rest of the country is cool. Winds are frequent, and evaporation is low.

The mean annual temperature is 10°C. The mean summer temperature is 15.5°C, and that of the winter 4.5°C. The air temperature is almost uniform throughout the country, no part of which is more than 115 km from the sea. It is only in the high hills and low mountains that growing temperatures are limited to five or six months in the year.

There are frequent soft rains: about 178 rain-days in the southeast and 200–225 on the west coast. The annual range is from 2 000 mm in higher regions of the southwest to 750 mm in the lowlands. Downpour averages about 1 194 mm annually for the entire country. Winter precipitation is about 50 percent greater than that of the summer. Snow, which is infrequent in Ireland, may persist several weeks in the northeastern mountains, but rarely for more than a few days at lower levels.

Bright sunshine is also infrequent, e.g., in 1980, the longest mean monthly duration in May was only 6.5 hours daily, and in December only 1.2 hours or a yearly average of 3.2 hours per day.

5. HYDROGRAPHY AND LIMNOLOGY

Although most of Ireland's rivers are cut in drift and have not reached rock-floor, there is a large underground drainage system underlain by limestone and providing a high water table. Stream density is low in many of the limestone lowlands, but water from underground sources reaches the interlacing surface network of rivers and lakes which acts as the central drainage artery of the country. Widespread peat beds also hold much of the surface water as evidenced by hydrologic changes when they are drained or stripped.

The Central Statistics Office (1988) indicates that major inland waters (“certain lakes, rivers and tideways”) constitute 1 391 km^2 or 1.98 percent of Ireland's total area. Table 4, whose original figures probably stemmed from the same source, indicates that the extent of Ireland's inland waters is 1 390 km^2. McGrath (1971), probably alluding only to lakes (see section 5.2) says that 1 445.2 km^2 of fresh water are under the administration of the Department of Agriculture and Fisheries, a figure of 2.06 percent of Ireland's total area. Ireland/EIFAC (1989) on the basis of a questionnaire sent to Ireland says that there are 3 350 km^2 of inland water in Ireland. This is about 4.8 percent of Ireland's total area.

The approximate annual, runoff from rainfall in Ireland is 710 mm resulting in a total annual river discharge of 50 000 million m^3 (Van der Leeden, 1975; ECE, 1978).

5.1 <u>Rivers</u>

Holden and Lloyd (1972) state that there are 11 400 km of streams in Ireland, and Piggins (1980) says there are 13 280 km of rivers. Obviously, all such estimates of stream length may be questioned, but there are undoubtedly a large number of separate drainage systems in this island country which flow in all directions, albeit often for only short distances. Thus rivers such as the Corrib and Sligo flow only a few kilometres between major lakes and their estuaries. Others, such as the Shannon, Blackwater and Suir drain large regions.

Those streams arising on the seaward side of the coastal mountain fringe are naturally short and rapid. The inland streams often flow slowly through marshes, bogs, and lakes and often enter the sea over waterfalls or rapids long distances from their sources. They have senile courses in the lowlands and are more youthful near the ocean. One feature of many Irish rivers is their tendency to expand into wide lakes (loughs) with irregular outlines. For example, almost one-half of the Shannon River above its estuary is made up of lakes. With respect to their underlying terrain, some of the rivers on granite or sandstone are fast flowing and very small. Some of the largest on the central drift and limestone plain are placid and sluggish. Lying on either side of these river channels are low-lying pastures or <u>callows</u> which may flood in the wet season.

The basic regime on Irish rivers is relatively simple; it follows the rainfall. The minimum flow is in late spring and early summer; the maximum is in early or late winter or from October through March. The flow of the Shannon is shown in Table 2.

With respect to water chemistry, Irish rivers can be divided into four categories:

(i) those originating on or flowing through limestone. Bicarbonate alkalinity is usually high (3.0–6.5 m Eq/1) with little fluctuation; pH generally 8.0 or higher;

(ii) those in regions with some limestone and mixed but not abruptly changing geology. Bicarbonate alkalinity is moderate (usually 0.5–2.0 m Eq/1) with small fluctuations; pH usually between 7.0 and 8.0 and stable;

(iii) those on limestone but with acid-rock headwaters draining various catchments. Both bicarbonate alkalinity and pH vary widely, and

(iv) those weakly buffered (bicarbonate alkalinity 0.1–0.4 m Eq/1) in limestone-deficient regions with a pH rarely reaching neutral (Kennedy and Fitzmaurice, 1971).

The River Shannon, with a catchment area of 15 700 km^2 or over one-fifth of the country's area, is the most important element in Ireland's drainage system. With a length of 260 km, plus a 112-km estuary and about 1 800 km of tributaries, it is the longest river in the British, Isles, surpassing the length of either the Severn or Thames. It has a mean monthly flow of about 180 m^3/sec. Rising at only 100 m near Donegal Bay, it flows southward through Loughs Allen, Ree and Derg. At Killaloe (at the southern end of Lough Derg), it passes through a series of rapids and then turns westward at Limerick to its long estuary leading to the Atlantic. Although the Shannon is a sluggish and partly canalized river, dropping only about 17 m in more than 160 km, it then falls more than 30 m in its last 26 km from Lough Derg to tidewater. This is the basis for its use for hydropower. It is navigable for 241 km.

There are 11 other rivers longer than 80 km, but as none of these drain more than 6 percent of the country, Ireland has a large number of separate river systems. All of these rise at a greater height than does the Shannon, one as high as 1 000 m, and are faster flowing.

Table 1 lists some of Ireland's representative rivers. A brochure of the Irish Tourist Board-Bord Failte (1979) lists 73 major rivers or river systems containing brown trout (Salmo trutta), and almost every stream in Ireland - whether brook or river - has conditions suitable for this species. Atlantic salmon (Salmo salar) and sea trout (5. trutta) also run in many Irish rivers. There are about 15 major salmon streams in Ireland and about 25 minor ones.

5.2 Lakes

Lakes (called loughs here) are numerous in Ireland, ranging from large limestone lakes noted for big brown trout to small acid lakes containing many small trout. Piggins (1980) (probably following McGrath (1971)) states that there are 1 445 km^2 of lakes in the Republic. Ireland/EIFAC (1989) on the basis of a questionnaire sent to Ireland states that there are only 221.26 km^2 in Ireland. Obviously, this figure is subject to question.

Table 1

Some representative rivers of Ireland

Rivers	Length (km)	Remarks
Eastern rivers (N–S)		
Boyne	113	
Kells Blackwater	64	
Liffey	132	Dublin's river
Slaney	117	
Southern rivers (E–W)		
Barrow	192	
Nore	140	
Suir	184	
Munster Blackwater	137	
Lee	85	Enters Cork Harbour
Bandon	72	
Western rivers (S-N)		
Laune	23	Drains Killarney lakes
Maine	40	
Shannon	372	Largest river in Ireland. Has a 112-km estuary, many large lakes, and important tributaries
Suck	97	
Brosna	48	
Feale	60	
Corrib	8	Short river entering Galway Bay out of Lough Corrib
Moy	101	Lough Conn in drainage
Erne	135	Extensive complex drainage in both Ireland and Northern Ireland

Source: Columbia Lippincott Gazetteer of the World (1966), Orme (1970), Irish Tourist Board-Bord Failte (1979)

Table 2

Discharge of the River Shannon, Ireland, 1935–65

Station	Drainage basin km^2	Mean monthly discharge, m^3/s												
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Killaloe	10 400	326	296	205	152	94.5	71	72.5	85	130	171	246	321	180

Source: Van der Leeden (1975) after Unesco, 1971

Many of the small lakes, such as those in the central lowland, are simply situated in depressions in glacial drift or in ice-scoured rock hollows (e.g., corrie lakes). Some of the larger lakes are situated in broad limestone basins of debatable age and origin. Included here are Loughs: Ree, Sheelin, Derravaragh, Owel and Ennell. Others, sited mainly in limestone but lapping against non-calcareous rocks are Loughs: Corrib (the largest lake in Ireland), Derg, Mask, Conn, Erne and Leane. These latter lake basins have been termed "solution lakes", their origin being attributed mainly to the solvent action of a river to deepen its bed through surface solution of limestone. However, recent studies (e.g., Williams, 1970) indicate that this theory cannot be accepted unanimously. For example, the great depth of Lough Corrib (46 m) and Mask (58 m) indicates glacial scouring, and Lough Derg appears to be an icehollowed basin. One lake, Lough Achree, called the "youngest" lake in Ireland, was formed by an earthquake in 1490.

In addition to its permanent lakes, Ireland has a number of intermittent turloughs unconnected by surface chains. These hollows, filled with water at times and dry at other periods, are dependent upon underground drainage fluctuations and subsidence of limestone.

Most of the big Irish lakes are shallow, open and exposed to wind. Although smaller ones may have a greater depth-surface area ratio, they are generally at higher altitudes (where cool temperatures and wind prevail) or are supplied by river or spring water. There is, therefore, little thermal stratification in Irish lakes. They are essentially orthograde with respect to temperature, and in general are well oxygenated at all depths even when highly productive.

The pH of the lakes varies from about 5.0 in upland lakes on granite surrounded by bog to about 8.5 in large limestone lakes. The bicarbonate alkalinity varies from about 0.2 in sandstone and granite to 4.6 m Eq/1 in some limestone lakes. Those lakes with a bicarbonate alkalinity of more than 2.0 m Eq/1 are the most productive of the Irish waters. (Kennedy and Fitzmaurice, 1971.)

As with the streams, nearly every Irish lake with access to the sea contains at least some brown trout, and salmon and sea trout are also found in some lakes, the latter mainly in acid lakes. The fastest growing trout are found in the clear high pH limestone lakes of the central plain. A few lakes hold the introduced rainbow trout (Oncorhynchus mykiss) and some are good coarse fish waters.

A list of some of the representative lakes in Ireland is provided by Table 3.

5.3 Reservoirs

There are a limited number of reservoirs in the Republic of Ireland, established primarily to produce hydroelectric power. Among these (their drainage basin is shown in parentheses) are: Poulaphouca Reservoir (Liffey), Leixlip Reservoir (Liffey), Bohernabreena (Dodder), Wexford (Slaney), Lee Reservoir (Lee), and Erne (Erne). Ireland/EIFAC (1989) on the basis of a questionnaire sent to Ireland states that the total reservoir area there is 38.04 km^2.

Most water service supply in the Republic (and also in Northern Ireland) is directly from lake or stream, and most of their reservoirs carry only a few days supply of water.

There is fishing in some reservoirs, but it is surpassed by that in the natural lakes.

5.4 Canals

Although there was a considerable development of canals in Ireland in the Eighteenth Century, their demise was hastened by the advent of railway transport and road building. All of the Irish inland waterways are now officially closed to commercial transport, although portions of the Shannon-Grand Canal are open to tourist traffic.

The two principal canals are the Royal, connecting the Shannon above Lough Ree to Dublin, and the Grand, connecting the Shannon between Loughs Ree and Derg with Dublin. The Barrow Navigation joins the Grand Canal to the Barrow.

The canals hold good stocks of coarse fishes, especially cyprinids, which are generally found in pockets.

Table 3

Some representative large lakes (loughs) in Ireland

Lake	Area (km^2)[a]
Shannon Basin	
Derg	116.35
Ree	105
Allen	35.8
Sheelin	19
Ennell	14
Derravaragh	11
Gara	11
Owel	9.5
Key	9
Corrib Basin	
Corrib	170
Mask	80
Carra	15
Other Lakes	
Conn	50
Leane	20.2
Gill	14
Oughter	13
Arrow	12.5
Cullin	11
Gowna	11
Carrowmore	9.6
Ramor	8

[a] Areas rounded

Source: Primarily from Flanagan and Toner (1975)

6. LAND AND WATER USE

Table 4

Pattern of land use in Ireland, 1986

	Percent
Arable and permanent crops	11.0
Permanent pasture	70.0
Forest and woodland	4.6
Other land	12.3
Inland water	1.98
Total	100.0

Source: 1987 FAO Production Yearbook, 41 (Publ. 1988)

The damp climate, lowland bogs, peat water, infertile mountains, and poorly drained lowland soils all menace Irish agriculture. Nevertheless, Ireland is predominantly an agricultural country, and although its economy is now about 59 percent urban and 41 percent rural, its general aspect is still rural. Furthermore, the virtual absence of important deposits of coal and most mineral resources has generally meant that its industry is still largely based on agriculture.

In Ireland, with its more than 200 000 family farms, farming is a mixed economy, with some arable land where cereals, potatoes, sugar beets, and vegetables are the major crops. The climate is, however, more favourable to the growth of grassland than to arable farming, and stock raising based on grass pasture is predominant. Climatic conditions preclude a need for irrigation, but drainage and flood prevention are major agricultural concerns.[1] The use of chemical fertilizers is relatively low.

[1] Statistics on irrigation in Ireland are not listed in FAO (1988)

With the exception of Iceland, Ireland is the least forested country in Europe; its forest production ranks about twenty-third among its nations. There is an afforestation programme, however, based primarily on introduced conifers, and production has increased in recent years. Investigation of the effects of this afforestation on fisheries, with respect to changes in water chemistry and food production, is in progress.

Mineral wealth is slight, but the extraction of sand, gravel, and peat is changing the shape of the land. Aside from these resources, there is some building stone, a little coal, of late years a working of silver, copper, lead and zinc deposits, and a little offshore oil. The use of milled peat for use as home fuel, in briquetting plants, and in thermal power stations (see below) has exposed large bog surfaces to erosion by wind and water. This means that considerable quantities of peat particles have found their way into streams with detrimental effects on fisheries. Most of the deep raised bogs will have been cut away by the year 2000, and the total peat resources are expected to be gone in about 80 years. Peat areas are being replanted with exotic conifers.

Many peat-fired thermal power stations have been introduced to Ireland since 1950. Other thermal power depends upon coal, natural gas, and imported fuel. Most of the hydroelectric power is derived from the lower Shannon where there is a large drop between Lough Derg and the river's estuary. Other hydro plants are found on the Lee, Liffey, Erne and Clady/Crolly, and there has recently been interest in the generation of electricity by small water turbines especially at old mill sites. In 1987, Ireland's installed capacity for electrical production was 3 880 000 kW. Almost 87 percent of this is thermal and 13 percent (512 000 kW) is hydroelectric. Hydroelectric production has impeded the runs of anadromous fish despite installation of fish passages (see sections 7 and 9). Meanwhile, Ireland has almost reached the limit of economical use of water and native fuels for power production.

Industry, largely based on agriculture, and now even surpassing it, includes sugar beet factories, tanneries, creameries, breweries, textile factories, and meat processing. Metals and engineering are also important. There has been an effort to encourage dissemination of industries to revitalize the entire country, but industry is still largely concentrated, e.g., in Dublin, Cork and Waterford.

The marine fishery, basically a near-water fishery, is growing in importance, and is of special value to the less developed (western) areas of the country. Per caput consumption of fish is low, only 11.1 kg in 1986. The inland fisheries are of both commercial and recreational value (see section 7).

Ireland has quite a good system of railways (about 3 000 km) and roads. Its 92 303 km of auto roads had a density of 1.3 km/km^2 in 1986, just a little less than that of the UK. Passenger car ownership is about 184 per thousand people (1985). Ireland has a number of good seaports, the major ones are Dublin and Cork (Cobh) with secondary ones in Limerick, Waterford, Drogheda and New Ross. The canals, no longer of importance for commercial shipping, are now being used for recreational travel and angling.

Underground water is plentiful in Ireland, minimizing the need for surface abstractions for domestic use. Mainstream hydroelectric plants also maintain water in the rivers. However, many arterial drainage projects have been implemented during the last 40 years. Although these may prevent flooding and improve the flow in rivers, they may also lower levels in lakes, create weed and silt problems, destroy spawning grounds, and canalize streams. A decline in the Boyne's commercial catch of salmon has been largely attributed to arterial change.

Water use for the disposal of domestic, agricultural or industrial waste, has been minimized in Ireland until recently. Today, a major cause of pollution is the disposal of agricultural wastes. A comparison of the fish kills reported during the 1969–74 and the 1980–87 periods made by McCarthy (1988) showed that while the number caused by sewage and industrial wastes did not change significantly, the damage from agricultural wastes had risen at an alarming rate. For example, effluents from agriculture and agriculture-based industries accounted for 97 of the 122 reported fish kills in 1987. In 1988, when the situation was far better (only 50 reported fish kills), agriculture wastes (runoff from silage and slurry or manure) still caused the majority of kills (McCarthy and Moriarty, 1989). See section 9.2 for additional discussion of water pollution in Ireland.

Tourism is Ireland's second largest industry (almost 9.9 million foreign tourists in 1986). The abundance of good fishing water for desirable sport species is a distinct part of its attraction.

7. FISH AND FISHERIES

Ireland has exceptional sport fishery resources for both anadromous and resident fish, as well as good commercial resources for diadromous fishes. However, it has a limited native inland fish fauna as compared to that of the European continent or even its neighbouring isle, Great Britain. For example, such widely distributed fish as the grayling (Thymallus thymallus), barbel (Barbua barbus), and chub (Leuciscus cephalus) are not present. Excluding the char (Salvelinus spp.) and whitefish (Coregonus spp.) of Great

Britain, there are ten species of purely freshwater fishes absent from Ireland although present in Great Britain (Went, 1946; Maitland, 1972), and according to Orme (1970), of about 16 species of strictly British freshwater fishes, only about 8 reached Ireland.

Opinions differ somewhat on exactly which species of inland fish are native to Ireland. Fitzmaurice (1984) says that the freshwater fish fauna of Ireland consists of only 20 species, and that after the last Ice Age (about 15 000 B.C.), the indigenous species probably consisted of Atlantic salmon (Salmo salar), brown trout and sea trout (S. trutta), char (Salvelinus alpinus), pollan (Coregonus albula), European eel (Anguilla anguilla), Twaite shad (Alosa fallax) and possibly the stickleback (Gasterosteus aculeatus) and ten-spined stickleback (Pungitius pungitius). He believes that it is more than likely that the other species which today complete the Irish freshwater list were introduced after the Twelfth Century. There appears to be general agreement that among the resident species definitely introduced to Ireland are: rainbow trout (Oncorhynchus mykiss), pike (Esox lucius), common carp (Cyprinus carpio), dace (Leuciscus leuciscus), roach (Rutilus rutilus), and tench (Tinca tinca). There is some doubt as to the position of the minnow (Phoxinus phoxinus) and European perch (Perca fluviatilis) according to Went (1980). Bream (Abramis brama) and rudd (Scardinius erythrophthalmus) are also found in Ireland. In addition to these, lampreys (Petromyzonidae), grey mullets (Mugil spp.) and the occasional sturgeon (Acipenser sturio) can be found in some Irish rivers. The relative importance of the major inland fishes used for food or sport in Ireland will be reviewed in sections 7.1 and 7.2.

In addition to finfish, Austropotamobius pallipes, the only crayfish indigenous to the British Isles is widely distributed in Ireland. Although lacking in the larger lakes, many acid coastal streams, and most of the sandstone rivers, it is generally abundant.

7.1 Capture Fisheries

Since the Middle Ages, Atlantic salmon have played a major role in Ireland's economy where they still constitute one of the world's premier salmon fisheries[1]. In fact, “Ireland is one of the few lands where the resource has increased rather than decreased in the Twentieth Century” (Netboy, 1974). Factors favourable to salmon sustenance in Ireland include: drastic reduction in fixed gear after 1863, the relative absence of industrial pollution common to several other salmon countries, and provision of fish passage and stocking hand-in-hand with dam construction.

[1] Other pre-eminent Atlantic salmon fisheries are those of: Canada, Iceland, Norway and Scotland. Piggins (1980) states that: “The total catches of salmon (in Ireland) have equalled or surpassed those of Scotland and Norway and over 95 percent of the catch is taken by commercial methods”

Salmon enter almost every Irish river. Among the finest are the: Munster Blackwater, Boyne, Suir, Nore, Bandon, Barrow, Liffey, Slaney and parts of the Shannon. In Ireland, most smolts are two-year olds and grilse form 80–90 percent of the stocks in some rivers. A spring run brings large fish up most of the coastal rivers, followed by a preponderance of grilse in a summer run. Spring-run salmon may average 3.6–5.4 kg depending on the river, and summer-run fish average about 2.7 kg. In 1986, the average weight of a rod-caught salmon in Ireland was 3.43 kg, about half a kilogram higher than the average weight of a commercially-caught salmon. The record Irish salmon, weighing 25.8 kg was caught in the Suir in 1874. In 1986 the total recorded catch in Ireland of salmon and grilse totalled 539 000 fish weighing 1 655 t with a value of £Ir 5.46 million.

Sea trout are associated with salmon both as a by-catch of commercial fishing and as a sport fish. The shorter coastal streams and acid coastal lakes, especially along the west and south coasts, provide most of the angling for this fish. The specimen weight is 2.7 kg.

The FAO Yearbook of Fishery Statistics (see, for example, Vol.64, page 105) does not list commercial catch statistics for the inland waters of Ireland, except for a curious 554 t in 1985 which seem to be cultivated rainbow trout, although it does list catches by Ireland of trouts, Atlantic salmon, and European eel for Marine Statistical District No. 27, the Northeast Atlantic. Comparison of these figures during the 1965–86 period with the figures listed by Ireland in its Fisheries Reports shows many differences[1]. Obviously, FAO has: confused Ireland's freshwater catch with marine catch; at least in some years has included the sport fishing (rod) catch for salmon and sea trout with the commercial catch (e.g., in 1977), and, although Ireland's primary fishery for eels is that for fish in inland waters, has placed its eel catch in a marine district.

[1] "Inland fisheries" in Ireland are those for salmon, trout, eels and coarse fish (see, for example, the Republic's "Sea and Inland Fisheries Report for 1980", p. 22)

I have, therefore, not reproduced any of the FAO Statistics for the commercial catches of salmon, sea trout, and eels in Ireland. Instead the catches for the 1965–86 period have been listed from reports emanating directly from Ireland (see Table 5). The catch of salmon and sea trout in Ireland for the years 1965, 1970, 1975, 1980 and 1985 has also been broken down to show the quantity of fish taken by each type of gear, whether commercial or sport (Tables 6 and 7).

7.1.1 Commercial fishing

Catches of the principal commercially taken inland fish of Ireland are shown in Tables 5–7. The tables, sensu strictu, do not include the catch from the Foyle Fishery which the Republic of Ireland shares with Northern Ireland (UK). See section 7.1 of the review of the UK for a discussion of the Foyle area.

In 1986, the commercial catch of Atlantic salmon was valued at £Ir 5.24 million, in 1980 it was valued at £Ir 3 090 663. The commercial catch of sea trout in 1985 was valued at £Ir 21 226, in 1980 it was valued at £Ir 170 143.

Drift nets took by far the greatest weight of salmon and grilse. Speaking more generally of Ireland's commercial salmon catch, Piggins (1980) wrote: "Drift netting at sea in public fisheries accounts for about 75 percent of the catch and about half of the estuarine catch is taken in public fisheries". In 1986 drift nets accounted for 88 percent of the Irish commercial catch of salmon, followed by 9 percent taken by draft nets and about 3 percent for other commercial methods.

With respect to sea trout, drift nets accounted for only 43 percent of the total commercial catch in 1986, as against 53 percent for draft nets and about 4 percent for other commercial gear. Little commercial fishing is performed specifically for sea trout; most of its commercial catch is made as a by-catch of salmon fishing. In fact, the rod catch of sea trout often exceeds the commercial catch (see section 7.1.2). Irish authorities feel, however, that the reported catch is badly underestimated.

The eel fishery in the Republic of Ireland is a rather small one with concentrations in the Shannon (Limerick) and Galway districts. The major fishery is based on the capture of silver eels as they migrate to the sea in autumn and early winter, and to a lesser extent on the capture of yellow eels in lakes. The catch has varied widely, e.g., 50 t in 1972 and almost 315 t in 1986[2]. However, illegal fishing has now developed to such a large scale that estimates of eel catch have become very difficult and the Government has decided to make an estimate of 250 t per year, knowing that a catch of that order is made (personal communication from Dr C. Moriarty, 4 April 1990). The most productive fishing methods are longlines, grid traps and weirs. There were 65 eel fishing authorizations in Ireland in 1986. The eel fishery of 1985 was valued at £Ir 371 505.

[2] Ireland/EIFAC (1989) on the basis of a questionnaire sent to Ireland states that the eel catch in Ireland is 145.34 t annually. Obviously the respondent used the figure for 1982 (cf Table 5)

In 1986, exclusive of persons engaged in the marketing and transport of fish, a total of 5 813 people had full or part-time employment in Irish inland fisheries. This figure included 4 144 persons estimated as engaged in netting for salmon, 220 engaged in eel fishing, 349 employed by Central and Regional Fisheries Boards on protection and development of fisheries, 650 engaged in netting and protection work in the Foyle area, 450 in the provision of ancillary services for inland fisheries, and the rest employed by proprietors of commercial and sport fisheries.

7.1.2 Sport fishing

Ireland has exceptional low-cost sport fishing resources for both resident and anadromous fishes. Permits can be obtained from several sources and some fishing is free.

Table 5

Nominal commercial catches by species of eel, Atlantic salmon and sea trout in Ireland, 1965–88[a b](in tons)

Species	1965	1966	1967	1968	1969	1970	1971	1972
European eel (Anguilla anguilla)	...	...	...	142.8	122.4	117.3	93.3	50.1
Atlantic salmon (Salmo salar)	1 113.6	919.2	1 113.6	1 112.7	1 462.6	1 531.7	1 434.3	1 590.1
Sea trout (Salmo trutta)	13.6	10.5	27.6	25.0	25.3	21.0	15.2	14.1
Total	-	-	-	1 280.5	1 610.3	1 670.0	1 542.8	1 654.3
	1973	1974	1975	1976	1977	1978	1979	1980
European eel	90.4	67.3	78.7	150.1	108.1	76.4	109.8	74.7
Atlantic salmon	1 718.5	1 933.7	2 136.1	1 448.8	1 266.8	1 147.9	1 033.3	854.7
Sea trout	17.1	35.6	44.8	32.7	13.7	15.1	12.7	19.2
Total	1 826.0	2 036.6	2 259.6	1 631.6	1 388.6	1 239.4	1 155.8	948.6
	1981	1982	1983	1984	1985	1986	1987	1988
European eel	94.1	145.3	116.8	88.7	87.3	86.7	-	-
Atlantic salmon	614.3	867.4	1465.0	802.5	1441.0	1588.2	1 197.3	1 532.7
Sea trout	7.7	7.9	11.2	15.7	9.0	6.4	5.0	-
Total	716.1	1020.6	1593.0	906.9	1537.8	1681.3	1 202.3	1 532.7

[a] Figures for 1965–72 recalculated (and rounded) from original measure in pounds
[b] Catches from the Foyle Fishery, shared by the Republic of Ireland and Northern Ireland (UK), are not included in the table. In 1984, its commercial catch of salmon totalled 84.7 t and in 1985 it totalled 135.9 t, and in 1986 it totalled 153.2 t.
... Not obtained

Source: 1965–67 - O'Connor and Whelan (1972)
1968–69 - (Republic of Ireland) Sea and Inland Fisheries Report for 1970
1970–72 - (Republic of Ireland) Sea and Inland Fisheries Report for 1972
1973–74 - (Republic of Ireland) Sea and Inland Fisheries Report for 1975

1975–77	-	(Republic of Ireland) Sea and Inland Fisheries Report for 1977
1978–80	-	(Republic of Ireland) Sea and Inland Fisheries Report for 1980
1981–82	-	(Republic of Ireland) Fisheries Report for 1983
1983–85	-	(Republic of Ireland) Fisheries Report for 1985
1986	-	(Republic of Ireland) Fisheries Report for 1986 (Its headings are incorrect)
1987–88	-	Ireland/EIFAC (1989)

The best salmon waters are strictly preserved, but boats can often be hired at moderate (for salmon fishing) prices, and there is still quite a bit of free fishing for salmon or waters open to hotel visitors. There is also considerable free fishing for sea trout, although most of the angling is under private or club control. Licences are required to fish for both species.

Tables 6 and 7 show the rod catch for these species in recent years. Ireland's sport catch of Atlantic salmon is not a large part of its entire salmon catch. For example, it constituted only 4 percent of the total catch of salmon in 1986 and only about 8 percent in 1988 by either number or weight. Nevertheless, the recorded salmon sport catch of 1986 was considered to have a value of £Ir 220 324. Conversely, the bulk of Ireland's sea trout catch in recent years has been made by the sport fishery. For example, either by number (24 769 individuals) or weight (15.3 t) in 1986, about 70 percent of the catch was made by sport fishermen, and had an estimated value of £Ir 50 629. It is believed that the official rod catch of salmon is underestimated. In 1970, an independent survey by the Economics and Social Research Institute estimated the rod catch to be 9 percent of the total catch compared with the official figure of (then) 3.9 percent. It has also been estimated that the expenditures by anglers in 1970 constituted 42 percent of the gross output of the salmon fishing industry, the balance being the value of the commercial catch (Piggins, 1980).

The most popular fishing in Ireland is for brown trout which are generally numerous. The largest trout are taken from the rich limestone waters of the central lowland, but the species is found in most fresh waters of the country, whether limestone or acid.

Table 6

Quantity of Atlantic salmon taken in Ireland by various types of gear, 1965, 1970, 1975, 1980, 1985[a]

Gear	1965 Weight kg	1965 No. of fish	1970 Weight kg	1970 No. of fish
Drift nets	360 930	--	785 837	--
Draft nets	567 591	--	572 488	--
Stake nets, weirs, etc.	185 141	--	173 426	--
Total commercial	1 113 662	--	1 531 751	478 707
Sport (rod and line)	189 000	54 900	62 129	17 890
Total	1 302 662	--	1 593 880	496 597

Gear	1975 Weight kg	1975 No. of fish	1980 Weight kg	1980 No. of fish	1985 Weight kg	1985 No. of fish
Drift nets	1 482 257	--	641 918	--	1 266 983	--
Draft nets	530 287	--	171 755	--	131 365	--
Stake nets, weirs, etc.	123 593	--	40 999	--	42 672	--
Total commercial	2 136 137	666 465	854 672	260 889	1 441 020	459 117
Sport (rod and line)	52 167	15 332	39 836	11 351	52 164	15 280
Total	2 188 304	681 797	894 508	272 240	1 493 104	474 397

[a] Catches from the Foyle Fishery, shared by the Republic of Ireland and Northern Ireland (UK) are not included in the table. In 1985 the total commercial catch of salmon in the Foyle Fishery amounted to 135 809 kg or 40 521 fish. In 1980 it was 145 776 kg or 49 223 fish. The total rod catch of salmon in the Foyle Fishery in 1985 amounted to 1 814 fish, in 1980 it was 1 134 fish

Source: 1965 - O'Connor and Whelan (1972)
1970 - (Republic of Ireland) Sea and Inland Fisheries Report for 1970
- (Republic of Ireland) Sea and Inland Fisheries Report for 1972
1975 - (Republic of Ireland) Sea and Inland Fisheries Report for 1975
- (Republic of Ireland) Sea and Inland Fisheries Report for 1977
1980 - (Republic of Ireland) Sea and Inland Fisheries Report for 1980
1985 - (Republic of Ireland) Fisheries Report for 1985

Char (Salvelinus alpinus) are relatively scarce fish in Irish waters, although fair numbers are reported from Loughs Conn and Corrib, and they can be fished for in a number of still waters. Rainbow trout, the major commercially reared fish in Ireland, are now also stocked for angling in about 20 lakes and ponds. There is little natural spawning of this species in Ireland; Lough Shure in Aranmore is an exception.

Coarse fishing has become popular and attracts many visitors from the UK. The most abundant coarse fish for angling are: pike, perch, bream, roach and rudd. Common carp and tench are unevenly distributed. Roach, apparently introduced in 1889 into the Munster Blackwater and once found only there, have now spread to other drainages, and there was another introduction of roach in the Foyle where it is said to have eliminated the rudd (Went, 1980). It is now a common species over most of the more productive waters. There is no closed season for coarse fishing, and most of the fishing is free. In 1986, a daily limit was placed upon pike, the first time in Ireland that a limit had been placed on a “coarse” fish species. The former Inland Fisheries Trust was instrumental in developing coarse fisheries, including the provision of over 18 000 fishing stands by 1980. Some stocking of carp for angling is practiced.

Despite the rise in coarse fishing, brown trout still hold the widest interest for anglers. Measures to promote its fishery include the installation of seasons, and size-limits, artificial stocking, and habitat improvement. Predators (pike) and competitors (perch and roach) are sometimes removed from brown trout waters.

Table 7

Quantity of sea trout taken in Ireland by various types of gear, 1965, 1970, 1975, 1980, 1985[a]

	1965		1970	
Gear	Weight kg	No. of fish	Weight kg	No. of fish
Drift nets	2 088	--	2 324	--
Draft nets	11 350	--	18 300	--
Stake nets, weirs, etc.	136	--	397	--
Total commercial	13 574	--	21 021	--
Sport (rod and line)	38 000	83 000	27 535	40 433
Total	51 574	--	48 556	--

	1975		1980		1985	
Gear	Weight kg	No. of fish	Weight kg	No. of fish	Weight kg	No. of fish
Drift nets	9 110	--	5 597	--	2 472	--
Draft nets	34 646	--	13 259	--	6 507	--
Stake nets, weirs, etc.	1 122	--	345	--	10	--
Total commercial	44 878	--	19 201	--	8 989	--
Sport (rod and line)	36 070	65 708	18 139	27 933	13 285	--
Total	80 950	--	37 340	--	22 294	--

[a] Catches from the Foyle Fishery, shared by the Republic of Ireland and northern Ireland (UK) are not included in the table. In 1985 the total number of rod-caught sea trout in the Foyle Fishery was 4 838 fish, and in 1980 it was 3 276

Source: 1965 - O'Connor and Whelan (1972)
1970 - (Republic of Ireland) Sea and Inland Fisheries Report for 1970
- (Republic of Ireland) Sea and Inland Fisheries Report for 1972
1975 - (Republic of Ireland) Sea and Inland Fisheries Report for 1975
- ((Republic of Ireland) Sea and Inland Fisheries Report for 1977
1980 - (Republic of Ireland) Sea and Inland Fisheries Report for 1980
1985 - (Republic of Ireland) Fisheries Report for 1985

All legal rod and line methods are generally allowed for angling, but a number of waters have “fly only” regulations. Furthermore, the use of live fish as bait is prohibited in Ireland, as is the transfer of live fish from one water to another without a special permit.

In 1962 there were considered to be 27 000 sport fishermen in Ireland: 18 000 brown trout anglers, 7 000 salmon anglers, and 2 000 coarse fish anglers. This would represent only about 0.94 percent of the total population at the time. By 1974, the total number of sport fishermen in Ireland had risen to about 63 000 or about 1.7 percent of the total population. In 1986, the total number of licences of all kinds issued for angling for salmon and sea trout in Ireland totalled 16 062. (Several types of licences may be issued so this figure does not equal the number of salmon and sea trout anglers.) Circa 1989, Ireland/EIFAC (1989) estimated the number of sport fishermen in Ireland as follows: 62 800 "game" (salmonid), 15 800 "coarse" (all other freshwater species), 43 600 marine.

7.2 Aquaculture

As for several other countries, statistics on aquacultural production in Ireland vary decidedly, depending upon the source (see, for example, under section 7.2, Denmark and the Federal Republic of Germany). Table 8, even if somewhat confusing, is therefore presented to illustrate some of these differences. All figures are taken from sources which might be considered as standard or which have received their information from standard sources. Differences in annual production figures resulting from rounding of figures are self-explanatory. Some may have resulted from the lumping of freshwater and seawater-raised fish. Some may have simply perpetuated the errors of estimates of others. Those emanating directly from Irish Governmental sources are considered to be the most accurate.

Commercial aquaculture in Ireland began with the cultivation of rainbow trout circa 1960. In that year, only 8½ t were produced, but (following Governmental statistics) the production was 111.1 t by 1971, almost doubling by 1974 to 206.8 t. In 1980, the production of farmed rainbow trout was 269 t, and the sea-cage yield of rainbow trout from six units was 133 t. According to Fish Farming International (Vol. 11(7)), Ireland's freshwater trout farm production was 550 t in 1983, and by 1987 it was still only 600 t (Aquaculture Ireland No. 38). Trout production did rise to 1 100 t in 1988, but then fell to 645 t in 1989 (FES, 1989). The drop was due in part to a corresponding rise in cultivated salmon production (see below).

Most of the freshwater trout farms in Ireland lie in the east and southeast. Interest in their establishment is in part due to eligibility programmes for grants under farm modernization schemes. Typically, an Irish trout farm uses river water rather than spring water. Concrete and earthern ponds are used, and fish are fed on artificial pellets. Cages have also been used in deep loughs, and there is also some sea-cage culture. Most of the fish are exported to Britain which uses 170–200 g fish. With good fishing available in many natural waters in Ireland, there is no real demand for fee fish-out ponds as in some countries.

Aquaculture Ireland No. 38 lists 320 t of sea trout produced in Ireland through aquaculture in 1987. Major developments in salmon culture for table fish took place in Ireland in the 1980s. Production in sea cages rose from 21 t in 1980 to 1 215 t in 1986, and the total commercial aquacultural production of salmon in Ireland continued to rise from 4 900 t in 1988 to 9 200 t in 1989 (FES, 1989). FAO Fish.Info.Data and Stat.Serv. (1989) agrees generally with these estimates. Most of the salmon that are reared mature at one year and are slaughtered before reaching maximum size. The value of farmed salmon in 1986 was £Ir 4.5 million, an increase of 44 percent over the 1985 figure.

By 1986, there were 14 freshwater trout farms, 24 for farming salmonids at sea, and 21 smolt rearing units in Ireland (Ireland/EIFAC, 1989).

In addition to commercial aquaculture in Ireland, brown and rainbow trout are raised for stocking open waters, and some carp have been raised to restock coarse fish waters. Atlantic salmon are also reared and stocked for the capture fisheries. For example, in 1986, the total production of ova was 3.2 million salmon and 2.8 million brown trout. Although a considerable number of ova and small fish are stocked, there is also a stocking of larger fish, including yearlings and smolts. At present, there are smolt-rearing stations in Ireland on the: Lee, Shannon, Erne, Burrishoole system, Boyne, Upper Lough Corrib and Scrube. In addition, many smolt-rearing stations are being established for the aquaculture industry.

The contribution of hatchery-reared salmon smolts to the Irish commercial salmon catch during a six-year study (1975–86) varied from 1.6 to 12 percent of the catch (Department of Fisheries and Forestry, 1980). In a study made in 1985, hatchery fish composed from 1.3 to 11.5 percent of the adult commercial samon catch (Department of the Marine, 1985).

Table 8

Production of cultivated trout in Ireland, 1960, 1975, 1980–89 (in tons)[a]

Source	1960	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Piggins (1967)	8.5	-	-	-	-	-	-	-	-	-	-	-
Ireland/EIFAC (1974)	-	-	-	-	-	-	-	-	-	-	-	-
Giorgetti and Ceshia (1982)	-	215	-	-	-	-	-	-	-	-	-	-
Brown (1983)	-	500–600	-	-	-	-	-	-	-	-	-	-
Rep. of Ireland Ann.Fish.Rep.			269									
(1975, 1977, 1980, 1986)	-	200+	133 sw	-	-	-	600	530	460	-	-	-
Shaw, Shaw and Thomas (1981)	-	400	600	750	-	-	-	-	-	-	-	-
Pino and Kirk (1982)	-	-	275	-	-	-	-	-	-	-	-	-
			50 sw	-	-	-	-	-	-	-	-	-
Fish Farm.Inter.,				490	610							
9(10) (1982)	-	-	400	170 sw	340 sw	-	-	-	-	-	-	-
Fish Farm.Inter.,												
11(7) (1984)	-	-	-	-	-	550	-	-	-	-	-	-
FAO Fish.Info.Data and Stat.												
Serv. (1989)	-	-	-	-	-	-	712	589	563	563F	-	-
FES (1986	-	-	-	-	-	-	-	500	-	-	-	-
FES (1989)	-	-	-	-	-	-	-	-	-	-	1 100	645

a Apparently all freshwater production unless otherwise indicated

b Agrees with Lewis (1981)

sw - sea water

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT AND INVESTIGATION [1]

8.1 Ownership and Availability

In the eyes of the law, all fisheries in fresh waters are deemed to be exclusive. Rivers usually belong to the owner of the land alongside or over which the waters flow. In many cases the fishing rights of former landowners have been retained after land has been sold. These rights include much of the best salmon angling. In some of these cases the fishing rights have been acquired by the State. In some instances, however, a state of de facto free fishing may prevail through failure of the presumed owner to preserve his rights. Open or "free" fishing rights are found on some lakes, the upper courses of large rivers, and on some smaller rivers. In tidal waters, the general presumption is in favour of the public right save where exclusive rights of fisheries are upheld by virtue of documentary title or immemorial usage.

8.2 Administration and Management

(i) The Department of the Marine, through its Inland Fisheries, Sea Fisheries and Aquaculture Divisions is responsible for the general administration of both sea and inland fisheries.

(ii) Local Administration. Under the Fisheries Act, 1986, the 17 former Boards of Conservators and the Inland Fisheries Trust, Inc., were dissolved, and replaced by a Central Fisheries Board and 7 Regional Fisheries Boards. Each Regional Board is a statutory body, answerable to the Minister of the Marine with whom final responsibility for inland fisheries resides. The Boards are responsible for conservation and development of every aspect of the fisheries within the Board's designated region, including the development of angling. They are empowered to collect fishery rates and issue licences. Members of these Boards comprise those elected by an electorate composed of holders of fishing licences, fishery rate-payers, and persons registered in a Register of Trout, Coarse Fish and Sea Anglers, and those appointed by the Minister for the Marine.

The Central Board coordinates and directs the work of the Regional bodies, and is also empowered to carry out such research work as it considers necessary for the performance of its functions.

(iii) Financing and Licensing. The Minister will pay grants to the Central Board out of moneys provided by the Parliament, and out of the Salmon Conservancy Funds (fed mainly by Exchequer subvention). The Central Board will pay grants to the Regional boards. Rates are struck on fishery heredıments. All commercial forms of fishing, such as weirs, draft nets, and drift nets for salmon, are required to be licensed. All angling in inland waters has to be licensed.

8.3 Investigation

(i) The Department of the Marine provides research and advisory services, e.g., in the field of fishery biology and engineering. A Fisheries Research Centre is its advisory arm. In addition, a Fish Pathology Unit was established in the Department in 1980.

(ii) The Salmon Research Trust of Ireland, Inc. (sponsored by Arthur Guinness and Sons, P.L.C., and the Minister for the Marine, and incorporated in 1955) conducts scientific and field research to improve, develop and extend salmon and sea trout fisheries in Ireland.

(iii) The science and engineering faculties of the universities (colleges at Dublin, Cork and Galway) take an interest in fishery work. The Electricity Supply Board, an extensive owner of fisheries, has undertaken experimental work in consultation with the Fisheries Division.

8.4 Other Concerned Agencies

(i) The Foyle Fisheries Commission, formerly the Moville Fishery District, originally established in 1952 to provide for the management, protection, and improvement of fisheries in the Foyle area, administers the Foyle Catchment which is situated in both the Republic of Ireland and Northern Ireland (UK). The Commission consists of representatives of the Republic's Department of the Marine and the Department of Agriculture for Northern Ireland (DANI).

(ii) Under the Local Government (Water Pollution) Act of 1977, which provides for the control of water pollution and other matters concerned with such pollution, responsibility for implementation of the Act rests with the Minister for the Environment and the local authorities under the aegis of that Minister. Under the Act, the Minister for the Marine and the Regional Fisheries Boards have both consultative and enforcement roles in its implementation. The Fisheries Acts, 1959–80, administered by the Minister for the Marine, also prohibit, except under and in accordance with a licence granted by the Minister, the entry or discharge into any waters of deleterious matter (including any explosive, liquid or gas), which is liable to render those waters poisonous or injurious to fish, spawning grounds, or the food of any fish.

(iii) There are numerous non-statutory angling associations in Ireland whose activities include: conservation, protection and improvement of the waters under their control.

1 Based largely on material from Ireland sent to EIFAC in 1979, Power (1978), O'Connell (1982), and Ireland/EIFAC (1989)

9. STATE OF THE FISHERY

9.1 Yield

Easily available gross catch statistics do not permit an evaluation of the state of the salmon or sea trout fisheries. Table 5 shows a peak annual commercial catch of salmon of 2 136.1 t in 1975 and a low of 614.3 t in 1981, and for sea trout a high of 44.8 t in 1975, an extreme low of 7.7 t in 1981 and a another low figure of 7.9 t in 1988.[1] However, many factors (such as bad weather for fishing, especially with drift nets) survival of smolts at sea, etc. may have an effect on the harvest of these fish. The Department of Fisheries and Forestry (1980) (a predecesor of the Department of the Marine) stated that the “catch per licensed fishing engine…is the only guide available at present for measuring the long-term trends in the salmon fishery…because the fishing effort exerted by such engines is almost constant from year to year”. Between 1974 and 1980 the average number of salmon caught per fixed engine unit varied from a high of 483 in 1975 to a low of 179 in 1979, but with an increase to 338 in 1980. The Department offered the cautious hope that the present stock of salmon was improving.

1 The total catch of Atlantic salmon in Ireland of 2 188.3 t in 1975 was the highest catch of salmon between 1927 (when collection of these statistics began) and 1986

The Irish eel fishery has maintained its output in recent years. In spite of a period of poor elver runs in the 1980s, storks are now high and expansion of the fishery is proposed.

Yields per unit area of various Irish waters have not been collected by the author; some of them must be very high. Yields in the Foyle catchment shared by the Republic and Northern Ireland are cited in section 9.1 of the review for the UK.

9.2 Factors Affecting the Fishery

Ireland has abundant water resources in relation to its size, population, and present economic trends[2]. Furthermore, its interlacing system of rivers and lakes distributes the water, and hence its fishing, throughout the country. It has a variety of streams, both small fast-running ones and large slow-moving rivers. Its numerous lakes include some of large size and high productivity.

[2] Such a condition is, of course, very favourable for Ireland's inland fisheries. However, opinions differ, thus Common (1970) speaks of "an overendowment of surface waters" in Ireland to the detriment of its agriculture and forestry

The native fish fauna of anadromous salmon (which enters most of the Irish rivers) and sea trout, and abundant populations of resident brown trout provide excellent game fishing. In addition, there is a good variety of coarse fishes. Although the total number of species is not large, most of its components are considered desirable either for food or sport, and the Irish authorities have resisted the introduction of others.

The soil, terrain, climate and growing season are all generally favourable for the development of fish, especially salmonids.

Unlike the situation in some of the warmer and drier countries where heavy demands are made for water abstraction or in some of the heavily industrialized countries where barriers to fish migration and water pollution have diminished stocks, Ireland's land and water uses have been generally favourable for its inland fisheries. Dry years have demonstrated the vulnerability of streams to abstraction, but its practice is still relatively small in Ireland and its impact on fisheries kept under scrating, and the presence of good supplies of ground water has kept surface water abundant. Arterial drainage has, however, been deleterious to the fisheries, and close attention is now being given to minimize its adverse effects. Mainstream hydroelectric development (as on the Shannon) has also interfered with the migration of both anadromous fishes and eels despite the installation of methods of fish passage. The intakes at thermal power stations have also been considered as traps for migrants.

The average annual runoff per caput is 13 011 m^3, a volume which provides a considerable dilution of effluent discharges. Such a factor, coupled with frequent high rainfalls to maintain flow, serves to minimize water pollution. Nevertheless, the use of pesticides, and enrichment of waters from land drainage, high fertilizer concentrations, and intensive livestock rearing is increasing Ireland's pollution problems. Discharges from creameries and processing plants, and from the working of one deposits augment these problems. Increased sewerage also adds to the effluent, but population distribution (a preponderance lives on the coast) minimizes interior river pollution since most of the domestic wastes are discharged into estuaries or coastal waters. Industrial discharges however, occur mainly in interior waters, and are in excess of the combined domestic and agricultural discharge. No pollution appeared to exist in the form of acid rain (1983). In 1972, nine percent of Ireland's rivers were considered to be polluted to varying degrees and 20 km had been rendered fishless (Holden and Lloyd, 1972), but in 1983 it was calculated that only 2 percent of Ireland's main rivers could be classified in "doubtful" or "bad" condition (An Foras Forbartha, 1983).

During the 1982–84 period, a national survey of 6 928 km of rivers showed that 2 percent of the total length surveyed were seriously polluted, 13.8 percent were slightly to moderately polluted, and 84.2 percent were unpolluted. Of 39 lakes classified in accordance with their trophic status, 5 were found to be hyper-eutrophic, 19 were eutrophic, and 15 were meso- or aligotrophic (Anon./Ireland, 1984). Some of the lake eutrophication caused by intensive pig-rearing operations since 1971 has been corrected; e.g., since 1980 excess pig slurry has been transported out of the Lough Sheelin catchment with the result that the lake has almost been restored to its pristine quality. Removal of phosphate from sewage plant effluent has similarly improved conditions in Lough Ennell.

Since 1977, the legislative position for pollution control has improved with the introduction of the Local Government (Water Pollution) Act (see section 8.4).

The problems of Ireland's anadromous fisheries are, of course, aggravated by the land and water uses mentioned above. Furthermore, there has been a considerable opinion that the somewhat controversial disease called UDN (ulcerative dermal necrosis) has caused a decline in stocks of salmon and sea trout[1]. Nevertheless, there seems to be a consensus that the major factor affecting the Irish stocks (especially salmon) is overexploitation, particularly by the drift net fishery. See, for example, Table 6 which shows a rise in the salmon catch by the drift net fishery from 360 930 kg in 1965 to 1 482 257 kg in 1975 or four times as much in ten years. Meanwhile, the catch by other commercial methods remained about the same, and the sport catch declined by over one-third. In 1962, there were only 363 drift net licences in Ireland. They then increased three-fold to 1 156 in 1972. During the same ten years, the drift net catch of salmon increased from 21 percent of the total in 1962 to 64 percent in 1972. By 1980, when catch records showed a definite decline, drift nets were taking 72 percent of the Irish salmon catch. The length and depth of drift nets have been limited, there has been imposition of an annual season and a weekly close time, and restrictions on the number of commercial licences, but evidence of a decline in stocks continues. It must be emphasized that illegal fishing has been blamed for much of this decline, and measures taken to combat it. In 1978, the proportion of illegally caught salmon which were marketed was estimated as from 20 to 50 percent of the total (Piggins, 1980a).

[1] UDN first made its appearance in Irish salmon streams in 1964. Among measures to offset its effect, has been the importation into Ireland of salmonoid ova from other countries, e.g., during the 1969/70 season, salmon ova from Iceland and Sweden and sea trout ova from Iceland and Poland were imported, and in 1970/71, salmon ova from Norway and Scotland and sea trout ova from Scotland were imported to restock Irish rivers (Department of Agriculture and Fisheries, 1970, 1971). Obviously, such changes in the genetic constitution of Irish stocks may affect the populations. In passing, it may also be noted that both salmon and trout have been imported from other countries to facilitate the development of fish farming. For example, 300 000 salmon smolts were imported in 1986

Easy access to good angling waters and a tradition of fishing promotes a growing use of waters for sport fishing, and angling brings in a considerable revenue from foreign tourists. The management of waters for sport fishing has been decidedly improved in recent years.

The history of commercial fish culture in Ireland is a very short one, limited to the rearing of salmonids, and these primarily for export rather than home consumption. The growing use of sea water is an important step forward.

With only one other country as an occupant of the island of Ireland, the Republic is directly concerned with international water or inland fishery problems only in the Foyle Catchment area managed jointly with Northern Ireland (UK), the Erne and Drowes Catchments and a number of smaller rivers.

In addition to the built-in physiographic, climatic and faunal factors, and the country's land and water use, Ireland's political policies have influenced the inland fisheries. Thus the provision of governmental grants, with emphasis on acquisition and improvement of boats and gear, has increased the catch of salmon along the north, west and south coasts. Drift netting for salmon has considerable socio-economic values for low income families along these coasts, but the increase in this fishery has caused a decline in estuarine and river fisheries (Piggins, 1980).

9.3 Prospect

Because of a general (and indeed, well-founded) belief in Ireland that its water resources are plentiful, the use of these resources may have proceeded without much thought of the overall results. That day is over. Sustained yield from the valuable salmon and sea trout fisheries will depend upon careful attention to the effects of any new type of land and water development. Attention must be given to provision of sufficient supplies of water of good quality, as well as continued vigilance with respect to installation and maintenance of facilities for fish passage, protection of spawning and nursery grounds, and the other measures generally taken to maintain anadromous fisheries. The latter include regulation of catch, particularly the Irish drift net fishery. In any event, the sea trout fishery is likely to expand.

The future of the eel fishery also depends upon measures for sustaining migration, as well as the stocking of elvers in upstream waters which they do reach naturally. It has been estimated that the present annual harvest of eels could be increased to 1 500 t by the annual transplantation of 13 t of an O-group of elvers (Moriarty, 1981).

Fishing pressure on both trout and coarse fish will mount, and tourist fishing will increase decidedly.

Climatic conditions and social preferences indicate that aquaculture will continue to be confined to cold water species, especially the well-tested rainbow trout and salmon. A report prepared by the National Board of Science and Technology (circa 1982), indicated that by the year 2000, the Irish Republic could raise 3 000 t of rainbow trout in fresh water, and 5 000 t of rainbow trout and 5 000 t of Atlantic salmon in sea water[1]. Although the production of cultured trout has lagged far below this prophecy (only 645 t in 1989), the production of cultivated salmon has already exceeded the prophecy of 5 000 t by the year 2000, being 9 200 t in 1989. An even more optomistic prophecy has been made by Murphy (1986) who stated that the Irish “potential” in fish aquaculture was 20 000 t of trout and 60 000 t of salmon annually. Cage culture will be extended, accompanied by selection for later maturity in salmon. To date, indications are that eel culture has only limited possibilities in Ireland.

[1] Not seen by the author. Information from Fish.Farm.Int., 9(5):8–9 (1982)

Salmon ranching has been considered in Ireland, but according to Piggins (1980a) it now seems to be non-viable as a private commercial enterprise, although perhaps useful if State-sponsored. Among the difficulties are securing legislation which would permit such an operation, costs of siting and rearing, and survival in view of exploitation by coastal netting.

As animal husbandry becomes more intensive (e.g., greater use of confined rather than ranging animals), and industrialization increases, there will be an increase in effluent production and overall water use. At present there are no major schemes for inter-river transfers and the construction of estuarine barrages (as in the UK) which could affect fisheries. The exhaustion of peat resources early in the next century will bring about changes in the production of electricity which may affect inland fisheries.

All in all, the prospect for inland fisheries in Ireland is better than in most countries.

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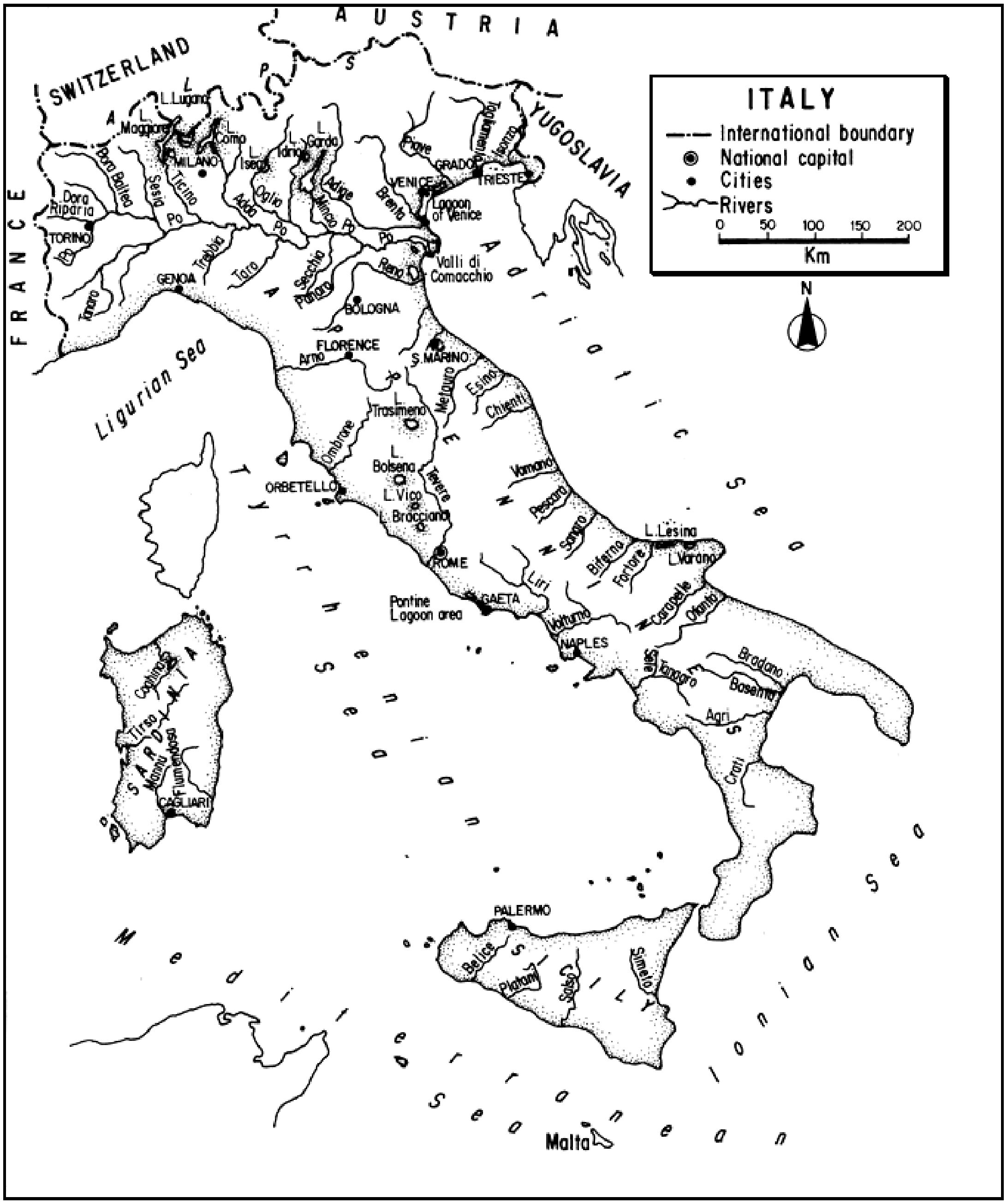
ITALY
International boundary
National capital
Cities
Rivers
0 50 100 150 200
Km
N
AUSTRIA
SWITZERLAND
YUGOSLAVIA
FRANCE
ALPS
APENNINES
L. Lugano
L. Maggiore
L. Como
L. Iseo
L. Idrio
L. Garda
MILANO
TORINO
GENOA
BOLOGNA
FLORENCE
S. MARINO
VENICE
Lagoon of Venice
Valli di Comacchio
GRADO
TRIESTE
L. Trasimeno
L. Bolsena
L. Vico
L. Bracciano
ORBETELLO
ROME
Pontine Lagoon area
GAETA
NAPLES
L. Lesina
L. Varano
SARDINIA
CAGLIARI
SICILY
PALERMO
Malta
Ligurian Sea
Tyrrhenian Sea
Adriatic Sea
Ionian Sea
Mediterranean Sea
Dora Riparia
Dora Baltea
Sesia
Ticino
Po
Adda
Oglio
Mincio
Adige
Brenta
Piave
Tagliamento
Isonzo
Trebbia
Taro
Secchia
Panaro
Reno
Tanaro
Arno
Ombrone
Tevere
Metauro
Esino
Chienti
Vomano
Pescara
Sangro
Biferno
Fortore
Liri
Volturno
Carapelle
Ofanto
Sele
Tanagro
Bradano
Basento
Agri
Crati
Coghinas
Tirso
Mannu
Flumendosa
Belice
Platani
Salso
Simeto

ITALY

The Republic of Italy occupies a long boot-shaped peninsula extending south from the Alps into the Mediterranean. At its toe is the island of Sicily; to its west is the island of Sardinia.

Primarily mountainous or hilly, and lacking good forest and mineral resources, Italy is essentially a heavily populated agricultural, industrial and touristic country. Water resources, including a series of beautiful sub-Alpine lakes, are abundant in the continental north. Farther south, the few lakes are essentially of volcanic origin, and as the climate becomes increasingly Mediterranean the streams diminish to a few of torrential regime, being very low or even dry in summer. Brackishwater lagoons are characteristic of parts of the long coast.

Centuries of land and water use without environmental concern have diminished aquatic productivity, and great demands continue on the use of water for irrigation, production of hydroelectric power, and disposal of effluent wastes.

Commercial fishing in lakes persists, but is diminishing with eutrophication. Brackishwater lagoon fisheries continue, and commercial trout culture is very important. Sport fishing is in ascendancy, although only on a local level.

1. AREA: 301 268 km^2

2. POPULATION: 57 563 000 (est. 1990) Density: 191 inh/km^2

3. PHYSICAL GEOGRAPHY

Italy is situated in southern Europe between 35°30 and 47°5'30"N latitudes and 6°33' and 18°31'18"E longitudes.

Its greatest length is 1 225 km and its greatest breadth over 435 km although the lower or peninsular part does not exceed 240 km in width. Its altitudinal range is from slightly below sea level (in some polders) to 4 634 m. The highest peaks are in its continental part where the Alps have over 100 peaks exceeding 3 000 m; the peninsula has peaks over 2 900 m.

Italy is bounded on the northwest by France for 514 km, on the north by Switzerland for 744 km and Austria for 430 km, and on the east by Yugoslavia for 209 km[1]. It is bathed on the northwest by the Ligurian Sea, on the west by the Tyrrhenian Sea, on the east by the Adriatic Sea, and on the southeast by the Ionian Sea. Italy encloses two politically separate mini-states: Vatican City (the Holy See), an enclave of Rome with a boundary of 3.2 km and an area of 44 ha; and the hilltop Republic of San Marino with a boundary of 39 km and area of 61 km^2.

[1] The lengths of these boundaries are taken from Worldmark (1984)

Its total coast including its two major islands is 7 458 km in length; the islands have a coast of 4 016 km.

Essentially mountainous, plains (i.e., the area below 300 m) cover only 23 percent of the total area, hills 41 percent, and mountains (i.e., the area over 1 000 m) 36 percent.

Italy can be divided into two major sub-divisions: (i) Continental Italy in the north, and (ii) Peninsular Italy consisting of a mountainous backbone (the rugged Appennines) and coastal belts on either side. The two major islands, Sicily and Sardinia, can be considered as part of the peninsula or treated as insular Italy.

Another common division by geographers is to subdivide the entire country into four parts: North Italy, Central Italy, South Italy, and Insular Italy.

North Italy. This is bounded by the Alps which sweep across the country from the Riviera on the west and then north and east into Dalmatia. The highest peaks are in the west, the central Alps are less lofty but wider, and the eastern Alps (characterized by an abundance of limestone) are even lower. Many of the transverse valleys which break through (south) to the Northern Plain are blocked by vast terminal moraines which form the "Italian" or Lombard lakes.

South of the Alps and their foothills is the great Northern Plain which constitutes about 63 percent of the flatlands of Italy. The western part of the Plain is drained by the Po River system which continues east to the Adriatic Sea to form a low-lying lagoonal and deltaic coast of irregular outline. The eastern part is drained by several important rivers which flow independently into the sea through other lagoon and deltaic areas.

South of the Plain, the high rugged Appennines form the lower limits of North Italy and extend south as the backbone of Peninsular Italy.

Central Italy. This rather arbitrary division extends southwards to include the regions of Toscana, Umbria, Marche and Lazio[1].

[1] Geographically, at least the southern part of the region of Emilia-Romagna might be included in Central Italy as might also the region of Abruzzi-Molise. The Italian Central Institute of Statistics prefers the system indicated here and also divides the entire country into two great areas: Nord-Centro and Mezzogiorno. The latter includes Insular Italy.

It is dominated by the Central Appennines, composed of several minor ranges and vast upland valleys. The mountains are bordered on each side by warmer and richer agricultural country extending to the seas.

Drainage on the Adriatic side is characterized by short rivers running straight to the sea. On the western side, the valleys of the Arno and Tiber or Tevere are dominant. The southern part of the Central area is in large part of volcanic origin forming hills containing crater lakes.

South Italy (the Mezzogiorno). The central mass of the Appennines continues south, bounded on the west by the plains of Campania and on the east by the plains and downs of Puglia - the largest such area on the peninsula. The extreme south continues to be mountainous, but is primarily granitic rather than limestone as in the northern part of the range. The extensively cultivated flatlands are characteristically "Mediterranean". The rivers are generally unimportant.

Insular Italy. The two largest islands in the Mediterranean are Italy's Sicily and Sardinia. Sicily, lying only 3 km west of the toe of the mainland, has an area of 25 707 km^2. It is essentially an area of mountains and plateaux, much of it porous limestone, similar to the mainland but lacking inland waters of consequence. Sardinia, an island of 24 092 km^2 largely of granite plateau-like mountains, lies 220 km west of the mainland. Primarily pastoral, its mountain streams support trout and its lagoons contain brackishwater fish.

Italy also possesses a number of smaller islands lacking inland fisheries. The Tuscan Archipelago includes Elba (223 km^2), Capraia and Gorgona. Islands in the Gulf of Naples are: Ischia (46 km^2), Capri (10.3 km^2) and Procida. Other islands are: the

Aeolian Isles and the Aegades off Sicily, the Sardinian isles of Asinara, Maddalena and Caprera, and the Trémiti in the Adriatic.

With respect to geology, the folded and intensely glaciated Alps consist mainly of a core of crystalline rock plus shales, slate, and a limestone fringe. The depressed Northern Plain is primarily alluvial. The Appennines, mostly eroded sandstones, marl and clays in the north, become mostly limestone centrally and granitic in the extreme south. Volcanic activity is evident, especially in central Italy and the south where four active volcanoes (Vesuvius, Etna, Vulcano and Stromboli) persist. Italy has 711 glaciers, all of which lie in the Alps except for the Gran Sasso in the Appennines. Brown podsols and renzinas are common in the mountains. Brown Mediterranean soil, terra rossa, gravels, sands, shales and limestone are represented elsewhere. It is characteristic of Italy to have large areas of easily erodible rocks forming a basis for soil erosion, stream siltation and the formation of deltas and marshlands. Conversely, large areas of permeable rocks (limestone and tufa) have beneficial effects on the regime of some peninsular rivers.

The Central European and Mediterranean botanical regions overlap in Italy. Forests and brushwoods of coniferous and deciduous trees predominate in the north, while hard-leaved ever green trees, shrubs and conifers characterize the peninsula. In the Pre-Alps, and Alps, plants range from oaks and olives upward through beech, larch and spruce to an Alpine flora of dwarf plants. The flora of the great Po Valley is almost entirely introduced: poplars and the cultivated cereals. The Appennines support chestnuts, oaks and conifers. Coastal areas of central and southern Italy support olives, citrus fruits and eucalyptus as well as the xerophytic macchia, cacti and aloes of the south. Many of the forests have been degraded through centuries of war, erosion and use.

4. CLIMATE

The continental climate of northern Italy is a basic variation of the Central European type-biting cold in winter and torrid heat in summer. Peninsular Italy is so long, narrow and open to sea winds that much of it can be said to have a coastal climate, mostly “sub-Mediterranean” except in the mountains where it becomes more continental. Nevertheless, both seasonal and regional variations are great due to the country's 10° extent of latitude, its varied altitudes and the influence of sea and topography. Thus, the Northern Plain is often chilled by cold Alpine winds while climatic oases along the steep concave southern face of the Alps enable citrus fruits to flourish near the Lombard lakes and parts of Sicily are sub-tropical or “extra-Mediterranean”.

Without consideration of the high mountains, annual temperatures average about 12–14°C in the north, 15–17°C in central Italy and 17–18°C in the south. Winter temperatures are lowest in the high Alps but at lesser elevations are lowest on the Northern Plain. The warmest winter temperatures are found in Sicily where the January mean on the coast is 12°C. In summer, the hottest temperatures are found in the heel of Italy; the mean August temperature in Taranto is 25°C. Some extreme maxima are 39.2°C in Bologna, 44°C in Foggia and 49°C in Sicily.

The approximate average annual precipitation in Italy is 1 000 mm, but rainfall is highly influenced by the relief. The highest annual rainfall (sometimes to 2 000 or 3 000 mm) is found in the Alps; the lowest in the southern lowlands. In the north the tendency is toward spring and autumn maxima; and in the extreme north, winter is the driest period. Only in the southern peninsula is there a true Mediterranean regime of winter torrents and summer droughts, coupled with a hot wind, the sciracco.

Frost may occur throughout the country but is rare in the south. Permanent snow is limited to the Alps above the 2 700–3 000 m level but the Appennines may have snow for three or more months, and snow may persist on the Northern Plain for up to ten days. There is extended ice-cover only on the higher lakes and the Po rarely freezes.

Relative humidity is normally low, and some parts of Italy have a high evaporative rate. For example, only 30 percent of the precipitation in Sicily remains as stream runoff.

5. HYDROGRAPHY AND LIMNOLOGY

Table 5 indicates that the total inland water area of Italy is about 2.4 percent of the country's total area or 7 210 km^2. The source of the table has not altered this percentage for at least 25 years. However, Italy/EIFAC (1974) states that the total area of Italy's inland waters (acque interne) is about 20 000 km^2 or 6.6 percent of the country's area. Barring the possibility of reporting error, the large discrepancy may stem from the question of definition of "inland waters". At first thought, one might think that the smaller estimate might include only fresh waters, while the larger one also included lagoons and other brackishwater areas. However, even if one adds up the following approximations based on the subsequent sections (lakes 2 045 km^2, reservoirs - 500 km^2 and lagoons -1 500 km^2) one still derives a total of only 4 045 km^2 [1].

[1] Each of these figures emanated from a different agency within the Italian Government and was sent to a different branch within FAO. The first group is primarily concerned with agricultural production and may have considered only fresh waters in its evaluation. The second group (Italy/EIFAC, 1974) is interested primarily in aquatic resources and may have included a much wider range of waters. Both Dill (1976) and FAO (1988) accepted the larger area of 20 000 km^2 - which upon examination today is obviously far too large

The average annual runoff from rainfall on Italian territory is 615 mm or 185 000 million m^3. An addition of about 2 000 million m$_3$m^3 is received from upstream countries resulting in a total annual river discharge of 187 000 million m^3 leaving the country (Van der Leeden, 1975 and ECE, 1978)[1].

[1] Another source (Framji and Mahajan, 1969) lists the annual runoff at 159 000 million m^3, but - for consistency - Van der Leeden (1975) and ECE (1978) have generally been used for all the countries under review

Overall, 69 percent of the water drains into the Adriatic, 21 percent into the Tyrrhenian Sea, 4 percent into the Ionian Sea, and 6 percent originates from Sicily and Sardinia.

5.1 Rivers (Fiumi)

All Italian rivers are subject to great variations in flow and it is only in northern Italy that most rivers have ample - if variable - supplies of water during the summer. On the peninsula, where snowfall is negligible, appreciable flows throughout the year are rare. The rivers are often torrential with floods during winter rains and - especially in the south - dry or almost dry during the hot summers. Thus, the Simeto in Sicily has varied from 1 081 m^3 /second in flood to only 1 m^3 /second at low water.

Broadly speaking, six main river regimes can be recognized:

(i) Alpine rivers, which are influenced primarily by melting snows and glaciers which provide their maximum flow in early summer and minimum flow in December–February. Their summer floods are furthered by spring rainfall;

(ii) Sub-Alpine streams, including the lower courses of the main Alpine streams, have two periods of flood: one corresponding with the early Alpine flow and a less conspicuous one coming with late summer and autumn rainfall;

(iii) rivers flowing into the Po from the south have floods in March and November and low water from July to September;

(iv) the main Po has floods in May and November and low water in February and August;

(v) in central Italy, the rivers reflect the rainfall regime of the region, i.e., high water in early spring, low water from July to September and a second high in November. Those with permeable basins have very little water during the summer;

(vi) in South Italy there is a typically Mediterranean regime. Drought is very marked in summer (even from May to October); many rivers dry up or merely trickle through wide pebbly beds. During the winter there are usually two short bursts of high water, one at the beginning and one at the end.

In addition to river regimes, note should be taken of the Italian springs (fontanili). In northern Italy, clayey impermeable beds force water to the surface in a line of springs extending clear across the Northern Plain. With good flows and temperatures ranging from 10 to 15°C, this has had important consequences for trout culture (see section 7.2).

As in several other European countries (see, for example, section 5.2 in the review of Belgium and France) attemps have been made in Italy to divide streams into various zones described by their predominant fish fauna. Studies in northern Italy by Sommani (1953) indicated that water temperature and flow were of more importance than gradient in determining the basic fauna.

Table 1 lists the principle rivers in Italy in order of their length as well as providing data on basin size and discharge.

De Angelis (1961) states that there are about 6 000 km of principal streams in Italy, but it may be noted that the 45 rivers listed in Table 1 have a combined length of 7 782 km.

Table 1

Principal rivers in Italy

Rivers	Length km	Basin area km²	Discharge in m³/second Maximum	Minimum	Mean
Po	672	69 382	7 000	214	1 720
Adige	410	14 700	2 500	100	220
Tevere(Tiber)	402	17 156	4 500	160	267
Adda	313	7 980	1 000	18	200
Oglio	280	6 640	425	36	137
Tanaro	276	7 985	1 700	-	123
Arno	248	8 443	2 000	15	100
Ticino	248	7 228	5 000	54	319
Reno	220	4 690	1 160	0.5	95
Piave	220	4 100	3 000	40	60
Sarca-Mincio	194	2 260	160	35	77
Volturno	175	5 680	2 000	32	70
Brenta	174	2 310	1 035	25	140
Tagliamento	170	2 590	1 500	50	80
Liri-Garigliano	168	5 020	1 340	25	-
Ombrone	166	4 200	1 975	2	90
Panaro	166	2 292	690	1	37
Dora Baltea	160	4 332	2 000	16	215
Secchia	157	1 250	790	4	42
Aterno-Pescara	152	3 130	2 790	18	42
Taro	150	2 083	1 200	0.5	42
Tirso	150	3 375	2 000	-	16.6
Basento	149	1 508	2 250	0.1	9.6
Ofanto	145	2 764	2 310	1.5	66
Bradano	140	2 735	2 000	-	10
Sesia	138	2 920	1 350	40	78
Isonzo	135	3 280	1 200	13	40
Dora Riparia	125	1 231	500	9	57
Nera	125	4 079	2 800	56	170
Flumendosa	122	1 782	2 230	0.2	16
Sangro	117	1 515	-	2.3	9
Trebbia	115	1 094	1 150	1.5	30
Simeto	115	1 832	1 850	-	16.7
Bacchiglione	113	1 600	770	38	78
Serchio	110	1 404	1 520	16	52
Aniene	99	1 415	480	16	32
Sinni	94	1 424	1 110	1	-
Tronto	93	1 192	1 325	2.4	20
Fortore	90	1 687	1 000	-	9.5
Scrivia	90	1 092	1 100	15	16
Crati	89	2 440	3 300	-	26
Biferno	85	1 311	-	1.5	11
Trigno	83	1 200	-	0.2	9
Sele	74	3 176	1 200	28	105
Magra	65	1 512	3 050	5	40

Source: Istituto della Enciclopedia Italiana, (1951), 19:728

North Italy. The dominant river of this area and also the largest river in Italy, draining one quarter of the country, is the 672-km Po River. Flowing as a mountain stream for 32 km and then meandering to its delta in the Adriatic Sea between Venice and Ravenna, it drains the western Italian Alps, the northern Appennines and most of the Northern Plain. The Po has abundant hydroelectric resources and en route to the sea it furnishes extensive irrigation to a broad cultivated valley.

Proceeding downstream, its major left bank (northern) tributaries are Alpine mountain streams: the Dora Riparia and Dora Baltea from the Val d'Aosta, Sesia, Ticino from Lake Maggiore, Adda from Lake Como, Oglio from Lake Iseo and the Mincio from Lake Garda. From the south, its major right bank affluents are the: Tanaro, Trebbia, Taro, Enzo, Secchia and Panaro.

At its mouth, the Po has a delta with subaerial area of 14 245 km^2. With an average water discharge of about 1 700 m^3/second, it discharges 67 million tons of sediment annually and its delta is growing at a rate of 26–61 m per year according to Shirley (1966) or 136 m per year according to Czaya (1981).

North of the Po, proceeding eastwardly, the main affluents to the Adriatic are the "Venetian" rivers. The most important of these is the 410-km Adige, with its two main tributaries the Isarco and Rienza, rising in a chain of Alpine lakes, flowing through the Alps for half its course and emerging on the plain above Verona. Four other important ones are the Brenta, Piave, Tagliamento and Isonzo.

South of the Po are a number of other rivers draining to the Adriatic and subject to spring floods: the Reno (formerly an affluent of the Po), Santerno, Lamone, Ronco and Marecchia.

<u>Central Italy</u>. The rivers of the peninsula follow the trend of the Appennines, draining either westerly to the Tyrrhenian Sea or easterly to the Adriatic.

On the west coast, as one proceeds southerly, the first major rivers are the Magra and its tributaries the Vara and Serchio entering the sea between La Spezia and Livorno. Next is Florence's river, the Arno, then the Ombrone, and then the Tiber (<u>Tevere</u>). The Tiber, with the second largest basin in Italy and third in length (402 km), flows generally south through Rome and to the sea to deposit 4–5 million m^3 of silt annually. Minor snowmelt affects both the Arno and Tiber and flow from limestone zones keeps the Tiber alive in summer. Below the Tiber there are some small spring-fed streams in the Pontine area, cool enough for trout and blocked by coastal ridges to form marshes.

Draining from the Appennines into the Adriatic is a series of short rivers: the Foglia, Metauro, Esino, Musone, Potenza, Chienti and Tronto. Mostly torrential, those in limestone areas have a more regular regime.

<u>South Italy</u>. The major Tyrrehnian rivers, north to south, are: the Liri-Garigliano, Volturno and Sele. The Volturno constitutes the only important river in an area equivalent to two-fifths of the national area. The major Adriatic rivers, north to south, are: the Pescara, Sangro, Trigno, Biferno, Fortore, Candelaro and Ofanto. Rivers entering the Ionian Sea include the Bradano, Basento, Agri and Crati.

<u>Insular Italy</u>. Sicily has only a few perennial rivers of consequence: the Platani, Salso, Belice and Simeto. Most Sicilian streams are dry during the summer. In Sardinia, the major river is the 150-km Tirso flowing into the Gulf of Oristano where there are several lagoons. Other streams include the Coghinas, Posada, Flumendosa and two Mannus. They are used extensively for irrigation.

5.2 Lakes (Lago/Laghi)

Estimates of the number of lakes in Italy range from the 365 of Great Britain, Naval Intelligence Division (1944) to the 1 500 of Encyclopaedia Britannica (1974). Such discrepancies are probably a matter of definition.

De Angelis (1961) states that the area of Italian natural lakes over 5 km^2 in area totals 124 859 ha. However, Table 2 Which shows the areas of 24 of the principal freshwater lakes of Italy shows a combined total area for these lakes of 1 216.4 km^2 although half of them are under 5 km^2 in area. (Since two of these lakes are shared with Switzerland, the actual Italian area of the ensemble is 1 143.1 km^2.) Possibly De Angelis included some coastal "lakes" or brackish waters in his summation (see section 5.5).

[1] The actual area of these five lakes is closer to 837 km^2; Ruggiu and Mosello (1984) used only the area of Lugano's northeast basin (27.3 km^2) in their calculations

Another more recent estimate of the total area of all of the lakes in Italy is 2.045 km^2. This is derived from the statement of Ruggiu and Mosello (1984) that the area of the five greatest Lombard lakes totals 818 km^2 and that the area amounts to 40 percent of the area of all the Italian lakes together[1].

Table 2

Principal lakes of Italy

Lake	Altitude m	Area km^2	Depth Maximum m	Depth Mean m	Volume million m^3
Garda (Benàco)	65	367.945	350.0	133.3	49 031
Maggiore (Verbano)	194	212.510[a]	370.0	177.5	37 502
Como (Lario)	198	145.910	410.0	154.0	22 500
Trasimeno	258	124.290	6.3	4.7	586
Bolsena (Vulsinio)	305	113.544	151.0	81.0	9 200
Iseo (Sebino)	186	61.800	251.0	123.0	7 600
Bracciano (Sabatino)	164	57.016	165.0	88.6	5 053
Lugano (Ceresio)	271	48.846[b]	288.0	130.0	5 540
Orta (Cusio)	290	18.150	143.0	71.6	1 300
Varese	238	14.950	26.0	10.7	160
Vico (Cimino)	507	12.080	48.5	21.6	260
Idro (Eridio)	368	11.500	120.0	65.0	684
Pusiano	259	4.933	24.3	14.0	69
Mezzola	198	4.810	69.0	36.7	176
Oggiono	224	3.810	11.3	6.3	24
Comabbio	243	3.590	7.7	4.6	17
Monate	266	2.510	34.0	18.1	45
Endine	334	2.340	9.4	5.1	12
Mergozzo	196	1.825	73.0	45.4	83
Annone	224	1.703	10.1	4.0	7
Alserio	260	1.228	8.1	5.3	7
Montorfano	397	0.459	6.8	4.2	2
Segrino	374	0.378	8.6	3.2	1
Pozzo di Riva	198	0.263	11.2	5.6	1

[a] Shared with Switzerland; Italian portion is about 170 km^2 or 80 percent

[b] Shared with Switzerland; Italian portion is about 18 km^2 or 37 percent

Source: Barbanti, Ambrosetti and Rolla (1981), except for mean depth of Lake Lugano and the Italian/Swiss areas taken from Istituto delle Enciclopedia Italiana, (1951), 19:729

The most common type of natural lake in Italy is the small (usually less than 50 ha) but deep, elevated Alpine lake occupying a rock basin hollowed out by recent glaciation. Among such lakes are: Caldonazzo, Molvena, Levico, Carezza and Santa Croce.

The largest and most spectacular of the Italian lakes, however, are the long, narrow, deep lakes of the Alpine foothills or pre-Alps, formed by Quarternary glaciers and dammed by moraines. These are the famous Lombard lakes, among the most beautiful lakes of Europe: Garda, Maggiore, Como, Iseo, Lugano, Orta and Idro.

A detailed description of the first five of these lakes will be found in Bonomi, Calderoni and Mosello (1979). These five oligomictic lakes exceed a volume of 120 km^3 and contribute about one third of the Po's drainage. They are all becoming more eutrophic, their algal production controlled by phosphorus. Using the approach of OECD (1982) for a classification of their trophic status, they have been classified as follows: oligo-mesotrophic (Garda), meso-eutrophic (Maggiore), eutrophic (Iseo and Como) and eu-hypereutrophic (Lugano) by Ruggiu and Mosello (1984). All except Orta drain to the Northern Plain. Like many of the smaller glacial lakes these have been regulated to produce hydroelectric power.

A brief description, based mainly on Bonomi et al. (1970) and Gommes et al. (1981) of the second largest of these waters, Lake Maggiore, follows as indicative of their limnology, fisheries and other uses. With a drainage basin of 6 599 km^2 in the Ticino (Po) system, Maggiore lies at an elevation of 194 m in a glaciated basin raised by a morainal dam. It has an area of 213 km^2 (80 percent of it in Italy); a length of 66 km, width of 10 km, perimeter of 170 km and volume of 37.5 km^3. It has a mean depth of 177.5 m and a maximum depth of 370 m in a crypto-depression. Chemically, it is now mesotrophic but in terms of P is oligotrophic. The mean pH is 7.4; the maximum 8.8. It has a conductivity of 137 u Scm^{-1}. Its water residence time is 4.1 years. There is no ice-cover. The lake is used for waste discharge, flood control, water supply, boating, swimming and fishing and furnishes water for irrigation and rice paddies. Pelagic fishes represent the bulk of its biomass, but of four planktonic species, only two were native: the bleak (Alburnus alborella) and a landlocked shad, the agone (Alosa fallax lacustris).[1] The other two are introduced: the pollan or lavarello (Coregonus lavaretus) from Lake Constance and the houting or bondella (C. oxyrhynchus) from Lake Neuchatel. Other species include trout, perch, pike, tench, chub and rudd. About 250 t of fish are taken annually (see sections 9.1 and 9.2).

[1] This shad seems to have disappeared. See section 9.2

A third class of Italian lake is represented by those which are intervolcanic or lie in volcanic craters, e.g., Bolsena, Bracciano, Vico, Albano and Nemi in Central Italy and Averno near Naples. Varying in size, they are usually roughly circular, deep and without large inflowing streams.

A fourth class includes those dammed by landslides or alluvium. With the exception of the 124-km^2 Lake Trasimeno in Umbria, which is partially tectonic, these generally shallow and irregular lakes are usually small in size. Many of them are held among the morainic hills at the mouths of Alpine valleys. The largest of these is Lake

Varese (14.9 km^2). Other examples are: Viverone, Monate, Comabbio, Pusiano and Annone in northern Italy and Alleghe, dammed by a landslide and partially tectonic.

A fifth class of Italian lake is limestone or karstic. Usually small and occupying irregular hollows, they often have underground drainage and variable water level. Examples are Lake Morto, Canterno, Matese, Circonia and Arsa.

A last class includes the coastal lakes (laghi costieri) similar to the brackishwater lagoons of the Adriatic (see section 5.5).

Most of the lakes provide fisheries for both cold and warm water species.

5.3 Reservoirs (Bacini artificiali)

Circa 1961, there were 30 000 ha of hydroelectric reservoirs and 1 500 ha of irrigation reservoirs in Italy according to De Angelis (1961). In addition to these there were thousands of small reservoirs. The total today far exceeds these figures but neither the size of nor the fish production from Italian reservoirs is as important as in a number of other European countries.

Italy has some very high dams. Of 252 "high dams" in Europe in 1962, Italy had 48 - a figure exceeded only by Spain. Among the major dams and reservoirs of the world listed by U.S. B.R. (1969), four are in Italy (see Table 3). Neither their storage capacity nor area is, however, large - thus lessening their value for fish production.

Table 3

Major dams in Italy (circa 1969)

Dam	Drainage	Height (m)	Reservoir capacity (million m^3)
Alpa Gera	Comori-Adda-Po	178	65 000
Place Moulin	Buthier-Dora Baltea	155	100 000
Santa Giustina	Noce-Adige	153	183 000
Speccheri	Leno di Vallarsa-Adige	157	10 000

Source: U.S. B.R. (1969)

5.4 Canals (Canali)

De Angelis (1961) reports about 30 000 km of artificial canals and Framji and Mahajan (1969) say that there are 74 083 km of irrigation canals alone. Some of these, such as those which link rivers such as the Sesia, Ticino and Po to furnish irrigation water, also aid in the dissemination of fish. About 847 km of canal are navigable. Many of these canals provide sport fishing.

5.5 Lagoons (Lagune)

As used here (and in other sections of this review), the term "lagoon" (laguna in Italian) refers generally to a coastal body of water in permanent or intermittent connexion with the sea by either natural or artificial means. Often on deltas, they are mostly shallow, separated from the sea by beaches or dunes, at sea level or only slightly above, and sometimes with streams draining into them. Many mud-floored lagoons in Italy have developed behind the spots where silt from a river has precipitated upon contact with salt water. Thus, Adriatic lagoons are deltaic, alluvial formations originated by the appearance of a littoral strand, and successively filled and replaced by new lagoons nearer the sea and in progressive advance of a river's delta. The outer zones (lagune vive) are vivified by tidal waters; the inner parts of these lagoons have been completely cut off from the sea to become laguna morta or muddy dead shallows.

Owing to a mixture of fresh or limnetic water and marine water, these lagoons are brackish or mixohaline. Some, such as the lagoons of Fogliano and Monaci on the Tyrrhenian coast, were originally (mixo) oligohaline, i.e., of very low salinity, but following land reclamation which has lessened the incursion of fresh water, have reached a high degree of salinity, e.g., 26.5–45.5 ppt for Fogliano. Similarly, the littoral lagoons of the Northern Adriatic are for the most part prevailing (mixo) polyhaline or at least (mixo) mesohaline with oligohaline waters limited to areas near freshwater inlets. Variations in salinity are considered more important for the lagunal fauna than the content itself. Similarly, there are great variations in water temperature, e.g., some Tyrrhenian lagoons vary from 5° to 30°C throughout the year. Although the fauna of the Italian lagoons is somewhat impoverished in number of species as compared with the adjacent seas, they can be very productive - especially if aided by control of salinity and temperature and often by increase in anthropogenic enrichment.

Lagoons that have a connexion with the sea have mixed populations of brackish or euryhaline fishes. These generally enter the lagoon in the spring and attempt to return to the sea in autumn but European eels (Anguilla anguilla) may remain longer, and some lagoons with good freshwater sources may also support fish such as common carp (Cyprinus carpio). Salinities of 15–30 ppt and water temperatures from 18° to 25°C are generally favourable for the euryhaline and eurythermic species which enter the lagoons and form the bulk of their fisheries. (See section 7 for the fisheries of Italian lagoons, and section 5.4 in the review of Greece for further general information on lagoons.)

In Italy, a distinction is not always made between a lagoon and a coastal lake (lago costiero). Thus, De Angelis (1961) stated that lagoons with capture fisheries are termed laghi (lakes) on the mainland and stagni in Sardinia. Recently, Brambati (1985) pointed out that the difference between lagoons and stagni costieri is that lagoons are coastal bodies of water under the direct influence of tides, while stagni costieri are not influenced by tides. It should also be noted that although many Italian lagoons have been modified to facilitate entrance, outward migration and capture of fish, the primary lagoon fishery remains essentially a capture fishery. In Italy, it is really only on the northern Adriatic coast (near Venice) that considerable areas of brackish water have been modified by complex installations to control the exchange of water and facilitate the culture of brackishwater and euryhaline fish. These are known as valli da pesca (see section 7.2) and the term should be reserved for these specialized fish farms. Unfortunately, variations in terminology (such as terming free lagoons valli), natural hydrological changes, man-made changes such as drainage for agricultural development and lack of up-to-date statistics, make estimates of the present extent of Italian lagoons or even their status (such as suitability for or type of fisheries) difficult.

Table 4 is an attempt to show Italy's lagoon area as specified by various authors during the 1954–83 period. Judging from this table, there may have been about 147 000 ha of lagoons in Italy circa 1960 and about 62 000 ha today[1]. Some of the more prominent or best studied lagoons or lagoon-groups are listed below.

[1] In making this assumption, I have used the figures of De Angelis (1961) except for the substitution of D'Ancona's (1959) Northern Adriatic lagoon area, and the most recent total of Panella, Della Seta and Hull (1982)

On the Tyrrhenian (western) side, proceeding from north to south, Ardizzone (1984) states that there are about 4 500 ha of coastal brackish waters used for fisheries and aquaculture between Orbetello and Gaeta: Orbetello (2 700 ha), Burano (140 ha) and the Pontine lakes (Fogliano, Monaci, Caprolace, Sabaudia, Fondi and Lungo) having a total area of 1 640 ha. For this same Tyrrhenian area, Panella, Della Seta and Hull (1982) list three lagoons in Toscana (Orbetello, Burano and Massaciuccoli) as comprising 3 650 ha, five lagoons in Lazio (Paola, Fogliano, Fondi, Caprolace and Monaci) totalling 1 600 ha, and five lagoons in Campania (Patria, Miseno, Fusaro, Lungo and Lucrino) totalling 400 ha.

Sardinian lagoons specifically mentioned by Kiener (1978) are: Cabras (2 000 ha) and Santa Gilla (2 150 ha). Cottiglia (1981) says that there are over 100 lagoons in Sardinia, totalling about 20 000 ha of which about 9 500 ha are used for fishing. He specifically mentions: Tortolli, Colostrai, Santa Giusta and Santa Gilla. Ravagnan (1981) mentions the following natural brackishwater “ponds” in Sardinia: Santa Gilla, Merceddi, Corru S'Ittiri, S'Ena Arrubbia, Santa Giusta, Cabras and Mistras, Calik, Tortolli, Colastrai, S. Teodoro, Casaraccio, Pilo and Cugnana. A comperhensive account of the lagoons in Sardinia is given in Consiglio Regionale della Sardegna (1981) according to Italy/EIFAC (1989). The author has not seen this account.

On the Adriatic side of the mainland there is an almost continuous series of lagoons, mostly open and tidal from Isonzo south to Venice. There is another series in the lower part of the Po delta, including the famous Comacchio. D'Ancona (1959) provided a summary of their limnological features at the time and grouped them from north to south as follows: Grado and Marano (12 717 ha), Caorle (1 696 ha including 1 596 ha of valli de pesca), Venice (54 889 ha) comprising three bodies of water in relation to the three mouths of (Lido, Malamocco and Chioggia), Caleri and Pozzattini (877 ha including some valli), Vallona (3 233 ha including valli), three valli, Ca' Zuliani, S. Carlo and Boccasette (87777777773 ha), the lagoon of Sacca degli Sardovari (3 184 ha) plus some adjoining valli (2 200 ha), Mesola (3 200 ha), and Valli of Comacchio (29 000 ha). His list totals 111 869 ha and he stated that the total area of northern Adriatic lagoons is about 120 000 ha.

A more recent publication, Zerbinato (1981), has a detailed listing of the valli of the Northern Adriatic. It will be noted that the areas he specifies are, of course, far smaller than the totals of full lagoon area given by other authors. Proceeding from north to south along the Adriatic, he groups the valli as follows: Valli della Laguna di Marano-Grado (1 870 ha and 56 in number), Valli della Laguna di Caorle (1 703 ha and 5 in number), Valli della Laguna di Venezia (8 770 ha and 6 in number), Valli della Laguna di Caleri e dei Polesini Vecchia (7 890 ha and 16 in number) and Valli di Comacchio (10 800 ha); these are comprehensive of some different basins as Valle Campo, Vacca, Fossa di Porto, Fattibello.

Well to the south in Puglia are two brackishwater coastal lakes opening to the Adriatic: Lesina (5 136 ha) and Varano (6 500–7 000 ha).

Table 4

Estimated areas of lagoons in Italy (ha)

Type	Tyrrhenian Sea	North Adriatic	South Adriatic	Sardinia	Sicily	Total	Source
Valli	-	20 097	-	-	-	-	D'Ancona (1954)
Lagoons, except North Adriatic ("valli")	4 300	50 000	12 200	11 000	-	77 500	De Angelis (1961)
Lagoons	-	120 000	-	-	-	-	D'Ancona (1959)
Valli	-	40 000	-	-	-	-	Ravagnan (1972)
Lagoons, managed	4 500	91 660+	12 160	16 000	-	135 000[a]	Kiener (1978)
Valli	-	35 000	-	-	-	-	Ravagnan (1981)
Lagoons	4 400	100 450	12 200	8 400	-	125 450	Amanieu & Lasserre (1981)
Lagoons and brackish water[b]	-	-	-	-	-	150 000	Colombo (1981)
Lagoons	-	-	-	10 000	-	-	Cottiglia (1981)
Valli	-	31 103	-	-	-	-	Zerbinato (1981)
Lagoons and valli	5 650	30 396	12 000	10 500	3 000	61 546	Panella, Della Seta & Hull (1982)
Brackish culture	-	40 000	-	-	-	-	Brown (1983)
Lagoons	4 500	-	-	-	-	-	Ardizzone (1984)

[a] Kiener's total of Italian lagoons "plus ou moins aménagées"

[b] Lagoons and brackish or salty water developed for aquaculture

There are also some small lagoons in Sicily with minimum importance with respect to fisheries production. Kiener (1978) mentions Marsala and Ganziri. Panella, Della Seta and Hull (1982) mention Stagnone di Marsala and Saline di Trapani.

In most of the lagoon areas, the principal activity is fishing followed by that of hunting.

6. LAND AND WATER USE

Table 5

Pattern of land use in Italy (1986)

	Percent
Arable and permanent crops	40.4
Permanent pasture	16.4
Forests and woodlands	22.3
Other land	18.4
Inland water	2.4
Total	100.0

Source: 1987 FAO Prod.Yearb., 41 (Publ. 1988)

Despite its bare hills, stony mountainsides and many unproductive plains, centuries of tillage and small-scale grazing have developed Italy as an agricultural country and it is still about 32 percent rural. Principal crops are cereals, potatoes, the vine, olives, fruit and early vegetables. On the whole, the size of the holdings is now small and calls for intensive cultivation to ensure subsistence. The use of chemical fertilizers is, relatively low, but is increasing.

Both drainage and irrigation have a long history in Italy and are widely practised today. For example, drainage of the 20-m deep Lake Fucino in central Italy was started in A.D. 52 but not completed until the late Nineteenth Century. Similarly, the drainage and canalization of the Pontine Marshes south of Rome which commenced in 312 B.C. was completed in this century. Drainage in Italy had several purposes: to gain ground for agriculture, prevent floods and improve water levels for rooting plants. It was also carried on to eliminate malaria, resulting in land reclamation to which irrigation was then carried.

Irrigation was known in Italy even before Roman times and important collective irrigation began in A.D. 1100–1200. In the south, it is a primary requirement of the agricultural economy, and is being extended to all parts of the country. By 1986, about 38 percent of the arable land was irrigated. A prime example is the tapping of the Sele River, a project carried on from 1906 to 1939, by the Apulian Aqueduct which conducts water from a Tyrrhenian Sea drainage about 250 km across the country to the slopes of the Adriatic.

Although Italy ranks about thirteenth in European roundwood production, the amount is not large and its forest industry is very limited. Most of the true forests are in the northern or Alpine regions and little natural forest remains. There has been almost uninterrupted deforestation since Etruscan times - a result not only of lumbering but of use for fuel, burning, over-grazing and violent rains causing erosion. Today, the watersheds are being improved through afforestation.

Italy's resource of basic industrial minerals is one of the poorest in Europe. Iron is largely lacking except in the northeast and on Elba, and coal is lacking except for some lignite in Sardinia. Bauxite, mercury, sulphur, salt, natural gas and oil are present in small quantities. Nevertheless, in spite of mining being only a minor industry, its destructive operations in some areas have greatly silted its streams, e.g., in Sardinia where the Piscinas and Navacauli rivers have been affected adversely.

Lack of coal stimulated the development of hydroelectric power in Italy. Starting in 185, it was almost its only source of power until 1945 and the country still relies heavily on its use. By 1966 there were over 2 700 hydro plants in Italy and by 1987, of a total installed, electrical capacity of 56 403 000 kW hydroelectric power represented about 32 percent (17 879 000 kW), nuclear power 2.3 percent (1 273 000 kW) and geo-thermal 0.9 percent. The remainder (36 745 000 kW) or 65 percent was thermal with most of the fuel being imported. There are very few large hydroelectric plants and most of these are in the Alps. Most plants are high head and use little water, sometimes collected from several streams. Some of the power originates from regulated natural lakes (e.g., the pre-Alpine lakes), some from artificial lakes with very high dams (see section 5.3). Storage in the Appennines is difficult because of torrential flows, but there are many medium-sized plants on most of its watercourses. In the south, many irrigation projects also provide electricity. A dense power grid extends throughout Italy; power is also imported from Austria and Switzerland.

Despite the lack of domestic raw materials and fuel, Italy has become one of the world's ten largest industrial powers. Emphasis is on engineering, auto and ship building, chemicals, metal-working, textiles and food processing. Despite concerted efforts by the Government to attract industry to the less developed Mezzogiorno, it remains concentrated in the northwestern industrial triangle of Turin-Milan-Genoa[1]. Industry is also spreading toward Venice-Mestre and other port cities such as Naples. There is a decided emphasis on state-owned or controlled industry and there is also a predominance of small establishments. The latter situation is in part responsible for wide-spread pollution of a minor nature.

[1] The "Cassa per il Mezzogiorno" (Fund for the Development of the South), which started in 1950, has placed emphasis on river control, irrigation, drainage and reforestation - all of which affect fisheries

The navigable river and canal system is primarily confined to the Northern Plain and northeast coastal area and lower reaches of the Arno and Tiber. There are 1 134 km of rivers and 847 km of canals, including a few locks, in the navigable waterway system. All of the larger pre-Alpine lakes and Lake Trasimeno are navigable throughout the year. Although the density of roads (about 1 km/km^2 in 1988) is not high for western Europe, there is an excellent motorway (autostrada) system in Italy, a maze of minor roads and a railroad system of about 20 000 km (1985) to most parts of the country. About 1 out of 3 people had an automobile in 1985. Good harbours are few in number.

Ground water resources, estimated at about 20 000 million m^3, are used for irrigation, domestic and industrial supply. Although this lessens the demand for surface waters, the latter are still used extensively for the same purposes.

Water pollution from industrial effluents has become very serious in Italy, especially in industrial areas far from the sea. The complex of effluents from sophisticated industries adds further to the problem. Metallurgical, chemical and electro-chemical industries, fertilizer plants and the processing of agricultural products are among the most important sources of polluting effluents. Sewage treatment is not generally practised in Italy, which adds to the problem of decreasing oxygen content of both rivers and lakes[2]. This lack of treatment is offset to some extent through land disposal.

[2] No more than 150 of Italy's 8 000 cities and towns had sewage treatment plants circa 1977

Water use for irrigation, domestic water, industry, etc., was about 41 000 million m^3 in 1969. In 1972, total water use in Italy was as follows: agriculture (61 percent), industry (21 percent), domestic (17 percent) and other uses (2 percent) according to ECE (1978). Considering the likely needs for water use by 2000 A.D., the demand for all types of water use may be expected to rise to 50 000 million m^3 (Framji and Mahajan, 1969).

Both commercial and sport fishing are practised widely in the inland waters of Italy. Even small lakes often have commercial or subsistence fishing for fish such as coregonids. Extensive use has been made of brackishwater areas for both fisheries and salt production since Roman times and in some cases the demand for salt (an important tax item) has been given the greater priority. Trout culture has made rapid progress in recent years. The marine fishing industry in Italy is a minor industry but has a relatively high labour force. Fish imports are very high, being more than half of the total commercial fish supply in 1988. The per caput consumption had stabilized at about 9.5 kg/year by 1987 (OECD, 1989).

In this country of great scenic beauty with countless centres of significance in both art and history, tourism is a most important industry - being the mainstay of its balance of payments position. Over 53.6 million tourists visited Italy in 1986 but sport fishing was not an important factor in their attraction.

7. FISH AND FISHERIES

There are about 56 species of freshwater and diadromous fishes in the inland waters of Italy as well as some euryhaline species. About 45 are freshwater species.

Among the commonest native species of economic importance are: the European eel (Anguilla anguilla), brown trout (Salmo trutta), barbel (Barbus barbus), chub (Leuciscus cephalus), roach (Rutilus sp.), rudd (Scardinius erythropthalmus), tench (Tinca tinca), and the euryhaline species called latterino (Atherina boyeri). Of lesser importance among the native fishes are: three species of now rare sturgeons (Acipenser and Huso), char (Salvelinus alpinus), grayling (Thymallus thymallus), pike (Esox lucius), burbot (Lota lota), and European perch (Perca fluviatilis).

Italy has a considerable number of introduced fishes in its inland waters. Among the most important of these are: rainbow trout (Oncorhynchus mykiss), pollan (Coregonus lavaretus), common carp (Cyprinus carpio), goldfish (Carassius auratus), North American bullheads or catfishes (Ictalurus melas, I. nebulosus and I. lacustris), mosquitofish (Gambusia affinis), pumpkinseed (Lepomis gibbosus), and largemouth black bass (Micropterus salmoides). Less abundant among the exotics are the American brook trout (Salvelinus fontinalis), grass carp (Ctenopharyngodon idella), European catfish (Silurus glanis), pike-perch (Stizostedion lucioperca), and silversides (Odontesthes honar).

The shads (Alosa alosa and A. fallax) frequent the Italian seas and enter the rivers and a subspecies, the agone (A. f. lacustris), is landlocked in some of the northern Italian lakes (e.g., Como) where it furnishes both food and sport. In addition to these, grey mullets (Mugil spp.), the European eel, the gilthead (Sparus auratus), sea bass (Dicentrarchus labrax), sole (Solea vulgaris) and the flounder (Pleuronectes flesus) enter lagoon waters seasonally to remain for one or more years during a period of nutrition and growth, and returning to the sea with the onset of sexual maturity.[1] A number of other euryhaline fishes also enter lagoons to feed during the spring and summer.

[1] An array of material on Sparus auratus and other euryhaline species will be found in Girm (1983) and Stickage and Winfree (1983)

It is of particular interest that some of the most utilized fishes (rainbow trout and coregonids) have been introduced.

In addition to the finfishes, Italy has two native species of crayfish: Astacus astacus with a marginal distribution in the northeast and the move widespread Austropotamobius pallipes. Astacus leptodactylus has been imported from Turkey, and Procambarus clarkii from Kenya and Spain.

7.1 Capture Fisheries

7.1.1 Commercial fishing

Commercial fishing in Italy is confined to some lakes and reservoirs and to a few reaches of the larger rivers.

Table 6 shows the commercial “catch” in the inland waters of Italy during the 1965–87 period as reported to FAO by Italy. During the 1965–69 period, the “catches” of common carp and trout were apparently lumped with those of other freshwater fishes. It is certain that the “catches” of trout in this table are mostly cultivated fish; of Table 6 with Tables 11 and 12. Italy's catch of European eels and mullet in the Mediterranean during the period of 1965–87 as recorded by FAO is shown in Table 7. It can be noted that other sources recording the catch of these euryhaline fishes differ. For example, the 1979 mullet catch in the sea is recorded as only 4 800 t by Panella, Della Seta and Hull (1982) as against FAO's 6 406 t.

Table 6

Nominal catches by species in the inland waters of Italy, 1965–87[a]
(in tons)

Year	Common carp (Cyprinus carpio)	Freshwater fishes n.e.i.	European eel (Anguilla anguilla)	Trouts (Salmo sp.)	Total
1965	-	15 100	2 700	-	17 800
1966	-	16 300	2 600	-	18 900
1967	-	16 800	2 600	-	19 400
1968	-	17 300	2 700[b]	-	20 000
1969	-	17 700	3 000[b]	-	20 700
1970	3 000	5 000	1 000	8 500	17 500
1971	3 000	4 700	1 000	8 500	17 200
1972	3 600	4 000	600	8 800	17 000
1973	3 200	4 900	600	8 700	17 400
1974	3 110	4 565	639	9 436	17 750
1975	3 012	4 312	663	11 113	19 100
1976	2 747	3 991	576	14 066	21 300
1977	2 962	3 931	592	15 415	22 900
1978	2 997	4 046	555	17 012	24 610
1979	3 374	4 477	665	19 714	28 230
1980	3 234	6 380	543	25 000	34 460
1981	3 011	5 256	530	28 000	36 797
1982	2 944	4 922	494	31 400	39 760
1983	3 095	5 266	449	32 500	41 310
1984	3 240	4 863	2 500	35 750	46 353
1985	2 973	5 046	2 500	33 000	43 519
1986	2 902	5 035	2 500	35 500	45 937
1987	3 331	5 822	2 000	39 050	50 203

(-) = This category not listed this year

[a] = In addition to these, the FAO Yearbook 64 (Published 1989) lists catches in the inland waters of Italy of Flathead grey mullet (Mugil cephalus) as follows: 3 200 t in 1984, 3 200 t in 1985, 3 200 t in 1986 and 3 500 t in 1987. Previous Yearbooks do not appear to list any specific catch of mullet in inland waters.

[b] = Estimated or calculated by FAO

Source: 1965–69 - Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–83 - FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1984–87 - Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

Table 7

Norminal catches of European eel and mullets in Marine Statistical Fishing Area 37 (Mediterranean) by Italy, 1965–87 (in tons)

Year	European eel (Anguilla anguilla)	Mullets (Mugilidae)
1965	500	5 200
1966	500	5 900
1967	500	6 300
1968	500	6 300
1969	400	6 500
1970	2 300	7 200
1971	2 400	7 500
1972	2 300	7 200
1973	2 300	7 400
1974	2 058	7 030
1975	2 310	7 210
1976	2 101	6 991
1977	1 870	7 626
1978	1 682	6 330
1979	1 757	6 406
1980	1 721	6 412
1981	1 810	7 662
1982	1 593	6 900
1983	1 627	6 697
1984	2 000	6 160
1985	2 000	6 668
1986	2 000	6 340
1987	1 500	7 226

Source: 1965–69 - Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–83 - FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1984–87 - Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

Another table (Table 8) derived directly from the Italian Government's own statistical yearbook distinguishes the fish caught in lakes and reservoirs from those caught in marine and lagoon areas but does not distinguish lagoon-caught fish from ocean-caught fish[1]. It does show, however, that during the years of record (1975–85) the strictly inland fish catch varied only from 1.8 to 2.6 percent of the total Italian catch of finfish, molluscs and crustaceans or 2.5 to 3.4 percent of the total Italian catch of finfish alone.

A fourth table (Table 9) illustrates the fish catch in 1980 and 1985 from lakes and reservoirs in the four major geographical areas of Italy. The importance of the Lombard lakes in contributing to this catch is emphasized by noting that the original sources shows that the Region of Lombardia furnished about one-third (3 178.1 t and 2 911.8 t) of the total catch in both years, and the neighbouring region of Piemonte furnished 12.5 percent (1 186.8 t) in 1980 and 8.4 percent (703.9 t) in 1985.[2]

[1] Here, as elsewhere, discrepancies between the FAO yearbook of Fishery Statistics and the Italian statistical yearbook (and some of its derivatives) cannot be explained

[2] With the exception of Lake Garda, which is shared between Lombardia, Trentino and Veneto, all of these lakes are in Lombardia and Piemonte

Table 8

Italian fish production 1975–85 (in tons)

Year	Marine and lagoon fish			Fish from lakes and reservoirs	Grand total
	Fish	Molluscs and Crustaceans	Total		
1975	257 360	109 220	366 580	9 100	375 680
1976	266 113	112 461	378 574	8 300	386 874
1977	250 975	87 019	337 994	8 500	346 494
1978	286 626	71 233	357 859	8 710	366 569
1979	296 770	82 912	379 682	10 030	389 712
1980	286 295	105 574	391 869	9 459	401 328
1981	289 969	102 292	392 261	8 797	401 058
1982	300 556	115 176	415 732	8 360	424 092
1983	290 499	124 206	414 705	8 810	423 515
1984	300 418	128 272	428 690	8 055	436 745
1985	305 130	125 505	430 635	8 301	438 936

Source: 1975–78 - Istituto Centrale di Statistica (1980)
1979–81 - Istituto Centrale di Statistica (1982)
1982–85 - Istituto Centrale di Statistica (1987)

Table 9

Italian fish production in lakes and reservoirs, 1980 and 1985

Geographic area	1980		1985	
	Tons	Percent	Tons	Percent
North Italy	6 649.4	70.3	5 594.2	67.4
Central Italy	2 501.2	26.5	2 334.5	28.1
South Italy	199.2	2.1	348.1	4.3
Insular Italy	109.4	1.1	24.6	0.3
	9 459.2	100.0	8 301.4	100.0

Source: Istituto Centrale di Statistica (1981, 1987)

Despite the existence of these “official” tables of fish “catch” or “production” in Italy, it is difficult to determine their exact species composition, those fishes taken by capture and those which are cultivated, those taken from brackish waters. As an aid toward such determinations, one must examine other sources.

About 50 years ago, Italia (1931) stated that there were 22 major lakes and 49 minor lakes in Italy with commercial fisheries. Of these lakes, seven were reported to have produced a total of 3 663 t in 1929. The fishes then dominating this lake catch were: coregonids, carp, tench, bleak, chub, landlocked shad, perch, eel and catfish. Neither rivers, canals, nor reservoirs were mentioned as having commercial fisheries.

Circa 1958, rough estimates by De Angelis (1961) indicated that the catches in Italian fresh waters totalled 8 000 t; 3 600 t (45 percent) from lakes and 4 400 t (55 percent) from rivers and canals. These statistics were considered to include the catch by both commercial and sport fishermen. It is the author's belief that the reported fluvial catch was primarily that by sport fishermen and that under any circumstances it was a highly speculative estimate.

Circa 1986, another De Angelis (1986) stated that the number of Italian lakes employed in fisheries are about 150, of which 107 have an area larger than 20 ha. He also stated that production (i.e., catch) was about 10 000 t annually, and that about three-quarters of this came from the 17 main lakes of North and Central Italy with a total area of about 1 169 km^2.

Table 10 is a breakdown of the catch in Italian lakes and artificial basins in 1972. Of this total (although partial) catch, about 82 percent (3 594.4 t) was taken commercially and about 18 percent (815.4 t) by sport fishermen.

A final table (Table 11) represents another breakdown of the commercial catch in Italian lakes, data for 1979 derived originally from the Istituto Centrale di Statistica. It may be noted that the percentages of the various species groups does not vary markedly from those shown for the 1972 catch (Table 10).

Both De Angelis (1986) and Ministero dell'Agricultura e Foreste (1988) state that an estimated Italian inland water catch of 10 000 t annually is composed about as follows: 50 percent eel, pike and perch; 35 percent cyprinids, and 15 percent trouts (rainbow and brown) and coregonids.

The catch in brackish water will be discussed in section 7.2 as it is difficult to distinguish capture fishery catch from valli culture.

7.1.2 Sport fishing

As in other European countries, sport fishing in Italian inland waters is becoming more important. In 1929, there were only 50 672 sport fishermen (Italia, 1931) or about 0.12 percent of the total population. Circa 1973, there were about 850 000 sport fishermen or 1.6 percent of the total population; in 1987 there were about 2 000 000 sport fishermen or 3.5 percent of the total population.

Most of the fish taken commercially are also taken for sport: several cyprinids, pike, perch, eel and trout, for example. Although wild fish constitute the bulk of the catches, many Italian fishing clubs now stock private ponds or sections of stream with hatchery-reared fish, especially rainbow trout, for a catchable programme. The introduced large mouth black bass is also popular, being widespread throughout Italy.

Italy's waters lack the appeal to the foreign angler possessed by countries like Norway, but do have two sub-species of brown trout whose scarcity in Europe has attraction for some anglers. These are the trota padana or marble trout (Salmo trutta marmoratus), found in the Alpine waters of the Po drainage as well as in Yugoslavia and trota sarda or macrostigma (S. t. macrostigma) also resident in Turkey and North Africa.

Sport fishing methods run the gamut from the use of lift nets from city bridges and heavy groundbaiting in canals to flyfishing for trout, grayling and cavedano (Leuciscus cephalus).

7.2 Aquaculture and Brackishwater Fisheries

Formerly noted for its brackishwater aquaculture, Italy has now become a major producer of cultivated rainbow trout and is expanding into other areas. De Angelis (1961) stated that the annual yield in Italy from aquaculture was 9 350 t: 1 200 t of trout and 8 150 t of brackishwater species. During the next 30 years, trout production reached over 30 000 t annually, while brackishwater production lessened to perhaps 6 000 t annually.

As in other Mediterranean countries, there are difficulties in obtaining information on aquacultural production in Italy: lumping of statistics from capture fisheries and aquaculture, the sometimes thin line between "extensive aquaculture" and capture fisheries and unclear expression by reporting authors. Because of such difficulties - particularly with respect to the catch/production in brackish water, the fisheries in Italy's lagoons, whether capture or culture, are discussed in this section. It should be understood that some of the material that follows might just as well as have been presented in section 7.1.1.

Table 10

Partial catches in Italian lakes and reservoirs, 1972

Species	Tons	Percent
Cyprinids	1 571.9	36.0
Pike and perch	714.0	16.0
European eel	344.2	7.8
Salmonids	422.7	10.0
Other fishes	1 337.0	32.0
Total	4 409.8	100.0

Source: EIFAC (1974)

Table 11

Catches in Italian lakes and reservoirs, 1979

Species	Tons	Percent
Carp, tench, bleak	3 400	34
Trout, char, coregonids[a]	1 500	15
Pike, perch	1 200	12
European eel	700	7
Other fishes	3 200	32
Total	10 000	100

Source: Panella, Della Seta and Hull (1982)

[a] The original statistics also specify carpione, a sub-species of brown trout (Salmo trutta carpio) endemic to Lago di Garda and introduced into other northern Italian lakes.

The more traditional culture of brackishwater species in Italy originated centuries ago, possibly with the Etruscans, certainly carried on by the ancient Romans, and known to be flourishing in areas like Comacchio in the Fourteenth Century. Not all of this can be called "aquaculture" sensu strictu, and in any case it is usually quite an extensive method. Some of it is derived from a modified capture or trap fishery where fish from the Mediterranean migrate naturally into a coastal lagoon during the spring and are then captured as they attempt to return to the sea in the autumn. A more sophisticated version of lagoon "culture" is the Italian system of valli culture or vallicultura found principally on the northwestern Adriatic coast from Grado south to Comacchio. In this system fish are held in embanked or fenced lagoons or fish farms called *valli da pesca*, which are subject to a considerable control of water levels, salinity and temperature. There are three general types of *valli*: (i) *valli aperti* (open), which are only enclosed temporarily with trellis or screens; (ii) *semi-arginate* or partly enclosed, which admit the flow of the tide and young fish but keep in the larger ones, and (iii) *valli arginate*, which are completely surrounded by earth and stone, except for carefully controlled channels to the sea. Depth in such culture lagoons is about 0.7–1 m, the salinity usually ranges from 10 to 30 ppt, and the water temperature from near freezing to more than 30°F. In the most elaborate *valli* there is control of freshwater and sea water (which may involve pumping), drainage channels, sluice gates, fish weirs and trenches to protect the fish from winter cold. Another method to protect the deeper salt water from cooling is to admit fresh river water which forms a thin sheet of ice over the lagoon.

The primarily brackishwater species reared in lagoons are: the grey mullets (*Mugil capita*, *M.auratus*, *M. saliens*, *M. chelo* and *M. cephalus*), European eel, gilthead, sea bass, flounder and sole[1]. *Atherina* is also caught in lagoons. These euryhaline fishes often migrate toward freshwater or brackish waters as young, and - unless restrained by closure of the outlet - move outwardly to the sea later in the year to breed or avoid cold water in the lagoon. Some fish raised in *valli* enter naturally from the sea, or they may be collected from other areas and stocked as fry or juveniles. Eels, for example, which stay in for some years, are often brought to the northwestern Adriatic lagoons from the Tyrrhenian coast where they are collected at barriers to streams, e.g., at outlets near power stations near Rome, or even transported here from the Atlantic coast of France. Under-sized fish may be held over winter in deep trenches with supplemental feeding and retained to grow for a second summer. Although lagoon fish may be taken in trammel nets, gillnets and seines or fykes (especially for eels), the more complex *valli* use fixed systems for capture. These are weirs constructed of concrete with metal screens. Called *lavorieri*, they capture the fish as they attempt to migrate to the sea when the channels are opened. The aquacultural production of mullets in Italy was estimated by FAO Fish.Info.Data and Stat.Serv. (1989) to be 3 200 t in 1984, 3 200 t (1985), 5 200 t (1986) and 3 500 t (1987).

[1] Although for purposes of uniformity, most of the scientific names used in this review are based on Blanc *et al.* (1971), the updated names more generally used in Italy today for these five grey mullets are in the same sequence: *Liza ramada*, *L. aurata*, *L. saliens*, *Chelon labrosus* and *Mugil cephalus*

Some of the brackish water forms are now also cultivated more intensely in Italy. For example, the sea bass has been reared in Sicily since 1979 (SIME, 1984). According to Ravagnan (1984), under extensive culture and under the climatic conditions of Venice, sea bass attain a commercial size of 350 g in 30 months and one of 350–400 g in 21 months when cultivated intensively in earthern or concrete ponds. He also states that the productivity of sea bass in a *valli* is 10–20 kg/ha/g. Gilthead are raised in valliculture exclusively under extensive conditions producing about 15–30 kg/ha/year. According to FAO Fish.Info.Data and Stat.Serv. (1989), about 250 kg of sea bass and 250 kg of gilthead were raised each year during the 1984–87 period.

Total yields from *valli* seem to range from about 100–200 kg/ha/year, as do the yields from some of the best lagoon fisheries. D'Ancona (1954) listed the mean annual production from Venetian *valli* (circa 1953) as 150 kg/ha/year and gave another estimate of this production as 140 kg/ha/year. About 20 years later, Ravagnan (1972) stated that the yield from a well managed extensive fenced lagoon should be about 150/kg/ha annually.

The aquacultural production of brackishwater fishes (pesce di valle) in 1973 was reported to be 4 000 t (Italy/EIFAC, 1974). Based on an assumed production of 150 kg/ha/year and a water area of 40 000 ha, Brown (1977, 1983) estimated the total annual brackishwater production in Italy to be about 6 000 t which he believed was divided about equally between mullets, eel, gilthead and sea bass. The ADCP (1979) estimated the annual finfish production in Italy from “traditional lagoon and valli culture” to be about: 2 200 t of mullet, 1 100 t of eel, 1 100 t of gilthead, 550 t of sea bass and 300 t of sole. This total estimate of 5 250 t annually is somewhat less than that of Brown (op cit.) and that of Panella, Della Seta and Hull (1982), who estimated a commercial production of consumable fish from Italian lagoons and valli of 5 700 t in 1979, composed as follows: 2 000 t of eel, 3 200 t of mullet and 500 t of gilthead and other species.

According to Brown (1977, 1983), these major brackishwater fish are generally sold at the following sizes and ages: mullet and sea bass, 300–1 000 g (3–5 years); gilthead, 150–400 g (1–2 years); silver eels, 400 g (7–9 years).

Not only are eels reared extensively in brackish waters in Italy, they are raised intensively in fresh water, with elvers stocked in concrete tanks with circulating water and fed artificially for about three growing seasons to attain a size of 200–300 g. Warm water is also being tried, using both thermal effluent and geothermal wells. De Angelis (1986) states that intensive production of eels in Italy is about 2 500 t annually, while the extensive production of eels in brackish water amounts to about 2 000 t annually. Another source (FAO Fish.Info.Data and Stat.Serv., 1989) says that the aquacultural production of eels in Italy ranged from 1 800 t in 1984 to 3 500 t in 1987 during this period.

The primary aquacultural production in Italy today, however, is that of portion size rainbow trout, perhaps the highest production in Europe. Originally, it took about two years to raise trout in Italian mountain water but most of the production today is in continental Italy just south of the Alps, where abundant spring water of good temperature (12–13°C) exists. Another major area is on the east coast near Pescara. Well water of 12°C is also used. Use of these sources rather than surface water (as is used in Denmark) has greatly lessened the chances of fish disease. Use of raceways, artificial feeds and other modern methods has likewise improved Italian trout production.

In 1961, Italian commercial production of rainbow trout was only 1 200 t, but following the use of spring water and new methods, production in 1968 was ten times greater, 12 000 t. Ten years later (1978) it was almost 18 000 t annually. In 1989 Italian production of portion-sized trout was 31 000 t and 1 000 t of large trout were also raised (FES, 1989). See Table 12, which lists the production from 1968 to 1989 according to various sources.

Market size is about 200–250 g. Exports have risen steadily; the major export markets are France, the Federal Republic Germany and Belgium. Sales of domestic trout have been about evenly divided between wholesalers and other outlets, with about 40 percent of the latter going to fish-out ponds.

FES statistics show Italy as also rearing 300 t of salmon in 1988 and increasing this amount to 500 t in 1989 (FES, 1986; 1989). FAO Fish.Info.Data and Stat.Serv. (1989) estimates an aquacultural production of common carp in Italy during 1984–87 period ranging from 800 t (1985, 1986) to only 500 t in 1987.

Cypriniculture was introduced into Italy at the end of the Nineteenth Century in areas in the Po Valley, where permanent rice fields and large canals already held fish populations. In addition to common carp, the goldfish and tench were used. The crop consisted of fingerlings and adults up to about four years of age, and average annual yields of 100 kg/ha/year were reported (Chiapelli, 1938). This ricefield culture increased for about 40 years and then declined to a point where it is no longer of importance in Italy. Changes in agricultural practices, including the use of weedicides and pesticides, were among the reasons for its decline. The practice persists today but only on a small scale, with some of the fish being sold to pond owners and fisherman clubs and with Italy importing some carp and tench from other countries. Brown (1983) estimated that the total production from rice fields in Italy would be less than 5 t annually. See also: Tonolli (1955), Coche (1967) and Vincke (1979). Panella, Della Seta and Hull (1982) estimated that in 1979, 500 t of carp were cultivated in Italy, a figure corroborated by De Angelis (1986) for annual production circa 1985.

The American bullheads or catfish have long been regarded as pests in Europe, both in open waters and in carp and tench ponds, and trade in live brown bullheads (Ictalurus nebulosus) is forbidden by law in Italy. Nevertheless, the black bullhead (I.melas) is now being produced in some quantity in Italy. In 1971, about 100 t were produced (Brown, 1977, 1983), which increased to about 1 200 t by 1979 (Ghittino, 1979, and Panella, Della Seta and Hull, 1982), and to about 1 900 t circa 1985 (De Angelis, 1986).[1] FAO Fish.Info.Data and Stat.Serv. (1989) records an annual aquacultural production of the black bullhead in Italy of 1 500 t during the 1984–87 period.

1 Italy/EIFAC (1974) stated that 500 t of carp and catfish were produced in Italy in 1973

The Chinese grass carp (Ctenopharyngodon idella) has recently been introduced into Italy for fish culture.

According to De Angelis (1986) there are about 500 fish farms with a total area of about 1 500 ha. Their distribution between fish species is unknown.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership and Rights

Public waters are or may be defined by Italian law but there is no definition of “private waters” - hence no such concept is deemed to exist. Rivers, torrents, springs, lakes and extracted ground waters are deemed “public waters” whenever they are or may become fit to satisfy public needs. They are part of the State's Public Domain. Waters other than public waters are termed “non-public waters”, are subject to rights of use exclusively, and are subject to doctrinal and jurisprudential controversies. The right to use non-public waters includes that of fishing and can involve exclusive fishing rights.

With respect to fishing rights in Italy, one can recognize:

(i) Exclusive fisheries rights: These are reserved for certain ancient properties recognized by the State under special laws. These primarily concern several zones of lakes and brackishwater ponds.

(ii) Public domain fisheries reservations: These are ancient estate properties which have been confiscated by the State and opened every six years to public bidding for fishing rights. They are mostly trout streams in northern Italy.

(iii) Concessions for fish culture: These are temporary fisheries reservations (for a maximum of 15 years). In order to use them, the concessionnaires are obliged to meet certain requirements, e.g., restocking or construction of works that facilitate fish production. Fish breeding in rice fields is subject to yearly authorization. The provincial administrations have the authority to grant these concessions.

8.2 Administration

The Ministry of Agriculture and Forestry, through its Agricultural Production Office, has overall responsibility on a national level for fisheries in inland waters and a central institute of research for hydrobiology and fisheries.

8.3 Management

8.3.1 At present, this Ministry prepares the framework of laws for fishing in inland waters but administrative functions concerning this fishing are delegated to the (20) Regions of Italy.

8.3.2 Within the Regions, the responsibilities for executive and regulatory functions for inland fisheries are carried out by the individual (94) Provinces. They also issue fishing licences and award concessions for fish culture.

8.3.3 Rules and regulations: The Fisheries Code is a compilation of regulations under two headings:

(i) Regulations governing fisheries: organization of fishery services; registered documents and fishing licences; supervision; penalties and judgements, and

(ii) Regulations governing assistance for fisheries and fishermen: tax and other exemptions; fisheries cooperatives and consortia; associations for the protection and promotion of fisheries for public benefit; vocational training; research, surveys and publications; insurance; marketing regulations, etc.

8.3.4 Licensing: There are four types of licences, all issued by the provincial administrations: (i) Type A for fishing with all types of gear for professional fishermen only; (ii) Type B for fishing with a simple rod or small square net with sides not exceeding 1.5 m; (iii) Type C for fishing with simple rods and small square nets, and (iv) Type D for foreign licences entitling the holder to the same rights as holders of the Type B licence.

<u>Table 12</u>

Estimated production of cultivated trout in Italy, 1968–89
(in tons)

	Brown (1983)[a]	Zerbinato (1981)	Giorgetti & Ceschia (1982)	Lewis (1981)[b]	Panella, Della Seta & Hull (1982)	Shaw, Shaw & Thomas (1981)[c]	Fish Farming Int., 9(10) (1982)	Fish Farming Int., 11(6) (1984)	Italy/EIFAC (1989)	FAO Fish. Info.Data Serv. (1989)	FES (1986, (1989)
1968	12 000	-	-	-	-	-	-	-	-	-	-
1969	13 000	-	-	-	-	-	-	-	-	-	-
1970	13 500	12 000	-	-	-	-	-	-	-	-	-
1971	14 000	13 000	-	-	-	-	-	-	-	-	-
1972	15 500	15 500	-	-	-	-	-	-	-	-	-
1973	15 000	15 000	-	-	-	-	-	-	-	-	-
1974	16 430	16 450	16 430	-	-	-	-	-	-	-	-
1975	16 120	16 100	16 120	-	-	-	-	-	-	-	-
1976	17 000	17 000	17 000	-	-	17 000	-	-	-	-	-
1977	17 250	17 250	17 250	-	-	17 000	-	-	-	-	-
1978	19 900	17 850	18 000	17 840	-	17 840	17 840	-	-	-	-
1979	19 900	19 900	-	18 000	20 000	18 000	19 900	-	-	-	-
1980	-	20 500	-	-	-	20 400	19 900	-	-	-	-
1981	-	-	-	-	-	21 500	20 635	-	-	-	-
1982	-	-	-	-	-	-	20 000	-	-	-	-
1983	-	-	-	-	-	-	-	19 000	-	-	-
1984	-	-	-	-	-	-	-	-	21 500	23 000	-
1985	-	-	-	-	-	-	-	-	21 500	25 000	20 500
1986	-	-	-	-	-	-	-	-	26 500	25 000	22 600
1987	-	-	-	-	-	-	-	-	-	30 000	-
1988	-	-	-	-	-	-	-	-	-	-	28 500
1989	-	-	-	-	-	-	-	-	-	-	32 000

[a] Rainbow
[b] Table trout
[c] Table rainbow

8.4 Investigation and Scientific Services

(i) The Ministry of Agriculture and Forestry directs a Central Laboratory of Hydrobiology in Rome, devoted primarily to research on marine and inland waters and offering technical consultative services;

(ii) The Regions provide piscicultural services in Rome (for the Region of Lazio) and in Brescia (for the Region of Lombardia). These services conduct investigations on fish conservation and management, perform experimental fish culture, supervise fishing concessions and exclusive rights, and provide consultative services on behalf of the provincial administrations.

(iii) The various universities in Italy, such as Rome, Parma and Padua, and other institutions also conduct research on fisheries.

8.5 Other Concerned Agencies

(i) Italian Federation of Sport Fishermen (FIPS), an organ of the CONI, under the Premier of the Council of Ministers, administers about 90 percent of Italian fishing waters and issues membership cards necessary for angling. It has its own provincial offices.

(ii) Other associations of sport fishermen.

8.6 International Agreements

Italy has a bilateral agreement with Switzerland concerning the water level in Lake Lugano and Lake Maggiore, one covering hydropower on the River Spoll, and one covering water quality in its boundary waters.

It has a bilateral agreement with Yugoslavia concerning water quality in the Adriatic Sea.

[1] This section is derived primarily from Gaudet (1974), material received from Italy in 1979 by EIFAC, Burchi and Masina (1979), and Italy/EIFAC (1989)

9. STATE OF THE FISHERY

9.1 Yield

Examination of Table 6 listing the total catch in the inland waters of Italy as recorded by FAO for the 1965–87 period shows a relatively stable catch varying between 17 000 and 21 300 t during the period of 1965–76 and then a rise culminating in a “catch” of 50 203 t in 1987. However, examination of the statistics for species groups shows that it is only the trout “catch” that has risen over the entire period and - as has been emphasized - this rise is due to inclusion of the cultivated trout production in the catch tables.

It should also be noted that during the period of 1965–69, the FAO Fishery Yearbooks did not list the catch in Italy of either trout or common carp separately. In fact, as late as 1974, the Yearbook (No. 36) apparently lumped them together with other “miscellaneous freshwater fishes” from 1965 through 1973 (see Dill, 1976, p. 74).

From the corrected table then, it seems apparent that the recorded catch of carp and other freshwater fishes was reasonably constant during at least the 1970–87 period but that the catch of eel in fresh waters declined during the 1972–83 period.

None of these figures casts any light on the trends in catch or “production” of such fishes as eel or mullets in lagoons, valli or other brackish waters of Italy, but with the gradual elimination or degradation of many brackish waters, it seems certain that these fisheries have declined overall.

As has been shown before, the major commercial catches from the fresh waters of Italy are in the large Lombard lakes lying south of the Alps. From statistics more than 50 years old (Italia, 1931), one can calculate the annual yield in kg/ha to commercial fishermen in 1929 in a number of these lakes: Como - 131; Iseo -32; Maggiore - 15; Garda - 13.3[1]. During the same year, the yield from Lake Trasimeno in Central Italy was 16.4 kg/ha. A more recent estimate of the annual yield from Lake Maggiore (290 t in 1965), said to be that of both commercial and sport fishermen, is 17.1 kg/ha/year. Of this total yield, 12.8 kg/ha is said to be of pelagic fish such as trout, coregonids, bleak and shad, and 4.3 kg/ha of littoral species such as tench, chub, other cyprinids, pike and perch (Bonomi et al., 1970). With respect to Lake Garda, annual yields in later years can be calculated as follows: 5.4 kg/ha in 1953, 18.9 kg/ha in 1965 and 13.5 kg/ha in 1975 (based on catches reported by Grimaldi, 1980) (see section 9.2).

[1] Based on total lake area. If only the Italian section of Lake Maggiore were meant to be included, the annual yield would have been 19 kg/ha

Yields of carp in some Italian rice fields in 1975 were said to be 30–35 kg/ha/year by Brown (1983).

If one accepts the figures of De Angelis (1986) there is an average annual yield to the commercial fishermen of about 60 kg/ha from the 17 main lakes of north and central Italy.

Reports on yields from brackishwater areas in Italy vary widely. Some are old, some are new, some are based on the statements of fishermen or owners who may have a bias, many fail to distinguish between the yields from lagoons with a predominantely capture fishery and those subjected to aquacultural processes. In short, they should be taken cum grano salis, which - like fish - is a major product of a lagoon. Zerbinato (1981) for example cites various studies in which the yields from valli in the Northern Adriatic range from 25 to 190 kg/ha/year. Of these, the yields from the best well tended and fertile lagoons appear to be about 150 kg/ha/year. These are close to those of D'Ancona (1954) who estimated 150 kg/ha/year, and more recently, Ravagnan (1972 and 1981) who estimated yields of 100–150 kg/ha/year.

Some recent annual yields of finfish per hectare from specific Italian lagoons with capture fisheries follow: Burano (65 kg), Fogliano (150–250 kg), Manaci (200 kg), Fondi (150 kg), Sacca di Scardovari (100 kg), and Orbetello (123 kg). In addition to the above yields (cited by Ardizzone, 1984; Rossi, 1981; Cognetti et al., 1981), some Italian lagoons have produced some rather amazing annual yields. For example, the highly eutrophicated 830-ha Santa Giustia lagoon in Sardinia had an average annual fish yield of 669 kg/ha during the 11-year period of 1967–77, and actually attained an average of 800 kg/ha/year during 1972–77, while the 220-ha Tortoli, another naturally rich but unpolluted Sardinian lagoon, produced an average of 342 kg/ha/year of finfishes during 1968–77 (Cottiglia, 1981). Quignard (1984) states that the average yield from the Mediterranean lagoon (including finfish and invertebrates) is about 40 kg/ha/year and can rise to 150 kg/ha/year. Kapetsky (1984), using worldwide statistics, has estimated that the median lagoon capture fishery yields 51 kg/ha/year with a mean of 113 kg/ha/year, and a median finfish yield of 47 kg/ha/year. Using these estimates as a basis of comparison, the yields from Italian brackishwater lagoons seem quite good.

9.2 Factors Affecting the Fishery

Italy has a wide variety of rivers, ranging from glacier- and snow-fed streams in the Alps to what are essentially wadis in southern Italy and the islands. Most of them are essentially unstable waters with geat variations in flow, sometimes in spate, sometimes almost dry. Even in the north many of the larger streams are braided, with narrow interlacing channels during dry spells but filled to the brim or over during flood stage. Some, like the Tiber, which flow through easily erodible areas carry a heavy silt load, and despite their size do not furnish a satisfactory environment for aquatic life. Steep gradients and wide variations in volume have caused many of the peninsular or Mediterranean rivers to incise their beds deeply in their middle courses, and their silt-choked lower reaches are often swampy or deltaic. Good stream fishing is, therefore, primarily confined to waters in the north or in some mountain streams of the Apennines (e.g., the Sangro), or in the lower courses of larger streams in the lowlands. In some of these, the abundance of limestone promotes water of good quality for fish growth, as does the general Mediterranean climate.

Italian lakes furnish more stable conditions for fish, and the country possesses a considerable lake area especially in the continental north. Conditions in these lakes range from oligotrophic to eutrophic. Not only are there a considerable number of small glacial lakes in the Italian Alps, but the huge sub-Alpine lakes provide large areas for both commercial and recreational fishing. Although significant acidification of rainfall has been reported in Italy, the lithological features of most of these lakes have minimized its effect (Mosello, 1981).

The inland fish fauna is similarly diversified, ranging from alpine chars to euryhaline marine fishes in brackish waters. Acclimatized fishes such as coregonids and rainbow trout add to the variety, and fish of the smallest size receive attention from the Italian fisherman.

In addition to the basic natural factors, several types of land and water use have long been important in affecting the inland fisheries of Italy. Continued deforestation since ancient times has affected the flow pattern of the streams, and coupled with other causes of erosion, such as mining, has aided in the process of lagoon formation and their subsequent aggradation[1]. Brackish lagoons, although faunistically poor, are usually quantitatively rich and have a high level of productivity which attracts migratory fish. Balanced against this is the inconvenience of eutrophism, especially stagnation and insufficient oxygenation. Thus, without renewal of water by tidal currents in summer, conditions of asphyxiation and high mortality may endanger lagoon fisheries.

[1] Attempts have been made to maintain water quality in Italian lagoons for centuries. In the Sixteenth Century, a group of hydrologists, biologists, and government officials called the savi delle acque (water sages) surveyed the Venetian lagoon to propose methods for keeping it in a satisfactory state. A river project extending over four centuries resulted in the diversion of inlets to the lagoon to discharge directly to the sea so that their sediments would not aggrade the lagoon (Colombo, 1977).

For many years, agriculture in Italy has depended heavily upon both drainage and irrigation. Drainage, which commenced centuries ago, has reduced many water areas, some important as producers of aquatic life. The necessity for irrigation has reduced the amount of water available to fish in natural channels and has resulted in a loss of fish through diversion to cultivated fields. Nevertheless, although the net effect on fisheries has not been appraised, the addition of many kilometres of canals has extended fluvial fishing waters, and the creation of many small ponds to supply irrigation water has also provided fish habitat.

The overall effect of hydroelectric development, stimulated in Italy by lack of fossil fuels, is also unknown. In the absence of anadromous salmonids, the construction of dams and diversions has not had the deleterious effects that it has had in countries with salmon or sea trout fisheries. Furthermore, regulation of lakes and reservoirs for hydroelectric purposes may have provided more constant flows in the streams below them, and the construction of new reservoirs has expanded lacustrine habitat. However, catcment areas are generally small, so most Italian hydroelectric reservoirs do not provide much fishing area. Barrage construction has, however, been responsible for hindering the migration of eels (Italy/EIFAC, 1970), and in the case of streamflow plants, some long areas of Italian streams contain little or no water.

Water pollution, is a major factor in large Italian industrial areas some of them having extremely high loads of dangerous chemicals (e.g., mercury and chromium). Both streams and lakes have been affected by metallic pollution. There are, for example, high concentrations of mercury in the Pallanza Basin of Lake Maggiore. Examination of five edible fish from this basin has shown mean values from 0.19 ppm in Coregonus to 1.28 ppm in Esox lucius (Locht et al., 1981). But pollution is also widespread and generally serious because of the multitude of small industries and general lack of sewage treatment. As a rough estimate of the extent to which water quality can be maintained, one notes that the average runoff per caput in Italy is only 3 248 m^3.

Centuries of cultivation, fertilization and encroachment on the margins of major lakes and streams have greatly increased the eutrophic processes. For example, the relatively shallow Lake Varese, a naturally eutrophic lake situated in a highly populated and industrial area near Milan, has received the impact of strong “cultural” eutrophication for about 30 years. This has caused anoxic conditions in the hypolimnion, disappearance of bottom fauna, and extensive algal blooms (Ruggiu, Saraceni and Mosello, 1981). But eutrophic processes have also been noticeable at the large and deep sub-Alpine lakes where originally oligotrophic waters have lost their clarity, become more fertile, and changed the composition of their fish populations. At Lake Maggiore, for example, the human population in its drainage basin (6 598 km^2) almost doubled from 350 000 people in 1860 to 670 000 in 1973, and supported about 12 million tourist-days annually, of which 5 million concentrated in the shore region (Grimaldi, 1980).

This same author has, however, warned against attributing all the changes in the fish populations of the Lombard lakes to trophic changes. He has pointed out that although the landlocked shad has disappeared from Lake Maggiore and that its coregonid fishery has collapsed, these changes may be due to competition with unexploited cyprinids and excessive fishing pressure. He notes, for example, that shad are still present in even more eutrophic lakes such as Lugano and Como. He also notes that although Lake Garda has been characterized by very stable oligotrophic conditions until recently, its catch has declined probably because of high fishing pressure. De Bernardi, Giussani and Grimaldi (1984) have similar observations with respect to Lake Maggiore, pointing out that eutrophication is not necessarily the only reason for population changes.

Italy has a general tradition not only for the use of brackishwater fisheries, but for fishing all inland waters both commercially and for subsistence combined with pleasure. Of late years, the latter factor has increased decidedly, facilitated by extension of the highway system, increased automobile ownership which ranks among the highest in Europe, and more leisure time.

The natural lagoon area coupled with the complex of brackishwater species, as well as the large number of cold springs (over 1 000 in Lombardy alone) have made both extensive and intensive aquaculture readily possible. Lagoon production has been limited by the availability of fry, but this picture is changing. See below. Fish diseases, such as viral haemorrhagic septicemia (VHS) and an eel disease, have had importance in recent years, but Italy remains a leader in table trout production today.

9.3 Prospect

No major increase in fishing area can be expected, since the construction of many more sizeable reservoirs is not anticipated. In the north, most of the good hydro sites are occupied, and in the south reservoir construction is very expensive because of the seasonal flows. There will, however, be more transbasin diversions.

Small-scale commercial fishing will continue in a more or less traditional manner in the Italian lakes, but with the composition of the catches changing toward less valued species, i.e., from pelagic to littoral species and gradual diminution of the practice. Conversely, angling will continue to increase in importance, along with an increase in “put and take” fishing near urban areas.

Trout and other forms of freshwater fish culture will continue to increase, sources of good water and suitable land being important determining factors. It has been predicted that with increased disease control and more intensive use of the available water, trout production might attain about 30 000 t annually (Brown, 1977, 1983). It has already surpassed this amount (Table 12).

Brown (1977, 1978) also estimates that eel culture, presumably in fresh water, might increase to 10 000 t, and that brackishwater production of mullets, gilthead, and sea bass might rise to over 90 000 t annually. If the latter type of production is to occur, it will have to follow far more intensive methods than those now practised in traditional lagoons or valliculture. It will involve the construction of smaller rearing areas (sometimes essentially ponds), better regulation of water movement, fertilization, feeding, and regulated stocking of fry and juveniles. A major deterrent to increased production in brackish waters is scarcity of stocking material from wild sources. Ravagnan (1981) has pointed out that in the upper Adriatic, the ascent of fry from the sea is of little or no importance. For years, fry have been collected in all the bays of the Po delta to restock the semi- or completely closed lagoons in which natural recruitment is insufficient. The collection of fry, regulated by the Government, varies according to the season, and a considerable effort is now being made to insure a constant supply of young stock through artificial propagation in hatcheries and grow-out facilities. Importation of wild stock from other countries (e.g., elvers from France) is also an uncertain business, and self-sufficiency is an objective.

Recent legislation has allocated Governmental funds to the development of both aquaculture and inland capture fisheries. Nevertheless, one can say that until quite recently there has been a general lack of environmental concern in Italy. This has been reflected in the ineffectiveness of watershed management, and a disorderly competition between different uses for land and water (Italy still has no general water code), resulting in diminished sustained flows in rivers, a dwindling of lagoons and coastal wetlands, and a degradation of water quality. To a large extent, the future of the Italian inland fisheries will depend upon the increased environmental awareness which is slowly taking form.

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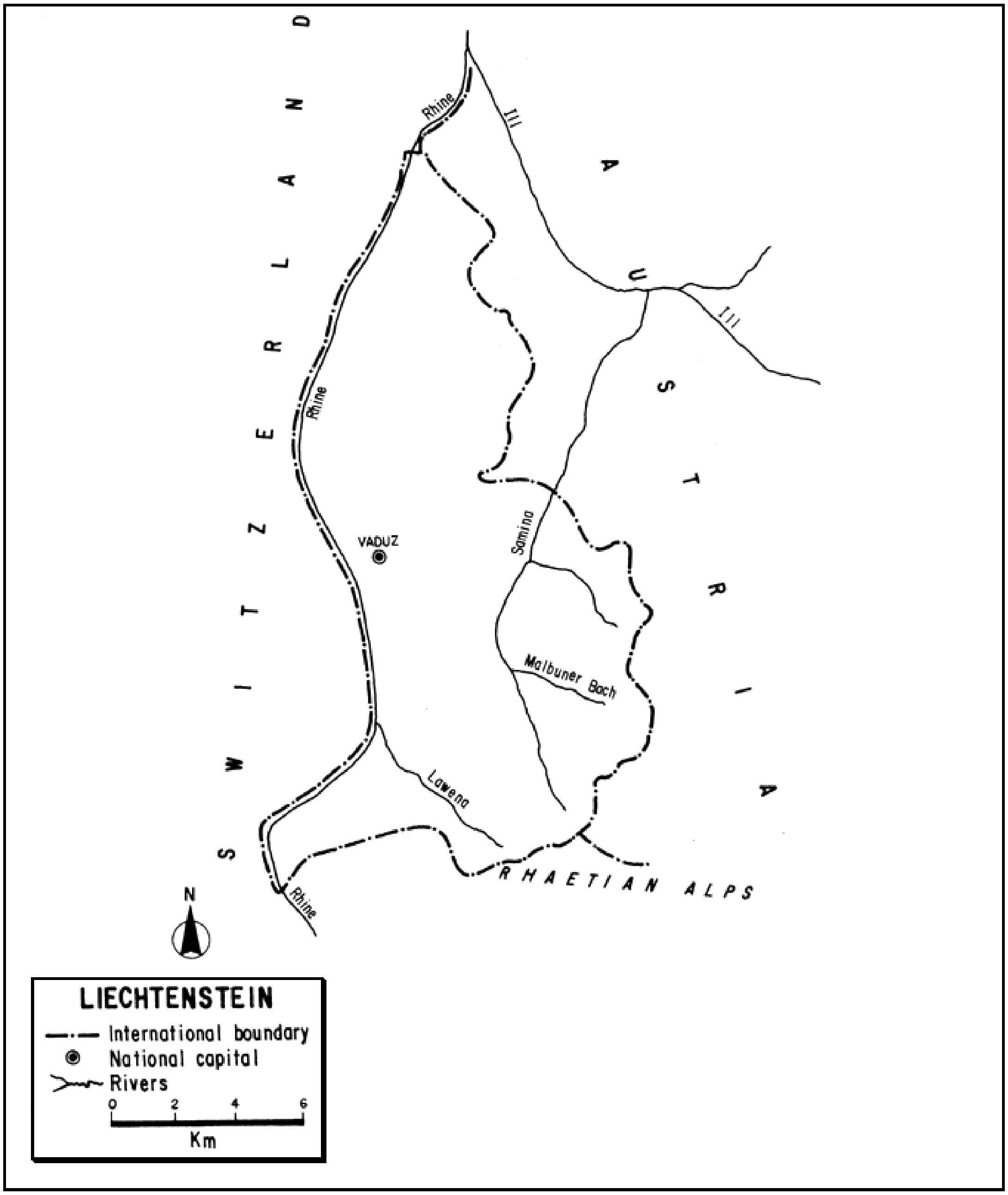

SWITZERLAND
AUSTRIA
Rhine
Ill
VADUZ
Samina
Malbuner Bach
Lawena
RHAETIAN ALPS
N
LIECHTENSTEIN
International boundary
National capital
Rivers
0
2
4
6
Km

LIECHTENSTEIN

Set amidst the Alps, between Austria and Switzerland, the Principality of Liechtenstein is one of Europe's touristic mini-states. Sometimes considered the fourth smallest country in Europe, it is united with Switzerland by a customs and monetary union.

Mostly mountainous, it lacks lakes but has some small trout streams and brooks, and as a boundary, the once torrential upper Rhine. Although well industrialized, its tradition of good land and water use should preserve its limited sport fishing.

1. AREA: 160 km^2

2. POPULATION: 28 000 (est. 1985) Density: 175 inh/km^2

3. PHYSICAL GEOGRAPHY

Liechenstein is situated between Austria and Switzerland, between 47°3' and 47°14'N latitudes and 9°29' and 9°38'E longitudes.

It is only 28 km long (N–S) and 9 km wide (E–W). Its altitudinal range is from 453 m in the Rhine Valley to its highest point at 2 599 m.

Its western and southern borders, one with Switzerland, mostly along the right bank of the Rhine, is 41.1 km. Its eastern border, with Austria, is 34.9 km[1].

[1] Boundary lengths after Statistisches Jahrbuch 1982 Fürstentum Liechtenstein.

Liechtenstein consists of a narrow alluvial strip along the Rhine, and a mountainous area occupying about four-fifths of the country. This latter area, a spur of the Raetian Alps is bisected by the Samina River, flowing from south to north to enter Austria and join the Ill River.

Forests, which occupy a fifth of the country are about 75 percent coniferous (firs, spruces and larches) and 20 percent beech. Alpine meadows occupy about 30 percent of the country. The mountains are largely dolomitic and limestone. Soils are more or less fertile.

There are only 11 towns (communes) in the country; the largest, Vaduz, the capital, has about 5 000 inhabitants.

4. CLIMATE

The climate is Alpine but mild. The average annual lowland temperature is about 9.5°C. The summers are cool, varying between 20° and 28°C. Winters are cold with about 35 days of snow in the Rhine Valley. Tempered by a warm south wind, they rarely go below -15°C. The dry, warm wind, known as the Föhn, dries up fields and meadows and helps spread fires.

The annual precipitation averages about 1 000 mm.

5. HYDROGRAPHY AND LIMNOLOGY

According to Europa (1979), 160 ha or one percent of the country is occupied by "watercourses".

The largest river, the Rhine (Rhein), bordering Liechtenstein's western boundary, is still relatively small, shallow and sometimes torrential. Frequently subject to flooding, sometimes disastrously (as in 1927), it has been confined by high stone banks. In 1940, its bed was above the valley; today, after exploitation of its gravel, it lies 3 m or less beneath the Rhine Valley. There is a canal parallel to the Rhine for about 25 km. With an average value of about 5–7 m^3 in its lower reaches, it serves as an outfall or catchment canal for mountain streams, drainage ditches and the main drainage and sewerage systems. It flows into the Rhine shortly before the frontier. The largest tributaries flowing into the canal are the Lawena, Giessen, Scheidgraben, and Esche.

The country's eastern drainage is through the Samina and its tributaries, the Malbuner Bach and Valorschbach, also in the Rhine drainage.

There are no lakes in Liechtenstein except for an old branch of the Rhine with a surface of 3 ha.

There is a hydroelectric reservoir holding 130 000 m^3 on the Samina. Ground water, which is close to the surface, is the chief source of drinking water.

There are also 11 small artificial ponds built since 1972 as part of a nature protection programme. Fishing is allowed in one of these.

6. LAND AND WATER USE

Table 1

Pattern of land use in Liechtenstein, 1986

	Percent
Arable and permanent crops	25.00
Permanent pasture	37.50
Forests and woodland	18.75
Other land	18.75
Total	100.00

Source: 1987 FAO Prod.Yearbk., 41 (Publ. 1988)

Originally an unproductive area of swamps and mountains, drainage and diking during the last century developed the small area of arable land in the Rhine Valley, and agriculture and pastoral husbandry were predominant for many years. In 1930, 70 percent of the working population of Liechtenstein were farmers, by 1941, 34 percent were still engaged in agriculture, but by 1984 the figure was under 3 percent. The major crops are corn, barley, wheat, potatoes, fruit and grapes. Cattle are still taken up to the mountain meadows, but steep slopes are no longer cultivated or hayed as in the past. Irrigation, drainage and heavy fertilization are necessary, although attempts are being made to reduce the latter to protect the Valley.

Raw materials for industry must be imported, lessening extractive pollution. Most industry, the main economic activity, is light, thus lessening the chances for water pollution. Metal working, ceramics, textiles and food processing are typical industries.

There is some lumbering (about 10 000–12 000 m^3 per year) but forests are maintained primarily to combat erosion. Forests which have been cut must be replanted in three years and slopes are afforested to prevent torrential landslides (avalanches of stones and mud) or Rüfen.

Two alpine rivers are affected by use for hydroelectric power: the Samina and Lawena, the former with a reservoir. The installed capacity, circa 1984, was 10 500 kW.

The ground water level of the Rhine Valley has been lowered after intense removal of gravel in the river bed. The result today is that 28 km of brooks are dry. There is no other mining.

There is a good system of paved roads (320 km), many footpaths, and 18.5 km of railroad. Road density was 2.1 km/km^2 in 1979 and passenger car ownership is very high, about 516 per 1 000 persons (1986).

All of the 11 villages of Liechtenstein are linked to purification plants, thus lessening water pollution. All wastewater is purified before reaching the Rhine.

Despite the small size of the country, both hunting on 19 hunting grounds, and angling are land uses which contribute to the Government's revenue. The rise of sport fishing is in keeping with Liechtenstein's change from an agricultural economy to one of industry.

Tourism is an important industry in this picturesque land (there were almost 86 000 tourists in 1985), but most tourists are transients and their presence does not affect fishing.

7. FISH AND FISHERIES

The principal fishing in Liechtenstein is for the native brown trout (Salmo trutta), the introduced rainbow trout (Oncorhynchus mykiss) and grayling (Thymallus thymallus). Most waters are good trout waters exclusively reserved for sport fishing.

The FAO Yearbook of Fishery Statistics (Vol. 36 for 1973, published 1974) has no record of fish catch in Liechtenstein during the 1938–61 period, but the Yearbook has recorded nominal “catches” since 1962 (see Table 2). The amounts ascribed are, of course, meaningless, and furthermore appear to be completely erroneous, since neither a commercial capture fishery nor aquaculture for food exist in Liechtenstein.

Table 2

Nominal catches in the inland waters of Liechtenstein, 1962–87[a] (in tons)

	Freshwater fishes
1962–69	0.0
1970–73	00
1974–87	0

0.0 negligible/insignificant
00 more than zero but less than 50 t
0 more than zero but less than half a ton

Source:		
	1962–69	Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
	1970–73	Yearb.Fish.Stat.FAO, 40 (Publ. 1976)
	1974–75	Yearb.Fish.Stat.FAO, 48 (Publ. 1980)
	1976	Yearb.Fish.Stat.FAO, 52 (Publ. 1983)
	1977–81	Yearb.Fish.Stat.FAO, 54 (Publ. 1984)
	1982–87	Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

[a] Catch, theoretically commercial, as reported by FAO, but erroneous (see text)

With the exception of the Rhine, only about 50 ha of the principality affords fishing. All of this is sport fishing by about 250 anglers, who take about 3 000 kg of fish annually.

Table 3 shows the reported catch for 1978.

Table 3

Sport fish catch in Liechtenstein, 1978

Area	Number	kg
Kanal	6 600	1 688
Saminabach	98	25
Stausee Steg	800	195
Rhine	2 630	804
Total	10 128	2 712

Source: Rechenschaftsbericht der Fürstlichen Regierung, 1978

The catch in the River Rhine in 1978 can be further broken down as follows: 2 300 trout (653 kg), 91 grayling (37 kg) and 239 other fish (114 kg).

Angling in Liechtenstein is done on a permit basis (daily, weekly and yearly). In 1978, for example, a total of 746 permits of all types were sold. Of these, 349 members of the Sportfischerein Liechtenstein purchased permits, youths and non-members purchased 143, and visitors purchased 209 (28 percent).

There is no commercial pond fish culture, but the local sport fishing association stocks both brown trout and rainbow trout in local waters.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT AND INVESTIGATION

All hunting and fishing is controlled by the State, which rents the rights to inhabitants of the country. Both rental of fishing rights and issue of fishing permits provide income to the State.

There is a treaty with Austria on the establishment of common principles for the regulation of the Rhine.

9. STATE OF THE FISHERY

Obviously, the size of the country and its waters make any fishery insignificant except to the residents and some of their visitors. Nevertheless, the rivers are protected by the Constitution so that injury (e.g., through pollution) will be minimized and a limited sport fishery - primarily for local use - will continue. The careful land and water use generally practised in Liechtenstein and this should continue to aid its small fisheries.

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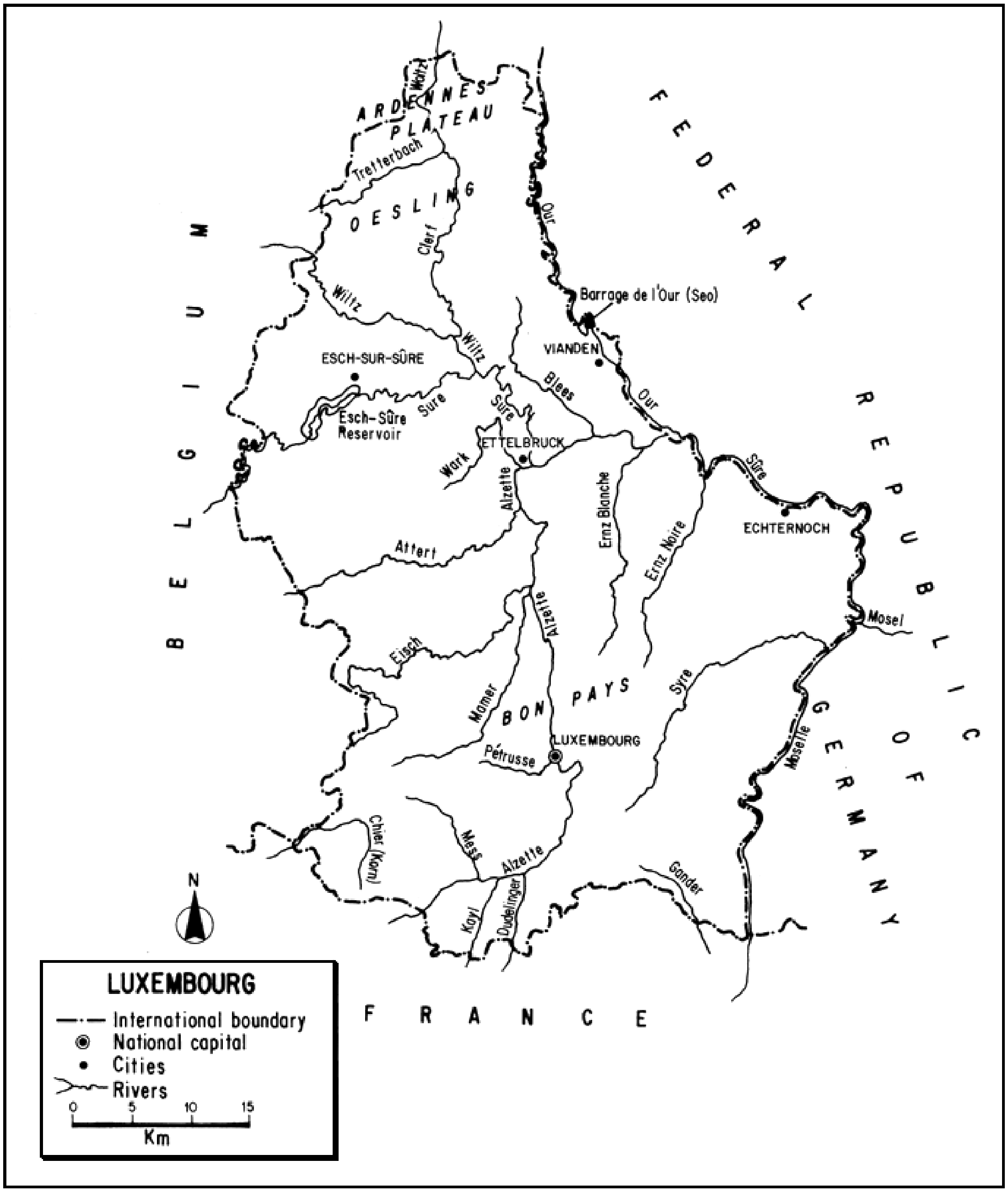

ARDENNES PLATEAU
OESLING
BON PAYS
BELGIUM
FEDERAL REPUBLIC OF GERMANY
FRANCE
Woltz
Tretterbach
Clerf
Wiltz
Wiltz
Our
Barrage de l'Our (Seo)
VIANDEN
ESCH-SUR-SÛRE
Esch-Sûre Reservoir
Sûre
Sûre
Blees
Our
ETTELBRUCK
Wark
Alzette
Sûre
ECHTERNOCH
Ernz Blanche
Ernz Noire
Attert
Alzette
Mosel
Eisch
Mamer
Syre
Moselle
LUXEMBOURG
Pétrusse
Chiers (Korn)
Mess
Alzette
Gander
Kayl
Dudelinger
N
LUXEMBOURG
International boundary
National capital
Cities
Rivers
0 5 10 15
Km

LUXEMBOURG

The Grand Duchy of Luxembourg, the sixth smallest sovereign state in Europe, is linked in an economic union with Belgium. Its carefully tended forests and farmlands contrast with heavy industrial development of iron and steel.

Landlocked and with no natural lakes, Luxembourg's fisheries - solely recreational in nature -are confined primarily to small trout brooks, the Sûre and Moselle Rivers, and its one reservoir of consequence. Small, but nevertheless valuable as both local and tourist attractions, the future of its salmonoid and coarse fisheries rests largely upon control of water pollution.

1. AREA: 2 586 km^2

2. POPULATION: 361 000 (est. 1990) Density: 140 inh/km^2

3. PHYSICAL GEOGRAPHY:

Luxembourg is situated at 49°26'52" and 50°10'58"N latitudes and 5°44'10" and 6°31'53"E longitudes in the heart of industrial western Europe.

Shaped like a shoe, its greatest length (N–S) is 82 km, its greatest width (E–W) is 56 km. Mostly over 250 m in elevation, its highest point is 558 m; its lowest point (the confluence of the Moselle and Sûre) is 130 m.

Luxembourg is bounded on the north and west by Belgium for 148 km, on the east by the Federal Republic of Germany for 135 km, and the south by France for 73 km[1].

[1] The lengths of these boundaries are taken from Grand-Duche de Luxembourg (1984)

The northern third of the country, the Oesling or Islex, is part of the Ardennes plateaux which has a mean elevation of 450 m. Composed largely of flat-topped or rounded eminences, it is deeply dissected by swift tributaries of the Sûre and Our. There is considerable moorland but most of the area is well wooded, with spruce and pine at higher elevations and oak, birch, hornbeam and beech at lower levels. Sparsely settled, the Ardennes has been partially cleared to support subsistence agriculture.

The lower two thirds of the country, the Bon Pays or Gutland, which averages 250 m in elevation, consists of low plateau and broad, though steep-sided cultivated valleys. Much of the forest has been removed; oak and beech are dominant trees.

Slates and quartzites prevail in the Ardenne which is deficient in calcium and phosphorus and rather infertile. In the Bon Pays, the underlying rocks are sandstones and limestones, and light fertile soils prevail. Alluvial deposits are found in all the river valleys with slight gradient.

4. CLIMATE

The climate is temperate, cool, rainy and mild - somewhat transitional between the maritime type of northwestern Europe and the semi-continental type toward the interior.

The mean annual temperature is 9°C. The mean summer temperature is about 16°C, the mean maximum is 23°C (in July). Winters average about 0°C with a mean minimum of -2°C (in January).

The average annual precipitation is about 760 mm (range, 620 mm in the Bon Pays to 1 020 mm in the Ardenne). In the south there are about 45 days of frost; in the

Ardenne there is frost for 100 days and snow cover for 20 to 30 days. Fringing ice may appear along the Moselle at times.

5. HYDROGRAPHY AND LIMNOLOGY

Luxembourg's surface drainage forms a hydrographic entity in that the waters of all its rivers save one are ultimately discharged into the Moselle (Mosel) and thence to the Rhine. The exception is the Chiers (Korn), a small drainage in the south-west, which flows to the Meuse in France.

The approximate annual run-off is 300 mm or 1 000 million m^3. Upstream countries contribute 4 000 million m^3, so that the total annual river discharge leaving Luxembourg is 5 000 million m^3 (Van der Leeden, 1975; ECE, 1978).

5.1 Rivers (Rivières)

Luxembourg has about 1 330 km of streams; 96 km are owned by the Government, 1 234 km are private. Table 1 lists the principal streams of the country.

The Sûre (Sauer) is considered to be the principal river of Luxembourg because of its length and its function as the major outlet of the country's drainage. From its origin in the Ardennes of Belgium, it flows east to the Belgian/Luxembourg border and follows the frontier for a short distance before winding tortuously in an easterly and then southerly direction for 160 km to its confluence with the Moselle. Before its junction with the Our (see below) it forms part of the Luxembourg/Germany boundary. The relative elevation and impermeable nature of the rocks in the Ardenne promotes a rapid runoff in its drainage from the north. The SOre's principal northern tributaries are the Wiltz and its affluent, the Clerf (Clervaux or Woltz) - both with headwaters in Belgium - which flows through deeply incised valleys. Other left-bank tributaries of the Sûre from the north are the torrential Blees and the larger Our River. The latter rises in Belgium and flows 80 km south (51 km in Luxembourg) to form Luxembourg's northeastern boundary with the Federal Republic of Germany for most of its course.

The Alzette is the Sûre's major right-bank or southern tributary, draining almost half of the Bon Pays. Arising in France, it flows north in Luxembourg for 60 km to its junction with the Sûre, fed en route from the left (west) by the Mess, Pétrusse, Mamer, Eisch, Attert and Wark, and from the right (south) by the Kayl and Dudelingerbach. Originating near the centre of the iron and steel industry, it has long been a heavily polluted stream.

Other tributaries of the lower Sûre from the south (right) are the Ernz Blanche (Weiss Ernz) and Ernz Noire (Schwarze Ernz).

The Moselle which flows northward between Luxembourg and the Federal Republic of Germany for 37 km, joined by the Syre (Syr) en route, leaves Luxembourg after its confluence with the Sûre to continue through Germany to the Rhine. With a low gradient and canalization, it is the country's only river for industrial transport.

All of the above streams are part of the Rhine drainage which ultimately reaches the North Sea. But in the extreme southwest of Luxembourg there is the Chiers (Korn) River which flows for 15 km in Luxembourg, passes into Belgium, and then France to join the Meuse (also North Sea drainage).

5.2 Lakes (Lacs)

There are no natural lakes in Luxembourg.

5.3 Reservoirs (Lacs artificiels or barrages)

Only one reservoir in Luxembourg has any great value for fishing, the 380-ha reservoir of Haute-Sûre (Esch-sur-Sûre), with a capacity of 60 million m^3, completed on the upper Sûre in 1969 primarily as a source of drinking water. There are also the Bassin supêrieur (48 ha) and Bassin infêrieur (97 ha) of Vianden.

There are also about 120 ponds with a total surface area of about 45 ha owned privately or by communes (the units of local government). The most important of these are in Echternach and Weiswampach.

Table 1

Principal rivers of Luxembourg

Name	Length in Luxembourg (km)
Rhine (Rhin/Rhein) Drainage	
Moselle (Mosel)	37
Gander (Altbach)	17
Syre (Syr)	30
Sûre (Sauer)	160
Wiltz	35
Clerf (Woltz)	45
Blees	14
Our	51
Ernz blanche (Weiss Ernz)	30
Ernz noire (Schwarze Ernz)	25
Altzette	60
Mess	11
Kayl	7
Dudelingerbach	7
Pétrusse	11
Mamer	25
Eisch	28
Attert	32
Wark	19
Meuse (Maas) Drainage	
Chiers (Korn)	15

Source: Annuaire Statistique du Luxembourg, 1988/89

6. LAND AND WATER USE

Table 2

Pattern of land use in Luxembourg, 1980

	Percent
Arable	22
Pasture	27
Forests	32
Built-on, “waste”	19
Total	100

Source: Europa (1982)

Luxembourg is considered to be 83 percent urban and 17 percent rural.

A considerable portion of the land was cleared of forest long ago to provide charcoal for the iron industry and to permit the cultivation of crops. Facilitation of natural regeneration and afforestation are both practised today, and about one third of the land is carefully kept forest. Deciduous trees predominate, then conifers and brushwood.

Over half of the country is pasture and small mixed farmland with crops of cereals, potatoes, vines and emphasis on the rearing of livestock. Heavy fertilization, using phosphate products of the steel industry is common.

The country is also heavily industrialized giving it an economic significance quite disproportionate to its size. Coal resources are lacking, but Luxembourg does have iron mines and these and steel-making form the basis of the country's prosperity. Although exploitation of the iron mines has been slight since 1981, Luxembourg continues to make steel using imported ore. Luxembourg's steel mills are located in the south of the country near the iron mines. Other industries include banking, chemicals, brewing, tanning and textiles. Industrialization has been accompanied by a high degree of water pollution from both industrial as well as domestic wastes. Water pollution has been particularly severe in the Bon Pays' Alzette River drainage, which supports the heaviest population in the country. Population density is low in the Oesling and there are no really large cities.

Luxembourg has excellent aquifers and until recently has drawn much of its domestic water supply from underground sources in porous sandstone. Stored water from the Haute-Sûre reservoir will replace much of this.

The total installed electrical capacity in 1987 was 1 238 000 kW of which 1 132 000 kW (90 percent of the total) was hydroelectric.

The Moselle is canalized to allow barges up to 1 500 t and it and part of the Sûre are dredged for gravel. There are about 37 km of navigable inland waterways. All of the country was accessible by a dense rail (270 km) and highway (5 220 km) network in 1987. The road density was 2 km/km^2 in 1982, and passenger car ownership very high, 443 per 1 000 persons (1978–79).

With attractive scenery (minor gorges, chateaux and vineyards), tourism (about 463 000 tourists in 1986) is an important industry and angling plays a part in its promotion.

7. FISH AND FISHERIES

The catch statistics in Table 3 are considered to represent a sport fishery, rather than the commercial fishery that is represented in most of the similar tables in this review. Possibly, some of the earlier figures represent a small commercial (or “subsistence”) effort, but information from Luxembourg/EIFAC (1977) states that the capture fishery is now “… considered essentially as a sport, there is no commercial fishery”. Worldmark (1984) modifies this statement by saying: “There is some commercial fishing for domestic consumption and much private fishing for sport”.

Table 3

Estimated sport catches in the inland waters of Luxembourg, 1938–75[1]
(Species unspecified, in tons)

1938	500	1961	400	1969	300
1948	500	1962	600	1970	200
1955	300	1963	600	1971	200
1956	300	1964	500	1972	200
1957	300	1965	500	1973	200
1958	400	1966	400	1974	150
1959	300	1967	400	1975	150
1960	300	1968	300		

Source: Luxembourg/EIFAC (1977)

1 The statistics in this table from 1938 to 1963 are identical with those in Yearb.Fish.Stat.FAO, 36 (Publ. 1974). The statistics for 1964–78 listed in various FAO Yearbooks of Fishery Statistics (through Vol. 48 for 1979) (published 1980) are given as "0.0", "00" or "0" - all indicating very small catches, at most 50 t. It has not been realized until recently that they should not have been listed at all - being primarily sport catch. As a result, the Yearbook for 1980 (Vol. 50, published in 1981) corrected the data for the 1971–80 period by listing the catch in Luxembourg as "-", meaning "none; magnitude known to be nil or zero". It has since been listed in this way (or as "0" in FISHDAB)

7.1 Capture Fishery (Sport)

Species well represented in the fishery are brown trout (Salmo trutta), rainbow trout (Oncorhynchus mykiss), grayling (Thymallus thymallus), European eel (Anguilla anguilla), pike (Esox lucius), European perch (Perca fluviatilis) and a variety of cyprinids: common carp (Cyprinus carpio), bream (Abramis brama), barbel (Barbus barbus), nase or hotu (Chondrostoma nasus), chub (Leuciscus cephalus), roach or gardon (Rutilus rutilus) and tench (Tinca tinca).

The Moselle and Sure Rivers, the reservoir of Haute-Sûre, and many of the small trout brooks are primary fishing areas.

There were about 10 000 fishermen in Luxembourg (2.8 percent of the total population) in 1977. Fishing is a touristic as well as local attraction.

7.2 Aquaculture

Aquaculture in the sense of raising fish for direct consumption is not practised in Luxembourg.

The Government's station at Lintgen rears trout from eggs imported from Denmark, but these are stocked in open fishing waters. The number stocked per year has varied decidedly, but of late years larger trout are stocked, e.g., in 1986, 276 150 one-summer and 9 450 two-summer fish. Frontier waters are stocked with coarse fish, also imported mainly from Denmark and the reservoir of Haute-Sûre has been stocked.

Since 1950, stocking has concentrated on: trout, roach, tench, carp and pike. Other stocked fish include: grayling, bream, perch and pike-perch (Stizostedion lucioperca).

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS

8.1 Ownership

There are two major classes of fishing waters in Luxembourg:

(i) Interior waters, including: (a) navigable streams and floatable waterways, for which the Government holds the fishing rights, and (b) non-navigable streams and floatable waterways whose fishing rights belong to the riparian landowners.

(ii) Frontier or boundary waters.

Licences to fish the non-navigable or non-floatable waters are awarded through public adjudication and the streams sub-divided under fishermen's organizations. Special licences are required on all the other waters.

8.2 Administration, Management and Investigation

The Ministry of Agriculture, Viticulture and Waters and Forests is responsible for the administration of inland fisheries in Luxembourg. Through its Directorate of Waters and Forests (Eaux et Forêts), it administers field services (e.g., fishery guards) in six forest cantons for forestry, hunting and fishing[1]. It also directs a Nature Conservation Service which includes a Hydrobiological Section devoted to: hydrobiological studies, pondfish culture, restocking and fish diseases.

There is also a High Council of Fisheries (Conseil Supérieur de la Pêche), a consultative body concerned with the conservation and protection of fisheries in cooperation with the Luxembourg Federation of Sport Fishermen.

[1] Luxembourg is divided administratively into: 3 districts, 12 cantons, and 118 communes

8.3 International Agreements

Luxembourg is a member of the International Commission for the Protection of the Rhine against pollution together with France, the Federal Republic of Germany, the Netherlands, and Switzerland, as well as the European Economic Community (EEC).

9. STATE OF THE FISHERY

9.1 Yield

Reference to Table 3, with acknowledgement that its catch statistics are estimates, leads one to conclude that the overall catch of fish in Luxembourg is declining. Information from the Government (Luxembourg/EIFAC, 1977) substantiates the belief that the natural yield from the rivers is slowly but steadily diminishing and that continual restocking is necessary to support their fisheries.

9.2 Factors Affecting the Fishery

The relative absence of static water (no large lakes and no major possibilities for more large reservoirs) precludes the establishment of either commercial fisheries or great increase in recreational fisheries.

The reported decline in stream fishing is apparently to be ascribed to water pollution, especially that caused by domestic waste. Governmental statistics which compare the state of pollution in Luxembourg's waters in 1973 with that in 1977 are shown in Table 4. It will be noted that during this period, the length of water courses classed as having “no pollution” remained constant and the length of those waters with “strong pollution” declined almost one-third. However, the percentage of those waters with more intermediate pollution increased somewhat, and in 1977 it was considered that about one-third of the country's waters were so polluted that their fishery was affected adversely.

The annual runoff per caput of Luxembourg's streams based on the amount of water leaving the country amounts to a high figure (13 850 m^3). This is, however, a misleading statistic since four fifths of this discharge leaving the country is derived from upstream countries and much of this flow is in peripheral or boundary streams. Based on the runoff originating only within Luxembourg, the annual runoff per caput is 2 700 m^3. The Alzette basin, which drains most of southern Luxembourg, is particularly vulnerable, being highly polluted with domestic and industrial effluents.

Aside from the general deterioration of both water quality and quantity, there is a continual fishing pressure in this country where almost every water is easily accessible. On the positive side, most of the land is well tended, and pollution control is being aided through establishment of some important sewage treatment plants.

9.3 Prospect

The capture fishery, for recreation, will continue to be a small one. Its future rests upon resolution of the conflict - a basic one in such a small country - between the growth of population and industrialization and the preservation of amenities. The maintenance of good water resources to support recreational fisheries for both local anglers and tourists will aid in attainment of the latter goal.

Table 4

The degree of pollution in Luxembourg's water courses 1973–77

	1973		1977	
Pollution index	km	percent	km	percent
None	177.0	29.3	176.6	29.2
Weak	296.7	49.1	322.3	53.3
Average	71.6	11.8	85.1	14.1
Strong	59.1	9.8	20.4	3.4
Total	604.4	100.0	604.4	100.0

Source: Modified from Table T.103 in Annuaire Statistique du Luxembourg 1982

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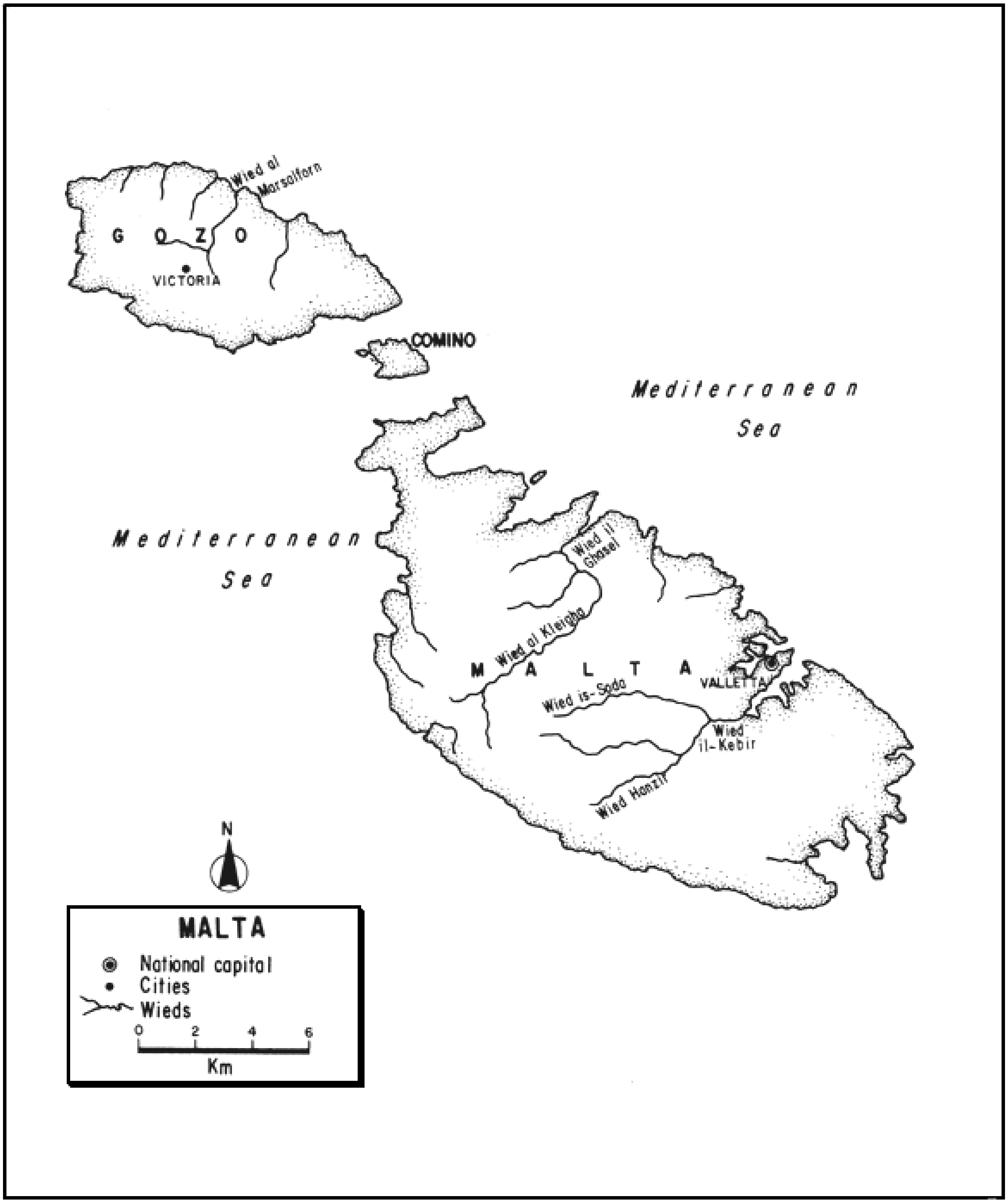
Wied al Marsalforn
G O Z O
VICTORIA
COMINO
Mediterranean Sea
Mediterranean Sea
Wied il Ghasel
Wied al Kleigha
M A L T A
VALLETTA
Wied is-Sada
Wied il-Kebir
Wied Hanzir
N
MALTA
National capital
Cities
Wieds
0 2 4 6
Km

MALTA

Among the sovereign states of Europe, the Republic of Malta is the fourth smallest and next to Monaco the most densely populated. A small group of islands in the Mediterranean Sea, Malta lacks mountains, lakes, perennial streams and even reservoirs of any size. Furthermore, heavy demands upon its meagre water resources preclude serious attempts to support freshwater capture fisheries.

Despite its notable lack of inland fishery resources and their aquatic base, Malta is a member of the European Inland Fisheries Advisory Commission (EIFAC). Possibilities may be entertained of at least establishing some sort of brackish or salt water aquaculture.

1. AREA: 316 km^2

2. POPULATION: 396 000 (est. 1990) Density: 1 253 inh/km^2

3. PHYSICAL GEOGRAPHY

Malta is situated in the central Mediterranean Sea, 93 km south of Sicily and 290 km from Africa, at 35°53'N latitude and 14°30'W longitude.

The Maltese Archipelago, whose greatest extent is 47 km, is composed of five islands. The largest of these, Malta is a low almost treeless plateau with terraced slopes and cliffs to 120 m. It has an area of 246 km^2, a length of 27.3 km, a width of 14.5 km, and a high point of only 240 m. The second largest, Gozo, has an area of 67 km^2, a length of 14.5 km, and a width of 7.2 km. It is similar to Malta but with less altitude. Comino is only 2.7 km^2 in area. The other two islets, Comminotto and Filfa, are smaller and uninhabited.

Wild vegetation, a poor garigue and tough grasses, is scarce in these dry, rocky isles. The principal native trees are carob and fig; olive, laurel and various fruit trees have been introduced.

The soils are shallow, largely thin limestones, interspersed with thin beds of crystalline sandstones and clays. Some are rich in phosphates and most of them are very porous.

The west coasts are cliff-like, the east lower. There is a well-indented coastline, some 137 km long on the island of Malta and 43 km on Gozo, and some excellent deepwater harbours cut deep into the rocky plateau. There is almost no tide, perhaps half a metre.

4. CLIMATE

Typically Mediterranean, with mild, rainy winters and hot dry summers.

The mean annual temperature is about 18.5°C (mean range, 14.3°–22.7°C). The average temperature is 12.8°C in January and 27.8°C in August, with maxima over 32°C common in July–September.

The average annual rainfall is about 559 mm. There is usually no rain during the May–September period, and most of the rainfall occurs between November and January.

5. HYDROGRAPHY AND LIMNOLOGY

There are no lakes or permanent streams in Malta, but there are some deeply cut valleys (wieds), and about nine seasonal creeks, including those of Sliema, Lazaretto, Msida and Marisa.

The approximate annual run-off is only 10 mm. Most of the precipitation is absorbed by the porous soil to be held by impervious clay layers and sometimes to issue as springs. Circa 1970, there were about 20 million m^3 of ground water - most of the natural water supply except for some small reservoirs impounding rain water.

6. LAND AND WATER USE

About 41 percent of Malta is arable or devoted to permanent crops, the rest is considered builton or unproductive (1986). There are no woodlands nor permanent pasturage, and the only mineral resources are limestone and salt.

The population is about 87 percent urban and 13 percent rural.

Agriculture, limited by the rocky but fertile nature of the islands, is characterized by terracing, the use of partially manufactured and imported soil, and crops such as grain, fodder, vegetables and fruit. There is a little irrigation, some with very saline water, of about 1 000 ha (1986). There is some grazing of sheep and goats.

Aside from its large ship repair yards, Malta has some light industry, e.g., textiles, food processing, electronics. All electrical power is thermal: 252 000 kW installed capacity in 1987.

Tourism has become an attractive type of income and creates a demand for fish. In fact, domestic consumption is lower than the reported per caput supply, 7.6 kg/year, indicates because of a substantial tourist consumption. With 1 302 km of roads, road density is exceptionally high, 4.12 km/km^2, and automobile ownership is about 200 per 1 000 people. There are no railways.

There is a small localized marine fishing industry, but it "…plays a rather less important role in the economy than might be expected from an island nation" (FAO, 1979). It remains, in general, a traditional industry carried out by individual families. In 1978, there were only 1 074 registered fishermen, over half of them seasonal. The marine catch in 1987 was only 1 003 t.

Demands for water are severe. About three quarters of the supply is for domestic use alone, followed by commercial and industrial use, and then by irrigation. The natural supply is augmented by distillation of sea water.

7. FISH AND FISHERIES

7.1 Capture Fisheries

Virtually non-existent.

7.2 Aquaculture

In reporting upon a fishery survey of Malta circa 1954, Burdon (1956) stated that fish culture in Malta was restricted to the maintenance of a few ponds in sheltered creeks where grey mullet (Mugil spp.) fry were stocked in the summer to be harvested during the winter. He recommended the establishment of mullet ponds to be operated intensively. Introduction of Tilapia spp. into some irrigation ponds, tanks and salt pans, even if for only short periods, was also recommended.

FAO (1970) suggested the possibility of rearing grey mullets in abandoned salt pans, and using salt pans and associated canals to raise shrimp for bait but warned that such projects would be expensive. See section 9.3. Girin (1989) states that there is little or no aquaculture in Malta.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT AND INVESTIGATION

Malta has a Fisheries Department, but its work seems to be confined almost entirely to marine fisheries.

Research on biology, fisheries and fish culture is being carried out by university personnel at St. Lucian Marine Station, and Girin (1989) states that there has been some work on introduced freshwater species here (the species are not specified).

9. STATE OF THE FISHERY

9.1 Yield

Apparently negligible.

9.2 Factors Affecting the Fishery

The absence of perennial lakes and streams and the lack of reservoirs of suitable size and retention period preclude the maintenance of an inland capture fishery - except, perhaps, for subsistence or sport in a few small water bodies.

In this country of limited rainfall and high population density, the demands for water for domestic and commercial use (including increasing tourism), as well as for industry and agriculture, are altogether too severe to provide justification for the establishment of conventional freshwater aquaculture. True, the use of highly intensive methods such as those using recirculated water might be considered, but it is hardly thought feasible.

Consideration of use of Malta's fresh water for either fisheries or aquaculture depends upon consideration of their potential values in this dry and sea-girt land with those of already well established and growing uses. The UN (1964) estimated that by 1970, the annual water demand in Malta would be 20 250 000 m, i.e., somewhat more than the amount of fresh ground water available. (Even such an amount would supply the present population with only about 51 m of fresh water per caput annually.)

Under the circumstances, it would appear that some sort of brackish or salt water aquaculture is the only real possibility.

9.3 Prospect

FAO (1979) has suggested that although there exists little possibility of freshwater aquaculture, the future potential in the culture of flatfish as well as sea basses and sea breams is promising, owing to favourable marine water temperatures and the accessibility of a number of inshore areas suitable for cage, ranch, or tank culture. Mollusc cultivation is also believed to have some potential. In fact, some oyster beds were laid out as early as 1867.

Finally, it should be mentioned that despite the apparent absence of either an inland capture fishery or aquacultural development in Malta, its description has been included in this review: (i) because Malta is a member of the European Inland Fisheries Advisory Commission (EIFAC), and is therefore presumed to have an interest in such fisheries, and (ii) to provide a compendium of basic knowledge as background for further action or inaction.

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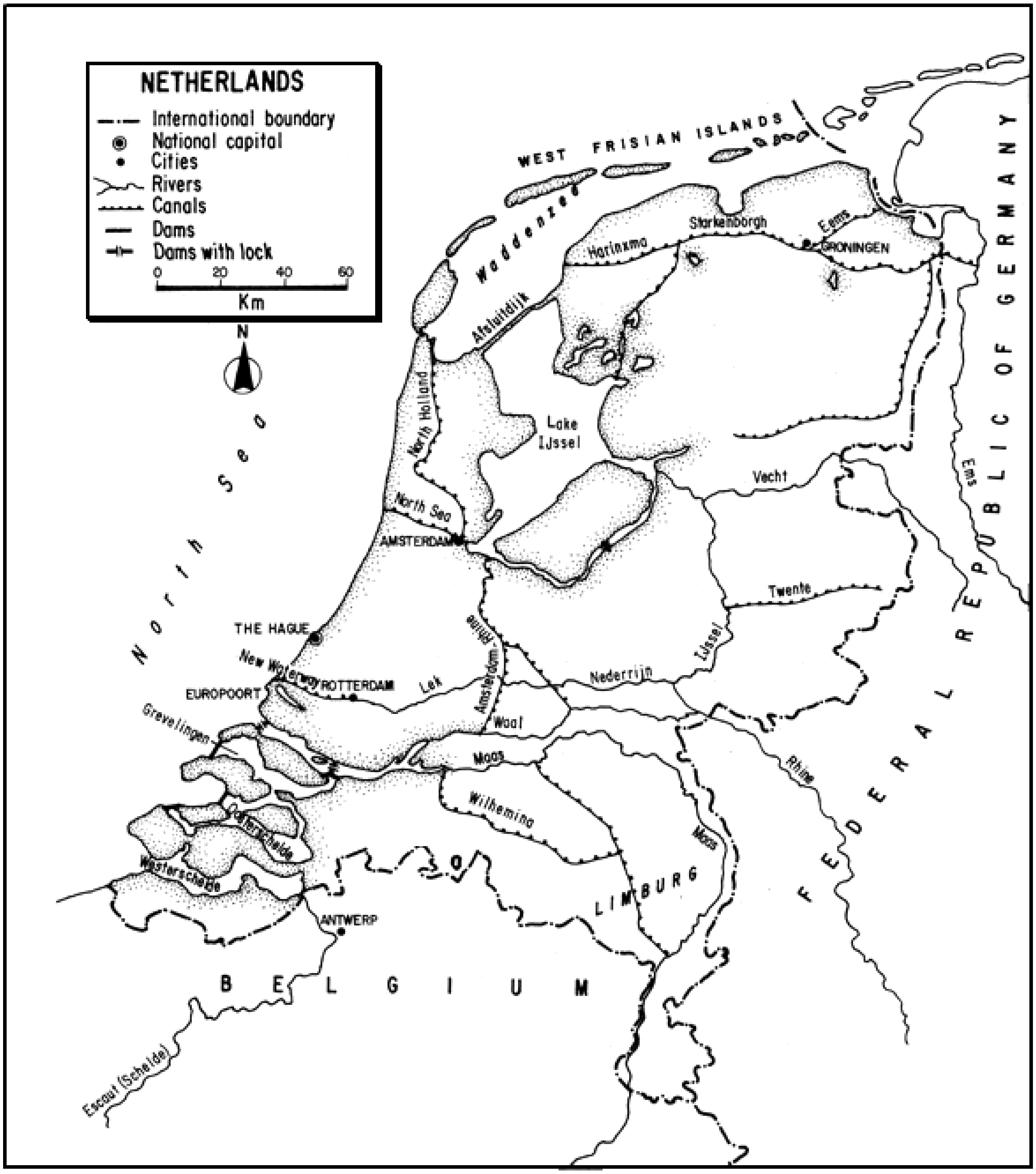

NETHERLANDS
International boundary
National capital
Cities
Rivers
Canals
Dams
Dams with lock
0 20 40 60
Km
N
WEST FRISIAN ISLANDS
Waddenzee
Afsluitdijk
Harinxma
Starkenborgh
Eems
GRONINGEN
North Holland
Lake IJssel
North Sea
Vecht
AMSTERDAM
Twente
THE HAGUE
Rhine
IJssel
New Waterway
ROTTERDAM
Lek
Amsterdam
Nederrijn
EUROPOORT
Grevelingen
Waal
Maas
Oosterschelde
Wilhemina
Westerschelde
LIMBURG
Maas
ANTWERP
BELGIUM
Escaut (Schelde)
North Sea
FEDERAL REPUBLIC OF GERMANY
Ems
Rhine

NETHERLANDS

The Kingdom of the Netherlands, in northwestern Europe, lies at the mouth of Europe's greatest river and in the centre of its greatest industrial growth. With much of its land reclaimed, and almost half of it lying below sea level, it has been called, “a gift of the Rhine and the North Sea”, from which it is protected by river dikes and seawalls. Its landscape is more completely artificial than any country of similar size in Europe.

Traversed by the great distributaries of the rivers Rhine and Maas, and laced by an interconnected system of canals, ditches, sluices, lakes and reservoirs, the country provides opportunities for both commercial and sport fisheries. However, with a very dense population, and high use of almost all its lands and waters, the Netherlands is particularly vulnerable to water pollution - much of this originating without its borders.

Its once great Atlantic salmon runs are gone, and commercial fishing in inland waters, now primarily for eel, has declined greatly. The development of sport fisheries, aided by angler's organizations, has priority in the Government's plans for inland fishery management. These plans are furthered by the attention given to the value of angling as recreational activity for the dense population, and a determination to alleviate water pollution. Aquaculture to provide food from inland waters is a minor industry in the Netherlands.

1. AREA: 41 864 km^2 (1988)

2. POPULATION: 14 748 000 (est. 1990) Density: 361 inh/km^2

3. PHYSICAL GEOGRAPHY

The Netherlands is situated in northwestern Europe between 50°45'5" and 53°52'5"N latitudes and 3°21'31" and 7°13'14"E longitudes.

Its extreme length (N–S) is about 310 km; its greatest breadth (E–W) is about 190 km. The complete altitudinal range is from -6.7 m to 321 m.

The Netherlands is bounded on the east by the Federal Republic of Germany for 584 km and on the southwest by Belgium for 496 km[1]. To the west and north it is bounded by the North Sea over a length of 1 370 km at flood mark (see below).

[1] The statistical yearbooks for 1981 and 1984 for the Federal Republic of Germany list its boundary with the Netherlands as 576 km, and Belgium's statistical yearbooks for 1981 and 1987 list its boundary with the Netherlands as 450 km. The distances given above are from the Netherland's statistical yearbook for 1988

The Netherlands, forming the lowest part of the great North European Plain, consists primarily of the delta lands of the Rhine, Maas and Schelde, and adjacent parts of the North Sea lowlands. Aside from these delta areas and a series of coastal dunes, it is primarily a flat country of polders (lands reclaimed from the sea, fens or lakes) and an intricate system of static and flowing waters. About 27 percent of the land surface is below sea level, less than one percent of the country has an elevation of 50 m, and only in a few places does it rise to more than 100 m. The lower two thirds are almost flat, the rest is undulating with a few hills, high fens and heathlands.

For centuries there has been a continuous struggle against the sea with its periods of inundation and increase in salinity of the inland waters. Dunes, seawalls and dikes protect the land from sea invasion, and dikes also protect the land from river floods. There is a continual reclamation of land from the sea, now totalling almost one fifth of the country. About 40 to 50 percent of the land would be innundated by the sea if there were no man-made barriers.

There are three natural physiographic areas in the Netherlands:

(i) an elevated strip of dunes, 9–50 m in height, along a coastal sandbar, occupied by a string of cities, and continuous except where broken by the sea;

(ii) the adjoining low polders covered with clays and peats, and

(iii) an eastern section of sandy heathland and once extensive peat bogs.

The delta areas lie in the south. Above them are the alluvial valleys of the south-central area, the joint floodplain of the Maas, Rhine and its distributary the IJssel, floored with clay and protected by dikes. The highest area of the country is the small South Limburg area in the southeast, a chalky plateau, partly wooded, and cut by tributaries of the Maas.

There is little natural vegetation in the Netherlands except in dune and heathland. Only about 8 percent is wooded and most of this is plantation area in the higher sand country.

Soils in the heathlands are primarily sandy, those in the polders mainly sea clays and peat. Overall, soils are about 50 percent sand, 40 percent clay, 8 percent peat, and 2 percent a loess-like loam.

The coastline has gradually been shortened as protective devices have been installed and more land reclaimed. In the year 1500, the shoreline was several thousand kilometres in length. It is now (1988) 1 370 km long, but if one disregards islands and estuaries it is only about 370 km in length.

4. CLIMATE

Situated in the temperate zone, the humid oceanic climate is marked by cool summers and mild winters owing to the influence of the Gulf Stream. There is generally a high cloud cover, often drizzle and mist, and the winters can sometimes be severe. Wind pressure (commonly from the west) almost always is present.

The average annual temperature is about 10°C. The average coastal temperature is about 16°C in summer and 3°C in winter; the average inland summer temperature is about 17°C and in winter about 2°C. The lowest temperatures (-1 to 1.5°C) occur in January and the highest (19–23°C) in July.

The average annual rainfall is about 750 mm, almost evenly distributed throughout the year and over the country.

The average annual evaporation is about 500 mm.

Frost averages 60 days annually. There is some snow during a period of about 10 to 45 days as one proceeds eastward. On rare occasions Lake IJssel and the mouth of the Rhine may freeze, but the Netherland's seaports are permanently open to navigation.

5. HYDROGRAPHY AND LIMNOLOGY

The smallest estimate of the area of inland waters in the Netherlands which the author has found is that of Worldmark (1988) which said that its inland water accounted for more than 2 060 km^2 in 1986 (i.e., about 5 percent of the total area). An estimate of the distribution of inland waters in the Netherlands is shown in Table 1. Here, inland water is shown to constitute about 8.2 percent of the country's total area at the time.

Another by Willemsen (1977) states that the area of Lake IJssel is only 120 000 ha and the total area of other lakes, rivers, canals and brooks totals 130 000 ha. This provides a total area of 250 000 ha of inland waters, or 6 percent of the country's area. A fourth estimate of the total extent of the inland waters of the Netherlands in 1987 is 3 370 km^2 as is indicated in Table 5[1]. The Centraal Bureau voor de Statistiek (1982), a more direct source, lists the inland water area as 3 704 km^2 or 9 percent of a country-wide area of 41 160 km^2, and the Central Bureau voor de Statistiek (1989) lists the inland water area of the Netherlands in 1985 as 9.2 percent (about 3 816 km^2) of a countrywide area of 41 473 km^2, a percentage of inland water surface exceeded in Europe only by Finland. A survey of 1977/78 summarized by van Haasteren and de Groot (1982) states that the total area of all surface waters in the Netherlands larger than 0.5 ha and over 6 m in width (exclusive of Lake IJssel) is 151 018 ha. Finally, Steinmetz (1982a) states that the country has 151 000 ha of available inland waters in addition to that of Lake IJssel. Using his figure of 200 000 ha for IJssel, this consitutes a total of 351 000 ha of inland water or about 8.5 percent of the total area of the country.

[1] The source of the table, FAO (1988) gives the total area of the Netherlands as only 37 290 km^2, however, and the percentages calculated in Table 5 are based on this figure. (The area of the Netherlands varies from year to year due to land building)

Table 1

Area of inland waters of the Netherlands (ha)

Lake IJssel	200 000
Marginal lakes of Lake LJssel	14 500
Delta lakes (salt, brackish, freshwater)	23 000
Polder reservoir systems	79 000
Major rivers	18 400
Minor rivers	2 800
Other waters	2 900
Total	340 600

Source: Netherlands/EIFAC (1974)

The approximate annual runoff from rainfall on Dutch territory alone is 250 mm or 10 000 million m^3. Added to this is 80 000 million m^3 received from upstream countries resulting in a total annual river discharge leaving the Netherlands of 90 000 million m^3 (Van der Leeden, 1975; ECE, 1978). Of this total, the Rhine alone contributes about 65–75 percent.

The general drainage of the country is to the northwest into the North Sea primarily through the Rhine (Rijn in Dutch), Maas (Meuse) and their distributaries. The estuary of the Schelde (Scheldt) is also in the Netherlands. There are no other rivers of real consequence, but there is a complex hydrographic network throughout the country of rivers, canals, ditches, lakes, reservoirs, drainage canals and sluices.

In addition to the natural areas occupied by the three large rivers, two great engineering feats have greatly altered the hydrographic picture in the Netherlands. The first of these is the creation of the freshwater Lake IJssel from the former saltwater Zuiderzee (see section 5.2). The second is the Delta Plan (considered operational in 1986) which closed off three of the four principal distributary arms of the Schelde-Maas-Rhine delta from the North Sea. The estuary of the Wester Schelde is left open to traffic to Antwerp and Rotterdam (through the New Waterway). The project protects polders in

Zealand, shortens the coast, prevents infiltration of sea water, and makes fresh water available for irrigation.

Throughout much of the country and throughout the year there is a vast system of lakes and canals fed with water pumped from the land. In times of heavy rain, the lakes serve to accommodate water until it can be conveyed to the sea. The excess is drained either into open water or into a boezem, the first stage of evacuation of surplus water - a means of temporary storage. This may be a lake, canal, river or marsh. With some exceptions, the waters are shallow, eutrophic and (especially the large ones) turbid.

5.1 Rivers (Rivieren)

Estimates of the length of the rivers in the Netherlands are difficult to obtain because of the many man-made waterways. Europa (1974) and Netherlands/EIFAC (1976) state that there are 6 400 km of flowing waters in the country, and Holden and Lloyd (1972) specify 1 900 km of rivers or 2 150 km including drainage ditches.

The mean annual discharge and total volume of annual runoff of the rivers in the Netherlands is shown in Table 2. The mean monthly discharge of the Rhine and Maas is shown in Table 3.

The Rhine has a drainage basin of about 224 000 km^2 and a total length of about 1 350 km. As it enters the Netherlands from the Federal Republic of Germany, it has an average discharge of about 2 200 m^3/sec, a maximum flow of about 12 200 m^3/sec, and a minimum of about 590 m^3/sec. Within the country, the Rhine breaks into three major distributaries in which the distribution of flow is listed by Hambloch (1977) as follows:

	Percentage of total discharge		
	Mean	High	Low
Waal	67	66	75
Neder-Rijn	22	11	16
IJssel	11	23	9
Total	100	100	100

Table 2

Mean discharge and annual runoff of rivers in the Netherlands

	Mean discharge (m^3/sec)	Mean annual runoff (million m^3)
Rhine (at border)	2 200	70 000
Maas	220	7 000
Small rivers	105	3 300

Source: Van der Leeden (1975) after Rijkswaterstaat (1964)

Table 3

Discharge of the Rhine and Maas Rivers in the Netherlands

	Rhine, Lobith (German border)	Maas, Lith	Maas, Borgharen (Belgian border)
Basin area km^2	-	28 950	-
January	2 594	553	435
February	2 813	591	465
March	2 642	444	324
April	2 775	429	311
May	2 562	304	190
June	2 517	193	115
July	2 228	163	87
August	2 020	151	83
September	1 910	163	91
October	1 656	184	112
November	1 776	323	245
December	2 569	572	453
Max. monthly flow m^3/s	6 166	1 500	1 308
Date	Dec. 1965	Dec. 1965	Dec. 1965
Min. monthly flow m^3/s	808	34	6
Date	Feb. 1963	July 1964	Oct. 1971
Period of record	1960–71	1960–71	1960–71

Source: Van der Leeden (1975) after Rijkswaterstaat (1973)

The IJssel proceeds northerly to Lake IJssel. The Neder-Rijn (Lower Rhine) continues west as the Lek to the New Maas and thence to the North Sea. The southernmost Waal, which carries the most water, flows west to empty into the North Sea.

The Maas (Meuse) forms a boundary between the Netherlands and Belgium for 48 km and then continues north and then west through the Netherlands to the North Sea to end its total journey of about 950 km from its source in France. Its mean discharge is about 220 m^3/sec.

South of the Maas is the estuary of the Schelde. Leaving Belgium, where it forms the harbour of Antwerp, it divides into a northern channel, the Ooster Schelde, and a southern one, the Wester Schelde. The Ooster Schelde has been dammed. Both banks of the channel belong to the Netherlands.

All the other rivers in the country, constituting only four percent of the total runoff, also eventually reach the North Sea.

The gradient of all the Dutch rivers is low. For example, the fall of the Rhine, Neder-Rijn, and Waal is scarcely more than 10 cm/km. Such sluggish flow aggravates problems of pollution.

5.2 Lakes and Reservoirs (Meren, Stuwmeren)

The extreme regulation of water practised in the Netherlands makes it difficult to distinguish between natural lakes, reservoirs, and other water bodies.

Anon. (1970) classifies the lakes and impoundments in the Netherlands as follows:

(i) Small lakes in the lower part of the country. These range in area from a few km^2 to tens of km^2s. Some are natural or partly natural through erosion of soft banks by wind-generated waves. Some, such as the Loosdrecht lakes near Amsterdam, are man-made through peat removal. A number of these were reclaimed for agriculture through the Seventeenth and Nineteenth centuries. Those left form part of a boezem system (see above).

(ii) Sand and gravel borrow pits. Most of these are less than 1 km^2 in area, but some are much larger, e.g., the 4.7-ha Lake Vechten.

(iii) Former tidal inlets in the delta. These have been dammed and the original saline and brackish water is being replaced with fresh water.

(iv) Lake IJssel. The largest body of fresh water in the country (IJsselmeer in Dutch) was created from a marine bay (salinity 10 ppt), the Zuiderzee, by a 30-km seawall, the Afsluitdijk, completed in 1932. The Zuiderzee itself was formed in the Middle Ages through penetration of the North Sea. The lake's original area of 3 600 km^2 has been reduced through poldering to about 2 000 km^2. Its fresh water is supplied by the Rhine's distributary, the IJssel River. The lake supplies agriculture and industry and checks infiltration of salt water into the subsoil. Constituting almost half of the inland waters of the country, it is highly important with respect to commercial and recreational fishing. Some parameters of the Lake are seen in Table 4.

One of the severest problems in water quality management of the freshwater Dutch lakes is eutrophication. About two thirds of this freshwater supply is from the Rhine which bears many nutrients; furthermore, most of the lakes are shallow and unstratified (see Los, De Rooij and Smits, 1984).

See Table 1 with respect to the extent of other static waters.

5.3 Canals (Kanalen)

The Netherlands has a famed and extensive canal system linking both its natural and artificial waterways and connecting them with many canal or river parts in Belgium, Germany and France. In 1987 there were 3 529 km of navigable canals in the Netherlands. They require continual dredging.

Among the major canals are those connecting large parts with the North Sea, the 27-km New Waterway for Rotterdam, and the 29-km North Sea Canal for Amsterdam. Amsterdam is also served by the Amsterdam-Rhine Canal connecting Amsterdam with the Waal River and making it a Rhine port. Other canals include the V. Harinxma, Ems, Juliana and Wilhelmina.

In addition to canals, the Netherlands have about 350 000–400 000 km of ditches, primarily to improve drainage. Shallow and often choked with vegetation, they furnish little fish habitat (Beltman, 1984).

Table 4

Characteristics of Lake IJssel

Parameter	
Area (km^2)	1 200[a]
Mean depth (m)	4
Maximum depth (m)	10.2
Bottom	sand/clay
Mean water temperature (°C)	10.4
Maximum water temperature (°C)	24.5
Transparency (Secchi disc, m)	0.65 (0.1–2.0)
pH, winter/summer	7.5–8.0/8.2–8.7
Oxygen saturation (%)	90–120
$P\text{-}P_{tot}$ (mg/l)	0.22
$N\text{-}N_{tot}$ (mg/l)	4
Cl (mg/l)	220
Primary production, entire year ($g.cm^{-2}.\ day^{-1}$)	2
Average residence time (mo)	6–9

[a] Steinmetz (1982a) and others say that its area is 2 000 km^2

Source: Willemsen (1977)

6. LAND AND WATER USE

Table 5

Pattern of land use in the Netherlands, 1987

	Percent
Arable and permanent crops	24.3
Permanent pasture	29.7
Forests and woodland	8.0
Other land	29.0
Inland water	9.0
Total	100.0

Source: 1987 FAO Prod.Yearb., 41 (Publ. 1988)

Diking in the Netherlands began in the Seventh Century, and since then man has actively continued to shape the lands and waters of the country. He has cleared the lands of vegetation, cut peat, dug clays and gravels, leveed and channelized the rivers, augmented the natural waterways through construction of canals and locks, built dikes and sluices, drained lakes, reclaimed vast areas of the sea through the erection of seawalls, pumped out water from the resulting enclosures, and flushed out both land and water areas with fresh water[1]. It has become difficult, therefore, to distinguish between natural and artificial elements of the geo- and hydrosphere.

[1] Higher polders can be drained by sluice at low tide; lower ones have to be pumped out

The economy of the Netherlands, now about 88.5 percent urban and 11.5 percent rural, plus its peculiar hydrographic conditions result in highly integrated and special uses of water. These special uses include flushing of boezems, control of water levels, and protection against salt water intrusion. In agriculture, water is chiefly used to keep the salt well above the surface of the ground. Its use for irrigation is comparatively new. Although about 14 percent of the country was said to be irrigated (1986), drainage, rather than irrigation, is the principal element of water control[1].

[1] In 1982, only about 7 percent of the country was reported as irrigated

Although such a densely populated nation must depend largely upon industry, it is also an intensively agricultural country, being the world's third largest exporter of agricultural products. The proportion of farmed land is high and agriculture is diverse and intense. There is high use of fertilizer (about 500 kg/ha/year) and mechanization. Cereals, fodder crops, vegetable, and flower crops are cultivated. The basis of the agricultural economy is, however, animal husbandry with much of the crop production consumed by dairy and meat cattle.

Almost no effort is devoted to forestry; the Netherlands ranks at the lowest level in Europe in roundwood production. Most of the “forests” are recent plantations (e.g., of Scots pine) in the sand country.

For many years, peat was cut for domestic and industrial use. Some of the cuts were drained, others have persisted to be used for fishing. Extensive gravel pits have also been left on the floodplains. There are very large reserves of natural gas, some coal (in Limburg), oil, gravel and salt. Otherwise, mining is not important.

Despite the lack of basic resources (such as iron), industrial development is high. Oil refining, chemicals, metallurgy, electrical equipment, steel, textiles, food processing and shipbuilding constitute the bulk of industrial output. Although concentrated in the Rotterdam-Amsterdam area, industry is rather widely distributed, thus increasing country-wide pollution.

There is little hydroelectric power development because of the flat terrain; in 1987 there was only about 2 000 kW. Total installed thermal power was 16 866 000 kW and there were also 508 000 kW of nuclear power, and 10 000 kW of geothermal power.

The Netherlands have one of the most extensive systems of navigable waterways in the world, consisting of a maze of the major rivers and canals. In 1987, there were 4 831 km of navigable rivers and canals plus 460 km on Lake IJssel and other waters; the highest percentage of waterways per unit area in Europe. Canals and other waterways function here for both drainage and transport, and are recipients of effluents. They provide a great deal of aquatic recreation: rowing, canoeing, water skiing, and yachting. They serve to disseminate fish throughout the country and provide fishing. Much of the waterway system was developed not for transport, but as defence against flooding. Nevertheless, about one third of the country's freight is carried on the inland waters by a fleet totalling about 5 million tons, including about 12 000 barges, which contributes to the pollutional load. The Rhine is Europe's most intensively navigated river. Rotterdam, at its lower end, is the world's largest port, and the Rhine is navigable upstream for 882 km to Basle.

There is a good system of State railways (2 867 km) used mostly for passenger travel, and an extremely well-developed system of over 111 000 km of surface roads enabling easy access to any section of the country. These roads have a density of about 2.7 km/km^2 (1986) and private automobile ownership is 347 per thousand (1987). There are about 12 000 km of bicycle roads and a bicycle ownership of about 746 per thousand (1987). However, despite the good transport system, most Dutch fishermen fish quite close to their homes, and this factor is taken into account by Government planners.

Concentrated for many years on the herring fishery, the contribution of marine fishing to the total Dutch economy is now marginal, but still important in some coastal areas. The Netherlands ranked thirty-fourth in total world fishing catch in 1987. A once thriving oyster fishery was virtually destroyed by flood control and land-gaining processes, and production of mussels in the estuaries now produces a far greater tonnage. Its future is also dependent upon the effect of dikes in the Schelde area. The main area of inland commercial fishing is Lake IJssel (see section 7.1.1). Per caput consumption of fish in the Netherlands is 10.3 kg (1984).

Water pollution is obviously a major problem of the country. The Rhine's salinity has increased eleven-fold over the last century, and much of its bed is covered with oily sludge. Bearing about 17 million tons of waste (phenols, organic matter, salts, etc.) annually, it enters the Netherlands in a very polluted condition. Johnson and Brown (1976) said that this was about one half of the total produced in the country. The Dutch waterways are used extensively for the conveyance of waste and the drainage from agricultural lands. Sewage, organic effluents from processing industries, and those from a multitude of other industries create serious conditions for aquatic life. Major industrial pollutants include effluent from potato flour, strawboard, sugar beets, dairies, food processors, paper, pulp and chemicals.

The large volume of water in the main rivers dilutes effluent to some extent, but the smaller, slow-moving canals are in much poorer condition. Furthermore, infiltration of sea water through dikes and sluices has led to increased salinity. In 1972, it was considered that over 95 percent of the rivers (including drainage canals) was polluted and 200 km rendered more or less fishless.

The Netherlands experiences great difficulties in procuring, storing and processing sufficient good water for drinking supply. One method of achieving this need is replenishment of ground water supplies through coastal dune storage. However, the dune water table has lowered, aquifers are limited, and the use of ground water lowers the water table and affects agriculture adversely. By the year 2000, over one half of the water will have to be derived from the great rivers, principally the Rhine (see section 9.3).

Many studies have been made of the use of water in the Netherlands. One such, Table 6, is a projection of water demand 1980–2000. The extremely large amount of water required to maintain water balance through flushing of boezems and other discharges illustrates a startling need unlike that of other European countries.

All such changes in land and water use have effect not only upon the aquatic resources but also upon their utilization. For example, as new land is created, new communities have arisen and the conversion of “dry” areas into “wet” areas has changed the fishing patterns of the recreational community.

Table 6

Projected water demand, 1980–2000, in the Netherlands

	m^3/sec		mm		$10^9 m^3$ [a]	
Needs and losses	1980	2000	1980	2000	1980	2000
Average evaporation	630	630	500	500	20	20
Domestic water use	19	33.5	15	27	0.6	1.1
Industrial use	51	86.5	40	69	1.6	2.7
Flushing of boezems, control of water levels, discharge to main rivers to combat salt water intrusion	1 680	1 680	1 335	1 335	53	53
Additional flushing due to supplementary irrigation	35	44	28	35	1.1	1.4
Excess	1 060	1 001	840	792	34	32.1
Total	3 475	3 475	2 758	2 758	110.3	110.3

[a] Thousand million

Source: Van der Leeden (1975) after Rijkswaterstaat (1964)

7. FISH AND FISHERIES

There are about 42 species of fish in the inland waters of the Netherlands. Most of these are best adapted to eutrophic waters. The principal freshwater and diadromous fishes entering the catches are: the European eel (Anguilla anguilla), European smelt (Osmerus esperlanus), pike (Esox lucius), common carp (Cyprinus carpio), bream (Abramis brama), roach (Rutilus rutilus), rudd (Scardinius erythrophthalmus), tench (Tinca tinca), European perch (Perca fluviatilus), and pike-perch (Stizostedion lucioperca). Others include: Twaite shad (Alosa fallax), brown and sea trout (Salmo trutta), the introduced rainbow trout (Oncorhynchus mykiss), barbel (Barbus barbus), white bream (Blicca bjoerkna), crucian carp (Carassius carassius), orfe (Leuciscus idus), chub (L. cephalus) and burbot (Lota lota). The flounder (Platichthys flesus) also enters the inland catch. (See especially, Ministerie van Landouvw en Visserij, 1972, for an account of the principal inland fishes.)

An addition to the Netherlands aquatic fauna is the introduced grass carp (Ctenopharyngodon idella). Since 1977, 20 000–30 000 kg of grass carp have been stocked annually as an alternative to chemical weed control and they are also fished.

At one time, the Rhine was the greatest Atlantic salmon (Salmo salar) river in Europe. Late in the nineteenth century, the lower reaches yielded more than 100 000 salmon averaging almost 7 kg in the Netherlands alone (Schwiebert, 1975). But dams, water pollution and other manmade hazards have ended the fine runs that used to enter the Dutch rivers. Deelder and Van Drimmelen (1960) provide an excellent picture of the decline of both the Atlantic salmon and eel fisheries in the Rhine and Maas. Today, salmonoid fisheries in the Netherlands are chiefly for those fish which are stocked, i.e., brown and rainbow trout, although there are some grayling (Thymallus thymallus) in small brooks.

7.1 Capture Fisheries

Except for Lake IJssel, which constitutes over half of the Netherland's inland waters, sport fishing is now considered to have priority over professional fishing in

Governmental policy (Steinmetz, 1982a). A considerable commercial fishery still exists in the inland waters, however, as will be seen below.

7.1.1 Commercial fishing

Table 7 illustrates the commercial catch in the inland waters of the Netherlands during the period of 1965–87 as reported to FAO. The total catches in this table agree closely with those recorded in the Netherlands Statistical Yearbook (e.g., that for 1983) and other publications emanating from the Netherlands (e.g., Steinmetz, 1988). From this table, it will be seen that the once greatest catch, i.e., "freshwater fishes n.e.i." (principally various cyprinids) has declined materially. In recent years the greatest commercial catches have been of bream, eel, European perch and European smelt. Although not illustrated in these statistics, tench is also given priority as a commercial species.

Table 8, showing the derivation of the inland commercial catch 1974, demonstrates the high percentage of fish (77 percent) taken from Lake IJssel alone. Comparison of Tables 7 and 9 also illustrates the high percentage of the nation's catch of three important species caught in Lake IJssel alone. Thus, in 1977, the following percentages of the nation's commercial inland catch were taken from Lake IJssel: European perch - 96 percent, pike-perch - 96 percent; European eel - 92 percent. It is also obvious from Table 9 that sport fishing in IJssel has little influence on the commercial catch.

Commercial fishing in Lake IJssel employs about 400 men with 120 boats (1984), and includes the use of various nets, longlines and pots. Longlines for eel fishing have been almost supplanted by baited eel pots (boxes). The number of fyke nets has been stabilized in order to protect the perch and pikeperch stocks.

7.1.2 Sport fishing

In general, no distinction is made in the Netherlands between game, sport or food fishes, although sport fishermen are defined as those who fish with one or two rods or a bob.

Table 11 lists some of the fishes most frequently caught by sport fishermen as well as indicating their relative abundance in catches made in Lake IJssel. To this list should be added the species enumerated above (head of section 7).

Most sport fishing in the Netherlands is a sedentary activity - fishing from the banks, especially for cyprinids. About 10 percent of the sport fishermen practice boat fishing usually or exclusively, with perch and pike-perch as major quarry. Trout fishing is primarily for stocked fish. A substitute for trout by fly fishermen is the rudd, which is stocked for this purpose. The use of angler-caught coarse fish as food is limited. On the average, over 80 percent of the fish caught are released, with the exception of eel, pike-perch and pike, of which about 60, 35 and 35 percent respectively are taken home (Steinmetz, 1982a). See also Table 9. The official landed commercial catches from Lake IJssel in 1986 and 1987 are given in Table 10.

Table 7

Nominal catches by species in the inland waters of the Netherlands, 1965, 1970, 1975, 1980–87 (in tons)

Species	1965	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987
Freshwater bream[a] (Abramis brama)	100	200	159	83	94	177	430	534	626	739	1 405
Common carp (Cyprinus carpio)	0	0	1	1	1	1	1	2	2	2	1
Roaches (Rutilus sp.)	300	200	57	24	55	71	112	275	162	89	33
Pike (Esox lucius)	0	0	0	1	1	0	0	1	1	0	1
European perch (Perca fluviatilis)	200	100	846	625	848	711	631	442	622	559	545
Pike-perch (Stizostedion lucioperca)	100	200	1 209	139	65	73	167	333	159	60	129
Freshwater fishes n.e.i.	10 700	100	994	248	0	51	299	184	140	77	85
European eel (Anguilla anguilla)	2 400	1 100	1 040	690	723	876	972	723	708	785	559
Trout (Salmo sp.)	0	0	0	1	1	1	1	1	1	1	2
European smelt (Osmerus eperlanus)	0	100	107	164	160	2 401	1 285	1 357	1 411	1 956	2 409
European flounder (Platichthys flesus)	-	-	8	7	4	2	2	4	2	2	10
Total	13 800	2 000	4 421	1 983	1 952	4 364	3 900	3 856	3 834	4 270	5 179

a Listed as "Freshwater breams, n.e.i. Abramis spp." in 1965–69 statistics

0 Probably nil, negligible or insignificant; or less than 50 t during the 1965–73 period, or less than half a ton thereafter

\- This category not listed this year

Source: 1965–69 Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–83 FAO Fish. Dept. Fishery Statistical Database (FISHDAB)
1984–87 Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

Table 8

Commercial catch in the inland waters of the Netherlands, 1974 (in tons)

Species	Lake IJssel	Marginal lakes of IJssel	Delta lakes	Polder reservoirs	Major rivers	Other waters
Bream and roach	263	139	-	?	200e	-
European perch	758	-	-	?	-	-
Pike-perch	205	-	-	?	-	-
"Coarse fish - not specified"	1 230[a]	-	300e[b]	?	?	-
European eel	843	843	81	79e	20e	?
Total	3 299	280	381	79e	220e	?

a Includes 0.1 t sea trout, 22 t European smelt, 14 t European flounder

b Plaice (Pleuronectes platessa) and European flounder

e - estimate

Source: Netherlands/EIFAC (1974)

Table 9

Estimated withdrawals of fully grown perch, pike-perch and eel from Lake IJssel, 1977

	Sport fishing[a]		Commercial fishing		All fishing	
Species	kg	%	kg	%	kg	%
European perch	50 400	8.8	524 067	91.2	574 467	100
Pike-perch	18 800	2.0	936 565	98.0	955 365	100
European eel	1 350	0.2	783 375	99.8	784 725	100
Total	70 550	3.0	2 244 007	97.0	2 314 557	100

a Based on the assumption that sport fishermen kept all of these three species rather than returning them to the water

Source: Van Ginkel (1982)

Public participation in sport fishing is far less in the Netherlands than, say, in the Scandanavian countries, but after the second world war Dutch sport fishing increased decidely and became one of the top outdoor activities. It rose to 545 413 licensed anglers in 1964–75 (about 4 percent of the total population), to 982 000 (7.1 percent of the total population) in 1977–78, and to over one million circa 1980. Another 650 000 (people under 15 years of age) required no licence to fish with one rod. In addition, there were estimated to be 300 000–400 000 illegal anglers (Steinmetz, 1982). Based on an estimated population of 14 082 000 in early 1980, the number of licensed sport fishermen in the Netherlands would have been about 7 percent, but the number of persons actually fishing was considered to be about 2.1 million or about 15 percent of the total population.

In 1983/84 there were about 918 000 licensed sport fishermen, but this number had decreased to only 741 000 in 1984/85, to 718 000 in 1985/86, 614 000 in 1986, and to about 605 000 in 1987 (Steinmetz, 1988). With only about 4.2 percent of the estimated population in 1986 licensed, such a decline is unusual. Among the reasons given by people for their non-participation in this sport were: that they had changed to other forms of recreational activities; that they had no time; or that they scarcely ever fished (personal communication by Dr B. Steinmetz, May 1990).

In the Netherlands, where space is at a premium, foreign fishermen have not been encouraged - as they are in some European countries.

Studies by de Groot and van Haasteren (1979) and van Haasteren and de Groot (1982) discuss the factors limiting the extent of sport fishing in the Netherlands restriction of fishing rights or entry, inaccessibility, unfishable slopes, unsuitable depths, too much overgrowth, poor water quality, utilization by other parties, etc. About 15 percent of the Dutch population go fishing once or several times a year, and on a “standard day” there are 110 000 people fishing - thus indicating the “required number of fishing places”. They consider that only about 11 000 km of a total shore length of 35 500 km is available for sport fishing. On the assumption that 25 m is the space required between anglers, they estimate that there is technically enough space for 434 000 fishermen to practice shore-fishing simultaneously.

Table 10

Commercial catch from Lake IJssel, 1986 and 1987 (in tons)[a]

	1986	1987
Cyprinids	779	1 284
European perch	538	488
Pike-perch	58	111
European eel	775	538
European smelt	1 881	2 317
Total	4 011	4 738

[a] Fishermen are not obliged to sell their catches via official markets. About 30–50 percent is sold directly to traders

Source: Steinmetz (1988)

Table 11

Estimated annual catches by sport fishermen at Lake IJssel based on surveys made in 1976 and 1977

Species	Number	Percent
Bream and white bream	100 000	6.7
Roach	914 000	61.6
Chub and orfe	7 500	0.5
Common carp	1 000	0.1
European perch	375 000	25.3
Pike-perch	54 000	3.6
European eel	33 000	2.2
Total	1 484 500	100.0

Source: Van Ginkel (1982)

Of the total available inland waters (151 000 ha excluding Lake IJssel) fishing rights for 93 600 ha are in the hands of organizations of sport fishermen and 28 000 additional ha are accessible to them by permit. In 102 000 ha of the 151 000 ha, fishing with one “normal” rod for fish such as the cyprinids is free because these waters are navigable streams with regular traffic of persons or goods of economic value (Steinmetz, 1982a).

Although the social aspects of sport fishing in the Netherlands have received more study than its economic aspects, it was estimated in 1974 that the gear of about

790 000 licensed fishermen was worth U.S.$ 12 million, and their boats and trailers an additional U.S.$ 6 million (Steinmetz, 1982a).

7.2 Aquaculture

Several species of fish are cultivated in the Netherlands, but about 90 percent of their production is used to stock waters for the benefit of anglers. Fish which have been cultivated for this purpose include: rainbow and brown trout, pike, common carp, rudd, grass carp (Ctenopharyngodon idella), European perch, and pike-perch. For example, in 1983, the Organization for Improvement of Inland Fisheries (OVB) reared and stocked the following: common carp (54 t), grass carp (31 t), rudd (5.5 t), pike (473 000), perch (49 200), and pike-perch (111 700). The number of fish stocked from year to year depends on the weather, predation from birds, and other factors; for example, in 1982 no perch were stocked but 10.5 t of rainbow trout were planted (Steinmetz, 1984; Organisatie ter Verbetering van de Binnenvisserij, 1984). Transfers of fish from open waters are also made, e.g., bream, roach and eels caught at outlets to the sea. The bream are sometimes removed to stimulate growth in the remaining population, and to decrease competition for benthic food with the commercially valuable eel. Conversely, roach caught by commercial fishermen are transferred to sport fishing waters. However, recent studies are beginning to question the efficacy of such measures as well as that of stocking pike -as opposed to habitat improvement (see Cazemier, 1984; Grimm, 1984; Riemens, 1984).

Pinot and Kirk (1982) say that the Netherlands produces 50 t of trout annually for commercial purposes. Brown (1983) states that 50–60 t of rainbow trout are cultivated commercially in the Netherlands for annual sale as food fish, and that negligible quantities are exported. Fish Farm. Inter., 12(2) (1985) says that in 1983 the Netherlands raised 200 t of freshwater trout, 50 t of seawater trout, and 90 t of eel. The FES (1989) does not list the Netherlands in its tables of trout and salmon production, but Steinmetz (1986) provides a rough estimate of 200 t of salmonids and 100 t of eel as raised for consumption in the Netherlands in 1984, and Steinmetz (1988) lists a similar production of salmonids as 200 t in 1986 and 190 t in 1987 and of eel as 100 t in 1986 and 200 t in 1987. FAO Fish.Info. Data and Stat.Serv. (1989) provide the following data on production of fish from aquaculture in the Netherlands during the 1984–87 period: Clarias spp. from 20 t (1984) to 300 t in 1987; European eel from 20 t (1985) to 200 t in 1987; European eel from 20 t (1985) to 200 t in 1987; rainbow trout from 150 t (1984) to 200 t in 1987. There is also some put-and-take trout fishing on some Dutch farms.

In culturing fish in the Netherlands, ponds, raceways (for trout), glass houses, recirculation systems, and cages utilizing power plant effluent have all been used.

The African catfish, Clarius gariepinus (formerly C. gazera) has recently been introduced to commercial fish culture in the Netherlands. Steinmetz (1966) gives a rough estimate of its production in the country as 15 t in 1984, 90 t in 1985 and Steinmetz (1988) lists its production for consumption as 300 t in both 1986 and 1987. This catfish has the advantage of tolerating low oxygen levels, and having a good food conversion, but it presents a severe marketing challenge in the Netherlands with respect to its acceptability.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership, Availability and Licensing

8.1.1 Fishing rights as a rule belong to the owner of the water. The owner may be the State, Province, a local authority, a foundation, private person, etc. There are, however, some waters (mainly along river banks) where the fishing rights are separated from ownership of the water due to historical rights established before 1838. Since then, separation of the two rights is forbidden by law.

A fisherman is authorized to fish in a certain water only if he owns the fishing right, or has obtained it by tenancy agreement, or if he is the holder of a permit obtained from the owner of the right. No such permit is required for use of one "common rod" (see below) for fishing in waters frequently used as navigable waterways.

Transfer of fishing rights by lease or permit is possible with approval by the Chamber for Inland Fisheries (see section 8.4).

8.1.2 Licensing. Fishing in inland waters either commercially or for sport requires a governmental certificate which is issued through the postal offices. The following licences are required:

(i) "Large fishing licence" (grote visacte) for all types of fishing permitted by law, e.g., with gill or fyke nets;

(ii) "Minor fishing licence (kleine visacte) for fishing with two rods, a bob, spinning and live bait;

Children under fifteen years of age do not require an angling licence.

[1] Based on Gaudet (1974), information received by EIFAC from the Netherlands (1979), Steinmetz (1982a), Röell and Teulings (1983), and Netherlands/EIFAC (1989)

8.2 Legislative Authority

The Dutch Fisheries Law of 1963 with decrees and possible revisions is a direct responsibility of the Minister of Agriculture and Fisheries (see below). It covers all regulations with respect to: legal sizes, seasons, licences, gear, the tasks and responsibilities of the OVB (see section 8.5), etc.

8.3 Administration

The administration of all fisheries in the Netherlands rests with the Ministry of Agriculture, Nature Management and Fisheries.

Two Departments are responsible for inland fisheries:

(i) The Directorate of Fisheries for the governmental policy concerning fish stocks and commercial fisheries, and

(ii) Directorate of Outdoor Recreation for sport fisheries.

8.4 Other Concerned Governmental Agencies

(i) **Netherlands Institute for Fisheries Research**. Part of the Ministry of Agriculture, Nature Management and Fisheries, it is responsible for fisheries research;

(ii) **Chamber for the Inland Fisheries**. All agreements concerning fishing rights either by lease or permit require approval by this Chamber (created in 1955).

Its main tasks ordered by Fisheries Law are to control agreements for the effectiveness of fishing proposed for a specific body of water, and to protect professional fishermen against unsuitable prices.

(iii) **Institute for Land and Water Management Research**. The behavioural aspects of sport fishermen are considered in relation to land development projects and studies.

(iv) **Limnological Institute Tjeukemeer Laboratory**

(v) **Delta Institute for Hydrobiological Research, Royal Academy of Sciences**. Estuarial changes

(vi) **Research Institute for Nature Management**

(vii) **Directorate-General of Nature Conservation, Recreation and Media** (Ministry of Culture, Recreation and Social Welfare). Responsible for total outdoor recreation including creation of some facilities for sport fishing. The Ministry also makes laws concerning a number of fish species forbidden to catch (in most cases of no importance to fishermen).

8.5 Semi-governmental Organizations

(i) **Marketing Board for Fish and Fishery Products**

(ii) **Board of Fisheries Industry**

(iii) **Organization for Improvement of Inland Fisheries (OVB).** Created in 1952, its aim is to improve inland fisheries through education, extension to fishery managers, stocking and other measures, such as financial support focused on improvement of the fish stocks or fishing water.

(iv) **Institute for Fishery Products**

8.6 National Organizations of Sport and Professional Fishermen[1]

(i) **Dutch Union of Associations of Sportfishermen (NVVS)**

(ii) **Central Dutch Organization of Sportfishermen (CNHV)**

(iii) **Association of Fishermen on Lake IJssel and Adjacent Lakes**

(iv) **Association of Freshwater Professional Fishermen**

[1] There are about 25 regional federations of sport fishermen clubs leasing waters of more than local importance, and close to 1 000 clubs responsible for management of stocks in smaller local water bodies. The latter, about 2 000 in number, have a total area of about 100 000 ha (Steinmetz, 1982)

8.7 Management

Since 1970, eel and (sometimes) tench management is in general the responsibility of professional fishermen, while the general responsibility for the management of other inland fish is in the hands of the sport fishermen. In 1984, it was estimated that some 5 000 people were concerned in the management of inland fish stocks in the Netherlands: most of them members of angling clubs and about 300 commercial fishermen (Steinmetz, 1982; 1984).

8.8 International Agreements

The outlines of an international statute dealing with the Maas and Schelde with respect to their use by the Netherlands and Belgium were laid down in 1839 and amended since then. Negotiations with respect to new treaties were still in progress in

1983. A Dutch-Belgian Commission was established in 1978 to study matters arising from the management of small rivers and groundwater extraction.

A Permanent Boundary Water Commission was set up in 1963, under the aegis of the Dutch-German Border Treaty, to deal with mutual interest in water management such as the hydrological regime of the rivers.

The Netherlands belongs to the International Commission for the Protection of the Rhine against pollution, established in 1950, given legal authority by a treaty signed in 1963, enhanced by other treaties completed in 1976, and signed by the Netherlands, France, the Federal Republic of Germany, Luxembourg, Switzerland, and the European Economic Community (EEC). The International Commission is charged with drawing up permit and discharge standards and will fix the maximum tolerable levels of pollution. The Netherlands also belongs to the Central Commission for Navigation on the Rhine to guarantee freedom of navigation on this river and signed by interested countries in 1868. Members also include France, the Federal Republic of Germany, Switzerland and the UK.

9. STATE OF THE FISHERY

9.1 Yield

The yield per unit surface area for one of the most important inland fish in the Netherlands, the European eel, has varied considerably depending upon the year and area. In Lake IJssel, the yield of eel during 1954–62 (when the lake area was 220 000 ha) was around 10 kg/ha/year according to Tesch (1977), still about 10 kg/ha/year in 1967 (Deelder, 1970). But in 1977, the yield of eel from all types of fishing in Lake IJssel (assuming an area of 200 000 ha) was only 3.9 kg/ha/year (see Table 9). This is approximately the same yield (3.8 kg/ha/year) of eel to be calculated from the commercial catch data shown for 1986 in Table 10. Meanwhile, according to Deelder (1970), another Dutch lake had a yield of about 20 kg/ha/year of eel in 1967, and yields of eel to about 60 kg/ha/year are known from some Dutch areas.

Some concepts of changes in both total catch and yield per unit area can be obtained by noting some of the changes in catch of other species that have occurred at Lake IJssel - especially important because IJssel comprises almost half of the Dutch inland waters. Netherlands/EIFAC (1974) pointed out that the catch of European perch in IJssel rose from 186 t in 1971 to 588 t in 1973, while during the same period pike-perch catches declined from 1 207 t to 660 t. The yields per hectare for these two species would then be as follows: for perch, 0.94 in 1971 and 2.9 in 1973; for pike-perch, 6.1 in 1971 and 3.3 in 1973[1]. Willemsen (1977) notes the trend for perch in Lake IJssel from 0.7 kg/ha/year in 1970 to 4.0 kg/ha/year in 1975. Commercial yields per year per hectare from these two species as calculated from Table 10 are as follows: perch - 2.7 kg in 1986 and 2.4 kg in 1987; pike-perch - 0.3 kg in 1986 and 0.55 kg in 1987.

[1] Based on data in Willemsen (1977), I assume that the area of Lake IJssel in 1971 and 1973 was 198 000 ha

However, the figures given above should by no means be considered exact. See especially the footnote to Table 10. Furthermore, writers do not seem to agree on the area of Lake IJssel. For example, Steinmetz (1988) records its area as 180 000 ha on one page (p. 67) and as 200 000 ha on page 68.

Table 9 lists some catch estimates at Lake IJssel for 1977 which show a total yield of almost 11.2 kg/ha/year for the species of most interest to commercial fishermen. It will be noted that the total catch by sports fishermen in this lake in 1977 was only 3 percent of the total catch, a negligible quantity - making a total yield of these desirable fishes of only 11.6 kg/ha/year.

The overall catches from inland commercial fisheries, as reported in the FAO Yearbook of Fishery Statistics (Table 7) declined decidedly during the period of 1965–87 - from a high of 15 900 t in 1966 to only 1 856 t in 1978. The decline is represented primarily by a reduction in the catch of a group of species not identified in the catch statistics but believed to be composed mainly of minor cyprinids. The catch of eels has also declined decidedly, from 2 700 t in 1967 to only 552 t in 1979.

The statistics cited may not indicate any startling decline in the fisheries for other desirable species. Fluctuations such as those for pike-perch, for example, which are very high, may be due to dominance of year-classes (Netherlands/EIFAC, 1974; Steinmetz, 1988). On the other hand the eel stock of Lake IJssel seems to be almost depleted by the fishery (Steinmetz, 1988).

9.2 Factors Affecting the Fishery

The small size of the Netherlands, its dense population and intensive use of land and water, and the overwhelming fact that most of its freshwater supply originates from outside the country - well beyond the capacity of the Dutch alone to improve its quality - are basic elements in determining fish production.

Lack of suitable spawning grounds and the generally eutrophic waters restrict salmonoid production, the turbid waters favour such species as pike-perch, and brackishwater conditions in some areas even favour the catch of such species as the flounder (Pleuronectes flevus). On the other hand, some of the cyprinids which thrive well are unappreciated by the Dutch fisherman.

Although much of the country is fundamentally deltaic, a normally favourable condition for many inland fisheries, the original hydrographic pattern has been altered for centuries and is continuing to be altered. Meanders have been shortened, overflow areas curtailed by levees and drained, and large salt and freshwater areas have been reclaimed to furnish agricultural land - all measures that have reduced aquatic habitat. Conversely, some salt water areas have been converted into freshwater lakes.

The heavy pollution in parts of the Netherlands is also to a large extent, a result of its geography. Lying as it does, at the bottom of Rhine-Maas system, it derives a large portion of its polluting agents from the heavily industrialized upstream countries[2]. In addition, intensive use of its inland waters for transport and both planned and inadvertent disposal of effluents further lower its productivity for fish. As in many other European countries, the diminution of phosphorus loading is being practiced to lower eutrophication. For example, in the Loosdrecht lakes, water will be replaced by a supply in which the P concentration has been lowered (Van Liere et al., 1984). Today almost all effluents are treated in water purification plants, in some cases, even with a third phase purification to diminish the phosphate load on recipient waters.

[2] In addition to a treaty aimed at lowering the salt content of the Rhine (section 8.8), the Dutch Government has recently contributed 34 percent of the cost of storage in the ground of salt emanating from potassium mines in France which are being discharged into the Rhine

With a yearly total discharge from its rivers of 90 000 million m^3, the annual runoff per caput is approximately 6 102 m^3. However, if one considers only the runoff originating within the Netherlands, one derives an annual runoff per caput of only 678 m^3.

Aside from pollution, the formerly abundant anadromous fish population, especially that of Atlantic salmon in the Rhine, has been decimated by water regulation (through dams and canalization, spawning areas were lost) and by the presence of barriers to migration. Conversely, the spread of fishes, especially exotics, has been greatly facilitated by the numerous water connexions.

Apart from Lake IJssel, the present area of inland waters that can support the fish stock is not more than about 151 000 ha. Consequently, fishing pressure, especially in the rest of the country, is severe. The Governmental policy now tends to separate eel fishing mainly reserved for professional fishermen, from fishing for other species, mostly reserved for recreational fishermen.

The yield from inland fisheries in the Netherlands is greatly affected by the continual changes in the quantity of surface waters available (it has actually been increasing) and in its quality - whether due to pollution, changes in salinity, or rises in temperature caused by thermal power stations. A decline in vegetated areas is considered responsible for the continued decline of pike. Water level management for agricultural purposes in Dutch polders and eutrophication are considered to be the major reasons for this decrease.

The management of these fisheries requires a careful but continually changing programme. It includes: habitat improvement including pollution control and weed removal, maintenance and construction of fish passes, stocking and transfer of stocks to augment natural propagation, introduction of exotics and hybrids, changes in fishing regulations, provision of fishing space and better access including launching sites, and changes in depth and slopes at fishing areas. Such measures are, of course, not unique to the Netherlands, but its changing ecological and sociological conditions bring them into intense multiple play.

As Gaudet (1973) and Steinmetz (1982a) have summarized the situation, until about 50 years ago in the Netherlands, inland fisheries were mainly in the hands of professional fishermen, and the fishing effort was well spread over all species of which the fish stocks were composed. Several factors have, however, changed this picture completely. Canalization and pollution of the major rivers and their tributaries have put an end to the great salmon fisheries, and affected the wellbeing and economic value of other species, especially trout, shad, eel and some coarse fishes. Secondly, there has been some overfishing and fishing has become more selective. Apart from a certain amount of bream, roach and carp, cyprinids are hardly caught commercially now because there is no market for them. This opens the door to unbalanced fish populations with all its dangers. finally, since the second world war, and in part due to the creation of new cities coupled with land reclamation, the development of recreational fisheries has been explosive. Furthermore, in some areas, its growth has been at the expense of commercial fisheries.

9.3 Prospect

The general prospects for future water use, as well as their implications for fisheries, have been outlined in section 6. There are, of course, some overwhelming difficulties concerning the provision of water of good quality for fisheries - especially when about 90 percent originates outside the borders of the country and reaches them in a severely polluted condition. However, in recent years some far going agreements have been reached between the several Rhine countries concerning both pollution and habitat improvement[1]. Furthermore, the Netherlands has set some firm goals toward overall water improvement. According to Johnson and Brown (1976), “In general the national goal is that water should be of adequate quality that, when treated, it can serve as the basis for drinking water and be usable for industrial purposes and suitable for agriculture and for recreation and for fish propagation…” Steinmetz (1986) points out that the Netherlands now say that all inland waters have a function for the life of fish and for recreational and economic use. They were headed for achievement of a “cyprinid” quality within three years.

[1] It is noted that in 1987 the following concentrations, in mg/l, prevailed at certain stations in two major Dutch rivers which originated in other countries. In the Rhine (at Lobith) dissolved oxygen had a mean of 9.3 and a minimum of 6.2, and BOD a mean of 2.0 and maximum of 3.8. Corresponding measurements in the Maas (at Eysden) were: oxygen 9.7 and 4.9, and BOD 2.5 and 6.2. (Centraal Bureau voor de Statistiek, 1989)

There does indeed appear to be progress in the control of water pollution in the Netherlands. For example, as measured in terms of min population equivalents, both the total gross discharge of oxygendemanding materials discharged with waste water and the load upon the surface waters was far less in 1975 than in 1970, and by 1985, the total gross discharge of such materials was only about 75 percent of that in 1975, and the load on surface waters was less than 40 percent (Central Bureau of Statistics, 1989). Furthermore, the linkage of the Netherlands's goals for improving surface water quality with other aspects of inland fishery improvement appears to be optimistic. For example, planned improvement of fish passage devices in the Maas River (replacement with fish locks) will not be very useful unless water quality also improves.

Sport fishing is now considered to be very important as open-air recreation for the Dutch people deserving serious attention in urban and country planning. “Planning” is now considered to be a “normal” process in the Netherlands, and both the biological and recreational aspects of sport fishing receive consideration. Thus, as new areas are reclaimed, especially in the Delta and the Waddenzee, planning for fishery development is an integral part of the overall planning, and sociological studies of angling rank high in Dutch fishery research. Emphasis is now placed on the close proximity of fishing areas to dwelling areas and to the improvement of angling facilities.

Recreational fishing will continue to be the major fishery concern in the inland waters of the Netherlands - sustained by sound but flexible management practices. As demands for water increase, it will require highly sustained effort to maintain the fishery in even a semi-natural condition.

Aquaculture will continue as a minor concern, with particular emphasis on eel culture which is undergoing expansion and on a growth in catfish culture.

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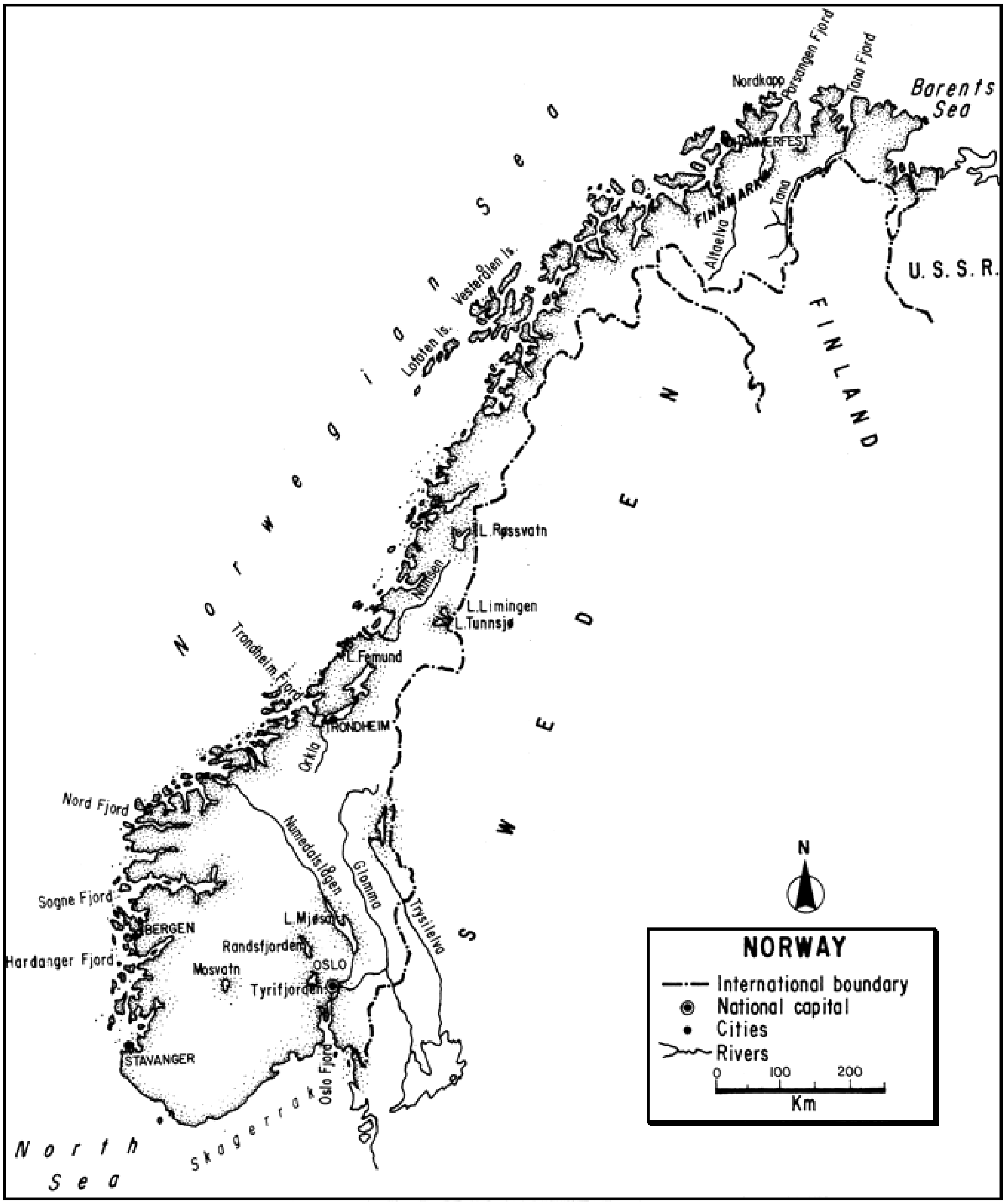

NORWAY
International boundary
National capital
Cities
Rivers
0
100
200
Km
N
Norwegian Sea
Barents Sea
North Sea
Skagerrak
SWEDEN
FINLAND
U. S. S. R.
Nordkapp
Porsangen Fjord
Tana Fjord
HAMMERFEST
FINNMARK
Tana
Altaelva
Vesterålen Is.
Lofoten Is.
L. Røssvatn
Namsen
L. Limingen
L. Tunnsjø
Trondheim Fjord
L. Femund
TRONDHEIM
Orkla
Nord Fjord
Numedalslågen
Glomma
Trysilelva
Sogne Fjord
BERGEN
L. Mjøsa
Randsfjorden
Hardanger Fjord
Mosvatn
OSLO
Tyrifjorden
STAVANGER
Oslo Fjord

NORWAY

The Kingdom of Norway faces the Atlantic shore of the Scandinavian Peninsula, its extremely long coast sheltered by thousands of islets and indented by deep fjords. From the coast, the land rises abruptly to a series of high barren plateaux and ranges separated by a ridge from Sweden on the east. With one-third of its area above the Arctic Circle and elevations to almost 2 500 m, the terrain of Norway ranges from frozen tundra and glacial fields to forested river valleys in the south.

Poor agriculturally, its natural wealth lies in an abundance of water (hence hydroelectric resources), offshore gas and oil, timber and minerals. Industrially, it is a major shipbuilding and trading nation and has important marine fisheries.

Over five percent of the country is occupied by fresh waters, mainly short, swift rivers and about 300 000 lakes and tarns. Supporting good inland fisheries, especially for salmonids such as trout and chars, its Atlantic salmon fisheries have been famous both commercially and for sport for many years.

Low population density and relative inaccessibility protect many of its fisheries, but of late years, acid rains threaten many of its inland waters.

Aquaculture, especially of salmonids in sea water, is a fast growing industry.

1. AREA: 323 895 km^2[1]

[1] This is the area of continental Norway, including 22 327 km^2 of coastal islands. In addition to this area, the country has sovereignty over an island area in the Arctic, Svalbard (62 700 km^2) and Jan Mayen (380 km^2), and some islands in the Antarctic. There is some fishing for anadromous char (Salvelinus alpinus) in the Svalbard area

2. POPULATION: 4 177 000 (est. 1990) Density: 12.9 inh/km^2

3. PHYSICAL GEOGRAPHY

Norway, situated in northwestern Europe, extends from 57°57'31" to 71°11'8"N latitudes and from 4°30'13" to 31°10'4"E longitudes. One third of the country is north of the Arctic Circle.

Occupying the western and northernmost portion of the Scandinavian Peninsula, its greatest length (N–S) is 1 752 km, its greatest breadth is 430 km and its narrowest 6.3 km. Its altitudinal range is from sea level to 2 469 m. Thirty percent of the mainland is below 300 m, the average height is about 500 m, and 20 percent is over 900 m.

Fronting on the Atlantic, Norway's sea boundaries are the Skaggerak on the south, the North Sea and the Norwegian Sea of the Atlantic on the west, and the Barents Sea of the Arctic Ocean on the north. With respect to land, it is bounded for most of its eastern length by Sweden for 1 619 km, and in the extreme northeast by Finland for 727 km and the USSR for 196 km[2].

[2] The lengths of these boundaries are taken from Statistik Sentralbyrå (1987)

The coast of Norway's mainland, mostly cliffbound, is extremely long. Disregarding bays and fjords it is 2 650 km in length; when these are taken into account it is 21 347 km. The coast is protected by extensive belts of low-lying islets or skerries. Of about 150 000 islets and large rocks constituting this system, estimated as having a coastline of 35 659 km, the Lofoten and Vesteralen groups are the largest components.

The Scandinavian Peninsula is a block of ancient granite and gneisses tilted slightly to the east. This results in a long eastern slope (across Sweden) toward the

Baltic, and a shorter more precipitous western slope (across Norway) down to the Atlantic.

Thus, from most of Norway's narrow coast the surface rises precipitously to high plateaux and ranges, with a ridge following the boundary with Sweden. In the south, however, Norway includes both sides of the block as well as the broad upland between the slopes. The upland areas (fjells) which are generally bare of soil and vegetation are more like plateaux than rugged mountains.

Of several ways to describe Norway's physiographic regions, the simplest is to divide them into: (i) the coastal region, north of the Trondheim Fjord (64°N) - a narrow, mountainous fringe with islands and rocks often covered with snow; (ii) the western fjord region south of Trondheim; (iii) an interior lofty area of fjells or plateaux and lakes, and (iv) a southeastern lowland with valleys draining into the Oslo Fjord.

The western region is cut into long, narrow, deep, steep-sided fjords - old glaciated river valleys which are now fingers of salt water.

The fjells, generally composed of bare rocks, low pasture and bogs, also contain a variety of shallow, irregular lakes. The southeast lowland has more clays and sands, is partly forested, and supports most of the population.

With respect to vegetaton, there are five natural regions: (i) a treeless coast covered with grass and shrubs, (ii) deciduous forests (of which birch, aspen, and alder are the most important) to the east, (iii) coniferous forest mostly farther inland and to the north, (iv) dwarf birches and willows in the north and at higher altitudes, and (v) grasses, mosses and lichens in the coldest areas.

Most of the country is composed of a complex of ancient igneous and metamorphic rocks which has been severely glaciated to create cirques, aretes and U-shaped valleys. There has, however, been little deposition of glacial material and the soils are scanty or poor. The rock base is largely impervious and produces little ground water. Peat bogs are extensive. Norway still has about 1 700 glaciers, which with ice caps cover about 3 100 km^2. The largest ice field is the 486-km^2 Jostedalsbreen.

4. CLIMATE

For a country lying as far north as Norway, the climate is quite mild because of the North Atlantic drift of warm water and air. On the west coast the climate is marine temperate with cool summers, mild winters, high precipitation and a mean annual temperature of 7°C. To the east the climate is an inland type with warm summers, cold winters and less precipitation. Temperatures in July vary from about 10°C in the north, to 14°C at Bergen on the southwest coast, and a mean of 16°C at Oslo. The January mean is about 3°C above North Cape (the extreme north), 1°C at Bergen and falls to about -10°C in central Norway.

The precipitation averages about 1 450 mm annually, rather evenly distributed throughout the year with spring the driest season. Geographically, however, it is more variable. In the mountains of the southwest it reaches as much as 6 000 mm per year (the highest in Europe) but in the far north and lee of the mountains the precipitation including snow does not exceed 250–300 mm per year[1].

[1] Enhancement of precipitation by mountains is a factor in the deposition of acid in rain and snow along their windward flanks. This is particularly true in southern Norway where major air masses from the British Isles and central Europe travel over the North Sea and areas of low relief before most of their pollutants are removed in a belt 100 to 200 km wide along the mountainous Norwegian coast (Likens, et al., 1979). See section 9.2 concerning acid rain

Most of the country is covered with snow from December to March except along the coastal strip. On the high plateaux the snow may lie for ten months near permanent icecaps. The snowline is low everywhere, ranging from below 915 m in the extreme north to 1 525 m in the south.

The North Atlantic drift of warm saline water keeps the coast ice-free all year. (The salinity in most areas of the Norwegian Sea is close to 34.9 ppt and that of the North Sea, 34–35 ppt.) The fjords are not penetrated by cold water from the open sea and neither the fjords nor the streams near the coast generally freeze. There is, however, a long period of ice-cover on interior streams and lakes; e.g., on Lake Øvre Heimdalsvatn, at 1 090 m in southern Norway, there is an ice-cover from mid-October to mid-June.

The growing season, based on frost-free days, is about 125 days in parts of Finnmark, rising to 305 days in the extreme south. Based on the average period with temperatures above 3°C between spring and autumn, it is about as follows, proceeding from north to south: Finnmark - 150 days; Trondheim - 160 days; Bergen - 260 days; southwest coast - 300 days, and Oslo - 190 days.

The winter nights are very long but there is almost continuous daylight from May through July above the Arctic Circle. There are long periods of cloud cover over most of the country. The evaporative rate averages about 250 mm annually, decreasing to 100–150 mm in the far north.

5. HYDROGRAPHY AND LIMNOLOGY

Well supplied with rivers and lakes, recent estimates of the total area of inland water in the country centre around 5 percent of the total area of continental Norway. Key (1956) states that 4.6 percent consists of a freshwater surface, Columbia Lippincott (1966) states that it is 4.75 percent, Anon. (1969) states that Norway has a freshwater area of 15 646 km^2 (4.8 percent), and the source for Table 4 that it is 16 360 km^2 or 5 percent. It is obviously some figure above all these, since a more authentic estimate (Statistik Sentralbyrå, 1983) states that the area of Norway's freshwater lakes alone is 16 390 km^2 or 5.06 percent of mainland Norway.[1]

[1] Norway/EIFAC (1989), on the basis of a questionnaire to someone in Norway, lists the total surface area of inland waters in Norway as 948 000 ha (9 480 km^2) composed of 1 640 km^2 of lakes, 5 000 km^2 of reservoirs and 2 840 km^2 of rivers. Such figures, which contrast decidedly with those already given, appear to be unacceptable

The approximate annual runoff from rainfall is 1 250 mm or 405 000 million m^3. Upstream countries contribute 8 000 million m^3 so the total annual river discharge leaving Norway is 413 000 million m^3 (Van der Leeden, 1975; ECE, 1978).

With the Scandinavian Peninsula tilted generally to the southeast, a ridge-like area (in part) called the Kjølen or keel separates the long slow rivers flowing across Sweden from the generally short rapid western rivers of Norway.

5.1 Rivers (Vassdrag)

Norway has about 1 000 main rivers. The longest of these are listed in Table 1.

Table 1

Longest rivers and largest lakes in Norway

Rivers	km	Lakes[a]	km^2
Glomma	598	Mjøsa	368
Tana (with Anarjokka)	360	Femund	210

Numedalslågen	337	Røsvatn	201
Dramsvassdraget	309	Randsfjorden	145
Skienvassdraget	244	Tyrifjorden	136
Otra	242	Snåsavatn	118
Namsen	210	Tunnsjø	99
Arendalsvassdraget	209	Limingen	96
Altaelva	200	Øyeren	87
Gudbrandsdalågen	199	Nisser	77
(above Mjøsa)		Mosvatn	74
Orkla	179	Iesjavri	68
Vefsna	160		
Trysilelva (to border)	132		

[a] Areas of regulated lakes refer to highest regulated water level

Source: Statistisk Sentralbyrå (1987) for all lengths and all areas except those for Mosvatn and Iesjavri which are taken from Statistisk Sentralbyra (1983)

Most of the rivers have small catchment areas (rarely more than 3 000 km^2), are short and swift, and drain westerly. Western streams generally run between steeply sloping walls (often in gorges 600 m deep), precipitously from the mountains to the valley and then rapidly to their mouths. The many waterfalls, especially on the shorter faster western streams are spectacular sights, but block the ascent of anadromous fish. Only in the southeast and north are the rivers of any length.

Southern and southeastern streams usually run rapidly from the mountains and rapidly down their valley except where - as is frequent - they are interspersed with lakes. Deep and sluggish rivers do not exist. Arctic Ocean rivers have gentle gradients, some rapids, but no important falls.

In the southeast there are several rivers more than 200 km in length. One of these is the Trysilelva which runs into Sweden where it is known as the Klarälven. Its total length is 652 km of which 132 km is in Norway. The country's principal river, however, is the Glomma. Rising at about 700 m near the Trondheim Fjord, it flows south to the Oslo Fjord and thus drains into the Skaggerak. With a catchment area of 41 000 km^2, it has an average flow of 704 m^3/sec and a length of 598 km (see Table 2). Another long river in this area is the Numedalslågen; rising in south central Norway, it runs for 337 km to the Skaggerak.

Table 2

Discharge of the Glomma River at Langnes, Norway (1930–40 and 1945–65)

Mean monthly discharge, m^3/s			
January	209	**Six-monthly average**	
February	158		
March	178	October–March	331
April	526	April–September	1 078
May	1 677		
June	1 476	Yearly average	704
July	1 126		
August	874	Mean annual runoff 1/s/km^2	17.5
September	787		
October	652		
November	447		
December	314		

Source: Van der Leeden (1975) after ECE (1970)

There are also two large rivers draining most of the north. One of these, the Altaelva, rises on the Finnish border and flows north for 200 km to the Alta Fjord on the Barents Sea. The other, the Tana (Tenojoki in Finnish) on the border of Norway and Finland, flows northeast for 360 km to the Tana Fjord of the Barents Sea.

Stream flows are generally high with respect to the area drained. For 38 rivers each draining more than 1 000 km^2 and representing in all little more than half the country, the average total discharge is no less than 4 000 m^3/sec. Owing to impervious terrain and steep slopes, runoff is rapid and variations in flow enormous. It is sometimes between 1 and 3 000 percent of the average. In the lake and reservoir areas, the flows are, of course, equalized to some extent. During the winter, many of the rivers freeze in their upper courses and rise rapidly during maximum rainfall and spring thaw to cause flooding unless they are controlled by lakes.

Most of the rivers have their maximum discharge in spring and the minimum in summer and late winter due to the precipitation regime and snow storage in winter. In the north there may be, however, two or even three discharge maxima due to snow melt in the forest regions ("home flood") and later due to the melting of snow and glaciers in the highest mountains ("mountain flood") western Norway, the large amount of precipitation during the year keeps a comparatively even discharge but there are still maxima.

5.2 Lakes (Innsjøer or Sjøer)

There are about 300 000 natural lakes and tarns in Norway, totalling about 16 390 km^2.

There are some cirque lakes in the high mountains and many irregularly shaped lakes on the undulating surfaces of the high plateaux. All of the large Norwegian lakes, such as Mjøsa and Tyrifjorden, owe existence mainly to glacial overdeepening of valleys. Lakes are most numerous in the southeast, strung out along the river valleys. Most of the river valley lakes of Norway are only expansions of the rivers and possess strong currents. Most of the lakes are long and narrow and of little area but of great depth. Norway has 35 lakes over 100 m deep, and many give soundings showing beds well below that of present sea level. Hornindalsvatn, for example, at an altitude of 55 m has a depth of 459 m below sea level.

In many cases, the low-lying lake near the head of a fjord is separated from sea water by a narrow neck of land which on further land subsidence would resemble the submerged sill characteristic of the underwater topography of the fjords (see section 5.4).

The lakes in the north and high interior freeze for varying periods each year, e.g., Djupvand at 975 m is often frozen throughout the year, and Haugatjern at 697 m in central Norway may be icecovered for 200 days. In the south, however, where the majority of the large lakes are situated, they become icebound only during severe winters.

The 12 largest Norwegian lakes are listed in Table 1, and some characteristics of the major ones are shown in Table 3. Of these lakes, Mjøsa, which has a retention time of six years, is the largest lake in Norway, and Hornindalsvatn the deepest lake in Europe and ninth deepest in the world.

Table 3

Some characteristics of seven major Norwegian lakes

	Altitude	Area	Mean depth	Max. depth	Length	Width	Volume
	m	km^2	m	m	km	km	km^3
Mjøsa	121	368	153	449	105	1.6–14.5	56
Femund	662	201	-	130	67.6	1.6–11.0	6.0
Tyrifjorden	63	136	-	295	-	-	-
Mosvatn	-	74	-	45	40.2	1.6–7.8	-
Hornindalsvatn	55	51.8	-	514	26	-	-
Tunnsjø	184	99	-	429	-	-	-
Bydgin	1 063	45.3	-	215	-	-	-

Sources: Encyclopaedia Britannica (1937), Myklebost and Strømme (1963), Columbia-Lippincott (1966), USSR (1978), Holtan (1978), Statistisk Sentralbyra (1982), Seip (1981)

5.3 Reservoirs (Vannreservoar)

Concrete dams of considerable size were started very early in Norway, one being built in 1890 and two others in 1915 and 1916. Data furnished to Van der Leeden (1975) list 11 major reservoirs in Norway as of 1973, with individual storage capacities ranging from 0.41 to 2.36 billion m^3 to total 10.43 billion m^3 and two others planned to hold 4.76 billion m^3. It is clear from the data, however, that at least some of these are natural lakes (e.g., Mjøsa). In Norway, many natural lakes (perhaps half of its lake area) have been impounded to provide and equalize water flow for hydroelectric production. The distinction between “reservoirs” and “lakes” is not as clear-cut as in some of the other (drier) European countries, but it is obvious that comparatively few impoundments have been constructed where the natural flows are low. They are concentrated where cheapest to construct, and are interconnected as part of a system.

5.4 Fjords

The fjords of Norway deserve special mention here because although they are now actually arms of the sea, they run far inland. Partially submerged glacial troughs, they are typically long, straight and narrow, with steep parallel sides and side arms and a shallow sill or threshold at the mouth[1]. With shallow water at their mouths (sills range in depth from a few metres to 100–200 m), they may be extremely deep farther inland. Most fjords do not exceed 600 m in depth, but the Hardanger Fjord has a depth of 884 m, and the Sogne Fjord has a maximum depth of almost 1 300 m.

[1] Some fjords in northeastern Norway lack sills

Fjords represent a balance between two layers of water: salt water of high density and salinity and the lighter fresh water from the land. The layering is most pronounced during the summer. Some fjords present special problems with respect to pollution in the deep water above (i.e., upstream of) the lower shallow section, which is subject to little change. The salt water mixes but little with the fresh water from the rivers floating above and out to sea. Effluents which sink to the bottom remain there, decaying and setting up anaerobic conditions.

The fjords provide migration paths for anadromous fishes and provide a variety of fishing.

The longest fjords in Norway are the: Sogne (204 km), Hardanger (179 km), Trondheim (126 km), Porsanger (123 km), Nord (106 km) and Oslo (100 km). Other well known fjords are the Ofoten, Lyngen and Varanger.

5.5 Canals (Kanal)

Although there are some canalized rivers - mostly connecting lakes - especially constructed canals are unimportant in Norway. Hard winters discourage their use. There are three principal canals, of which the largest is 104 km, used mostly for floating logs and by tourists.

6. LAND AND WATER USE

Table 4

Pattern of land use in Norway, 1986

	Percent
Arable and permanent crops	2.6
Permanent pasture	0.3
Forests and woodland	25.7
Other land (mostly mountains, snow and ice)	66.4
Inland water	5.0
Total	100.0

Source: 1987 FAO Prod.Yearb., 41, Publ. 1988

Norway is now about 75 percent urban and 25 percent rural. It derives about 70 percent of its income from industry and mining, construction, commerce and sea transport - thus minimizing its direct use of land and water.

With fertile zones constituting only about four percent of the total area, agriculture, on small holdings, is obviously a minor use of land (less than three percent). Dairying and production of livestock, hardy grains, hay, potatoes and some fruit are its principal activities. Steep slopes, heavy precipitation (and the presence of a thriving chemical industry) promote the substantial use of fertilizers, almost twice the European average. Their use as well as the discharge of effluents from industries associated with agriculture have adversely affected a number of inland waters. There is a little supplemental irrigation in some areas, about 92 000 ha (0.28 percent) of the country received irrigation in 1986. Most of this is sprinkler irrigation and some sewage water is used for this purpose.

With conifers (four-fifths Scots pine, the rest mainly spruce) covering one-quarter of the country, forestry is important, especially for the pulp and paper industry and as an export source. The total production of about 11.4 million m^3 of roundwood in 1985 is however still relatively low, ranking only eleventh in European national productivity. Felling does not exceed the rate of growth and there is considerable reforestation. One of the principal uses of Norwegian rivers is log floatation, which started on the Glomma in 1200 A.D. Thirty to forty million logs have been floated annually during spring and summer months, sometimes with adverse effects on fisheries. A great deal of water is needed in the pulp industry, about 1 000 t for one ton of pulp. The forest processing industry is also a source of water pollution.

Mining is restricted to a few minerals, primarily iron pyrites (a source of pollution), copper, zinc, ilemite and molybdenum[1]. The production of offshore oil and gas is highly important in Norway today, but has little effect on inland fisheries.

[1] Some coal is imported from Svalbard

Industry, which is increasing in importance, is rather concentrated, especially in the Oslo region, near large ports or near hydroelectric plants. Food, fish, forest products (especially pulp and paper), aluminium, using imported ores, ferro-alloys, electro-chemistry and electro-metallurgy are important industries as is shipbuilding. Great demands on water and hydroelectric power are made by some of these industries and pollution also stems from their activities. New industries are, however, encouraged to locate in the areas least sensitive to pollution, e.g., along the coast. For a discussion of Norway's very serious pollution from acid rain, see Section 9.2.

Offsetting the lack of coal and (until lately) oil, Norway is admirably situated for the production of hydroelectric power. Precipitation is ample and well distributed, the evaporative rate is low, winters on the coast are mild so that the streams do not freeze, there are great drops or falls to create a high head, the relatively impermeable rock makes unlined tunnels possible, and there are many lakes on the high plateaux for natural storage. Low head power is also produced on a few rivers with catchments large enough to produce sufficient volume. In 1985 there were 625 hydroelectric power stations in Norway. In 1989, the installed electrical capacity in Norway was 23 236 000 kW of which 22 991 000 (99 percent) was hydroelectric and the rest thermal. With much of the country's lake area regulated to develop electricity, 31 700 million m^3 of water were developed by 1966, and it is estimated that the total effective storage that can be constructed is 75 000 million m^3.

The terrain and climate in Norway make transport by either road or rail (about 4 275 km) difficult. Thus, although automobile ownership (381 per 1 000 persons in 1986) is fairly high, road development is among the lowest in Europe, only 0.26 km/km^2 in 1986. Consequently, large areas are left relatively untouched by a population three quarters of whom live within 20 km of the sea. There are about 1 600 km of inland waterways (1980) and water transport along the coast, on the fjords, and on some of the larger lakes (the rivers are seldom navigable) causes some pollution.

For many years, Norway has been one of the world's most important marine fishing nations. Although fisheries have lately constituted less than two percent of the GNP, the export value of fish and fishery products amounts to over 10 percent of the merchandise exports. Domestic consumption of fish for food is high, about 40 kg per caput per year (1987), accounting for over 10 percent of the nation's protein supply. Sport and household fishing are important in Norway's lakes and rivers which also have limited commercial fishing.

With respect to total water use in Norway, it was estimated in 1972 (by the Norwegian Water Resources and Electricity Board) that a total of 1 430 million m^3 of water was used as follows: industry 84 percent, municipal supply 14 percent, and agriculture 2 percent. Most of the domestic water supply is obtained from surface sources, there being little ground water available, but treatment is relatively rare. Sewerage is increasing, and a national programme called for all of the population to be served by sewage treatment facilities by 1990.

7. FISH AND FISHERIES

Like its neighbour, Sweden, Norway has a limited freshwater fish fauna - there are about 30 species - dominated by salmonoid fishes. In Norwegian lakes, the brown trout (Salmo trutta) is the commonest species and in tens of thousands of these lakes it is the single species present (Jensen, 1977). According to Aass (1984) the brown trout populations in Norway, especially in the high-lying forest and mountain regions are mainly the result of introductions going back to the Stone Age and continued today.

Other important fishes include the Atlantic salmon (Salmo salar), sea trout (S. trutta), char (Salvelinus alpinus), various coregonids (Coregonus spp.), grayling (Thymallus thymallus), European perch (Perca fluviatilis), pike (Esox lucius), burbot (Lota lota) and the European eel (Anguilla anguilla). Crayfish (Astacus astacus) are also taken, but their numbers have been affected by the crayfish plague, (Aphanomyces astaci) first noted in Norway in 1981.

7.1 Capture Fisheries

Although the brown trout is its commonest species, it is the anadromous Atlantic salmon which has made sport fishing in Norway world famous[1]. Norway has more salmon rivers than any other country; they include about 150 listed streams of which about 50 are suitable for sport fishing, and 75 percent of the rod catches are made in 10 rivers. Until recently, these waters have been extremely productive and their fish have been of large size. The world record Atlantic salmon taken by angling is a 36-kg fish from the Tana River and the world fly record, a 31-kg fish from the Arøy. The salmon run up the rivers mainly from the end of May through September. As has been indicated, the Norwegian salmon caught by angling are exceptionally large. Some Norwegian rivers also have fine runs of sea trout (Salmo trutta). Sea trout generally enter the rivers sometime later than do salmon, say from mid-July and continuing through September. The combined catch of these two species in the top Norwegian rivers in 1976 and 1986 is shown in Table 5.

[1] Norway also has some land-locked Salmo salar: the bledge of southern Norway and the smablank of the Namsen River (Laird and Needham, 1988)

Table 5

Catch of Atlantic salmon and see trout in the highest yielding Norwegian rivers (i.e., above 5 t in either year), 1976 and 1986 (in tons)[a]

	1976	1986
Tanavassdraget	164.5	67.9
Lågen (Numedalslågen)	28.1	24.6
Altavassdraget	22.2	14.4
Namsenvassdraget	18.9	11.7
Gaulavassdraget	16.7	24.2
Bondalselva	15.6	2.6
Driva (Sunndalselva)	11.6	5.7
Stjørdalsvassdraget	9.3	8.9
Neidenelva	9.2	9.4
Komagelva	7.8	1.7
Orkla	7.6	12.1
Stordalselva m/ Stordalsvatnet (i Åfjord)	7.5	5.4
Vefsna	7.2	2.5
Ørstaelva	6.4	2.1
Laerdalselva	6.3	6.7
Surna m/ Rinna	6.1	3.6
Rauma	5.3	1.0
Straumgjerdeelva m/ Velledalselva og Fetvatnet	5.2	1.6
Ogna	-	8.7
Håelva	-	8.1
Figgjoelva	-	7.2
Drammenselva	-	6.8

Målselvvassdraget	4.1	5.5

[a] Live or round weight

Source: Statistisk Sentralbyrå (1978, 1987) from NOS Lakse-og sjøaurefiske

Schwiebert (1975) states that the total catch of salmon spawned in Norwegian rivers was about 1 000 t each season in the first half of this century, with 85 percent taken in salt water commercial nets and traps or by trolling lines. The other 15 percent was taken in rivers mostly with sport fishing equipment but also with nets and traps. He further states that after mid-century, the annual catch in Norwegian waters doubled to about 2 000 t and continued at this rate for almost 20 years. The annual catch then dropped to about 1 000 t. He ascribes almost all of this decline to commercial fishing with drift nets and longlines (capturing 50 percent of the commercial catch) and simple bag nets for the other 50 percent. He says that there were only 100 bag nets in Norway a century ago, but that their number was almost 10 000 at the close of the nineteenth century and has ranged from 5 000 to 8 000 in this century.

Although net fishing is not permitted in the estuaries, it is allowed in the rivers where the fishing rights belong to the owner of the nearest shore. Set bag nets are the principal gear. Although commercial fishing with drift nets and longlines has been banned within the 12-mile limit, it is common farther offshore and bag netting in shallow waters continues.

Further to the fishing strain on Atlantic salmon, Berg (1977a) states that: "In Norway, the fishery in the sea takes such a large proportion of the salmon returning for spawning in their home river that in some rivers only the smallest possible number necessary to maintain a stock is left". Some steps have been taken since then to tighten the regulations on the catch of Atlantic salmon, and therefore, it is hoped, to increase the stocks in rivers, especially for anglers. Thus, in 1986 and again in 1988, the Norwegian Storting (Parliament) passed legislation placing a ban on drift nets, the use of monofilament for nets, the use of longline fishing, and prawn and worm fishing in Norwegian rivers, as well as restrictions on the riparian use of nets in rivers.

Catch statistics furnished by Norway with respect to Atlantic salmon, "trout" and another diadromous fish, the European eel (Anguilla anguilla) caught in marine waters by Norway are available in the FAO Yearbooks of Fishery Statistics (see Table 6). Comparison of the figures for Atlantic salmon in this table with those given above by Schwiebert (1975) seem roughly comparable.

Although Norway collects and publishes statistics on the catch of salmon and sea trout in its inland waters, the FAO Yearbooks of Fishery Statistics did not publish them until the advent of its Volume 52, which did list some of the inland fishery catches in Norway during the period 1978–81[1]. Thus, reference to the earlier volumes give one a misleading picture of this catch which is so important in Norway. Reference to the FAO Fisheries Department's Fishery Statistical Database (FISHDAB) will, however, provide "catch" figures in Norway's inland waters for Atlantic salmon and rainbow trout (Oncorhynchus mykiss) from 1970 onwards. These are reproduced here in Table 7. It seems quite clear, however, that they represent both actual catches (capture fishery) and the products of aquaculture. Simply compare these figures with those published directly by Norway (Tables 8 and 10) or sent directly to EIFAC by Norway (Table 9). With respect to Atlantic salmon, one example using 1975 statistics should suffice. The actual catch in Norwegian rivers for that year was 505 t (Table 9). If one adds this catch to the 862 t of salmon reared aquaculturally in Norway in that year (Table 10), one arrives at the sum of 1 367 t shown in Table 7 based on FAO data. In other later cases it appears that most, if not all, of the entire “catch” of salmon represented in Table 7 is actually aquacultural production. Note the close coincidence of figures in Tables 7 and 10; for example, the 17 604 t reported caught in 1983 (Table 7) with the 17 298 t reported as reared in 1983 (Table 10). Reference to these tables will also show that all of the rainbow trout listed in Table 7 are cultivated fish.

1 Depending upon the particular volume up to Volume 52, the catches in Norway's inland waters of Atlantic salmon were listed as “not available” or the species was unlisted. Similarly, Norwegian trout of any kind were unlisted during this period

It is best, therefore, to use Table 8 for catch records of salmon and sea trout by Norway in the country as a whole and in the rivers during the 1958–86 period. A breakdown showing the species composition of these catches in the rivers alone during the 1969–75 period appears in Table 9.

Table 6

Nominal catches of diadromous species in Marine Statistical Fishing Area 27 -Northeast Atlantic, by Norway, 1965–87 (in tons)[a]

	European eel	Atlantic salmon	Rainbow trout	Trouts n.e.i.[b]
1965	500	1 700	-	-
1966	500	1 600	-	-
1967	500	1 700	-	-
1968	600	1 400	-	-
1969	500	1 300	-	-
1970	400	1 000	-	-
1971	400	1 200	-	-
1972	400	1 700	-	-
1973	400	1 700	-	-
1974	383	1 400	-	-
1975	411	1 280	-	-
1976	368	1 099	-	-
1977	352	1 184	-	0
1978	347	817	-	0
1979	374	1 528	-	0
1980	387	1 563	-	0
1981	369	1 379	-	1
1982	385	1 087	-	1
1983	317	1 270	-	1
1984	309	23 236	3 569	5
1985	352	30 796	5 237	3
1986	271	46 142	4 384	0
1987	283	48 473	8 787	1

a The catches for salmonids listed for this area are obviously incorrect from 1984 through 1987. See text

b This category not included in FAO Fish.Stat. Yearbooks as a Norwegian “catch” in this area until Vol. 52

0 Probably nil, negligible or insignificant or less than half a ton

Source: 1965–69 Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–83 FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1984–87 Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

It will be noted in Table 9 that the reported catch of sea trout each year is quite consistent but that there has been a remarkable rise in the reported harvest of salmon during the 1973–75 period. According to Norway/EIFAC (1977), a substantial part of this rise was caused by a better “control” of fishing in the Tana River (Tanavassdraget) in Finnmark which had produced an apparent increase in yield from a “bottom” of 7 865 kg in 1971 to 184 327 kg in 1975. The dominance of the Tana catch in 1976 is shown in Table 5: it constituted almost one-third of the country's entire river catch of slamon and sea trout. However, the Tana River catch in 1986 - although still leading the country - had fallen to only 40 percent of its 1976 catch, and 18 percent of the entire river catch. Large swings in the harvest from other Norwegian slamon and sea trout rivers will also be noted.

It was noted above that the catch of European eel in Norway's marine waters is shown in Table 6. According to Gundersen (1979), the eel fishery in Norway is a small one. Most of the fishing takes place in the sea and these are the only catches included in Norwegian statistics although fishable stocks also occur in fresh waters. From 1920 to 1933, the landings increased from 80 t to about 700 t, and then declined to about 400 t in 1939. Since then, the highest catch has been 600 t in 1968, the lowest 102 t in 1945.

Table 7

Nominal catches by species in the inland waters of Norway, 1965–87 (in tons)[a]

	Atlantic salmon	Rainbow trout	Total
1965	...	-	
1966	...	-	
1967	...	-	
1968	...	-	
1969	...	-	
1970	200	0	200
1971	300	400	700
1972	400	800	1 200
1973	600	1 000	1 600
1974	1 089	1 726	2 815
1975	1 367	1 655	3 022
1976	1 899	2 045	3 944
1977	2 472	1 795	4 267
1978	3 805	2 105	5 910
1979	4 717	2 988	7 705
1980	4 607	3 668	8 275
1981	8 716	4 624	13 340
1982	10 984	4 627	15 611
1983	17 604	5 405	23 009
1984	352	-	352
1985	381	-	381
1986	363	-	363
1987	425	-	425

[a] The catches are obviously incorrect especially from 1984 through 1987. See text

... Data not available according to source; - Not listed in source

0 Probably nil, negligible, or insignificant; or less than 50 t

Source: 1965–69 Yearb.Fish.Stat.FAO, (36) (Publ. 1974)
1970–83 FAO Fish. Dept. Fishery Statistical Database (FISHDAB)
1984–87 Yearb.Fish.Stat.FAO, (64) (Publ. 1989)

The yield of crayfish has been estimated at 109 000 to 188 000 individuals per year (Jonsson, 1988)

It is obviously difficult to estimate the total catch of either anadromous or resident fish in Norway's inland waters. Not only is it difficult to secure accurate figures on even a single body of water (the Altaelva, for example, has about 300 landholders along the river) but virtually impossible to collect information on catch in the thousands of small water bodies in the country. Some estimates are, of course, made; thus MacCrimmon and Gots (1980) estimate that 650–1 000 t of resident char are caught annually. However, total catch statistics for strictly "inland" fish (i.e., nonanadromous fishes such as brown trout, char, pike and perch) are not available from any source.

Some indication of the magnitude of this inland catch may, nevertheless, be derived from some estimates based on the assumed catch per unit area of Norway's lakes. (The bulk of the "inland" catch is made in lakes and is primarily of trout.) In 1962 it was estimated that the annual yield per hectare from Norway's lakes averaged about 1.5–2 kg. Based on an estimated that lake area of about 15 000 km^2, the total inland catch (exclusive of sea-run fish) was then estimated at about 2 000–3 000 t (EIFAC, 1964). At a later date the average annual yield/ha of lake surface was reestimated at 2–4 kg/ha, providing a new estimate of total catch in Norway's lakes of 3 000–6 000 t (Norway/EIFAC, 1974, 1977), and in 1980 the total yield of Norway's inland fisheries was estimated to be in the order of 5 000 t (Swang, 1981).

Table 8

Catch of Atlantic salmon and sea trout in Norway, 1958–86

	in tons[a]		Value in NKr '000	
Year	River catch	Total catch	River catch	Total catch
1958	251	1 490	2 624	16 835
1959	209	1 404	2 240	16 006
1960	237	1 659	2 804	19 808
1961	198	1 533	2 395	19 236
1962	264	1 935	3 304	24 816
1963	233	1 786	2 818	22 138
1964	320	2 147	4 223	30 070
1965	294	2 000	3 607	24 816
1966	269	1 863	3 799	28 206
1967	361	2 052	5 095	31 877
1968	275	1 593	3 705	20 949
1969	220	1 466	3 058	25 523
1970	235	1 251	3 287	20 964
1971	266	1 288	4 375	23 027
1972	294	1 653	5 860	35 901
1973	449	1 806	7 807	33 674
1974	532	1 702	8 008	26 483
1975	553	1 611	9 560	28 052
1976	514	1 597	13 106	41 927
1977	381	1 560	10 514	44 048
1978	307	1 117	7 841	28 651
1979	376	1 896	10 811	59 985
1980	341	1 892	11 318	71 332
1981	341	1 713	10 384	48 742
1982	338	1 416	10 692	46 718
1983	360	1 626	11 874	54 370
1984	356	1 698	12 541	58 902

1985	388	1 646	14 329	62 124
1986	373	1 684	13 699	59 446

[a] Live or round weight

Source: Statistisk Sentralbyrå (1978, 1987) from NOS Lakse-og sjøaurefiske

Table 9

Catch of Atlantic salmon and sea trout in Norwegian rivers, 1969–75 (in kg)

Year	Salmon	Sea trout	Total
1969	178 280	41 413	219 693
1970	187 549	47 163	234 712
1971	221 655	44 507	266 162
1972	241 338	52 771	294 109
1973	400 595	48 500	449 095
1974	487 546	44 123	531 669
1975	505 420	47 922	553 342

Source: Norway/EIFAC (1977)

With respect to fishing methods, salmon fishing has been described above. Fishing for anadromous chars is carried on mainly in the river mouths when the fish return in late summer or early autumn. Commercial fishing in lakes is primarily with traps and gillnets. Fishing continues winter and summer. Brown trout are caught under ice but the main salmonid taken under ice is char.

It should be noted that the mere weight of fish caught in Norway is not a true indication of the value of the resource. The cost of rental rights to fish some of Norway's finest salmon streams is staggering (e.g., as long ago as 1969, the Laerdal rented for U.S.$ 83 000 and the Driva for U.S.$ 63 750 and circa 1966 one month on the Altaelva cost U.S.$ 28 000). The average weight of rod-caught salmon early in the season on the Altaelva is about 11 kg, and only 10 rods are allowed on the upper 40 km in late June, early July. Each rod will then pay about US$ 6 500/week. In 1988, the following prices for a rod/week of Atlantic salmon fishing in Norway were quoted by Frontiers (1988): US$ 4 490 on the Orkla; US$ 4 800 on the Laerdal (Oye Beat), and US$ 5 900 on the Gaulafoss Pool. According to official statistics, the total income from lease of Norway's salmon streams in 1975 was a little less than U.S.$ one million, but there are good indications that unreported and current returns would make this a much higher figure[1].

In 1973, records of fishing licence sales in Norway indicated that there were about 242 000 sport fishermen or 6.4 percent of the population. However, a survey made in 1970 by the Central Board of Statistics showed that 34 percent of the Norwegian population in age-group 15–74 years had been fishing in the year September 1969–August 1970. If true then 900 000 people should have been sport fishing in Norway's inland waters (Norway/EIFAC, 1977)[2]. The estimate of 900 000 Norwegian anglers agrees with that of Anon. (Norway) (1980). Such a figure would represent closer to 20 percent of the total population at the time. Actual license sales in 1988 were 253 421 (Norway/EIFAC, 1989).

1 Norwegian river owners are taxed on the amount of salmon caught on their beat of the river; consequently some reporting may be too low. In a survey conducted by the University of Trondheim, figures on the famous Gaula River were 50–60 percent higher than those reported to the Government (Dalenson, 1984)

2 An act of 1964 states that any person wishing to fish for freshwater fish (including salmonids) must have a national fishing license, but children under the age of 16 are exempted

7.2 Aquaculture

The water temperature in Norway limits aquaculture to cold water species such as trout and salmon. The climatic conditions, however, are not very suitable for "Danish-style" trout farming, i.e., raising rainbow trout (Oncorhynchus mykiss) in freshwater ponds to portion size of 150–250 g. Even in southern Norway, most fresh waters have temperatures well below 4°C and often approach 0°C for almost half the year.

On the contrary, the seas around Norway, conditioned by the Gulf Stream, do not have the disadvantage of low water temperatures. Except for the small east coast under the influence of the Baltic current, the sea water up to about 68°N latitude has an average annual minimum temperature above 4°C, for much of this area the minimum is above 5°C, and summer temperatures never become excessive, rarely reaching 18°C. Furthermore, there are many areas not only ice-free but sheltered from wind and wave action that provide good sites for salmonid farms. Given such conditions, and unable to compete successfully with the foreign market, private trout farms in Norway have shifted emphasis from freshwater to saltwater production.

As early as 1912, the Norwegian Storting (Parliament) approved the culture of rainbow trout in salt water, but the original attempts were a failure. Trials again commenced in the 1950s. In 1962 about 300 t of trout were raised, and by 1971 production had risen to 444 t. In the meantime, during the 1960s, trials were also made to raise Atlantic salmon in sea water. Progressing slowly at first, salmon rearing became well established in Norway. By 1977, it had well surpassed that of rainbow trout, and by 1981 Norwegian salmon production was almost twice that of rainbow trout, and in 1983 it was almost three and a half times as large. In fact, in 1983 Norway alone farmed more than the world's total catch of "wild" Atlantic salmon (Jensen, 1984). By 1986, the farmed salmon production in Norway was more than ten times as large as that of rainbow trout (Table 10). Salmon is now the single most important species in the Norwegian fishery which means that the first hand value of salmon now exceeds that of cod, Cadus morhua (OECD, 1986).

Table 10 shows the quantity of rainbow trout and Atlantic salmon reared and "slaughtered" in Norway during the 1971–86 period, as well as the number of rearing units according to official Norwegian statistics. (Cf Table 8.) These figures can be supplemented by more recent ones. OECD (1989) provides the following preliminary figures for 1987: salmon - 47 417 t, and rainbow trout-8 787 t. The Fédération Européene de la Salmoniculture (FES, 1989) shows the following production in Norway in tons:

1988	Salmon	80 000	trout	7 500
1989	Salmon	130 000	trout	4 000
1990(est.)	Salmon	150 000	trout	6 000

The FES also estimates that the "ex-farm price" per kilogram of these salmonoids is N.Kr 28.50 to 34.50.

It may be noted that (according to FES) Norway concentrates on rearing salmon and large (rather than portion-size) trout. In this field, Norway is easily the largest producer in Europe.

In 1973, a new Norwegian law, intended to improve the economic situation for rural workers, limited the size of new sea farms to a production capacity of 8 000 m^3. This meant a capability for each farm of producing only about 60 t of salmon annually - hardly an optimum productive size economically - and in 1989 the size was increased to 12 000 m^3.

Under the sea farm system, fry, fingerlings and smolts are first reared in fresh water in the usual way, and then transferred to sea water. At normal sea water temperatures in Norway, rainbow trout require from 1 to 1½ years and salmon about 2 full years to reach marketable size. The mean sizes at which they are marketed are 2 kg for rainbow and 4 kg for salmon. (These sizes are similar to those of fish caught by capture fishing.) Only about 25 percent of the rainbow trout are exported but over 80 percent of the salmon have foreign markets, especially in France, the Federal Republic of Germany and Sweden.

In addition to these fish, attempts have been made in Norway to cultivate Pacific pink salmon (Oncorhynchus gorbuscha). First attempts were made in 1963. Consumption fish of 400 g may be produced from fry in sea water in less than a year (Berg, 1977).

Table 10

Trout and salmon, reared and slaughtered in Norway, 1971–86

	in tons[a]			Working units reported[b]	
Year	Rainbow trout	Atlantic salmon	Total	Trout	Salmon
1971	444.0	97.8	541.8	56	5
1972	778.3	145.5	923.8	74	5
1973	1 001.0	171.0	1 172.0	80	4
1974	1 726.0	601.0	2 327.0	155	13
1975	1 655.0	862.0	2 517.0	120	45
1976	2 045.0	1 431.0	3 476.0	116	61
1977	1 795.0	2 137.0	3 932.0	112	84
1978	2 105.0	3 540.0	5 645.0	124	116
1979	2 988.0	4 389.0	7 377.0	154	147
1980	3 668.0	4 312.0	7 980.0	165	173
1981	4 624.0	8 418.0	13 042.0	189	215
1982	4 627.0	10 695.0	15 322.0	192	263
1983	5 405.0	17 298.0	22 703.0	183	301
1984	3 569.0	21 881.0	25 451.0	152	354
1985	5 142.0	29 473.0	34 615.0	217	414
1986	4 384.0	44 831.0	49 215.0	-	-

[a] Live or round weight

[b] One working unit might have both rainbow trout and salmon

Source: Statistisk Sentralbyrå (1978, 1987) from NOS Lakse-og sjøaurefiske for the 1971–85 data.
Jensen (1984) for 1982 data
Norway/EIFAC (1989) for the 1986 data

The original feeds were cheap marine fish such as capelin (Mallotus villosus), and prawn carapaces, but the use of dry feeds is increasing.

Although there are some fish farms on land using sea or brackish water, most of the salt water rearing sites are along the sea itself where there is less ice and better circulation and less pollution than in the fjords. There are some enclosed areas where the shore forms one side and staked nets the other sides, but floating net cages are the commonest enclosures. Sites for sea cages are limited by legislation rather than by geography. Thus, there is a tendency to locate the fish farms in offshore waters using seaworthy construction. The results from sea cultivation can be excellent, but both capital costs and risks are high at these sites. OECD (1989) states that there were about 600 sea farms in Norway in 1987. Ackefors (1989) says that 728 licenses have been issued in Norway for farming young salmon and trout, and that 611 procurers of smolt have been reported there.

With respect to freshwater fish production in Norway, most of the fish farms are located in the extreme south or east with water derived from springs or lowland rivers. Some farms use electric heating or water from power stations. Few producers overwinter the fish but rear trout to 50–150 g and salmon to smolt size for ongrowing in sea water.

There is also a small aquacultural production of European eel in Norway. Circa 1989, two fish farms using recirculation systems were scheduled to produce 430 t and the addition of one which was planned would boost the total production to 530 t.

About 150 hatcheries in Norway produce salmonids for release into natural waters. Fry and fingerlings are usually planted, as put-and-take sport fishing is not common. In 1972, the production for stocking rivers and lakes was (according to Norway/EIFAC, 1974):

Brown trout	-	7 200 000
Atlantic salmon	-	6 360 000
Sea trout	-	1 260 000
Rainbow trout	-	1 090 000

In recent years there has been a considerable stocking of the American eastern brook trout (<u>Salvelinus fontinalis</u>) especially in acid waters (see section 9.3). The mainstay, however, continues to be brown trout. Circa 1984, about 3 million brown trout, mainly fry and autumn fingerlings were being stocked annually. About two-thirds of these went into hydroelectric reservoirs. The proportion of released fish in catches is now between 30 and 50 percent (extremes of 5 and 75 percent), and stocking of sizeable fish has proved to be the most effective (Aass, 1984).

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership

In Norway, fishing rights usually belong to the owner of the surrounding land area who can derive income from their rental.

There are, however, various categories of ownership, among them: public lands in Finnmark, public lands in Norland and Troms not entered in the land register, public lands entered in the land register, State common land, municipal common land, private land owned jointly or by an association of landowners, and land owned by individual landowners. The differing categories are subject to varying acts and their fishing rights are administered in different ways. Two examples may suffice. In Finnmark, the most northerly county (<u>fylker</u>), most of the land is owned by the State, hence Norwegian citizens have the right to fish with a rod or handline in all watercourses; in areas that have been leased out a fishing permit must be obtained. This applies to most salmon rivers and to some extent to most lakes. Foreigners may fish on public lands in Finnmark in rented watercourses and otherwise only in limited areas and must purchase both a national licence and a local fishing permit. In many of the mountain areas far from the nearest community, fishing rights also belong to the State. Here, the commercial interests of the neighbouring communities are acknowledged by giving everyone living in them a right to fish for a nominal fee. Moreover, all citizens can buy a licence entitling them to do some sport fishing in these areas.

Approximately two-thirds of all the land area of Norway is privately owned, and here the landowner possesses the fishing rights. Land estates owned by a single individual are relatively rare in Norway. The general practice is for several landowners to organize associations covering large areas, where they jointly maintain stocks of fish and lease rights and sell permits to both citizens and foreigners, including rod and gun clubs.

Under certain circumstances, fishery rights can be expropriated on behalf of the public. The former owner is entitled to full payment for his rights.

[1] Based on Gaudet (1974), material sent to EIFAC by Norway in 1979, Anon. (Norway) (1980), and Norway/EIFAC (1989)

8.2 Administration, Management and Research

In Norway, the Ministry of Fisheries is concerned only with marine or sea fisheries. With respect to inland fisheries and those for anadromous salmonids in both salt and fresh water, it is the Ministry of Environment that is responsible for their administration.

Within this Ministry is a Directorate for Nature Management with a Director-General in charge, Under the Director-General there are several divisions, each run by a Deputy Director, among which there is one for aquatic ecology. The others are those for: terrestrial ecology, nature enhancement, outdoor life, and administration.

8.2.1 In Norway research on natural resources is organized in a private company, the Norwegian Institute for Nature Research, founded by the Ministry of the Environment. The District Offices are now working for County Environmental Administrations.

8.2.2 Inland Fisheries Boards. Under the Salmon and Inland Fisheries Law of 1964, these Boards are organized for each of Norway's communities (450 in 1979). Each consists of five members elected by the administration of the community. Preference is given to those engaged in inland fisheries, but at least two members cannot be owners of fishing rights. Their major mandate is to supervise and improve inland fisheries in their individual community in collaboration with the Directorate's fishery consultants in the District.

In a community with salmon fishing, one member of the Board must be chosen from the members of the Salmon Fisheries Board of the District (see below).

8.2.3 Salmon Fisheries Boards. An old division of the country into 35 or 40 salmon districts is maintained for anadromous salmonids, each with its Salmon Fisheries Board.

8.2.4 Sport Fishing Clubs. Much of the work such as hatching, rearing and stocking of fish is done by local sportsmen's clubs in cooperation with the fishery consultants of the Directorate.

8.2.5 Revenue and Use. Norwegian citizens above 16 years of age are required to purchase a licence to fish for salmon, sea trout, migratory char or inland fish. Additional permits may be required for particular areas. The income is used for freshwater and salmon fishery development.

In addition, some money is granted by the State to salmon and inland fisheries development and from sources such as a salmon tax and hydroelectric boards (1974).

8.3 International Agreements

Bilateral agreement exists between Norway and Finland concerning their fisheries in boundary waters. Special conventions have been made concerning fishing in the Tana and in the Näätätämönjoki, a salmon river which runs through both countries. Norway also has a bilateral agreement with Sweden concerning the Trysilelva- Göta river system (the Trysilelva flows from Norway into Sweden where it is known as the Klaralven above Lake Vanern and the Göta alv below). It also has a bilateral agreement with the USSR concerning their boundary streams. A trilateral agreement concerning regulation of Lake Inari (in Finland) exists between Norway, Finland and the USSR.

9. STATE OF THE FISHERY

9.1 Yield

It has already been pointed out (section 7.1) that recent estimates of total annual yield in Norway's lakes and tarns have ranged from 1.5–2 to 2–4 kg/ha. Some lakes have, of course, much higher yields. Trout lakes at lower levels in western and middle Norway have a yield of 5 kg/ha/year (Jensen, 1978). Norway's largest lake, Mjøsa, also has a yearly yield of 5 kg/ha, mostly of coregonids but also of trout, pike, perch and burbot. In one mountain lake of central Norway, the maximum sustainable yield of char has been estimated as 7 kg/ha/year (Jonsson, 1988).

Lack of overall statistics on the catch in the inland waters of Norway makes it difficult to discuss general trends as has been attempted for some of the other European countries. The longterm trend in salmon fisheries, however, has been an increase in total catch (both sea and river) from about 1 000 t before the middle of the 1950s to about 1 700 t in the 1960s and 1970s. As shown in Tables 8 and 9, the reported river catch of Atlantic salmon and sea trout has varied from about 220 to 553 t during the 1969–75 period. This was attributed (Norway/EIFAC, 1977) not to an increase in fishing effort but to an actual increase in the stocks believed to have been brought about by strict control (from the air) of closed periods for the use of bag nets. It will be noted (Table 8) that it has decreased since that time (301 t in 1978 and 373 t in 1986).

9.2 Factors Affecting the Fishery

Norway has abundant water and with its low population density (the lowest in continental Europe and about the 46th least populated country in the world), no special problem for maintenance of either adequate water quantity or quality has existed countrywide until the recent onset of acid precipitation[1]. The average runoff per caput is about 99 875 m, an extremely favourable figure. Rapidity of stream flow also aids water quality in dissipating the effects of pollution. Given Norway's petrographic base, its waters are generally infertile, and low water temperatures have compounded the existence of generally oligotrophic waters and salmonid stocks.

[1] About one-quarter of the country is considered uninhabitable

A great number of lakes and many streams (even if most are short) adds to the diversity of waters for fish life, including the opportunity for runs of valuable anadromous species. The presence of lakes along the streams may also offer the opportunity for greater survival of descending kelts than lakeless rivers.

Land and water uses have been relatively kind to Norwegian inland fisheries. Agriculture is such a minor use of the land and climatic conditions require so little irrigation that have little conflict with fisheries. Log-floating, which has affected about 14 500 km of rivers, is now being replaced to some extent by the use of trucks.

Similarly, industrial development is rather limited in extent, thus preserving most waters in good state, and the deleterious effects from both forestry and mining are limited. About 65 percent of the people live along the southern shores, thus limiting the areas of high fishing intensity and water pollution.

To date, salmon rivers have not been greatly influenced by hydroelectric development - extensive as it is - although danger to some of the lower rivers is increasing, and about 40 percent of the resource is still to be utilized. Construction of access roads to new hydro-sites has increased the number of people fishing the areas (Paine, 1982). Norway has built over 300 fishways, most of them between 1946 and 1960, thus substantially increasing the biotopes for salmon. Efforts have also been made to secure water releases in streams below dams and to build weirs to convert otherwise semidry areas into strings of shallow “lakes” to hold fish and to increase their density.

There are, of course, unfavourable elements. Most of the land above 600 m has steep slopes or is bog, bare rock, scree, or poor soil. There is a long period of winter, including a damp, cloudy climate and snow and ice cover. There is a very short ice-free period in many lakes (e.g., it may be only two to two and a half months in lakes between 800 and 1 300 m). The growing season is short (see section 4) and cold water lengthens the life history of its fish, e.g., in the cold north, salmon parr may stay in fresh water for three or four years and also for a longer time in the sea. The underlying rocks are granites, gneisses or other hard rocks with poor buffering capacity (□kland, 1980). The surface waters are, therefore, cold, infertile and readily susceptible to acid pollution[1].

1 Brown trout hardly grow below 4°C (Frost and Brown, 1967)

Most of the lakes are oligotrophic and although this ensures a supply of desirable salmonids, it also means that the fish production is low - perhaps 2 to 4 kg/ha/year on average. Furthermore, about half of the lake area is impounded or influenced by impoundment in the catchment basins. Their use as storage basins for the production of power causes them to fluctuate and thus further diminish their productivity.

As in many European countries, human activities have resulted in an increasing eutrophication, including excessive algal development, in a number of originally oligotrophic lakes, e.g., Lake Mj□sa. Conversely, there has been a very serious increase in acid pollution in both lakes and streams. The acidification is attributed to emission, oxidation, and long-range aerial transport of sulphur and nitrogen oxides from various parts of industrialized Europe using fossil fuels. Reproductive stages are the most sensitive to acid stress but kills of adult fish have also been reported. Studies in 1972 of barren (i.e., fishless) lakes in southern Norway showed that most of them had pH trends below 5.0 and that the incidence of barren lakes increased with lower pH and decreasing conductivity. Of 700 lakes that were studied, the fish populations (largely brown trout) had been eliminated from 40 percent and were only sparse in another 40 percent (Wright and Snekvik, 1978).

By 1980, it was reported that in an area of 33 000 km^2 (i.e., one-tenth of continental Norway) in the southern countries, fish populations were virtually extinct in 13 000 km^2. Within the remaining 20 000 km^2 area, the lakes were in the process of losing their fish populations. Of 2 823 brown trout lakes in that area, 1 454 had lost their fish populations in recent years, 760 were on the point of losing theirs, and only about 600 of these lakes still held good trout populations (Swang, 1981). With respect to streams, it can be noted that by 1977, the catch in seven southern salmon rivers had declined to almost nothing, the pH having dropped below the value critical for salmon reproduction (Norway/EIFAC, 1977), and by 1987, Atlantic salmon had disappeared from over 10 Norwegian rivers (Jonsson, 1988).

Furthermore, the Norwegian fish farming industry itself may create serious pollution problems. The organic waste from a fish farm of 8 000 m^3 may be close to 100 t/year. Expressed in terms of “person equivalents”, this waste is equal to that of 2 500 persons. Waste organic matter from the Norwegian fish farming industry as a whole can be said to be equivalent (in 1986) to that resulting from about 1.8 million persons (Breiby, 1986).

Aside from such perils, which can be directly attributed to man, recent attention in Norway has been drawn to the infestation of at least thirty salmon rivers by the fluke (Cyrodactylus salaris) which causes severe losses to salmon parr, estimated in 1988 at 250–500 t, and for which no cure has been found (Jonsson, 1988).

On an overall basis, it should be noted that the country as a whole has focused most of its attention with respect to fisheries on its marine resources and commercial fishing for inland species has been relatively minor. Nevertheless, in essentially rural communities, fishing in inland waters for both food and sport is - as in other Nordic countries - an established and important way of life. In fact, the close linkage of land ownership or residence to fishing has, as has been pointed out, often resulted in overfishing of salmon stocks.

9.3 Prospect

Yields from Norway's oligotrophic lakes and rapid streams cannot be expected to increase in view of their inherent limiting factors, including: cold, infertile waters and a native population of coldwater fishes, coupled with the increasing threats of acid pollution. The latter danger is an international as well as national problem, shared with other Scandinavian countries, and ameliorative measures such as liming are only local and temporary alleviations.

Assuming eventual relief from acidification, Norway's large number of lakes offer accommodation to many fishermen. River angling for trout is the most popular recreational fishing in Norway (Aass, 1984), and its salmon and sea trout fisheries are a most valuable resource which will increase in value for both resident and foreign anglers. However, with a decline in wild salmonoid fisheries, there will be greater utilization of neglected or “coarse” fish species.

Protection from pollution, ensurance of stream recruitment for anadromous fishes (including not only provision of passage but relief from overfishing) and provision of management to offset lake fluctuations caused by hydroelectric storage are among the important measures that will maintain good fishing. For example, substitution of char which seem to withstand the reduction in bottom fauna in reservoirs better than trout. Three rather special measures to protect the inland fisheries are: a ban on the introduction of fish species to a watercourse where it is not present; a ban on the use of live fish for bait; and mandatory disinfection of fishing tackle used outside Norway or in certain waters where fish diseases have been established.

Angling for Norway's prized species, especially salmon, will continue, although often as a “rich man's” sport. Its future is dependent not only upon Norway, but is dependent upon action of the North Atlantic Salmon Conservation Organization (NASCO), established in 1984, of which Norway is a member. As Norway becomes more urbanized, the emphasis on capture fishing in inland waters will centre more and more on angling and household fishing.

Aquaculture for salmonids will continue to develop, primarily in the salt water environment. There will be a growth in the number of farms and in total production, and continued emphasis on Atlantic salmon rather than trout production. Some measure of the trend is illustrated by the observation of Kurtyanek (1982) that there were 450 fishfarms in Norway, and 400 awaiting licensing. Another observation is that by the early 1990s Norwegian aquaculture could be producing 80 000 t of salmon annually (Fish Farm.Int. 11(10), 1984), a production which was actually attained in 1988. Furthermore, both the FES (1989) and a Norwegian projection by Kralheim (1986) envisage a production of about 150 000 t in 1990.

To this will be additional attempts with other species, sea trout, chars and Pacific pink salmon. Ocean ranching will have its trials, but unless returns (now only about one to two percent) are decidedly increased, better results will be obtained by sea farming.

Norway has reviewed and listed all sites with aquaculture potential so that administrators in charge of land planning and development are aware of them and can avoid conflicts between competing sectors such as urban development, tourism, merchant marine, navy, industry, fisheries and agriculture.

Allied to some extent with aquaculture, is a possible shift to greater use of sea trout (in place of Atlantic salmon) and the firm establishment of the pink salmon as a wild species. As the upper portion of Norwegian rivers used for hydroelectric purposes diminish in usefulness for the spawning of Atlantic salmon, their lower portions and estuaries continue to be generally undisturbed physically, and in addition maintain a better water chemistry due to neutralization by sea water of airborne acidity. Pink salmon, already resident in some parts of Norway as a result of stocking by the USSR in the Murmansk and White Sea area, can utilize such areas and may become a partial replacement for the native Atlantic salmon.

There will also be greater use of another exotic fish, the eastern brook trout (<u>Salvelinus fontinalis</u>) as a substitute for the native brown trout in acidified waters. Although this fish was introduced from America to Norway in 1876, only a few naturalized populations exist in the country, principally in the upper parts of small streams. Since the 1970s, it has been stocked extensively, especially in rivers and lakes where acid precipitation has led to fish mortalities. Relative sensitivity to acid water appears to be in this order: rainbow trout, Atlantic salmon, brown trout, and least of all eastern brook trout. In some cases the latter may live well in lakes with pH values of 4.6–4.7 and even lower (4.3–4.5) if other conditions are good, although reproduction usually will not occur with the pH below 5.0 (Grande, 1984). There is hope, therefore, from exotics to offset some of the deleterious factors hampering Norwegian inland fisheries.

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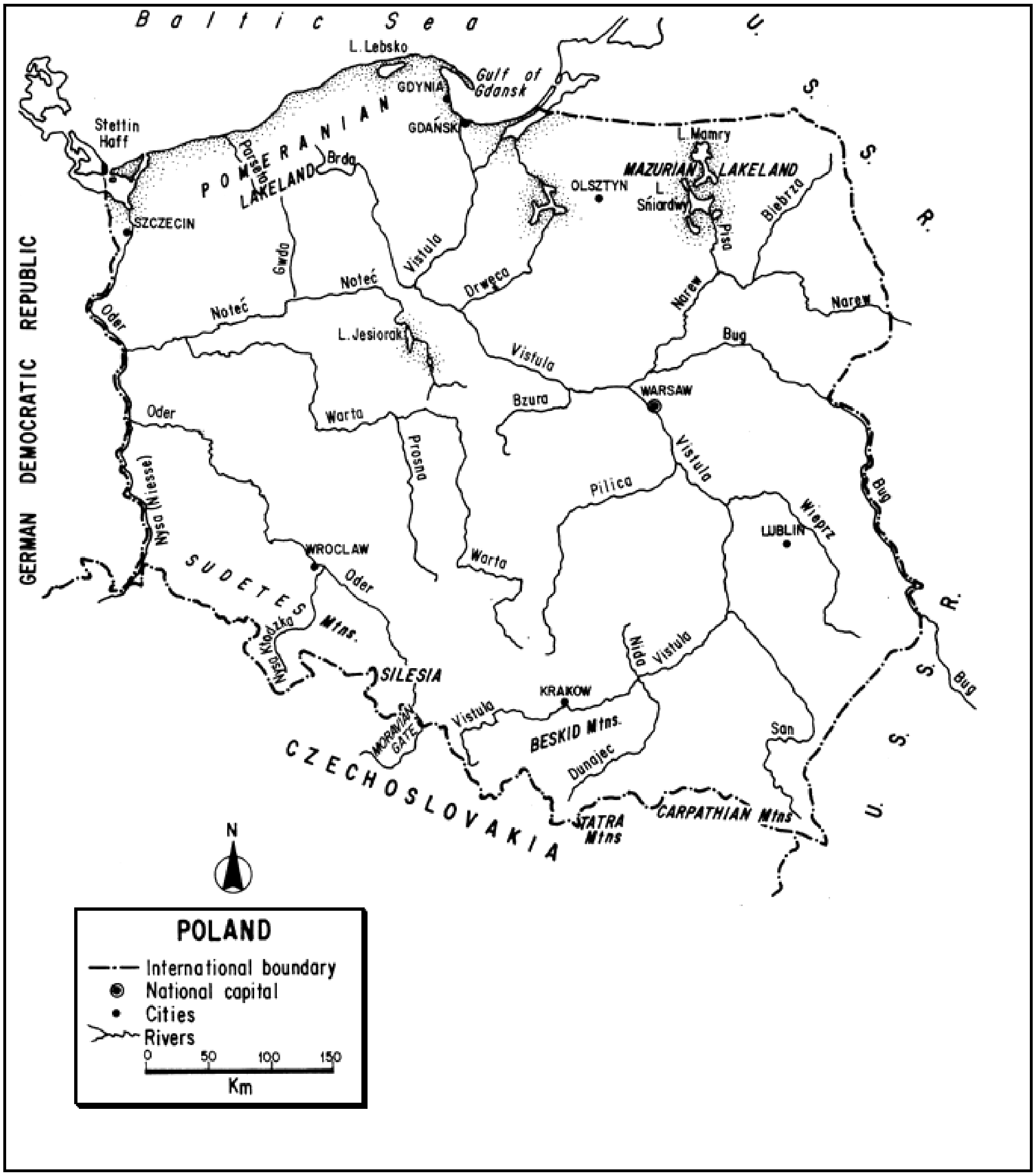
Baltic Sea
U.S.S.R.
L. Lebsko
Gulf of Gdansk
GDYNIA
GDAŃSK
Stettin Haff
POMERANIAN LAKELAND
Parseta
Brda
L. Mamry
MAZURIAN LAKELAND
OLSZTYN
L. Śniardwy
Biebrza
Pisa
SZCZECIN
GERMAN DEMOCRATIC REPUBLIC
Gwda
Vistula
Drweca
Noteć
Narew
Oder
L. Jesiorak
Bug
Vistula
WARSAW
Bzura
Oder
Warta
Prosna
Nysa (Niesse)
Pilica
Vistula
Wieprz
LUBLIN
WROCLAW
SUDETES Mtns.
Oder
Warta
Nysa Kłodzka
SILESIA
Nida
Vistula
KRAKOW
MORAVIAN GATE
Vistula
BESKID Mtns.
San
Dunajec
CZECHOSLOVAKIA
TATRA Mtns
CARPATHIAN Mtns
N
POLAND
International boundary
National capital
Cities
Rivers
0
50
100
150
Km

POLAND

The Polish People's Republic, transitional between Central and Eastern Europe, lies between Czechoslovakia, the German Democratic Republic and the USSR.

Although backed by mountain masses on its southern border, Poland is primarily a great glaciated plain sloping north to the Baltic Sea. Its high mountains have swift streams and some small deep lakes, but its greater area is dominated by the slow-moving rivers of the Oder and Vistula systems and thousands of shallow, lowland glacial lakes. Traditionally agricultural, its economy, aided by its thermal resources, has become largely industrial.

Poland's long standing capture fisheries in lakes, rivers, reservoirs, and brackish waters, show signs of decline. Meanwhile, aquaculture (especially for carp) also of long standing in this country, has increased in importance and methods for its enhancement have improved. Sport fishing in inland waters has been encouraged by the Government, and its harvest has now surpassed that of the commercial capture fishery.

1. AREA: 312 683 km^2
2. POPULATION: 38 513 000 (est. 1990) Density: 123 inh/km^2
3. PHYSICAL GEOGRAPHY

Poland is situated between 49° and 54°50'N latitudes and 14°07' and 24°08'E longitudes.

Roughly circular in shape, its greatest length (E–W) is 689 km and its greatest width (N–S) is 649 km. Its altitudinal range is from 1.8 m below sea level in the Vistula Delta to 2 499 m on Rysy Peak in the High Tatra.

Politically, Poland is bounded on the west by the German Democratic Republic for 460 km, on the south by Czechoslovakia for 1 310 km, and on the east by the USSR for 1 244 km. In addition, it is bounded on the north by the Baltic Sea for 524 km between the mouth of the Oder on the west and the Gulf of Gdansk on the east. About one-quarter of the boundaries is river-bound[1].

[1] Length of boundaries from Glowny Urzad Statystyczny, Rocznik Statystyczny, 1988

The average elevation is 173 m; 71 percent is less than 200 m, 26 percent is between 200 and 500 m, and less than 3 percent is above 500 m.

Over three-quarters of Poland has been subjected to glaciation. Most of the country consists of gently rolling plains sloping gently from the Sudetes and Carpathian mountains northwest to the Baltic, bordered by the Oder on the west and the marshy Polesic lowlands on the east.

Proceeding from south to north, it can be divided into four natural physiographic regions: (i) Southern Mountains; (ii) Central Uplands; (iii) Northern Plains and Glacial Lake Basins, and (iv) Baltic Coastal.

(i) Southern Mountains. Forming a border with Czechoslovakia on the south, are the Sudetes in the southwest and the Carpathians on the south. These mountains are separated by the Moravian Gate (or Corridor), a hilly depression opening to the north through the Oder River and south through the Morava. The Sudetes, which rise sharply to 1 520 m, are a series of short rounded massifs of granite, gneisses, quartzite, and limestone. The higher Carpathians reach 2 499 m in its eastern group, the High Tatras.

This latter group, which is partly granitic, lacks glaciers but is otherwise Alpine in appearance with jagged ridges, hanging valleys, and glacial lakes. The rest of the Carpathians, of which the Beskids constitute the outer (northern) range, are mostly sedimentary rocks, more rounded, and better forested. Treeline is about 1 200 m in the eastern Carpathians, and 1 500 m in the High Tatras.

(ii) Central Uplands. North of the high mountains lies the hilly and undulating area of Silesia and the south Polish plateau which rises in places to 600 m. Much of this area is covered with fertile loam (loess).

(iii) Northern Plains. This area, stretching north to the coastlands, and constituting the larger part of Poland, is a low-lying part of the great North European Plain. It is the heartland of the country, cradling both its principal agriculture and industry. Icesheets have left a thick mantle of drift, clay, sand and gravels which have filled in many of the depressions in the southern part. The lower or northern part of these plains called the Baltic or Glacial Lake Region, is, however, occupied by frontal moraine ridges to 300 m, studded with thousands of glacially created lakes, and well forested. Poland's major river, the Vistula, divides this region into the Pomeranian lakeland which extend west toward the Oder and the Mazurian lakeland which extends east to the country's northern and northeastern border.

(iv) Baltic Sea Coast. Finally, on the extreme north, lying along the Baltic Sea is a narrow area of swamps and dunes, and a shore straightened by sandy bars to form small bays and coastal lakes. Proceeding from west to east, the coastal plains are divided into: the Oder delta or lowlands of Szczecin, the Kaszubim Coast with many relict lakes, the Vistula Delta above the Gulf of Gdansk and the lakeless Prussian Plain in the east. Just south of the Gulf of Gdansk is an area of 596 km^2 lying below sea level.

Cutting across all of these physiographic regions are the major river systems of Poland which terminate in the Baltic (see section 5).

Poland has a mosaic of soils, mostly glacial, acid tolerant and leached of nutriment, especially in the south. Sandy podsols with low humus content occupy from 50 to 70 percent of the area; the remainder consists of boulder loams, alluvial soils, silt and loess, and peaty/swampy areas. The richest soils (chernozems and brown forest soils) are in the loess belt in the south. The mountain soils are generally thin and poor.

Poland, which is about 28 percent wooded, lies in the mixed forest zone transitional between the Atlantic European forest and the coniferous zone of the Baltic. There are four types of forest: coniferous (about 70–80 percent), mixed deciduous, alder swamps, and humid woods in river valleys subject to flooding. Pines are found in the lowlands and spruce in the mountains. Natural cover is now very scarce because of repeated clearings.

4. CLIMATE

The climate of Poland is transitional between oceanic and continental, with great variance from year to year and day to day. Mild moist winters alternate with heavy dry ones, and similar thermic and precipitation variations are found in summer. It is coldest in the northeast and warmest in the southwest.

The mean annual temperature (excluding that in the mountains) is about 7°C. The mean monthly temperature in July ranges from 16.5°C on the Baltic to 19°C in the southwest. January means range from 0°C on the coast to -4.5°C in the northeast.

Rain occurs mainly in the summer, being highest in July. Winter (December–March) precipitation is about two-thirds snow. The mean annual precipitation is about 600 mm. In the mountains it exceeds 1 200–1 500 mm, and coastal lowlands have only 450 mm annually.

Snow-cover varies from 40 days in the west to 80 in the east, and up to 200 days in the high mountains.

Frosty days vary from 23 on the seacoast to 137 days on the summit of Sniezka in the Sudetes. The length of the vegetative (growing) period with an average temperature higher than 5°C is 190 to 220 days in the lowlands.

5. HYDROGRAPHY AND LIMNOLOGY

Recently published estimates of the total area of inland waters in Poland range from about 440 000 ha to about 890 000 ha. Table 1, which lists some of the estimates made between 1954 and 1989 illustrates the difficulties apparent in specifying this area as well as that for each component of this system.

<u>Table 1</u>

Polish inland water areas (ha)

Rivers	Reservoirs	Lakes	Ponds	Total	Source
		316 927 [a]			Majdanowski(1954)
85 000		316 927	66 779	468 706	Patalas (1965)[b]
89 870		325 000	65 370	480 240	Dabrowski and Walus (1965)[c]
				780 000	Framji and Mahajan (1969)
		325 000			Leopold (1972)
90 000	30 000 [d]	299 000	40 000	459 000	Kossakowski (1973)
				890 000	Europa (1974)
67 000	33 000	302 000	60 000	462 000	Poland/EIFAC (1974)
	20 000	320 000			Kondracki (1974)
100 000					Poland/EIFAC (1976)
100 000		300 000	60 000	460 000	Olszewski (1978)
104 000		305 000	60 000 [e]	470 000	Leopold (1983)
138 000	51 200	306 200	59 700	582 000	Bninska and Leopold (1987)
				821 000	Europa (1988)
				819 000	FAO, (1988) (Table 9)
			40 000	440 000	EIFAC (1989)
		300 000	62 000		FAO (1989)

[a] 9 296 lakes exceeding 1 ha

[b] Patalas (1965) derived his lake area from Majdanowski (1954), his estimated average water surface area for rivers was given (i.e., printed) as 88 000 ha, a figure corrected in ink in my copy received from the Government. He stated that the river area is about one-quarter of the total lake surface area, and also said that the total area of artificial ponds accounts for 16.8 percent of the total area of inland waters in the country. If so, then the latter figure would amount to only 397 494 ha rather than the total shown in the table above. (He did not estimate total reservoir area for Poland)

[c] According to Dabrowski and Walus (1965), the area of rivers was based on estimations made by individual provinces, and with reference to major rivers included the areas between protective longitudinal dams periodically flooded. The inventory of lakes and ponds was derived from an old survey (then 60–80 years back). Lake areas included islands, fluctuating reservoirs, and vanishing water basins. Pond area included dikes, roads, and uninundated ponds

[d] With surface area over 20 ha

[e] Leopold (1983) says that actual pond water surface area in Poland constitutes about 70 percent of total pond area

Poland/EIFAC (1976) has explained that the difference between the largest estimation (890 000 ha) and the third smallest one (462 000 ha) is simply a matter of definition, i.e., that the higher figure includes the area of the brackish water estuaries of the Oder and Vistula (the Szczecin and Vistula "haffs" or "firths"). This explanation, although appealing, cannot be considered completely accurate, since the combined Polish area of these two bodies is considered in official Polish publications to be only 70 000 ha (see section 5.5). It seems probable, therefore, that other brackish water areas have also been included in the larger estimates.

It will be noted that the "total" water area in Table 1 does not always agree with the sum of the tabulated components (e.g., Bninska and Leopold, 1987). In a personal communication, 29 January 1990, Dr M. Bninska informed me that it was extremely difficult to obtain proper data on water area in Poland - due to a complicated statistical system based on current water use and users rather than on "reality". The data in Bninska and Leopold (1987) refer to the so-called "natural" waters of Poland which embrace all inland waters with the exception of ponds; i.e., "natural waters" are: rivers, dam reservoirs, lakes, and "other waters" (pools, channels, bodies formed after clay or gravel excavations, old river beds, etc.). The difference between the "total" area and the summation of the other components tabulated by Bninska and Leopold (1987) in Table 1, is represented by the area of "other waters". Their figures, gathered from each of Poland's 49 Vovevodstvas (Districts) are based in geodetic measurements and not on water use. (See section 7.2 for remarks on estimations of artificial pond area.)

Tentatively, it is concluded that the freshwater area in Poland (including reservoirs and artificial fish ponds) may be in the neighbourhood of 500 000 to 600 000 ha or about 1.6 to 2 percent of the country's total area. The average runoff from rainfall on Polish territory is 158 mm or 49 000 million m^3 to which can be added 6 000 million m^3 received from upstream countries. Thus, based on this data, both Van der Leeden (1975) and ECE (1978) state that the total river discharge leaving the country is 55 000 million m^3. However, Glowny Urzad Statystyczny (1988) states that the total river discharge leaving Poland during the 1970–87 period varied from 59 400 million m^3 in 1985 to 89 000 million m^3 in 1980.

Of the total area of Poland, about 99.9 percent drains into the Baltic Sea: 55.9 percent through the Vistula, 34.1 percent through the Oder, 0.6 percent through the Niemen, and 9.3 percent through coastal rivers. Only about 0.1 percent from a small area in southern Poland drains into the Black Sea.

5.1 Rivers (Rzeki)

The total length of all Poland's rivers is about 100 000 km and the total length of its main rivers is about 29 500 km (Poland/EIFAC, 1976). Estimates of the total water surface of Polish rivers (even more difficult to determine) are shown in Table 1.

Table 2 shows the principal rivers of Poland: their length, basin size, and discharge. Collectively, their length within Poland totals 11 164 km. Table 3 shows the monthly flows in three major Polish rivers.

Table 2

Principal rivers of Poland[a]

River	Length (km) Within Poland	Length (km) Total	Basin area (km^2) Within Poland	Basin area (km^2) Total	Mean discharge (1951–85) (m^3/sec)
Oder (Odra)	742	854	106 056	118 861	573
Mala Panew	132	132	2 132	2 132	11.7
Nysa Klodzka	182	182	3 744	4 566	40.0
Kaczawa	84	84	2 261	2 261	9.41
Barycz	133	133	5 534	5 534	18.5
Bóbr	269	272	5 830	5 876	46.0
Nysa Luzycka	198	252	2 197	4 297	31.5
Warta	808	808	54 529	54 529	219
Widawka	96	96	2 385	2 385	14.3
Prosna	217	217	4 925	4 925	18.4
Kanal Mosiński	117	117	2 495	2 495	5.48
Welna	118	118	2 621	2 621	8.60
Obra	164	164	2 758	2 758	10.1
Noteć	388	388	17 330	17 330	79.8
Gwda	145	145	4 943	4 943	27.4
Drawa	186	186	3 296	3 296	20.7
Ina	129	129	2 189	2 189	12.2
Rega	168	168	2 725	2 725	21.1
Parseta	127	127	3 151	3 151	28.4
Wieprza	112	112	2 170	2 170	23.0
Vistula (Wisla)	1 047	1 047	168 699	194 424	1 100
Przemsza	88	88	2 122	2 122	20.1
Dunajec	247	247	4 852	6 804	84.0
Poprad	63	170	483	2 077	24.7
Nida	151	151	3 865	3 865	22.3
Wisloka	164	164	4 110	4 110	36.4
San	443	443	14 390	16 861	129
Wislok	205	205	3 528	3 528	24.6
Tanew	113	113	2 339	2 339	13.7
Kamienna	138	138	2 008	2 008	9.72
Wieprz	303	303	10 415	10 415	38.2
Tyśmienica	75	75	2 689	2 696	9.66
Pilica	319	319	9 273	9 273	50.1
Narew	448	484	53 873	75 175	333
Biebrza	155	155	7 051	7 057	34.1
Pisa	80	80	4 500	4 500	27.4
Omulew	114	114	2 053	2 053	11.8
Orzyc	146	146	2 074	2 074	9.21
Bug	587	772	19 284	39 420	162
Krzna	120	120	3 353	3 353	11.5
Nurzec	100	100	2 083	2 102	10.5
Liwiec	126	126	2 779	2 779	12.5
Wkra	249	249	5 322	5 322	22.0
Bzura	166	166	7 788	7 788	30.7
Drweca	207	207	5 344	5 344	30.4
Brda	238	238	4 627	4 627	28.0
Wda (Czarna Woda)	198	198	2 325	2 325	14.3
Pasteka	169	169	2 294	2 294	18.7
Lyna	190	264	5 719	7 126	35.0

[a] The following rivers are navigable: Oder - 711 km; Nysa Luzycka - 15 km; Warta - 407 km; Noteć - 282 km; Ina - 59 km; Vistula - 941 km; Przemsza - 24 km; Dunajec - 30 km; Wisloka - 22 km; San - 90 km; Narew - 300 km; Biebrza - 84 km; Pisa - 80 km; Bug - 587 km; Brda - 14 km; Wda - 5 km; Pasteka - 9 km.

Source: Rocznik Statystyczny, 1988

Table 3

Seasonal discharge of three major rivers in Poland (m^3/sec)

	Oder Gozdowice	Oder Gozdowice	Vistula Tczew	Vistula Tczew	Vistula Warsaw	Bug Wyszkow
Basin area km^2	109 360		193 870		84 695	38 665
January	538	576	816	895	436	125
February	591	611	911	982	504	127
March	721	579	1 480	1 570	856	218
April	728	787	1 890	1 920	932	336
May	556	590	1 080	1 160	544	152
June	454	455	854	857	520	98.0
July	398	405	793	835	533	83.2
August	365	377	766	828	446	85.3
September	332	368	686	710	395	78.9
October	363	380	715	710	397	94.2
November	451	448	870	827	482	122
December	481	515	832	856	420	126
Year	498	522	974	1 010	539	137
Period of record	1921–37 1946–65	1901–65	1921–37 1946–65	1901–65	1921–37 1946–65	1921–37 1946–65

Source: Van der Leeden (1975) after Unesco (1971)

Most Polish rivers have a niveous-pluvial regime with two periods of high water each year. In the spring (March–April) their flow is augmented by melting snow and the release of ice dams, and in summer (June–July) by rains. Low water usually occurs in the late summer or autumn. The rivers are also fed by ground waters (which lie beneath most of the lowlands) and springs, and karst water sometimes emerges as springs as at the source of the Vistula. In their upper courses, most of the Carpathian rivers have a variable flow because of their impermeable substratum of schists and sandstones.

The courses of most Polish rivers are sluggish and laden with sediment. They have wide basins, their tributaries are entwined, and on the plains their divides are so low that one river may flood into another and it is easy to establish artificial waterways between them. Only the upper reaches of rivers starting in the Carpathians show gradients as large as 25 per mille. For example, 90 percent of the Vistula's course has gradients of only 0.15–0.3 per mille. A simple method of classification is, therefore, to denote the rivers as: (i) highland (approximately the trout and grayling zones), and (ii) lowland. About 87 percent of Polish rivers are “lowland”.

Generally speaking, most of the waters within the Vistula and Oder systems represent the barbel (Barbus) and bream (Abramis) zones, whereas the Carpathian rivers of the south and the Pomeranian rivers of the north represent trout (Salmo), grayling (Thymallus) and barbel zones. Table 4 indicates fish zones based on the gradient theory (see also section 5.1 under France).

Chemically, Polish rivers are characterized by a preponderance of carbonates and calcium against small amounts of sulphates, chlorides, silicates, sodium, magnesium and potassium. The most frequent values for total hardness (and carbonate hardness) range from 150 to 200 mg/l $CaCO_3$.

Water temperatures keep within the limits of 0°–27°C, and the 27°C recording is considered to be an exceptional case. Polluted streams may be higher than the norm. Minimum water temperatures occur from November to March; maximum usually occurs in July, about 22°–23°C.

Ice-cover appears as follows: in eastern Poland for 60–80 days within the December–March period; in western and southwestern rivers for 0–20 days in January. Ice-cover usually ranges up to 60 cm.

Table 4

Fish zones in Polish rivers

	Slope gradient/per mille/for the streambed width				
	0–1 m	1–5 m	5–25 m	25–100 m	100–300 m
Brown trout	6–80	3–40	1.5–20	2–8	-
Grayling	-	-	4–8	2–3	-
Barbel	-	2–4	0.7–4	0.3–1.5	0–0.5
Bream	-	-	0.5	0.2–1.2	0–0.1

Source: Simplified from Starmach (1956)

Vistula. Known in Poland as the Wisla, this 1 047-km river is the longest in the country. Rising at 1 106 m as a mountain torrent in the Beskids (lower Carpathians), it flows in a great curve through southeastern, central and northern Poland, through Krakow and Warsaw, across the great glacial plains to the Baltic's Gulf of Gdansk. Here it debouches in a delta region of 1 560 km^2, a drained marshland which is diked and channelled. In its upper reaches the Vistula has a mean annual water temperature of about 8°C which rises to 9.5°C in its middle and lower reaches, i.e., about 2°C higher than Poland's mean annual air temperature. In winter, the Vistual averages 2–3°C, and in summer 12–15°C, but in thermally affected areas may be 6–10°C higher. Like the other Baltic rivers, the Vistula is asymmetrical with its right bank comprising 73 percent of its basin. Proceeding downstream, its major tributaries are the: Dunajec, San, Wieprz, Pilica and Narew. The Narew originates in the USSR, and its major tributary, the Bug, which also originates in the USSR, forms about 280 km of the Polish-Soviet border. The Vistula is navigable for about 90 percent of its length.

Oder. Rising at 634 m in northern Czechoslovakia (known both there and in Poland as the Odra), the Oder has a total length of 854 km of which 742 km lies in Poland. After passing the Moravian Gate, the Oder runs generally northwest to be joined by the Nysa and continue north as the 187-km border of the Democratic Republic of Germany. It debouches in the Szczecin Haff on the Baltic. The delta side belongs to Poland but the larger river ports are on the German side. Its flow is similar to that of the Vistula, and high water moves a large amount of alluvial material into the channel where continual dredging and bank reinforcement are required. Canalized in part by locks, the Oder's flow is stabilized by a number of reservoirs on tributaries. It is navigable almost to the point where it enters Poland, and is heavily polluted. Ice usually lasts about 30 days but has been extended to 80 days. Like the Vistula, its right bank comprises about 70 percent of its basin. Its most important tributary is the 808-km Warta which also has a very important affluent, the Noteć. Another tributary to the Oder is the Nysa or Nysa Luzycka (also known as the Niesse). Rising in Czechoslovakia, it forms Poland's boundary with the Democratic Republic of Germany from the Czech border to its mouth.

5.2 Lakes (Jeziora)

Most figures as to the number of Polish lakes generally agree. Majdanowski (1954) gives the number over 1 ha in area as 9 296. V.H.W. and Melezin (1957) say there are some 9 300 lakes and that their number is declining. Kondracki (1974) reiterates the statement that the number of Polish lakes over I ha in area is about 9 300 adding that this figure does not include valley floor oxbow lakes, reservoirs or artificial ponds. Poland/EIFAC (1974; 1976) agree on a total of 9 300 lakes. Europa (1988) says there are some 5 000 lakes. Figures concerning the total lake area in Poland are given in Table 1. Accepting the earliest citation as reasonably correct, there appear to be about 9 300 lakes in Poland totalling about 3 200 km^2 as is shown in Table 5. The area, depth, and elevation of the largest and deepest Polish lakes are shown in Table 6.

Table 5

The number of Polish lakes and area distribution in size classes

Size class (ha)	No. of lakes	Percent	Area (ha)	Percent
1–5	4 734	50.9	10 388	3.3
5–10	1 316	14.2	9 239	2.9
10–20	1 091	11.7	15 284	4.8
20–50	1 043	11.2	32 748	10.3
50–100	533	5.7	36 783	11.6
100–1 000	545	5.9	136 262	43.0
over 1 000	34	0.4	76 243	24.1
Total	9 296	100.0	316 947	100.0

Source: Majdanowski (1954)

Most of Poland's lakes are of glacial origin. A small number of cirque lakes are found in the Carpathian and Tatra mountains (e.g., Wielki Staw and Czarny Staw), but most Polish lakes lie on the plains of the northern lake regions. The commonest type in Poland is the “tunnel” or “channel” lake which lies in a channel excavated by melt water flowing under glacial ice (e.g., Miedwie, Beldany and Hańcza). The other major type of lake, found in areas of ground and frontal moraines, are formed in cavities following glacial accumulations or melting of separate dead-ice blocks and sometimes as a result of damming in the area of a terminal moraine (e.g., Mamry). There are also some shallow lakes in the valley regions formed by natural obstructions or subsidence, and a few karst lakes outside the last glaciation between the Wieprz and Bug rivers. There are also some shallow lakes formed in river deltas or replaced bays cut off from the Baltic by sand banks (see also section 5.5).

Patalas (1965) has listed the four largest groups of Polish lakes as follows. The largest group is in the Pomeranian Lakeland between the lower Oder and lower Vistula (northwestern Poland): 4 129 lakes totalling 115 300 ha in area. The second largest is the Mazury Lake District (northeastern Poland): 2 561 lakes totalling 141 700 ha. The largest Polish lakes, Sniardwy and the Mamry complex are found in the Mazurian district. The third largest lake area is situated between the Middle Oder and middle Vistula: 1 711 lakes with a total area of 53 100 ha. The fourth group, the Leczyca-Wlodawa Lakeland is situated north-northeast of Lublin in eastern Poland: 68 lakes, 2 730 ha.

Small but deep lakes (to 79.3 m) in the mountains constitute another distinct group; there are 43 lakes over I ha in area in the Tatras alone. Most of these granite-bound oligotrophic lakes were barren of fish until the end of the Nineteenth Century when stocked with char and trout.

Most of the Polish lakes less than 50 ha in area are shallow, up to 15 m in depth. Among those greater than 50 ha, most have maximum depths from 15 to 30 m, and there are only about 25 lakes 50–85 m upward in depth.

Most of the lakes are of carbonate type, the pH a little below 7, conductivity 100–150 uS/cm. There are, however, various lakes richer in electrolytes.

Thermal conditions are typical for the climatic zone with a summer stagnation period of 4 to 6 months and a winter stagnation of 1 to 4 months. In summer, surface temperatures mostly keep to 18°–22°C, and bottom waters usually keep within 6°–9°C. In winter, bottom waters usually keep within 2.5° and 4°C. The period of ice-cover is generally between end-December and end-March. In the large Mazury group, ice is usually 30–40 cm in depth.

Table 6

Principal lakes of Poland

Lake	River basin	Area (km^2)	Max. depth (m)	Elevation (m)
In order of size				
Śniardwy	Pisa	113.8	23.4	116.1
Mamry	Wegorapa	104.4	43.8	116.2
Lebsko	Leba	71.4	6.3	0.3
Dabie	Oder River Mouth	56.0	4.2	0.1
Miedwie	Plonia	35.3	43.8	14.1
Jeziorak	Drweca	34.6	12.0	99.5
Niegocin	Pisa	26.0	39.7	116.2
Gardno	Lupawa	24.7	2.6	0.3
Jamno	Coastal lake	22.4	3.9	0.1
Wigry	Czarna Hańcza	21.9	73.0	131.9
Goplo	Noteć	21.8	16.6	76.9
Drawsko	Drawa	19.6	79.7	128.4
Roś	Pisa	18.9	31.8	115.4
Wielimie	Gwda	18.7	5.5	132.7
Talty z Ryńskim	Pisa	18.4	50.8	116.1
Nidzkie	Pisa	18.3	23.7	117.7
Bukowo	Grabowa	17.5	2.8	0.1
In order of depth				
Hańcza	Czarna Hancza	3.1	108.5	226.5
Drawsko	Drawa	19.6	79.7	128.4
Wielki Staw	Dunajec	0.3	79.3	1 664.6
Czarny Staw	Dunajec	0.2	76.4	1 579.5
Wigry	Czarna Hancza	21.9	73.0	131.9
Wdzydze	Wda	15.0	68.0	133.8
Wuksniki	Pasleka	1.2	68.0	111.4
Babiety Wlk	Krutynia	2.5	65.0	140.7
Morzycko	Slubia	3.4	60.0	51.4
Trzesńiowskie	Pliszka	1.9	58.8	106.0
Pilakno	Krutynia	2.6	56.6	139.7
Elckie	Elk	3.8	55.8	120.2
Uzewo (Ozewo)	Rospuda	0.6	55.5	191.3

Source: Rocznik Statystyczny, 1988

There are few oligotrophic or dystrophic lakes in Poland. Considerably larger is the a- and bmesotrophic group and the more numerous eutrophic lakes. The largest group of all represents pondtype lakes (less than 6 m in depth); however, in terms of overall area, lakes in the eutrophic and bmesotrophic groups have the largest share.

The hypolimnion of the eutrophic lakes often has an oxygen content below 1 mg/l for about five months, is often devoid of O_2, and registers high H_2S. In many tunnel lakes more than half the bottom area is often inaccessible to fish for several months during the summer.

From a fishery standpoint, Polish lakes have sometimes been classified with respect to their indicator species and predominant catch as follows: (i) whitefish (Coregonus spp.) lakes; (ii) bream lakes (Abramis brama, Rutilus rutilus, Alburnus alburnus); (iii) pike-perch lakes (Stizostedion lucioperca, Anguilla anguilla); (iv) tench and pike lakes (Tinca tinca, Esox lucius); (v) crucian carp (Carassius carassius) lakes. In reporting on a survey made in 1953, Zawisza (1965) states that whitefish (coregonid) lakes then constituted almost 40 percent of the lake area, bream, pike-perch, and tench and pike lakes each about 20 percent, and crucian carp lakes about 3 percent[1]. Whitefish lakes corresponded to a- and b-mesotrophic and to some of the deeper eutrophic lakes. All of the other four types were eutrophic. No clearly marked differences in the amount of catches between the respective types were recorded, and within each group productivity varied from high to low. The basic typology may be useful, but large-scale stocking with coregonids (emanating from commercial hatcheries and primarily Coregonus lavaretus and C. peled) has now made their value as indicator species less useful.

[1] Nagieć (1977) agreed in saying that about 20 percent of Poland's lake area was characterized by the presence of pike-perch. Such areas had low mean depths, lack of thermal stratification, intensive mixing, low transparency, and frequent algal blooms

5.3 Reservoirs or Dams (Zapory)

Kossakowski (1973) said there were about 30 000 ha of reservoirs with surface areas over 20 ha in Poland. Kondracki (1974) said there were about 50 reservoirs in Poland with a total area of some 20 000 ha. Poland/EIFAC (1974) said there were about 33 000 ha of large reservoirs in the country, and that about 18 000 ha of reservoirs were then being exploited for commercial fishing. Backiel (1985) stated that there were more than 100 reservoirs in Poland with a capacity of more than 1 million m^3. Bninska and Leopold (1987) and Poland/EIFAC (1989) say that the total reservoir area in Poland is 51 200 ha. Most of the Polish reservoirs are designed for flood control, as aids to navigation, and for the generation of hydroelectric power. All of them are used for recreational fishing. Table 7 which is derived from the Polish Statistical Yearbook for 1988 lists 23 reservoirs whose total area is 30 160 ha.

5.4 Canals (Kanaly)

The low divides between Poland's lowland rivers have made canal construction relatively simple and there is a considerable connection of waterways between rivers, as well as lakes. Table 8 provides some data on Polish canals (see also section 6).

5.5 Other Waters

The Baltic Sea, a shallow almost landlocked basin fed by many streams is quite brackish. Its salinity off the Polish coast is low, about 7–8 ppt. The coast has several bays as well as “lagoons”, “firths”, or “haffs” and coastal lakes either cut off from the Baltic or connected by narrow straits. The two largest of these are the Szezecin or Stettin Haff (635 km^2 of which 372 km^2 is Polish) at the mouth of the Oder, and the Vistula Haff or Lagoon (838 km^2 of which 328 km^2 is Polish). These two haffs may be considered to be in a stage of transition to coastal lakes. For example, the Vistula Lagoon is only about 5 m deep and connects with the Gulf of Gdansk through a narrow channel. Bukowo, with an area of 1 747 ha and maximum depth of 2.8 m is an example of a coastal lake in which the transition has been completed. The water of the small lagoons is less salty than that of the main Sea, but even in the Sea there are populations of fluvial fishes, such as bream, roach, and pike, which are fished for commercially (see section 7). See the reviews of Finland and Sweden for further information on the Baltic.

Artificial fish ponds, which constitute a large share of Poland's inland waters are discussed in section 7.2

Table 7

Important Polish reservoirs

Name	River	Area (km^2)	Volume (million m^3)	Height dam (m)	Age
Wloclawek	Vistula	70.4	408.0	34	1970
Goczalkowice	Vistula	37.1	163	17	1956
Turawa	Mala Panew	19.5	107	13	1948
Debe	Narew	33.0	94	24	1962
Nysa (Glebinów)	Nysa Klodzka	20.4	117	16	1971
Otmuchów	Nysa Klodzka	20.0	125	17	1933
Solina	San	22.0	474	82	1968
Roznów	Dunajec	16.0	174	49	1941
Koronowo	Brda	15.6	81	23	1960
Tresna	Sola	10.0	100	38	1967
Dzierzno Duźe	Klodnica	6.2	94	9	1963
Slup	Nysa Szalona	4.9	38.4	19	1978
Przeczyce	Czarna Przemsza	5.1	21	14	1963
Zur	Wda (Czarna Woda)	4.4	16	18	1930
Porabka	Sola	3.6	27	38	1936
Czchów	Dunajec	3.5	12	22	1949
Pilchowice	Bóbr	2.4	50	62	1912
Myczkowce	San	2.0	10	18	1961
Gaskowo	Slupia	1.6	18	9	1914
Lesna	Kwisa	1.4	15	45	1908
Zlotniki	Kwisa	1.3	11	37	1924
Straszyn	Radunia	0.7	3	23	1910
Lubachów	Bystrzyca	0.5	8	45	1917

Source: Rocznik Statystyczny, 1988

Table 8

Principal canals of Poland

Name	Connections	Length(km)	Age
Wieprz-Krzna	Wieprz - Krzna Poludniowa	140.0	1961
Augustowski	Czarna - Hańcza - Biebrza	80.0	1840
Elblaski	Jeziora Drweckie - Jezioro Druzno	62.5	1850
Gliwicki	Klodnica - Odra	40.6	1938
Slesliński	Warta - Jezioro Goplo	32.0	1950
Notecki	Noteć - Kanal Bydgoski	25.0	1892
Bydgoski	Brda - Notec	24.7	1914
Zerański	Wisla - Narew	17.6	1963
Laczański	Wisla - Wisla	17.2	1961

Source: Rocznik Statystyczny, 1988

6. LAND AND WATER USE

Despite its rather unfavourable climate and soil, Poland is one of the world's leading agricultural countries. Its principal crops are: cereals (rye, wheat, oats), sugar beets and potatoes. Live stock production is also important. By broad indications its lands have sufficient natural moisture, and only 0.32 percent of the country is irrigated (100 000 ha in 1986). Irrigation therefore creates only a slight demand upon its water resources, and, in fact, shows a reduction from the 202 000 ha irrigated in 1971. Drainage has long been the principal method of land reclamation. A considerable amount of liming and fertilization is now being practiced, and the use of pesticides is increasing. For example, in the Brodnica lake district, fertilizer use has increased from 35 kg/ha/year in 1960 to 200–250 kg/ha/year in 1980 (Churzi, 1983). Overall use of fertilizers in Poland was somewhat above the European average in 1984.

Table 9

Pattern of land use in Poland, 1986

	Percent
Arable and permanent crops	47.4
Permanent pasture	13.0
Forests and woodland	27.9
Other land	9.0
Inland water	2.7
Total	100.0

Source: 1983 FAO Prod.Yearbk., 41, Publ. 1988

Poland's forests, which are mainly coniferous, were sixth in European production in 1985 and some of the rivers are used for floating timber.

Mining, although mostly confined to the southern part of the country, is a much more important industry. The most important mineral resource is hard coal, of which Poland is a principal world producer and brown coal is also important. There is little iron ore, but sulphur, copper, zinc, lead and rock salt production is high, and there is a large reserve of peat, and rich sources of natural gas. Subsurface resources belong to the State.

Poland produces a great deal of power, now seventh in Europe, with an installed capacity of 30 million kW in 1987. However, only 6.6 percent (1 976 000 kW) of this is hydroelectric; thermal power using brown coal is dominant. Poland's rivers are, therefore, largely untapped as a source of energy. Although some of the Carpathian streams have high slopes, and the lower terrain permits cutting across meanders to create drop, the potential for more hydroelectric power is limited. The first nuclear power station was scheduled to open in 1989.

Although Poland is still about 37 percent rural, it is now using its great power production for and industrial base. Major industrial activities include: shipbuilding, engineering, machine building, and production of steel, chemicals, textiles, and food. Its industrial areas now cover almost one-fifth of the country although concentrated in the west.

Transport facilities reach most areas in Poland through a dense network of rails and by roads which are increasing in number but are still not of high quality. Paved road density was about 0.5 km/km^2 in 1985 and car ownership about 103 per 1 000 inhabitants. There are three large ports on the Baltic and about 11 fishing ports. A system of navigable waterways is composed of natural rivers and lakes (about 25 percent), canals (25 percent), and regulated streams (about 50 percent). The latter are controlled by dams, levees and locks. Statistics on the extent of navigable waters differ somewhat: about 4 600 km navigable and 2 250 km for rafting (Keefe et al., 1973); 6 907 km of which only 4 581 km are fully navigable (Kostrowicka, 1974); 3 786 km (CMEA, 1977); 3 734 km (Economist, 1981); 3 997 km (Europa, 1988). Inland navigation may be impeded by ice for one to three months in the winter although icebreakers are used in the lower waters. Pipelines have now become more important than canals for the bulk of inland transportation.

Overall water use in Poland is distinctly slanted in favour of industrial use as shown in Table 10.

Table 10

Total water demand in Poland
(billion m^3 yearly)

	1970	1980	1987
Municipalities	1.5	2.7	3.0
Agriculture	1.7	1.3	1.6
Industry and power plants	6.9	10.1	10.8
	10.1	14.1	15.4

Source: Rocznik Statystyczny, 1988

With high demand for water in limited supply, water pollution is a severe problem in Poland. Among major sources are sewage, wastes from food and agricultural industries such as effluents from starch, sugar, and dairy production, and wastes from the wood industry. Thermal pollution from the discharge of hot water by power plants into lakes and streams is also common in Poland. In 1965 it was considered that some 12 000 ha of lakes were in danger of water pollution or polluted to the extend that fish production was excluded. An evaluation of the state of water pollution applied to 100 main rivers in Poland with a total length of 11 493 km showed that one-third of these rivers consisted of waste waters (Kolaczkowski and Manczak, 1971). By 1973, it was estimated that heavy pollution existed in 6 percent of the lakes, about 35 percent of the river area, about 38 percent of the larger reservoirs, and about 4 percent of the fish ponds (Kossakowski, 1973). An even more alarming picture is painted by Vita (1990) who states that 95 percent of Poland's river water is unfit for human consumption and that 50 percent of it is unfit for industrial use. The latter statement is confirmed by Harper's Index (1990) based on information from the Worldwatch Institute. Fully verifiable or not, there is no question but that Poland's water quality has been severely impaired.

Marine fisheries, encompassing both Baltic and distant water fishing, is important in Poland as is the construction of fishing vessels. Commercial fishing in inland waters is of long standing here although now being outstripped by sport fishing. Pond fish culture has long been an important use of water in Poland, for example, in 1939 the total fish pond area was over 18 percent of all its inland waters, an extension of the carp culture which began circa the Thirteenth Century. The per caput consumption of all food fish was 18.3 kg/year circa 1989, and about 1 kg/year of freshwater fish alone circa 1982. Tourism in Poland is low.

7. FISH AND FISHERIES

Gasowska (1965) lists 55 species of freshwater fish belonging to 17 families as resident in Poland. Of these, about 25 native species belonging to 10 families, are of major importance in the commercial and recreational fisheries of the country (see Table 11). In addition to these, the American brown bullhead (Ictalurus nebulosus) is established in many Polish waters, and other introductions include: rainbow trout (Oncorhynchus mykiss), the American brook trout (Salvelinus fontinalis) which is found in the Tatra Mountains, Siberian whitefish (Coregonus peled), largemouth black bass (Micropterus salmoides), and some of the Chinese carps.

Fishes formerly abundant in Poland were the sturgeon (Acipenser sturio) now rarely encountered, and the Atlantic salmon (Salmo salar). Larsson (1980) estimates that in 1900, Polish smolt production of the Atlantic salmon was about 10 000 which had been reduced to about 1 000 by 1970. At the time of writing, he further states that the Drawa River, a tributary of the Oder, was the only Polish water where spawning of this fish occurs regularly. Poland/EIFAC (1989) also says that Polish Atlantic salmon still reproduce naturally only in the Drawa River, but that their overall situation has improved due to stocking both in the Pomeranian rivers and in the Baltic Sea. Smolt production and release of Atlantic salmon and sea trout in 1986 amounted to 619 691 and 6 131 500 feeding sea trout hatchlings. High summer temperatures have harmed Polish efforts to raise salmon, and sea trout are easier to raise. Based primarily on Bartel and Zielinksi (1989), Poland/EIFAC (1989) further describes the situation by saying that in 1986, the Polish commercial catch of Atlantic salmon and sea trout (Salmo trutta) (the two species are not distinguished in the catch) amounted to 276.2 t, derived as follows: 137.2 t from the Baltic Sea, 84.6 t in Baltic coastal waters, 5.8 t from “lagoons” (mainly the Vistula estuary), and 48.6 t in Polish rivers.[1] Sea trout can still reproduce naturally in a number of Pomeranian rivers, and many Altantic salmon and sea trout are caught by angling in these rivers.

[1] Only the Baltic catch of “Atlantic salmon” in 1986 is recorded in the FAO summations for Poland (Tables 12 and 13)

Two other prized salmonoid game fishes are also found in Poland: the grayling (Thymallus thymallus), and the huchen (Hucho hucho), which is found naturally only in the River Czarna Orawa and its tributaries in Poland's small Danube drainage. The huchen has also been introduced into other Polish streams, e.g., the Dunajec and Poprad in the Vistula drainage.

<u>Table 11</u>

Commonest exploited inland fishes of Poland

Species	Lakes	Rivers
Fine food fishes[a]		
Lampern (<u>Lampetra fluviatilis</u>)		x
European eel (<u>Anguilla anguilla</u>)	x	x
Brown trout (<u>Salmo trutta</u>)	x	x
European whitefish (<u>Coregonus albula</u>)[b]	x	
Pollan (<u>C. lavaretus</u>)[b]	x	
Common carp (<u>Cyprinus carpio</u>)	x	x
Pike (<u>Esox lucius</u>)	x	x
Common bream (<u>Abramis brama</u>)	x	x
Bolen[c] (<u>Aspius aspius</u>)		x
Barbel (<u>Barbus barbus</u>)		x
Crucian carp (<u>Carassius carassius</u>)	x	x
Swinka[c] (<u>Chondrostoma nasus</u>)		x
Orfe (<u>Leuciscus idus</u>)		x
Chub (<u>L. cephalus</u>)		x
Tench (<u>Tinca tinca</u>)	x	x
Certa[b] (<u>Vimba vimba</u>)		x
European perch (<u>Perca fluviatilis</u>)	x	x
Pike-perch (<u>Stizostedion lucioperca</u>)	x	x
Coarse fishes[a]		
Smelt (<u>Osmerus eperlanus</u>)	x	
Common bream (small) (<u>Abramis brama</u>)	x	x
Bleak (<u>Alburnus alburnus</u>)	x	
White bream (<u>Blicca bjoerkna</u>)	x	x
Roach (<u>Rutilus rutilus</u>)	x	x
Rudd (<u>Scardinius erythrophthalmus</u>)	x	
European catfish (<u>Silurus glanis</u>)	x	x
Burbot (<u>Lota lota</u>)	x	x
European perch (small) (<u>Perca fluviatilis</u>)	x	x

[a] These divisions are derived from Backiel (1965) and Zawisza (1965), the sources of this table. In some countries, many more of these fishes would be termed “coarse”

[b] However, see below for other names for these Coregonids

[c] Polish name

The European eel (<u>Anguilla anguilla</u>), which is important both as a commercial and sport fish, no longer enters Polish rivers according to Poland/EIFAC (1989). However, starting on a small scale in 1948, it is now widely and intensively stocked with elvers imported from France and the Federal Republic of Germany. Catches of eel by commercial fishermen show a continuous increase both as a percentage of total catch and in total weight (average annual catch 432.25 t during 1951–81). Furthermore, studies in 1979 showed that the eel catch from sport fishing reached an annual total of 1 786 t or 2.6 times higher than the commercial catch (Leopold and Bninska, 1984).

Aside from the anadromous fishes and the catadromous eel, Poland possesses a number of freshwater fishes which are tolerant of the brackish water of the Baltic. Among these are the whitefishes or coregonids (Coregonus spp.), in Poland otherwise confined to postglacial lakes in the Baltic lakeland. Falkowski, Luezynski and Vuorinen (1988) list the native coregonids of Poland as "vendace (Coregonus albula) and whitefish (C. lavaretus)". They also say that a third species, the peled (C. peled) was introduced into Poland from the USSR in 1966. Another foodfish is the semimigratory Vimba vimba, a cyprinid known in Poland as the certa. Other fishes of commercial importance which are caught in the Baltic as well as in fresh water are listed in Table 13.

In addition to these finfishes, Poland possesses three species of crayfish: the native Astacus astacus, and the introduced A. leptodactylus and Orconectes limnosus[1]. A. leptodactylus was introduced after the decline of A. astacus by the crayfish plague and Orconectes was introduced about 90 years ago from the USA. Kossakowski (1973) states that in recent years the total catches of Poland of these three crayfishes have reached 25–30 t/year: Astacus astacus about 90 percent and A. leptodactylus about 10 percent[2]. He believes, nevertheless, that the stocks have declined, attributing this to crayfish plague (Aphanomyces astaci), and destruction of habitat through flood control, irrigation works and pollution. Kossakowski (1975) believes that the potential catch of Orconectes limnosus could be as high as 100 t annually if catching methods were effective and a good Polish market existed.

Table 12 shows the "catch" in Polish inland waters during the 1965–87 period as compiled by FAO from data contributed by the Government of Poland. It will be noted that starting in 1984, there was a marked change in the type of statistics presented; i.e., they became much more specific. However, no distinction was made in the FAO Fishery Yearbooks between fish derived by capture fishing and those produced through aquaculture. It is apparent however, that the greater part of the "catch" recorded in this table represents cultivated fish[3]. Poland/EIFAC (1976) emphatically stated that the Polish "catch" of both common carp and trout shown in the FAO Fishery Yearbooks through 1973 was derived from aquaculture while the remainder of the reported inland fishery catch was from commercial fishing. Poland/EIFAC (1989) modified this statement by saying that while the bulk of the "catch" of carp shown in the FAO Fishery Yearbooks through 1983 (Table 12) was produced aquaculturally, the Yearbooks also included the true commercial catch of carp and that the "catch" of trout shown through 1983 was primarily true catch or capture. Since 1984, however, the "catch" of trout reported in the FAO Yearbooks (Table 12) seems to refer only to production by the State Fish Farms. They usually include trout produced in pond culture and trout produced in cage culture; both are actually aquacultural production. (See section 7.2 for a true presentation of aquacultural production.)

As another example of somewhat misleading statistics, one notes the practice in some reports on aquacultural production to include only the consumable (marketable) production, i.e., "table fish", while others include the production used for stocking and/or the brood fish. For example, during the 1970–73 period, Europa (1974) listed the total Polish catches for freshwater fish, in thousands of tons, as follows: 1970 (21.6), 1971 (23.4), 1972 (26.5), and 1973 (28.6). It will be noted that the corresponding figures in Table 12 are less. Poland/EIFAC (1976) explains the discrepancy by noting that the Europa (1974) figures include "stocking material". Europa (1982) has similar figures for freshwater catches during the 1974–80 period, in thousands of tons as follows: 1974 (27.9), 1975 (30.7), 1976 (32.9), 1977 (34.5), 1978 (26.9), 1979 (27.4), and 1980 (26.7); as does Europa (1985), 1981 (31.1), 1982 (36.5), and 1983 (42.6). All of these catches are higher than those shown in Table 12, and it has been assumed by the author that the same reason explains the difference. Poland/EIFAC (1989) agrees[4].

[1] In 1972, the American signal crayfish, Pacifastacus leniusculus, was brought in from Sweden

[2] Table 12 which shows much smaller catches of crayfish is intended to include only the reported commercial catch

[3] For many years, the FAO Fishery Yearbooks have, as a policy, lumped the production from aquaculture with the catch by commercial capture fishing, even when, as is the case with Poland, they have been distinguished in the original data

[4] The Europa statistics are taken from the Central Statistical Office of Poland (Glowny Urzad Statystyczny) which - according to Poland/EIFAC (1989) disposes only overall data and thus includes stocking material in the data on total production which other sources have then included as part of the "catch"

In addition to the strictly freshwater catch (specified here as "inland"), there is a substantial catch of fluvial and diadromous fishes by Poland in Marine Statistical Area No. 27, the Northeast Atlantic, which includes the Baltic Sea (see Table 13). Undoubtedly, all of the freshwater fish shown here are caught in the very brackish Baltic.

Table 12

Nominal catches by species in the inland waters of Poland, 1965, 1970, 1975, 1980–87 (in tons)

	1965	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987
Freshwater bream (Abramis brama)	1 600	1 900	2 117	1 925	1 677	2 342	1 981	2 210	1 914	2 588	2 113
Freshwater bream n.e.i. (Abramis spp.)	-	-	-	-	-	-	-	0	18	14	27
Common carp (Cyprinus carpio)	9 700	9 700	14 295	8 793	13 190	11 647	16 543	17 985	18 189	16 714	18 472
Tench (Tinca tinca)	-	-	-	-	-	-	-	199	149	157	103
Crucian carp (Carassius carassius)	-	-	-	-	-	-	-	0	9	14	16
Roaches (Rutilus spp.)	2 000	2 100	2 337	1 898	2 091	2 976	2 631	2 990	2 364	2 452	2 461
Orfe (Leuciseus leuciseus)	-	-	-	-	-	-	-	...	...	...	9
Grass carp (Ctenopharygodon idella)	-	-	-	-	-	-	-	...	...	...	1
Silver carp (Hypophthalmichthys molitrix)	-	-	-	-	-	-	-	...	...	...	0
Cyprinids n.e.i. (Cyprinidae)	-	-	-	-	-	-	-	...	...	...	2
Lampreys n.e.i. (Petromyzonidae)	-	-	-	-	-	-	-	...	...	...	1
Pike (Esox lucius)	700	500	475	271	287	408	413	551	251	247	296
European catfish (Silurus glanis)	-	-	-	-	-	-	-	...	...	...	2
Burbot (Lota lota)	-	-	-	-	-	-	-	...	...	...	0
European perch (Perca fluviatilis)	200	200	293	124	146	121	147	180	106	107	102
Pike-perch (Stizostedion lucioperca)	200	200	205	148	145	227	221	350	219	220	184
Freshwater fishes n.e.i. (Osteichthyes)	2 500	2 300	2 479	4 593	4 519	7 028	6 846	6 039	2 660	3 983	4 000
European eel (Anguilla anguilla)	400	600	641	504	703	839	918	1 497	1 041	777	713
European whitefish (Coregonus albula)	300	500	466	444	533	622	668	803	439	543	575
Pollan (Coregonus lavaretus)	-	-	-	-	-	-	-	...	...	...	0
Atlantic salmon (Salmo salar)	-	0	0	12	15	0	0	0	0	0	0
Rainbow trout (Oncorhynchus mykiss)	-	-	-	-	-	-	-	1 715	1 515	1 571	1 600
Trouts n.e.i. (Salmo spp.)	0	0	27	10	13	16	18	20	23	47	27
Total finfish	17 600	18 000	23 335	18 722	23 319	26 226	30 386	34 539	28 897	29 434	30 704
Crayfishes (Astacus/Cambarus)	0	0	5	0	0	1	0	1	3	5	7
Total	17 600	18 000	23 340	18 722	23 319	26 227	30 286	34 540	28 900	29 439	30 711

- This category not listed this year
0 Probably nil, negligible or insignificant; or less than 50 t during the 1965–73 period, or less than half a ton during later years
... Data not available or included elsewhere

Source: 1965–69 Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–83 FAO Fish.Dept. Fishery Statistical Database (FISHDAB)
1984–87 Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

Table 13

Nominal catches of fluvial and diadromous species in Marine Statistical Fishing Area 27 (Northeast Atlantic) by Poland, 1965–87 (in tons)

	Freshwater bream	Roaches	Pike	European perch	Pikeperch	Freshwater fishes	European eel	Atlantic salmon	**Total**
1965	700	400	100	0	400	400	500	200	2 700
1966	800	400	100	100	500	400	600	100	3 000
1967	1 000	500	100	200	400	500	600	100	3 400
1968	1 000	400	100	100	600	1 400	600	200	4 400
1969	700	400	100	100	700	1 200	600	100	3 900
1970	900	600	100	100	600	1 000	400	100	3 800
1971	1 000	400	100	0	700	2 100	400	100	4 800
1972	1 300	300	100	0	300	3 100	300	100	5 500
1973	1 200	400	100	0	600	2 200	200	100	4 800
1974	0	0	0	0	0	5 028	272	119	5 419
1975	1 044	475	34	0	632	3 190	276	88	5 739
1976	933	196	16	0	605	2 431	300	103	4 584
1977	899	389	12	0	440	2 656	267	80	4 743
1978	888	391	34	0	445	2 448	271	87	4 564
1979	752	124	8	0	418	3 031	294	85	4 712
1980	676	103	0	0	79	4 120	406	70	5 454
1981	84	211	1	0	72	4 203	49	100	4 720
1982	107	122	0	0	37	3 713	56	179	4 214
1983	504	1 498	10	664	357	224	185	196	3 638
1984	637	1 279	9	540	331	16	201	233	3 246
1985	396	1 361	6	336	277	368	296	280	3 320
1986	567	1 479	6	540	255	607	357	222	4 033
1987	1 080	1 262	7	613	395	485	249	401	4 492

0 Probably nil, negligible or insignificant; or less than 50 t during the 1965–73 period, or less than half a ton during later years.

n.e.i.: Not elsewhere included

Source: 1965–69 Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–83 FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1984–87 Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

In summary, one can merely say that the presence of various discrepancies in the reports (both cited and uncited) of Poland's freshwater catch and aquacultural production must leave both the author and reader somewhat dissatisfied. Some explanations follow.

7.1 Capture Fisheries

In contrast to many countries, the commercial fishery of Poland is carried out on most of the lake area, and at the same time most of the lakes are used by the recreational fishery. Circa 1975, from about 400 000 ha of inland waters said to be suitable for angling, the Polish Angler's Association (PAA) used about 280 000 ha for recreation, out of which 58 percent consisted of lakes managed by the State Fish Farms (SFF). Members of the PAA used over 57 percent of the total area of lakes belonging to

SFF (Leopold, 1977). See section 8 concerning the percentage of waters managed by these two organizations.

All fish of any appreciable size (several hundred grams) are of interest to commercial fishermen and anglers. The major species exploited are shown in Table 11.

7.1.1. Commercial fishing

An estimate made by Dabrowski and Waluś (1965) for the annual harvest from Polish freshwater fisheries excluding angling was as follows: lakes 7 300 t; ponds 12 300 t; and rivers 1 000 t. Thus, the commercial catch in open waters at that (unspecified) time was considered to be about 8 300 t annually.

About nine years later, in 1974, the size of the commercial catch was not markedly different. The commercial catch in lakes in that year amounted to 8 015 t with most of about 290 000 ha being exploited. The commercial catch in rivers and reservoirs was about 700 t from about 75 000 ha of water. (Both river and lake statistics are from Poland/EIFAC, 1976 and Poland/EIFAC, 1989.) If one subtracts this combined commercial catch of 8 715 t from the total finfish “catch” of 21 874 t shown in Table 12 for 1974, one derives the figure of 13 159 t which is reasonably close to the figure of 13 335 t representing the combined “catch” of common carp and trout shown in the same table, thus substantiating the previous statement of Poland/EIFAC (1976) that most of the carp and trout shown in Table 12 through 1973 (and also 1974) represent aquacultural production while the other species are derived from the capture fishery.

Regardless of Table 12, the most basic figures known to the author are those contributed by Poland/EIFAC (1989). It clearly states that the commercial catch in Polish open waters (lakes, some reservoirs, and rivers) was 9 348 t in 1984, 9 402 t (1985), 9 325 t (1986) and 8 997 t (1987).

Dembiński (1965) has provided a succinct account of the freshwater fishing gear used in Poland for commercial fishing. It has been assumed here that the methods have not changed drastically since that time. About half of the lake fish are taken with bag seines, the others mostly with fyke nets, set gill, and trammel nets. In rivers, drift nets are used for about 60 percent of the fish landed. Trammel nets are used for bream, gillnets for Vimba vimba, salmon and sea trout. Fish traps and other gear are also used.

In lakes, seines are used for a variety of cyprinids, pike, perch and eel. Whitefish are taken in gillnets, and pike, bream, eel and tench in trammel nets. Fykes and other traps are used for bream, pike-perch, eels, tench, etc.

Poland has done considerable work on developing freshwater fishing gear and methods. Not only have natural materials been replaced by synthetics (manufactured in the country), but fishing has become more mechanized. The use of under-ice seine fishing techniques which yield considerable quantities of fish is noteworthy, and electrofishing to take eels and other fishes has become common.

Fish are mostly sold fresh, also smoked and canned. Both live and processed fish (e.g., eel, pike, tench, carp) are exported as are fish eggs (pike, sea trout) for stocking.

7.1.2 Sport fishing

There are no legal definitions in Poland of either food or sport fish. The latter include almost any species (about 28 in all) that can be caught by angling methods.

Table 14 shows the average annual catch of the Polish angler, the percentage of anglers catching particular species, and the angler's preference for each of these species. Ninety-seven percent of the angler's catch consists of the 14 species listed in this table, and the average annual catch of the Polish angler is almost 50 kg per year.

The average number of fishing days per angler is 61 with a duration of 6 hours, a very high intensity of angling[1]. Seventy-five percent of the angling time is during the period of May–September.

[1] This high intensity can be explained in part by the work hours in Poland (usually 8.00 to 15.00 hours) enabling 34 percent of all angling to be done on normal working days

<u>Table 14</u>

Annual sport catch in inland waters of Poland

Species	Average annual catch per angler (kg)	Percentage of anglers catching this species	Angler preference[a] of catch by species
Roach	17.5	91.2	3
Pike	9.1	78.0	1
Bream	6.8	37.5	7
Perch	6.6	75.1	4
Common carp	4.1	43.2	2
Eel	2.4	45.2	5
Tench	1.2	16.0	6
White bream	1.0	8.9	--[b]
Catfish	0.8	5.0	9
Crucian carp	0.7	6.7	--[b]
Pike-perch	0.7	6.4	8
Chub	0.7	7.3	11
Trout	0.5	8.5	12[c]
Rudd	0.5	6.3	--[b]
Total	51.9	--	--

[a] Barbel was tenth in preference
[b] Anglers prefer <u>not</u> to catch this species
[c] Trout are generally one of the fishes most desired by anglers. Apparently the anglers participating in this survey listed as preferred only those fishes which are rather abundant in Polish waters.

Source: Leopold, Bninska and Hus (1982)

The figures above are based on questionnaire studies embracing about 15 000 people (with preliminary analysis of 1 100 questionnaires) undertaken (apparently about 1979) among members of the Polish Angler's Association (PAA) by Leopold, Bninska and Hus (1982). If the figure of 50 kg as the average annual angler-catch were to be extended to all members of the PAA, i.e., about 750 000 in the number at the time of the study, then the total annual sport fish catch by PAA members alone would amount to about 37 500 t. This would be almost double the entire annual inland commercial catch and aquacultural production reported in 1979 in Table 12, and would not include the catch by all the other Polish anglers who do not belong to the PAA.[1]

Only a few years before, Poland/EIFAC (1976) reported that, according to data from the Ministry of Agriculture, the "…total commercial yield from lakes, reservoirs and rivers is 8 700 t…(the) total yield by angling is 10 500 t. The angling catch from rivers and reservoirs-7 000 t." It was further reported that these catches were made by the then 535 000 angler members of PAA, and about one angler per 0.3 ha of inland water[2]. They imply an average catch by all anglers (i.e., 1 535 000) of only 6.8 kg/year, or even if one assumed that the entire estimate of 10 500 t were caught only by the then 535 000 PAA-anglers, the average catch per angler per year would amount to only 19.6 kg. These estimates do not even come close to those published several years later by Leopold, Bninska and Hus (1982) or Leopold (1983) which cited the average annual catch of Polish anglers as 54.3 kg. Clearly, either the 1975 or the later estimate is erroneous. Poland/EIFAC (1989) states that the earlier estimates have been proved to be far too low and that the average catch per angler is almost 50 kg per year. This statement is based not only upon recent studies (see below) but upon catch registers introduced for anglers in a few districts in Poland[3].

1 "Members of the PAA constitute approximately 2% of the country's population, but it is believed that all together 6% of the population fishes at least occasionally" (Anon./Poland, 1982). According to Polish law, non-members of the PAA have no right to angle (Poland/EIFAC, 1989)

2 Indicating by inference, 460 500 ha of inland water

3 Since 1988, anglers throughout Poland are obliged to register their catches

Another set of figures on the recreational fish catch in Polish inland waters follows, from Leopold (1983). He first estimates that the recreational catch from rivers and dam reservoirs amounts to about 10 000 t annually; no year is specified. He then states that the average number of Polish anglers during the 1957–79 period amounted to 372 600 and the average annual catch per angler was 54.3 kg, thus providing a total annual recreational catch of 20 232 t during this period. Based on the number of angling days spent on lakes (37 percent of the total) he assumes that lake fish catches constitute 37 percent of the total recreational catch or almost 7 500 t annually during this period. He concludes by saying that: "At present fish production in the inland waters of Poland is at least 40 000 t…annually. About 60 percent of this value is obtained from commercial fishery (obviously including pond production); the rest represents recreational fish catches." The conclusion from these statements is that the Polish inland recreational catch is or has been about 16 000–20 000 t annually, and exceeds the catch of the commercial capture fishery.

Corroboration of such figures has been made on the basis of more extensive studies (Bninska, 1985) that in 1979 angler's catches in Poland amounted to about 25 935 t: 11 487 t from rivers and reservoirs, and 14 448 t from lakes. (The commercial fishery in Polish lakes produced only 9 043 t in the same year.)

The waters in Poland fished by anglers are primarily rivers and smaller streams (40.6 percent) and lakes (37.4 percent), followed by small reservoirs (11.2 percent), large reservoirs (6.9 percent), and canals (3.9 percent) according to Leopold, Bninska and Hus (1982). Angling methods are similar to those in other countries with heavy emphasis on the use of ground baits for cyprinids.

Extensive studies have been made in Poland of the economics and sociology of sport fishing (see the references cited above, including their bibliographies); some of their conclusions follow. Angling in this country is considered not only as a sport experience, but one connected with the overall aspects of recreation and environmental quality. It is, however, also closely concerned with the taking and keeping of fish for food. It is primarily a male activity, and one of urban dwellers (only 15 percent of the anglers live in the country). The average annual angling expenditure amounts to 73.5 percent of the average monthly salary, and the market value of fish caught constitutes 38 percent of these expenses.

As has been indicated above, it is difficult to determine the total number of anglers in Poland. Gaudet (1973) using Polish data recorded 400 000 "registered" sport fishermen or 1.3 percent of the total population. Leopold (1977) pointed out that the term "sport fishermen" in Poland should include "illegal anglers" as well as members of PAA and that the above figures might be closer to 1 200 000 persons or about 4 percent of the total population. He also stated that the PAA estimated that in 1975 PAA had 535 000 members and that 1 070 000 additional Poles were sport fishermen, i.e., a total of 1 605 000 people or 4.7 percent of the population at that time[1]. A few years later the PAA was estimated to have 750 000 members and altogether about 6 percent of the total Polish population was believed to fish at least occasionally (see Anon./Poland, 1982; Leopold, Bninska and Hus, 1982). This would indicate a total angling population of about 2 148 300 in 1980. The validity of such estimates has been questioned by the reporters themselves. Nevertheless, since they believe that the number of anglers in the PAA itself is increasing at a rate of about 10 percent annually, it is obvious that sport fishing ranks high as a recreational activity in Poland.

[1] Leopold (1977) concluded, however, that the total number of anglers in Poland amounted to about 1 900 000

Conflicts between sport fishing and other direct uses of water, such as commercial fishing have been well explored in Poland. They exist, but present conclusions are that they are not significant.

7.2 Aquaculture

Most pond farms in Poland were created many years ago, some in the Thirteenth or Fourteenth Century. In the Middle Ages, ponds were only an adjunct of agriculture and were sometimes constructed for aesthetic purposes rather than for practically. Small, shallow, and often dispersed, many of them need reshaping to be efficient.

With respect to aquaculture in Poland, emphasis is placed on the culture of common carp, a tradition of more than 600 years. Other fishes cultivated here, often in carp ponds, are: tench, crucian carp, pike-perch, coregonids (Coregonus spp.), and rainbow trout. They constitute, however, only a small amount of the total production. In recent years, exotics such as the bighead (Aristichthys nobilis), silver carp (Hypophthalmichthys molitrix) and grass carp (Ctenopharyngodon idella), which were introduced to Poland in 1964 (Opuszynski, 1979), and the Siberian Coregonus peled have also been cultivated.

The artificial pond area in Poland circa 1965 was considered to be 66 779 ha (Patalas, 1965), and 60 000 ha circa 1983 (Leopold, 1983; Ackefors, 1989), i.e., about one-fifth the natural lake area (see Table 1). According to Dr M. Bninska (personal communication of 29 January 1990) it is difficult to state clearly the actual area in Poland occupied by artificial fish ponds since the Ministry of Agriculture and Food distinguishes between total pond area and that actually used for fish culture. For example, according to Poland/EIFAC (1986) the Ministry lists the total pond area in Poland in 1983 as 64 028 ha of which only 44 488 ha were actually used and in 1987, 70 111 ha of which 51 016 ha were actually used. Of the latter area, almost 61 percent was used by the State Fish Farm, 14.5 percent by the Polish Angler's Association (PAA) and the rest by other users (cooperatives, forestry, etc.).

The principal concentrations of fish ponds are in areas devoid of or poor in natural lakes, i.e., in Central or South Poland. Some ponds are fed by rivers, many merely by precipitation on their individual drainage basins, fewer by springs or artesian water. Most ponds are on poor agricultural land. Pond farms vary between 300 and 1

500 ha, and individual carp ponds usually vary in size from less than 1 ha to several hundred hectares.

Carp culture in Poland is conducted using traditional European methods. In fact, the Dubisch (Dubisz) method of spawning carp originated in Silesia around 1870, laying the foundation for modern carp culture. Carp reproduction usually occurs in late May using the Dubisch method augmented by pituitary gland injection. Both fertilization and artificial feeding are practised to increase yields.

Domestic consumers in Poland demand a carp between 500 and 1 500 g in weight, an attainment which is reached slowly in Poland.

Experiments by M.A. Szumiec (1979) indicate that 14°C is the lowest temperature favouring common carp growth in Poland, and according to Lovell (1977), the period when the water temperature in Poland is above 15°C is only about 90 days, and there are only about 40 days when it is above 20°C. Ground water is too cold to run directly into carp ponds during the summer, and freezing of ponds during the winter make it necessary to remove fish to "wintering" places where the water is aerated or kept moving. Pond water temperatures in Poland thus restrict the carp feeding period to less than five months annually, and the growing period is perhaps only some 150–180 days/year. Leopold (1983) says that the favourable natural climatic conditions for carp last only 150–160 days (of vegetative period under section 4). A weight of 1 000 g of carp is, therefore, usually reached no sooner than the third year. Carp production is designed mainly for domestic consumption with the highest demand reached in December. The export trade in carp is not important.

Circa 1974, the total aquacultural production in Poland was about 20 000 t, of which 6 400 t were used for stocking[1]. (See also the penultimate paragraph of this section for later years.) This production was derived from a total pond area of 60 000 ha, of which 38 000 ha were exploited commercially (Poland/EIFAC, 1974). This provided a total yield of 526 kg/ha/year, but the production of edible or consumable carp was 13 600 t or 358 kg/ha/year. If most of the entire "catch" of common carp specified in the FAO Fishery Yearbooks continues to represent only aquacultural production (see section 7), then between 1965 and 1987, the cultivated carp production in Poland varied between only 8 793 t in 1980 to 18 472 t in 1987 with wide yearly variations (see Table 12).

[1] A standard reference (Pillay, 1979) has inadvertently listed the estimated aquacultural production by Poland in 1975 as 38 400 t. Reference to the original data shows that this figure included not only aquacultural (pond) production but the commercial catch by the capture fishery

Such speculation may be interesting and perhaps even useful in the absence of other evidence. However, as with figures for the commercial catch in Poland, the most basic figures on carp production in Poland are those furnished by Poland/EIFAC (1989) and shown in Table 15.

According to Leopold (1983) carp production in Poland is characterized by significant variability, primarily as a result of varying climatic conditions. During the 1983–87 period, however, the carp production seemed to be relatively stable, centering around 21 000 t annually.

Table 15

Annual aquacultural production of carp in Poland, 1983–87 (in tons)[a]

Year	Table fish	Stocking material	Total
1983	21 943	12 255	34 198
1984	25 190	10 865	36 053
1985	19 499	9 366	28 265
1986	20 112	12 455	32 567
1987	21 716	11 464	33 180

[a] This production is about 90 percent common carp; the rest is tench, crucian carp, and Chinese carps. It represents the production from both State Farm and private producers.

Source: Poland/EIFAC (1989) on the basis of data of the Ministry of Agriculture and Food

Much higher yields than those recorded for 1974 are quite possible in Poland, and some carp farms have achieved a level of production of over 1 000 kg/ha annually. Matina and Berka (1987) say that an average output of more than 1 000 kg/ha/year is obtained only in a total pond area of around 500 ha. Experiments in Poland by J. Szumiec (1979) have shown that ponds in good condition can provide 2 000–3 000 kg/ha/year when carbohydrate food is used, and 3 000–6 000 kg/ha/year when protein-rich pellets are used, and Backiel (1978) cites an experimental culture of carp of 7 400 kg/ha/year in 1977. It should be noted, however, that in the same year (1977), the average yield of marketable (table) carp in Poland amounted to 900 kg/ha/year (Leopold, 1983). Despite high experimental yields, the general policy in Poland is still to use low densities of carp and utilize as far as possible natural food resources rather than scarce high-protein foods.

Production of rainbow trout in Poland is low and designed principally for home markets, especially restaurants. Backiel (1978) says that a autumn-spawning strain of rainbow trout grown in heated water enables marketable trout to be produced in 12–14 months. Lovell (1977) said that in 1977 about 1 000 t of trout were raised in ponds, raceways, and cages, mostly on moist feeds. Leopold (1983) says that present trout production in Poland is about 1 000–1 500 t annually. Poland/EIFAC (1989) lists more exactly the aquacultural production of trout in Poland from 1973 to 1986 (Table 16). Discrepancies between the tonnage of trout produced annually described in Table 10 and recorded in Table 12 cannot be explained except to reiterate the remarks previously made.

Table 16

Annual aquacultural production of trout in Poland 1973–86 (in tons)

Year	Production	Year	Production
1973	123.5	1978	850
1974	190	1979	1 200
1975	256	1980	2 000
1976	460	1986	3 000
1977	805		

Source: Poland/EIFAC (1989) based upon Leopold et al. (1981) and Leopold (1986)

In recent years, the production of Chinese carps imported from the USSR is increasing. There has been an increase in cage culture, including illumination to attract plankers to feed coregonids (Brylinski, et al., 1975), and the use of thermally heated waters for culture is receiving more attention. Poland has also done considerable work on the control of fish diseases.

FAO Fish.Info.Data and Stat.Serv. (1989) agrees almost exactly with the "catch" of common carp and rainbow trout for 1984–87 in Table 12, but calls it "production from aquaculture". It also lists an agricultural production ranging from 300 to 400 t annually of "Osteichthyes" during this period. It considers the total value of Poland's aquacultural production during this period to range from US$ 47 495 million to US$ 51 980 million. (In view of other evidence, the author considers such estimation to be only moderately correct.)

In addition to cultivation of fish for food, there are a number of hatcheries and pond centres to provide fish for stocking open waters. Trout, coregonids, pike, pike-perch, and various cyprinds are among those stocked. A number of Polish articles seem to treat this type of fish management as "aquaculture". Leopold (1983), for example, speaks of the commercial fishery in Poland as "lake fish farming", especially because of intensive lake stocking and the reported high harvest to the fisherman as a result.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership and Availability

Under the Water Law of 1974, all flowing waters, except that in ditches, is property of the State. Practically all Polish fisheries in natural inland waters (open waters) belong to the State. The exceptions are those waters surrounded by the land of one proprietor. The latter concerns only some small lakes of negligible total area, although they may be of value to their owners.

Commercial fishing rights may be awarded for management to appropriate State Enterprises, and rented to other legal or natural persons under the condition of conducting them with qualified personnel. Thus, the Ministry of Agriculture and Food lets fishing rights to corporate (legal) bodies like State Fish Farms, cooperatives, and the Polish Angler's Association (PAA)[2].

All legal anglers must be members of the PAA, which involves paying an annual fee. This fee does not, however, give the member any fishing rights. Fishing rights are obtained by buying a license.

Licenses for waters managed by the PAA are issued by this organization. It issues a variety of licenses for different areas and for different methods and the price of these varies. (See also section 8.4 for more on the PAA.)

The State Farms also make about 55 percent of the lake area which they manage available for angling. Licenses for these lakes are issued both by the PAA and State Farms. Again, there are different types of licenses. The State Farms also issue licenses for lakes not generally available for angling. These "special" or "closed" fishing grounds are very expensive.

In all cases, the income from licenses is taken by either the PAA or State Farms, depending upon which agency manages the water.

[1] This section is derived from Gaudet (1974), material received by EIFAC from Poland in 1979, Surowiec and Deja (1978), Anon./Poland (1982), papers by Leopold et al. cited in section 10, and Poland/EIFAC (1989)

2 The State Fish Farms are the principal producers of freshwater fish and control about 91 percent of the lake area. See section 8.4 for control by the PAA

8.2 Administration and Management

The Polish Parliament (SEFM) lays down laws. With respect to inland fisheries, the Ministry of Agriculture, Forestry and Food formulates these laws and is responsible for their implementation. It is also responsible for the administration of inland fisheries which is carried out by its Department of Animal Breeding through its Fishery Inspectorate operating at central level and fishery inspectors on a district level. Presidia of National District Councils, Division of Agriculture and Forestry, look after general fishery matters in their regions.

8.3 Investigation, Education and Extension

8.3.1 Research is carried on by the:

(i) Inland Fisheries Institute (Ministry of Agriculture, Forestry and Food) with the headquarters at Olsztyn-Kortowo: hydrobiology, ichthyology, fishing techniques, fishery management, fish culture, fishery economics, extension, fishery courses, etc.;

(ii) Department of Fish Diseases in the Institute of Veterinary Sciences (Ministry of Agriculture, Forestry and Food);

(iii) Centres for Combatting Fish Diseases alloted to Veterinary Hygienic Laboratories in various districts;

(iv) Faculty of Water Protection and Inland Fisheries of the Academy of Agriculture in Olsztyn-Kortowo (under the Ministry of National Education);

(v) Sections of Fisheries within various Institutes in the Academies of Agriculture in several cities, and

(vi) Sea Fisheries Faculty, Academy of Agriculture in Szczecin (Ministry of National Education), and Sea Fisheries Institute in Gdynia (Ministry of Transport, Navigation and Communication). Both carry out some research on freshwater fishes in brackish waters.

8.3.2. Education in inland fisheries, in addition to that noted above, is carried out by:

(i) Several schools of fisheries (under the Ministry of National Education), which provide secondary and basic education, and

(ii) State Agricultural Enterprises at various State Fish Farms.

8.4 Other Concerned Agencies

(i) The Polish Academy of Sciencies Institutes and Laboratory at Krakow, Warsaw and various Chairs at Universities of Torun and Krakow, particularly the Laboratory of Aquatic Biology at Krakow with its experimental fish farm;

(ii) National Union of Fishery cooperatives, Gdynia, which affiliates Sea and six Inland Fisheries Cooperatives which run commercial fishing on the Vistula and Oder rivers;

(iii) Polish Anglers Association (PAA) with District Boards in every Voyevodstva or District;

The PAA was the manager of 16.3 percent of the total lake area in Poland, 74.6 percent of the total river area, and 69.8 percent of the reservoir area in 1987. In addition to its activities concerning angling, the PAA carries on commercial fishing and fish breeding on a limited scale.

(iv) Associations of Fish Culturists in several districts. These affiliate private fish producers, mainly trout and carp culturists, and are represented at central level by their union, and

(v) Fisheries Section of the Society of Agricultural Engineers and Technicians.

8.5 International Agreements

Poland has bilateral agreements concerning the uses of water in boundary streams with Czechoslovakia and the German Democratic Republic. It has an agreement with the USSR concerning use of and technical cooperation on the Bug River.

It has a trilateral agreement with Czechoslovakia and the German Democratic Republic on uses of the Nysa Lużycka or Niesse River.

9. STATE OF THE FISHERY

9.1 Yield

Estimates of the standing crops of fish in Polish trout rivers have wide variance, e.g., a range of 7.7 to 375 kg/ha in several southern rivers (Solewski, 1962), and 24 to 123 kg/ha in several northern rivers (Kaj, 1955).

Of more practical importance are the specific yields through fishing shown in Table 17. In addition to these yields, some exceedingly high annual yields have been reported by Zawisza (1965), who called them “maximum”: 430 kg/ha in the 60-ha Duzy Dom Lake and 370 kg/ha in Lake Track. These were obtained less than two years after a poisoning of fish by industrial wastes. Yields of 100–200 kg/ha/year are not unusual in Polish waters in which winterkill has occurred, but a lower level of yield usually follows within a few years.

Table 17

Yields from open waters in Poland

Water	Type of fishing	Major species	kg /ha/yr	Source
Vistula R. Estuary[a]	Commercial	Vimba (40%); sea trout (10%)	60	Backiel (1965a)
Vistula R. Middle	Commercial	Bream (40%)	10–30	Backiel (1965a)
Odra R. Estuary[a]	Commercial	Eel (30%); bream (40%)	100	Backiel (1965a)
Odra R. Middle and Warta R. Lower	Commercial	Bream (20%)	10–30	Backiel (1965a)
San R. Middle and Lower	Commercial	Swinka (60%)	10	Backiel (1965a)
Rivers and Reservoirs 75 000 ha (1974)	Commercial		9.3	Poland/EIFAC (1976)
Rivers and Reservoirs	Commercial, Angling		102.5	Poland/EIFAC (1976)
Reservoirs, Lowland	Commercial		20–40	Backiel (1965a)
Lakes	Commercial		28	Zawisza (1965)
Lakes, 240 000 ha (1974)	Commercial		33.4	Poland/EIFAC (1976)
Lakes	Commercial, Angling and Illegal		48[b]	Poland/EIFAC (1976)
Golawskie Lake (1977)		Bighead and silver carp	70	Backiel (1978)
Lakes (ca 1979)	Commercial, Angling		50–60	Leopold (1983)
Lakes (ca 1980)	Commercial, Angling		ca 80	Bninska (1985)
Rivers	Angling		51.5–123.9	Bninska (1985)

[a] Migratory species account for a large proportion of the catch in estuaries, and fishing effort there is greater than in the upper rivers.

[b] Estimated.

The Polish statistics as reported by FAO (Table 12) show a gradual rise, with occasional setbacks, in the overall inland fishery “catch” from 17 600 t in 1965 to 26 199 t in 1977, followed by a decline to 18 722 t in 1980 and then a resurgence to 30 386 t in 1983 and 34 540 t in 1984. Almost all of the 1965–77 increase was in carp production which increased from a low of 9 700 t in 1965 to a high of 16 208 t in 1977, and then declined to only 8 793 t in 1980 (its lowest point during this period) before ascending to 18 472 t in 1987. Meanwhile, the rest of the reported catch (supposedly almost all from the commercial capture fishery) remained fairly constant during the 1965–74 period with an average annual catch of 8 300 t (range 7 900–8 579). It then rose to 10 895 t in 1979, declined to 9 929 in 1980, and rose again to 14 580 t in 1982, 16 555 t in 1984 and 12 239 t in 1987. It might appear therefore, that the total harvest by commercial capture fisheries has not only been well sustained for the 23 years of record, but has shown an increase. However, as shown in section 7.1.1, the actual Polish commercial catch (based on Poland/EIFAC, 1989) was 9 348 t in 1984 and 8 997 t in 1987.

In 1974, the yield by commercial fishing from all exploited waters (rivers, reservoirs and natural lakes) was approximately 23.9 kg/ha/year (see section 7.1.1).

Assuming that the same area of water was fished commercially in 1987, the yield by commercial fishermen in that year would have been about 33.5 kg/ha. But all such calculations are rather theoretical. Therefore, in view of the difficulties in obtaining exact figures, the author prefers to use only those provided by Poland/EIFAC (1989) which says that 272 693 ha were exploited commercially in 1986. Since the actual commercial catch in that year was 9 325 t (see section 7.1.1), the commercial yield of the capture fishery was, therefore, about 34.2 kg/ha/year.

The total harvest and yield per angler from Polish inland waters by sport fishermen has been discussed in section 7.1.2. The yield from pond fish (primarily carp) has been discussed in section 7.2. Circa 1974 the yield of table or consumable carp was 358 kg/ha/year. In 1987, this yield was 426 kg/ha. (In each case, only the pond area actually used entered the calculation.)

9.2 Factors Affecting the Fishery

Poland does not have a wide variety of inland fishing waters. Good habitat for the once abundant anadromous salmonids is now quite limited. There are only a few oligotrophic trout lakes in the southern mountains, and other trout water is mainly limited to the southern streams of the Carpathians and the Pomeranian rivers of the northwest. The larger part of the river systems are best suited for lesser fishes, the barbels and bream. There is, however, an extensive network of thousands of lowland lakes with a mixed fauna of: coregonids, cyprinids, percids, pike, eels, etc. There has also been a natural exchange of fish stocks through flooding over the low divides between lowland rivers, as well as exchange through the easily facilitated interconnexions by artificial waterways. Brackishwater systems along the Baltic further enlarge the distribution of fluvial fishes.

Generally speaking, the glaciated soils of Poland are not rich in nutrients either for crops or for aquatic fertilization. The growing season at this latitude is short, and the hydrographic and climatic conditions often limit the lake area accessible to fish during the summer.

Land and water use in Poland has greatly changed the original hydrographic conditions. Hydroelectric development has not contributed as much to these changes as in many countries, both because of its relatively low potential and the presence of rich coal resources. However, other forms of river regulation, e.g., for flood control and navigation, have included the construction of dams which have blocked or impeded the migration of diadromous fishes. The sturgeon is now virtually extinct in Polish rivers, and Backiel (1985) believes its disappearance is linked with regulation and channelization of the Vistula estuary. The Atlantic salmon is also very scarce. Sea trout persist although conditions for survival are difficult and stocking for this fish is now practised. The semi-migratory cyprinid Vimba vimba is also affected by barrier dams.

It has been emphasized (in section 6) that industrial demands for water greatly outrank any other uses in Poland. Such large demands (see Table 10) diminish the quantity and affect the quality of water for fisheries. Conversely, Polish demands for water for irrigation are not great. Most of the crops do not require its use, and throughout the country summer precipitation is approximately double that of the winter and usually provides adequate water for crops. (Only in areas with light soils with 50 percent dry months is it really required.)

Drainage, a much more important measure for agriculture here, has diminished fishery production since the middle of the Nineteenth Century by accelerating the process of water-level reduction. Deforestation has also been a means toward this end. Erosion after removal of natural forest cover has not, however, been the problem in Poland that it has in countries with steeper terrain.

Finally, with respect to uses of water adverse to inland fisheries, is the effect of pollution caused by discharge of navigational, industrial, domestic and agricultural (e.g., sugarbeet effluent) wastes. Kindler (1978) stated that the volume of wastes in Poland was estimated to have almost doubled between 1970 (4.4 thousand million m^3) and 1980 (8.4 thousand million m^3) and further estimated to increase by one and a half times to 12.5 thousand million m^3 by 1990. However, as shown in Table 18 (whose source is Poland's main statistical bureau), the volume of wastes discharged into Poland's open waters was already 8.5 thousand million m^3 in 1970, 12.0 thousand million m^3 in 1980 and had surpassed Kindler's prediction by 1985.

The annual runoff per caput is only about 1 428 m^3 which is decidedly below the European average and makes effluent dilution difficult. In recent years, the discharge of hot water by thermalelectric power plants has constituted a new type of pollution problem. The area of warm lakes in which the temperature is not expected to drop below 6–8°C in winter, will cover several thousand hectares. This change in temperature may, however, be advantageous in raising fish in some areas.

Table 18

Waste discharge into Poland's open water, 1970–87

Year	Volume in thousand million m^3	Percent of wastes treated	
		Biological	Chemical
1970	8.5	8.1	5.6
1980	12.0	-	-
1985	12.9	-	-
1986	12.8	-	-
1987	12.8	21.9	5.6

Source: Glówny Urzad Statystyczny (1981, 1988)

In addition to consideration of the physical and biological factors which affect the fishery, note should be taken of certain historical and social factors which affect inland fishery development favourably. Poland has a long history of interest in both wild and cultivated stocks of inland fish, including early attempts at regulation of fishing effort and the practice of pond culture. There is a high demand for freshwater fish, including acceptance of many otherwise considered as coarse or weed species. There is also an old tradition of free access to inland waters, and (at least in recent years) sport fishing in the sea is prohibited by law. Such traditions and considerations may in part account for the high percentage of freshwater anglers including many who are unlicensed. Private transport of anglers to fishing areas is handicapped by the very low number of private passenger cars, but is compensated for by the proximity of fishing areas. There are conflicts between commercial and recreational fishermen but these do not appear to be significant. Some of these conflicts have been resolved on streams by dividing them into angling and commercial areas.

In recent years there have been concerted efforts to: conduct up-to-date fishery research; institute an active programme of management involving protection of the environment, legal regulation of the catch, and stocking; and organize the processes of inland fishery development. The expected decline in marine fishery development with introduction of Exclusive Economic Zones (EEZ) has been a factor in this latter development. Thus, the Government exempted some areas from tax, and made other funds available (Backiel, 1978).

Pondfish culture, which is more amenable to close control than are capture fisheries, has been increasing its production in Poland but has had its ups and downs. Pertinent to these fluctuations are unfavourable factors such as: the short growing season, use of old ponds of poor quality and poorly dispersed (neither large nor compact) on poor soil or fed by small streams and used for other purposes, and an actual decrease in pond area of about 10 percent due to the demands of other water uses and pollution. Conversely, intensive culture, including increased use of mineral and organic waste fertilizers, supplementary low-protein carbohydrate feeds for carp, use of heated effluents, and polyculture including exotic species are among the measures designed to increase yields.

9.3 Prospect

The commercial capture fisheries in rivers, where decline has already been indicated, will continue to decline in yield. This is a concomitant of environmental deterioration, particularly dam construction, river bed correction and pollution. Sturgeon and Atlantic salmon appear to be doomed although the latter are still holding on especially through smolt stocking for the Baltic. Sea trout have a better chance, particularly if stocked as smolts. Vimba, whose spawning grounds are downstream from those of salmon, are not as endangered but are still vulnerable to increased dam construction.

The commercial capture fisheries on lakes may continue to produce at about the same level. However, sustained or increased yields are dependent upon: abatement of pollution, replacement of winter-killed or otherwise decimated stocks, and stocking of non-reproducing species such as eels. In fact, most of the valuable species are now stocked as water quality deterents and the facilities for this form of management are being increased. Among other designed management measures are innovations such as the rearing of coregonids in illuminated cages so that they subsist on plankters rather than on feeds which pollute water.

Sport fishing as in most countries will continue to increase. The sport catch has already surpassed the overall commercial catch and will increase in greater proportion in the Polish lakes.

The overall picture for increased production of food fish is brighter for aquaculture than for capture fisheries. Despite the decrease in pond area, a long-range fish cultural development plan envisions an increase from the 500 million m^3 of water held for ponds circa 1965 to 1.5 thousand million m^3. Such an increase would include not only the construction of new ponds, but an increase in average depth from 80 to 120 cm. Overall hydrologically, the enlargement of pond area and capacity can be viewed not only as a means of increasing fish production, but as an increase in retention reservoirs useful for Poland's water economy.

Despite the lowland lake and river systems, the total water resources of Poland are not large, in relation to its size and population, its needs for water, and the decided diminishment of its quality by pollution. By 1969, a quantity of water equal to about 15 percent of the runoff leaving the country was being used. It was then estimated that by 1980 the water requirements for industrial, agricultural, and domestic uses would exceed 50 percent, and in a very dry year 80 percent of the entire available flow. Calculated per head of population, Polish water resources are among the lowest in Europe. Very limited expansion of the capacity of surface storage reservoirs is possible. According to Kindler (1978), the maximum possible useable capacity of surface storage reservoirs in Poland amounts to only 15 percent of the mean annual runoff from the area of the country. In future, water resource development in Poland may not be related as much to individual river basins as to specific economic regions and their needs. Interbasin redistributions to correct water deficits can be visualized, and their patterns will further affect the inland fisheries.

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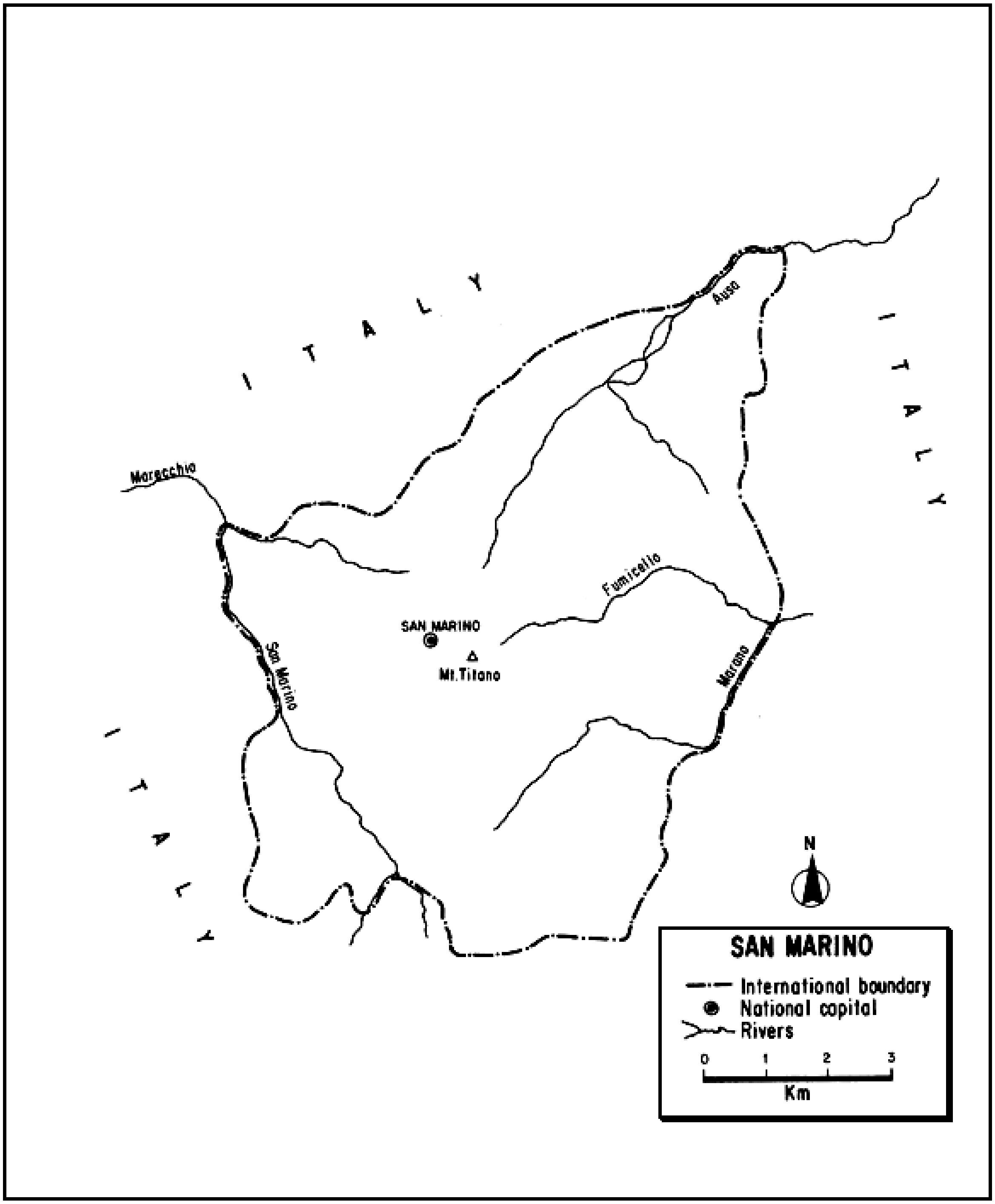
ITALY
ITALY
ITALY
Marecchia
Ausa
Fumicello
SAN MARINO
Mt. Titano
San Marino
Marano
N
SAN MARINO
International boundary
National capital
Rivers
0
1
2
3
Km

SAN MARINO

The Most Serene Republic of San Marino is the third smallest country in Europe, the oldest republic in the world, and (next to Nauru) the smallest republic in the world. A tiny enclave, perched on a mountain in north-central Italy, San Marino supports itself primarily through agriculture and tourism, including the sale of postal stamps and wine.

It is reported that there is some fishing (undoubtedly angling) in the Republic.

1. AREA: 61 km^2

2. POPULATION: 23 000 (est. 1985) Density: 377 inh/km^2

3. PHYSICAL GEOGRAPHY

San Marino is an enclave in north-central Italy between the Italian regions of Emilia-Romagna and the Marches. At 43°56'N latitude and 12°27'E longitude, it is about 25 km inland from Rimini on the Adriatic Sea. It has a maximum length (S-NE) of 12.6 km, maximum breadth (E–W) of 8.6 km, and a boundary of 39 km.

Situated on the slopes and summit of a sandstone ridge of the Apennines, Mount Titano, there are level areas for agriculture at the base of the mountain which attains a height of 749 m.

4. CLIMATE

Generally mild in winter, although frequently below freezing, it is warm and pleasant in summer. The range in air temperature is from -2° to 30°C. Rainfall is moderate, about 890 mm per year.

5. HYDROGRAPHY AND LIMNOLOGY

San Marino is in the Adriatic drainage between the valleys of the Marecchia to the north and the Conca to the south. The waters of the southwestern section are collected by the torrent of San Marino which forms a partial boundary, and flows northward to join the Marecchia River. The eastern section drains to the Ausa River toward the north and the Marano, which forms a partial eastern boundary, toward the south.

6. LAND AND WATER USE

About one-fifth of the population lives in the capital city of San Marino, and the country is considered essentially as urban.

About 17 percent of the country is considered to be arable according to the 1987 FAO Production Yearbook. Farming is the most important use of the land. Maize, wheat, grapes, and fruit are cultivated, and livestock are also raised. Some wood is cut and some stone is mined. Electric power is imported. There is a little light industry: cotton textiles, leather, paper, brick, tile, tanning, ceramics and souvenirs.

Transport is by auto road, bus and railway to the coast. Tourism in this picturesque republic is a major source of income.

7. FISH AND FISHERIES

During the 1965–87 period, the FAO Yearbooks of Fishery Statistics have dubbed the fisheries of San Marino variously as “nil”, “negligible”, “insignificant”, “none”, or “zero”, and of San Marino, Worldmark (1988) says “There is no fishing”.

With a paucity of water, one might assume that there would be little or no fishing in the enclave. However, Europe (1984) says: “There are facilities for shooting, fishing and various other recreations”, and Polk (1985) says: “Hunting, fishing and swimming are available in season…”

8. OWNERSHIP AND ADMINISTRATION OF FISHERIES

No information on this subject has been available.

9. STATE OF THE FISHERY

It is obviously slight since the waters are of the type known in Italy as “torrenti”.

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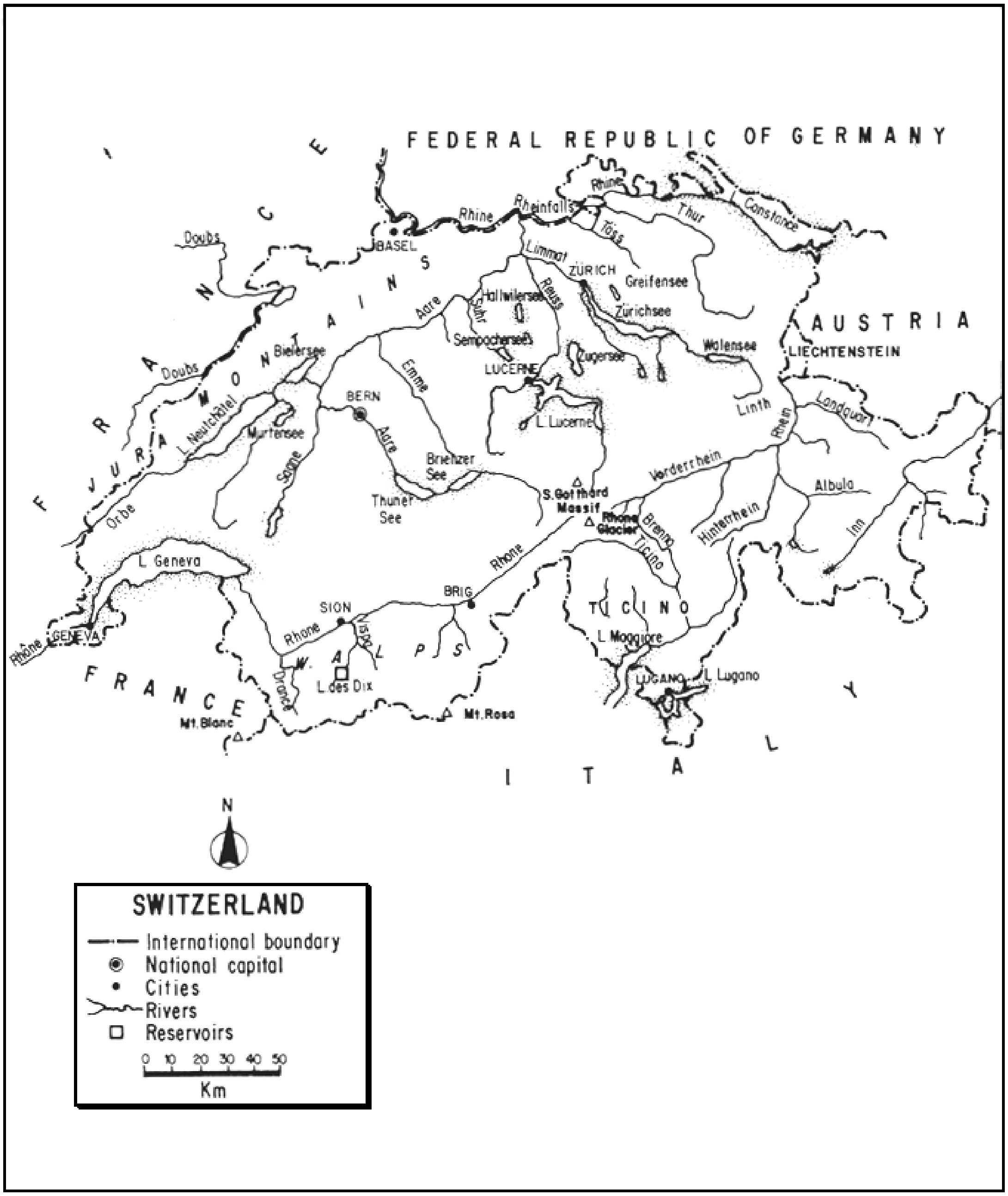
FEDERAL REPUBLIC OF GERMANY
FRANCE
AUSTRIA
LIECHTENSTEIN
ITALY
JURA MONTAINS
ALPS
TICINO
BASEL
ZÜRICH
LUCERNE
BERN
SION
BRIG
GENEVA
LUGANO
Rhine
Rheinfalls
Thur
Constance
Töss
Limmat
Greifensee
Doubs
Aare
Hallwilersee
Suhr
Reuss
Zürichsee
Sempachersee
Zugersee
Walensee
Bielersee
Emme
L. Neuchâtel
Murtensee
L. Lucerne
Linth
Rhein
Landquart
Saane
Brienzer See
Thuner See
Vorderrhein
Orbe
S. Gotthard Massif
Rhone Glacier
Brenno
Ticino
Hinterrhein
Albula
Inn
L. Geneva
Rhone
Visp
L. Maggiore
L. Lugano
Rhône
Dranse
L. des Dix
Mt. Blanc
Mt. Rosa
N
SWITZERLAND
International boundary
National capital
Cities
Rivers
Reservoirs
0 10 20 30 40 50
Km

SWITZERLAND

Landlocked in west-central Europe, the Swiss Confederation occupies the summit of the Continent, with drainage to four seas. Two-thirds mountainous and one-quarter “unproductive”, this small country has a diversity of attractive natural features: iceclad peaks, Alpine pastures, forested slopes, alluvial plains, rushing rivers, and a complex of large sub-Alpine lakes.

With its population engaged primarily in specialized manufacturing, commerce, and services, demands on its water resources are relatively small. True, its use of water for development of hydroelectric power is intense, but with respect to fisheries this is largely compensated for by the increase in static water (reservoirs) and stream regulation.

Switzerland's large lakes, mountain tarns, and many rivers provide habitat for cold water fishes, especially coregonids and salmonids, and for both commercial and recreational fishing. As a result of the country's subdivision into rather autonomous cantons, the management of fisheries differs in different regions, but coordination by Federal authority serves to promote their development.

Although stayed by a policy of good land and water use, environmental deterioration and multiple-use of surface waters may bring about subsidence in commercial fisheries. Interest in sport fisheries will, however, rise, accompanied by a small increase in cold water aquaculture.

1. AREA: 41 293 km^2

2. POPULATION: 6 387 000 (est. 1990) Density: 155 inh/km^2

3. PHYSICAL GEOGRAPHY

Switzerland is situated between 45°49'09" and 47°48'35"N latitudes and 05°57'24" and 10°29'36"E longitudes.

Roughly ovate, its greatest length (E–W) is 348 km and its greatest breadth (N–S) is 220 km. Its altitudinal range is from 193 m (the surface of Lago Maggiore) to 4 634 m (Mt. Rosa). Its mean altitudinal range is 1 350 m, the highest of any European country.

A landlocked country, the Swiss Confederation is bounded on: the north by the Federal Republic of Germany for 345.7 km; the east by Liechtenstein for 41.1 km and by Austria for 165.1 km; the southeast and south by Italy for 734.2 km; and the west and northwest by France for 571.8 km - a total of 1 857.9 km[1].

[1] These boundary lengths, taken from the Statistisches Jahrbuch der Schweiz 1989, are without enclaves. With enclaves, the Italian/Swiss border is 741.3 km and that with Germany 362.5 km

Switzerland consists of three natural regions, roughly paralleling each other, NNE-SSW:

(i) the Jura mountains in the northwest, 10 percent of the country;
(ii) the Western Alps, in the south, covering 60 percent of the country and constituting the steepest and most contorted of the Alpine chain, and
(iii) the Midland Plateau of fertile plains, rolling hills, and many rivers, between the Jura and the Alps, covering 30 percent of the country.

(i) The Jura. This folded mountain system of ridges and valleys consists primarily of stratified limestone well covered with conifers and beeches. It possesses few streams and much of the drainage is underground. Seldom over 900 m, it rises to 1 680 m.

(ii) The Alps. The Swiss Alps constitute the most imposing section of Switzerland. They consist of Pre-Alps (to about 2 700 m) which are primarily of limestone, lack glaciers, and are covered with snow only in winter. South of the Pre-Alps are the High Alps with peaks 3 000 to 4 600 m and U-shaped glacial valleys. Above 2 500 or 3 000 m these mountains have eternal snows. The highest peaks are of hard crystalline rocks (granites and gneisses) but the lower ones, like the Pre-Alps, are limestone. It is in the Alps that the major Swiss rivers arise.

(iii) Midland or Central Plateau. About 290 km long, 50 km wide, and averaging 457 m in height, this series of valleys and hills begins in the southwest rising from Lake Geneva and ends in the northeast under Lake Constance. Its gently sloping surface is covered with glacial debris and alluvial soil. Along the foot of the Jura is a long flat valley with several lakes draining into the Aare River. The consequent streams from the Alps cut deep valleys into the Midlands. This is the heartland of Swiss farming and industry.

Not only are the effects of past glaciation evident in Switzerland's physiography, it still has over 1 000 glaciers occupying about 1 556 km^2. Nineteen of these are over 10 km^2 in area. The most typical are valley glaciers including the 86.8-km^2 Great Glacier of Aletsch, the largest in Europe.

In this humid country, physical and chemical weathering is constant, creating soils of crystalline origin (Alps), limestone (Jura) and colluvial (Midlands). Soils in the Jura and Alps are thin and leached, those in the heartland are more fertile.

About 55 percent of the forests are in the Alps, 25 percent on the Plateau, and 20 percent in the Jura. Up to 1 200 m, the cover is mainly broad-leafed deciduous forest: oak, maple, beech and hornbeam. Between 1 200 and 2 000 m, the forest cover is fir, larch and pine. Alpine pastures are also found above the deciduous forest, with grass growing to about 3 000 m and Alpine flora above 2 000 m. An exception to this general pattern is found in the southernmost area, the Ticino, which is shared with Italy. Here one finds Mediterranean vegetation: chestnut, cypress, and groves of lemons and oranges.

4. CLIMATE

The climate of Switzerland varies remarkably with altitude, wind pattern, and relief rather than with latitude, which is only 2°. North of the Alps, the climate is temperate, often cool and rainy with winter averages near freezing and summer temperatures rarely above 21°C. Average annual temperatures range from 7°C on the Plateau to 1.5°C in the mountains. Frost occurs above 1 800 m in the Alps and Jura. South of the Alps, the canton of Ticino has a warm Mediterranean climate, frost being almost unknown.

The average annual precipitation (including snow) is 1 470 mm. Precipitation varies with the topography. It is over 3 200 mm annually in the high mountains, about 1 100 mm in the Midlands, and only 600–700 mm in some Alpine valleys. Above 3 500 m, most of the precipitation is in the form of snow.

Snowline in the western Alps is at about 2 700 m, and in the drier eastern Alps at about 3 200 m. On the north side of the Alps, the dry hot wind, the “Föhn”, melts the snow early, thus contributing to the flood of Alpine streams.

5. HYDROGRAPHY AND LIMNOLOGY[1]

Table 5 indicates that the total inland water of Switzerland is 1 520 km^2 or 3.7 percent of the country's total area. The Switzerland, Bundesamt für Statistik (1979) lists the inland water area of the country as 141 558 ha of lakes and 11 128 ha of rivers, totalling 1 526.86 km^2.

According to Van der Leeden (1975), the average annual runoff from rainfall in Switzerland is 1 000 mm or 42 000 million m^3 and in addition, 8 000 million m^3 are received from upstream countries. ECE (1978) lists the approximate average runoff in Switzerland as 42 500 million m^3 annually and a flow of 7 500 million m^3 received from upstream countries. They agree, therefore, on a total annual river discharge of 50 000 million m^3 leaving the country.

Situated on the summit of Europe, the drainage of Switzerland belongs to the continent's four major rivers, all of which originate near the St. Gotthard Massif in the Alps. Hydrographically, this water tower of Europe consists of three great river valleys (the Rhône, Rhine and its tributary the Aare) lying to the north of the main chain of the Alps and including within their basins the area of the Central Plateau. The southernmost area of the country, the Ticino, drains into the Po system. In the extreme east, a small portion drains into the Danube through the Inn or Engadine Valley. These major hydrographic basins are shown in Table 1.

[1] As Switzerland has three “official” languages (French, German and Italian), more than one name is used here for many waters

Table 1

The major hydrographic basins of Switzerland

River basin	Swiss basin area		Mean annual discharge	Drainage
	km^2	Percent	m^3/sec	
Rhine	27 956	67.7	1 028	Atlantic (North Sea)
Rhône	7 556	18.3	315	Mediterranean
Po	3 964	9.6	several brooks	Adriatic
Danube	1 817	4.4	52	Black Sea

Source: Framji and Mahajan (1969); Switzerland, Bundesamt für Statistik (1981)

5.1 Rivers (Flüsse/Fleuves)

Switzerland's rivers have a total length of about 30 000 km (Switzerland/EIFAC, 1974; 1979). Their surface area has been calculated as totalling 11 128 ha (Switzerland, Bundesamt für Statistik, 1979).

The principal rivers of the country, including length, basin area and discharge, are listed in Table 2.[1]

[1] Switzerland has been recording precipitation and gauging streamflow for many years, far longer than have most countries

River discharge is a function of both rainfall and snowmelt. Alpine rivers have floods in late spring and early summer while Midland rivers have floods after rainstorms, mainly in summer. Thus, the Rhine's peak flow is in June/July and its minimum in January. The Rhône's monthly maximum is in July, its minimum in February and March. There is less retardation of runoff on the southern slopes of the Alps where the mountains are steep. In the Jura there is some percolation through the chalk, and many of the valleys having glacial till are also permeable. The lakes act as equalizing basins so that variations in river flow are smaller than in many other countries. Furthermore, artificial embankments have been erected along many rivers to accommodate excess water accumulated from rainfall and snowmelt.

The major rivers of Switzerland are described below.

5.1.1 Atlantic drainage

Rhine. The Rhein or Rhin, as it is called in Switzerland, travels from its source to its mouth in the North Sea for 1 350 km passing through or being a border for Switzerland, Liechtenstein, Austria, Germany, France, and the Netherlands en route. Arising in the eastern part of the Swiss Alps by the junction of two mountain rivers, the Vorderrhein and Hinterrhein, it flows northerly as an Alpine river (low water in winter and spate in spring or summer) to enter Lake Constance. En route it forms Switzerland's eastern border with Liechtenstein for 41.1 km and also the eastern border with Austria for 23 km. It is partly regulated during this course, and the Lake also acts as a regulator. Upon leaving the Lake at Konstanz, it widens into the Untersee and then flows westward for 165 km to Basel where it turns north and leaves Switzerland. During its course of 375 km in Switzerland, it descends from 2 200 to 200 m. Below Lake Constance, it changes in character, becoming narrow and plunging between rocks and over rapids including the Rheinfalls, the most powerful falls in Europe: 150 m wide and 21 m high.

Table 2

Principal rivers of Switzerland

River	Length[a] km	Basin area km^2	Mean annual discharge m^3/sec	Period	Station
Rhine/Rhein/Rhin	375.0	36 494	1 032.0	1808–1982	Basel
Vorderrhein	67.5	1 514	32.5	1962–82	Ilanz
Hinterrhein	57.3	1 693	--	--	--
Albula	36.0	950	15.8	1926–82	Tiefencastel
Lanquart	42.6	618	24.8	1926–82	Felsenbach
Thur	125.0	1 724	46.8	1904–82	Andelfingen
Töss	57.6	442	7.8	1921–82	Neftenbach
Glatt	36.0	416	--	--	--
Aare	295.2	17 779	560	1935–82	Untersiggenthal
Lütschine	27.0	380	18.7	1924–82	Gsteig
Kander	43.5	1 126	--	--	--
Simme	52.9	594	11.7	1921–82	Oberwil
Saane/Sarine	128.5	1 892	53.7	1949–82	Laupen
Sense	45.8	433	8.50	1928–82	Thörishaus
Orbe	57.0	488	12.3	1973–82	Orbe
Broye	86.0	854	--	--	--
Areuse	31.0	393	12.3	1923–82	Champ du Moulin
Schüss	40.5	282	--	--	--
Emme	80.1	983	19.2	1922–82	Wiler
Wigger	39.7	380	--	--	--
Suhr	34.1	371	--	--	--
Reuss	158.5	3 425	141	1935–82	Mellingen
Sarner Aa	9.4	338	10.1	1934–82	Sarnen
Kleine Emme	58.3	477	18.2	1978–82	Littau
Linth-Limmat	140.0	2 416	97.1	1938–82	Zürich
Sihl	73.1	341	6.80	1938–82	Zürich (Sihlhölzli)
Ergolz	27.2	301	3.71	1934–82	Liestal
Birs	73.0	924	15.2	1917–82	Münchenstein
Rhône/Rhone	264.0	10 403	322.0	1946–82	Aire
Vispa	40.2	787	16.3	1965–82	Visp
Borgne	29.4	385	--	--	--
Drance	43.3	678	2.36	1957–82	Châble
Doubs	74.3	1 310	33.0	1921–82	Ocourt
Allaine	28.0	319	--	--	--
Ticino	91.0	1 616	69.3	1921–82	Bellinzona
Brenno	34.4	404	4.53	1961–82	Loderio
Moësa	43.8	477	--	--	--
Maggia	55.8	926	3.84	1982	Bignasco
Tresa	13.4	754	24.8	1923–82	Ponte Tresa
Poschiavino	24.6	238	6.04	1931–82	Le Prese
Mera	21.1	190	--	--	--
Rambach	13.7	188	--	--	--
Inn/En	104.0	2 150	54.1	1970–82	Martina

[a] Within Switzerland

Source: Statistisches Jahrbuch der Schweiz/Annuaire statistique de la Suisse 1984 (The latest Jahrbuchs (1989, 1990) seen by the author do not include this detail)

Aare/Aar. The major affluent of the Rhine in Switzerland is the 295-km Aare, the longest river completely within the country. Arising from Grimsel Lake, fed by glaciers, it flows generally northwest through the Brienzersee and Thunersee to Bern (where it is dammed to form the Wohlersee). Farther on, it is diverted into the Bielersee, and then proceeds northeasterly to join the Rhine near Coblenz. It is larger than the Rhine at this point.

5.1.2 Mediterranean drainage

Rhône. The third largest drainage system in Switzerland rises in the Rhône Glacier in the Alps and proceeds generally westwardly and then northwesterly to enter Lake Geneva. Its upper area is a mountain torrent, but from the junction of the Massa at Brig it flows on an alluvial plain, then passes through Lake Geneva (which regulates its flow) for 72 km, and enters France 20 km below the lake. Here its minimum flow is in January–February; its maximum in July. The Rhône's total length from source to its mouth in the Mediterranean is 812 km.

Ticino. The Ticino River rises in the southern Swiss Alps and flows south for 91 km to enter Lake Maggiore. Its monthly mean minimum flow is in February; its monthly maximum flow is in June. A number of other Swiss rivers (see Table 2) enter its drainage which ultimately reaches the Po which debouches in Italy in the Adriatic Sea.

In addition to the Ticino, there are some minor rivers such as the Poschiamo and Mera which are also in the Po drainage, and the Rambach which joins the Adige drainage to empty into the Adriatic.

5.1.3 Black Sea drainage

Inn/En. The last of the foremost drainages in Switzerland is that of the Inn, which, like the Rhine rises in extreme eastern Switzerland, but farther southwest. Starting in lakes near St. Moritz, the Inn follows the valley of the Engadine northeast for 104 km to Austria where it joins the Danube. Its mean minimum flow is in February; its major flow in May and June.

5.2 Lakes (Seen/Lacs)

There are 1 484 natural lakes in Switzerland: 1 358 in the Alps, 112 in the Midlands, and 14 in the Jura (Framji and Mahajan, 1969). Worldmark (1988) states that there are also about 12 900 smaller bodies of standing water in the country. The total lake area in Switzerland including reservoirs is listed at 1 415.58 km^2 by Switzerland, Bundesamt für Statistik (1979).

Table 3 lists the 28 Swiss natural lakes over 0.5 km^2 in area. The total area of these 28 lakes is 2 079.41 km^2, but of this total only 1 289.01 km^2 (62 percent) belong exclusively to Switzerland.

Switzerland is characterized by the presence of many large natural lakes including several shared with other countries: Geneva and Lac des Brenets shared with France, Constance shared with Germany and Austria, and Maggiore and Lugano shared with Italy.

Some of the lakes are tectonic, e.g., the Lac de Joux in the Jura which lies in a tectonically dammed syncline. The Lac de Brenets also in the Jura is a landslide lake. Most of the Swiss lakes, however, have been formed by glacial excavation or corrasion. The foot of the Alps where the large valleys leave the mountains is marked by especially large glacial lakes with terminal moraines.

Most of the large sub-Alpine lakes are deep, subject to thermal stratification in summer and winter and to turnover in autumn and spring. Most of these, although originally oligotrophic, are tending toward eutrophication - the cumulative effect of years of settlement and the highly augmented entrance of organic substances in recent years. Lake Brienz is one of the last large Swiss lakes still considered to be oligotrophic.

Some characteristics of the largest Swiss lakes, in addition to those shown in Table 3, follow.

<u>Lake Geneva (Lac Léman or Genfersee)</u>. Shared with France (Switzerland's portion is 347.3 km^2 or 60 percent), and acting as a regulator of the Rhone, it is the largest of the Alpine lakes. It is 72 km long, has a maximum width of 14 km, a mean depth of 152 m, and a retention time of 12 years. It is now considered to be eutrophic. Born at Morges, on the shores of Lake Geneva, it was at this famous lake that E.A. Forel (1841–1912) made most of his studies and formally christened the science of limnology.

<u>Lake Constance/Bodensee/Konstanz</u>. Situated in extreme northeastern Switzerland, Lake Constance, the third largest lake (after Geneva and Balaton) in Central Europe, is shared with Austria and the Federal Republic of Germany. Switzerland's portion is 173.2 km^2 or a third of the lake's total area. Fed by the Rhine, the lake is divided into the main body, called the Obersee, a northwest area the Überlingersee, and a southwest extension below Konstanz called the Untersee or Lac Inferieur. The entire lake, with an area of 541.2 km^2 is 62 km long and 13 km wide, has an average depth of 90 m, and an average volume of 48 340 million m^3. There is a fluctuation in water level of about 160 cm. Its summer surface temperature is about 22°C, its minimum temperature about 3.7°. It can be considered as just dimictic. The German and Swiss Untersee is connected with the rest of the lake by a 3.2 km stretch of the Rhine. It has an area of 62 km^2, is about 16 km long, has an average width of 4.8 km, an average depth of 28 m, and a maximum depth of 46 m.

Table 3

Principal natural lakes of Switzerland (over 0.5 km^2)

Name	Total area[a] km^2	Altitude m	Maximum depth m
Geneva/Léman/Genfersee[b]	581.3	372.0	310
Constance/Bodensee[c]	541.2	395.6	252
Neuchâtel/Neunenburgersee	217.9	429.4	153
Lago Maggiore/Lac Majeur[d]	212.3	193.5	372
Lucerne/Vierwaldstättersee/Lac des Quatre Cantons	113.6	433.6	214
Zürichsee/Lac de Zurich[e]	90.1	405.9	143
Lago di Lugano/Luganersee[f]	48.7	270.5	288
Thunersee/Lac de Thoune	48.4	557.7	217
Bielersee/Lac de Bienne	39.8	429.2	74
Zugersee/Lac de Zoug	38.3	413.6	198
Brienzersee/Lac de Brienz	29.8	563.7	261
Walensee/Lac de Walenstadt	24.1	419.1	150
Murtensee/Lac de Morat	23.0	429.2	46
Sempachersee/Lac de Sempach	14.5	503.8	87
Hallwilersee/Lac de Hallwil	10.3	449.0	47
Greifensee/Lac de Greifen	8.6	435.0	34
Sarnersee/Lac de Sarnen	7.5	469.0	52
Ägerisee/Lac de Ageri	7.2	724.0	82
Baldeggersee/Lac de Baldegg	5.3	463.0	66
Silsersee	4.1	1 797.0	71
Pfäffikersee	3.3	537.0	35
Silvaplaner and Campfèrsee	3.2	1 791.0	77
Lauerzersee	3.1	447.0	14
Öschinensee	1.1	1 578.0	56
St. Moritzersee	0.78	1 768.0	44
Daubensee	0.69	2 205.0	--
Lac des Brenets[g]	0.69	750.0	32
Mauensee	0.55	504.0	9

a Without islands
b Shared with France. Swiss portion is 347.3 km^2 (60 percent)
c Including the Untersee/Lac Inferieur. Shared with Germany and Austria. Swiss portion is 173.2 km^2 (32 percent)
d Shared with Italy. Swiss portion is 42.3 km^2 (20 percent)
e Including the Obersee
f Shared with Italy. Swiss portion is 30.7 km^2 (63 percent)
g Shared with France. Swiss portion is 0.29 km^2 (42 percent)

Source: Statistisches Jahrbuch der Schwiez/Annuaire statisque de la Suisse 1984

Once oligotrophic, there has been a progressive eutrophication of the lake since 1950, due primarily to untreated municipal waste containing sewage and detergents. About one-third of the eutrophication derives from agricultural practices. The main basin is now considered to be between meso- and eutrophic. Annual fish yields have increased with eutrophication but the composition of the major fish stocks in the Obersee has shifted from coregonids to cyprinids and perch (Hartman and Nümann, 1977). The fish catch in the Obersee during the 1970–74 period was divided as follows: Switzerland

41 percent; Federal Republic of Germany 41 percent, and Austria 18 percent (Deufel, 1975). According to Milway (1970) it has an annual yield of about 4 000 t of fish.

Lac de Neutchâtel/Neuenberguresee. Neutchâtel, the largest lake lying completely within Switzerland, lies east of the Jura in the Aare River drainage, fed by the Thiele or Zihl River. It has a length of 39 km and a width of 6–8 km. It can be called mesotrophic. Canals connect it with the 16-km long Bielersee (Lac de Bienne) and the 9-km long Murtensee (Lac de Morat).

Lago Maggiore/Lac Majeur. Only 20 percent (42.3 km^2) of this sub-Alpine lake, lying south of the Alps in the Ticino (Po) drainage, belongs to Switzerland. The remainder, like Lago di Lugano di Lugano (see below) lies in Italy. The entire lake has a perimeter of 170 km, a length of 54 km, width of 10 km, mean depth of 175 m, and a volume of 37 100 million m^3. It is now considered meso-eutrophic. (See section 5.2 in Italy for further description.)

Lago Lucerne/Vierwaldstättersee/Lac de Quatre Cantons. Commonly called Lake Lucerne, although the Luzernersee is but one of its four arms, this 38-km long lake, with a volume of 11.8 million m^3, situated in central Switzerland is fed by the Reuss River, a major tributary of the Aare. It has a minimum water temperature of 4.3°C and is considered monomictic.

Zürichsee. This dimictic to warm monomictic lake, 40 km long, 4 km wide, with a mean depth of 51 m, also lies in the Aare drainage. Formerly fed directly by the Linth River, since 1827 it has been fed by the Linth Canal which emerges at the city of Zürich as the Limmat River. Like other Swiss lakes, the Zurichsee changed from an oligotrophic to eutrophic condition within the last 85 years, but has now improved decidedly with bypass of sewage water into its outlet.

Lago di Lugano/Luganersee. This very irregular lake, lying south of the Alps, drains through the Tresa River into Lago Maggiore. Sixty-three percent (30.7 km^2) belongs to Switzerland; the rest is Italian. Its greatest length is 35 km, its greatest width 3 km, its average depth is 130 m and its volume 6.5 km^3. It has a minimum temperature of 5.2°C and is monomictic. Like the other sub-Alpine lakes, it is becoming more eutrophicated now being considered eu-hypertrophic. Fish such as the landlocked shad or agone (Alosa fallax lacustris) have diminished.

Thunersee/Lac de Thoune. Largest of the lakes on the Aare is the Thunersee, 18.5 km long and 2 to 2.8 km wide. Occupying the terminal basin of a glacier, it is separated by a lacustrine delta from the smaller Brienzersee (Lac de Brienz), 14.5 km long and 2.4 km wide. Over a 40-year period, the Thunersee has gradually evolved from oligotrophic to mesotrophic, but the yield is still almost completely of coregonids.

Bielersee/Lac de Bienne. Situated at the foot of the Jura range, the Bielersee is fed by water from the Aare and also receives water from Lac de Neuchâtel. It is 12 km long and 4 km wide. It is also eu/mesotrophic.

Zugersee/Lac de Zoug. The tenth largest Swiss lake is the eutrophic Zugersee, 14.5 km long and 4 km wide. Lying directly north of Lake Lucerne, it is in the Reuss (Aare) drainage.

5.3 Reservoirs (Speicherseen or Stauseen/Lacs d'accumulation)

Switzerland has more than 70 large reservoirs, most of which serve for hydroelectric production. Forty-five of these reservoirs totalling 93.12 km^2 in area are listed in Table 4. Twelve of these waters are natural lakes converted into reservoirs by control structures enabling greater water storage.

Most of the reservoirs are situated at much higher altitudes than Switzerland's major lakes, and are less productive than the natural lakes. Especially noteworthy among them is the Lac des Dix at an elevation of 2 364 m on a tributary of the Rhône in southern Switzerland, which was filled in 1966. Its 284-m gravity dam is the greatest piece of hydroelectric engineering in the country and has one of the highest heads in the world. Its capacity of 400 million m^3 is almost twice as large as that of its nearest Swiss competitor. Other especially high dams are that of the Zervreilasee (151 m) in the Grisons, and the 156-m dam of the Lac de Tseuzier or Zeusier near Sion.

Aside from their partial use for fishing, the fact that these reservoirs hold back summer runoff for winter use helps reduce water pollution during periods of low natural discharge. An amendment to the Swiss constitution provides for Federal regulation for maintenance of minimal stream flows.

5.4 Canals (Kanäle/Canaux)

Switzerland has some canalized river stretches and a number of cross-connexions between lakes or rivers, but no canal system of consequence.

Table 4

Principal reservoirs of Switzerland

Name	Area (km^2)	Max. elevation (m above sea level)	Useful capacity (million m^3)
Sihlsee	10.85	889.3	91.8
Lac de la Gruyère	9.60	677.0	180.0
Lac de Joux et Brenet (N)	9.56	1 005.0	30.0
Schiffenensee	4.25	532.0	35.5
Wägitaler See	4.18	900.0	76.1
Lac des Dix	4.03	2 364.0	400.0
Klöntaler See (N)	3.29	846.8	39.8
Lac d'Emosson	3.27	1 930.0	225.0
Grimselsee (N)	2.72	1 908.7	93.9
Lac de Mauvoisin	2.08	1 961.5	180.0
Lungerer See (N)	2.01	688.7	50.0
Lago de Poschiavo (N)	1.98	962.3	15.1
Lac de Salanfe	1.85	1 925.0	40.0
Lai da Sta. Maria	1.77	1 908.0	67.0
Mattmarksee	1.76	2 197.0	100.0
Lago di Vogorno	1.68	470.0	84.4
Zervreilasee	1.61	1 862.0	100.0
Lac de l'Hongrin	1.60	1 255.0	52.1
Lago Bianco (N)	1.50	2 234.4	18.4
Lago Ritom (N)	1.49	1 850.1	47.5
Oberaarsee	1.46	2 303.0	56.0
Lai da Marmorera	1.41	1 680.0	60.0
Lac de Moiry	1.40	2 249.0	77.0
Limmerensee	1.36	1 857.0	92.0
Göscheneralpsee	1.32	1 792.0	75.0
Lago di Luzzone	1.27	1 591.0	87.6
Lago da Albigna	1.13	2 162.6	68.6
Lago di Sambuco	1.11	1 461.0	62.0
Lac da Nalps	0.91	1 908.0	44.5
Sufnersee	0.90	1 401.0	18.3
Lac de Tseuzier	0.85	1 777.0	50.0
Lac da Curnera	0.81	1 956.0	40.8
Lac de Monsalvens	0.74	800.8	11.0
Lago di Naret (N)	0.73	2 310.0	31.1
Gigerwaldsee	0.71	1 335.0	33.4
Lac de Moron	0.69	716.0	15.8
Räterichsbodensee	0.67	1 767.0	25.0
Gelmersee (N)	0.64	1 850.2	13.4
Lac des Toules	0.61	1 810.0	20.0
Griessee	0.60	2 386.5	18.0
Davoser See (N)	0.59	1 558.7	11.3
Lac du Vieux Emosson	0.55	2 205.0	13.5
Lago di Lucendro (N)	0.54	2 134.5	25.0
Melchsee (N)	0.54	1 893.3	3.0
Lac de Cleuson	0.50	2 186.0	20.0

(N) Natural lake converted for storage

Source: Statistisches Jahrbuch der Schweiz/Annuaire statistique de la Suisse 1984

6. LAND AND WATER USE

Table 5

Pattern of land use in Switzerland, 1986

	Percent
Arable and permanent crops	9.9
Permanent pasture	39.0
Forests and woodlands	25.5
Other land	21.9
Inland water	3.7
Total	100.0

Source: 1987 FAO Prod.Yearb., 41 (Publ. 1988)

In spite of its mountainous terrain, agriculture is important in Switzerland, and great efforts are made to use even steep rocky slopes for this purpose. Cereals are grown but the climate is mostly too wet for good production. Fodder crops, fruit, and the vine are major products. The livestock industry is important with emphasis on dairy products. Switzerland is a country of small holdings, preventing agricultural use on a large scale, and irrigation on a large scale is not practised. There is only some simple irrigation using torrents and in some areas under adverse climatic conditions. Only about 0.6 percent of the country is irrigated (1986). Fertilizer use is small.

Forests (about 75 percent coniferous) which cover about one-quarter of Switzerland are well used throughout the country which ranks about sixteenth in European forest production. An exemplary forest law forbids the reduction of woodlands, and many areas are planted with trees to protect against landsides, avalanches, and to slow down runoff.

Mining is of almost no importance. Rock, salt, sand and gravel are produced.

Switzerland's “white gold” is hydroelectricity. Its waters are used intensively for its production using the large flows from lakes and of rivers on the plateau, and from high head reservoirs and natural lakes in the mountains. There are more than 400 large hydroelectric plants in the country and numerous low-pressure plants on the rivers. Of its total installed capacity in 1978, about one-third was in run of the river plants and two-thirds in accumulation plants. In 1987, of a total installed capacity of 15 250 000 kW, hydroelectric power represented 75.5 percent (11.51 million kW). Thermal power represented only 5.2 percent, and nuclear power 19.3 percent.

Next to services, industry is the most important economic activity in Switzerland. The absence of major mineral resources, such as coal and iron, has conditioned the type of industry toward production of high value specialized products which are export oriented. In general order of dominance are metallurgy, machinery and equipment, chemicals, drugs, watch manufacturing, textiles, clothes, and food. Hydroelectric power furnishes most of the energy, and in Switzerland manufacturing is a relatively clean industry. Furthermore, it is well distributed over the country without great pollutionridden industrial concentrations. There are, however, some high concentrations of effluent, especially near Basel where large quantities of chemical waste, together with cooling waters, are discharged into the Rhine.

Switzerland is threaded with an excellent system of railroads and paved highways making any area easily accessible. For a mountainous area, it has a high road density (1.7 km/km^2 in 1986), and one of the highest passenger car ownerships in Europe (429 vehicles per 1 000 in 1987). It has 12 navigable lakes but only about 65 km of navigable waterways, e.g., sections of the Rhine below Lake Constance.

There has been a considerable regulation of both rivers and lakes for flood control and to avoid sedimentation and erosion. Thus, rivers have been canalized to prevent floods on flat lands. The Rhine and Rhône have been partially embanked, and rivers have been diverted into lakes to prevent sedimentation, e.g., the Aare.

About two-thirds of the public water supply comes from underground water with which Switzerland is well provided. Difficulties in transport of surface supplies in the cantons and the competing use of water for hydroelectric power have lessened demands for surface waters although both lakes and rivers are used for public supply.

Switzerland is considered to be about 60 percent urban and 40 percent rural, and about 30 percent of the people live in the country's five largest cities. Most communities of any appreciable size are on the shores of lakes or banks of sizeable rivers. This has influenced the state of sewage treatment, sanitary sewer systems having come rather late. The very high domestic water consumption by the Swiss makes sewage rather weak and modern treatment has increased rapidly. Nevertheless, both lakes and rivers still receive considerable domestic effluent. With respect to total water use, industry with 67 percent and public water supply with 23 percent use most of the water. The use of water for commercial fisheries and aquaculture is minor (see section 7) but the policy of the government has been to support fishing as a useful and fundamental way of life. Protection of fish farm waters is included in the categories requiring specific conditions of water quality.

Per caput consumption of fish has ranged from 5.1 kg/year in 1976 to 7.4 kg in 1986, but 85–90 percent of the fish eaten is imported.

Switzerland's complex of Alpine mountains, beautiful lakes, clear streams, and picturesque cities, in addition to an excellent system of transport and an emphasis on environmental considerations has made tourism a major industry, accounting for about 10 percent of the country's receipts. Angling has not, however, been emphasized in tourist literature, where other water sports seem to receive just as much emphasis.

7. FISH AND FISHERIES

Exploited fish species in Switzerland include: European eel (Anguilla anguilla), landlocked shad (Alosa fallax lacustris), brown trout (Salmo trutta), char (Salvelinus alpinus), coregonids (Coregonus spp.), grayling (Thymallus thymallus), pike (Esox lucius), several species of cyprinids, especially bream (Abramis brama), roach (Rutilus rutilus), tench (Tinca tinca), and common carp (Cyprinus carpio), burbot (Lota lota), European perch (Perca fluviatilis) and pike-perch (Stizostedion lucioperca). In addition to these native European fishes, the introduced rainbow trout (Oncorhynchus mykiss) is widely distributed, and two other North American fishes, the brook trout (Salvelinus fontinalis) and lake trout (S. namaycush), are present in some waters.

7.1 Capture Fisheries

As has been customary in this series describing European inland fisheries, a table has been included showing the inland fishery catch as compiled by FAO from data furnished by the country involved. Table 6 illustrates the “catch” in Switzerland during the 1965–87 period as recorded by FAO and amended by the author. However, it must be said at the outset that the original FAO presentation is highly misleading. Although no distinction was made in the FAO statistics between fish derived by capture and those produced through aquaculture (FAO's normal procedure to date) it is obvious from other information that most, if not all, of the listed catch came from commercial fishing. Note, for example, that although the largest tonnage of trout listed by FAO for any one year was 272 t in 1984, we know from other sources that cultivated trout production in Switzerland was already about 1 000 t annually by 1980, and was in fact 1 023 t in 1984 (see section 7.2).

An even more serious error in the FAO table, however, lies in the complete misidentification of a species group. In addition to the categories of "pike", "European perch" and "trouts", the FAO Yearbooks listed three other categories in the Swiss catch: "Freshwater fishes, nei", "European whitefish (Coregonus albula)", and "whitefishes, nei (Coregonus spp.)". From various evidence, particularly the original two-language version of a table in the Statistiches Jahrbach der Schweiz 1979, it is apparent that the FAO Yearbook's "Coregonus albula" probably represented more than one species of coregonid (Family Coregonidae), and its "whitefishes, nei" undoubtedly represented several species of cyprinids (Family Cyprinidae), i.e., the fishes known generally in French as "poissons blanc" and in German as "Weissfische", rather than coregonids[1]. This view of the author has been corroborated by Switzerland/EIFAC (1989). Because of these and possibly other mistakes, estimates, and misinterpretations in the FAO Yearbooks, a much better picture can be obtained by direct reference to publications by the Swiss Government.

[1] Coregonids are generally termed corégones in French and Felchen in German. Even in English, cyprinids are frequently termed "whitefish" by the layman

Table 6

Nominal catches by species in the waters of Switzerland, 1965–87 (in tons)

	Pike	European perch	Freshwater fishes, nei	European whitefish	"Whitefishes" nei[b]	Troutsnei	Total
1965	-	-	2 700	-	-	-	2 700
1966	-	-	3 000	-	-	-	3 000
1967	-	-	3 000	-	-	-	3 000
1968	-	-	3 500	-	-	-	3 500
1969	-	-	3 500	-	-	-	3 500
1970	100[a]	1 100[a]	0	500[a]	600[a]	100[a]	2 400
1971	100[a]	1 300[a]	0	600[a]	700[a]	100[a]	2 800
1972	100	1 700	0	700	900	200	3 600
1973	100	1 700	0	700	900	200	3 600
1974	76	1 824	19	741	912	228	3 800
1975	78	1 887	21	762	918	234	3 900
1976	79	1 900	20	764	917	235	3 915
1977	80	1 950	22	771	921	238	3 982
1978	75	1 811	20	743	940	231	3 820
1979	74	1 908	29	734	911	234	3 890
1980	70	1 711	23	690	805	201	3 500
1981	74	1 781	24	721	835	241	3 676
1982	77	1 870	25	757	877	253	3 859
1983	76	1 880	26	787	879	269	3 917
1984	74	1 892	28	810	909	272	3 985
1985	81	2 102	29	790	1 111	270	4 383
1986	73	2 250	31	800	1 300	271	4 725
1987	75	2 001	29	901	1 549	252	4 807

[a] Statistics estimated or calculated by FAO
[b] Not Coregonus, but miscellaneous Cyprinidae (see text)

0 Probably nil, negligible or insignificant; or less than 50 t during the 1965–73 period, or less than half a ton during later years

nei Not elsewhere included

\- this category not listed this year

Source: 1965–69 Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–83 FAO Fish.Dept. Fishery Statistical Database (FISHDAB)
1984–87 Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

Studies on harvest by species are compiled yearly by the Swiss cantonal agencies. The Federal fishery agency of Switzerland then collects these data and issues a national harvest statistic on the 20 major Swiss lakes every two years. One of the most recent compilations is shown in Table 7 which shows the average catch of both commercial and sport fisheries in 20 Swiss lakes during the 1981–86 period. Another table (Table 8) provides additional data on the same 20 lakes: their yield and the percentage of important fish categories in the catch of each lake. It is true that only 20 lakes are represented, but these comprise not only the most important lakes in the country for commercial fishing but constitute about 90 percent of Switzerland's lake water.

Both the harvest from these lakes and the yield of species groups has varied over the year. For example, during the 1972–79 period, a compilation of catch data on 18 Swiss lakes, constituting 84 percent of all static water in Switzerland, indicated a harvest of 33 percent coregonids (true whitefishes), 25 percent cyprinids, 39 percent perch, and only 3 percent for all other species (Statistiches Jahrbuch der Schweiz 1979). It is quite obvious, nevertheless, that the first three groups (coregonids, cyprinids and European perch) are the most important groups which are harvested in Switzerland's lakes. Furthermore, figues in both Staub (1987, Figure 7) and Müller (1988, Figure 1) demonstrate that this has been true since at least 1967.

Table 7

Average annual yield of commercial and sport fisheries in 20 Swiss lakes, 1981–86

Lake (without foreign parts)	Total (kg)	Bream	Carp	Tench	Other cyprinids	Pike	Catfish	Turbot	European perch
Geneva[a]	404 824		229	1 544	162 546	2 504		1 174	192 374
Neuchâtel	517 221	30 258	1 501	643	188 007	5 646	216	388	135 128
Constance	594 025	51 883	309	388	20 085	4 800	3	1 277	274 437
Lucerne[a]	379 851	5 737	28	195	64 911	4 078		3 485	11 260
Zurich	290 479	14 617	550	897	113 243	8 084		2 335	61 283
Thun[a]	43 475	3		10	135	270		46	146
Maggiore[b]	172 715		25	7 312	17 213	12 406		1 080	12 881
Biel[a]	117 052	7 036		157	39 625	3 084		914	12 966
Zug	106 174	6 170	330	189	59 709	1 470		1 174	11 375
Lugano[b]	32 421		444	870	20 987	247		1 122	5 716
Brienz[a]	29 243	1			145	67		99	16
Walenstadt	44 003	73	3	2	2 880	1 032		2 450	4 424
Murten	60 552	13 757	166	245	30 207	2 874	1 611	18	10 563
Sempach	77 729	4 117	92	777	6 694	2 308		186	5 660
Hallwil	20 665	328	62	143	865	1 120		14	1 443
Joux	21 286			21	2 177	2 649		2	1 861
Sarnen	25 250			32	7 906	840		244	1 228
Aegeri	9 548			31	1 697	1 596		55	1 450
Baldegg	11 247	1 386	382	48	2 878	549		10	1 939
Lungern	10 480				1 815	548		24	258
Total	2 968 240	135 366	4 121	13 504	743 725	56 172	1 830	16 097	746 408

Lake (without foreign	Pike-perch	Eel	Whitefish (coregonids)	Trout (Salmo trutta)	Other trout	Char	Grayling	Other fishes
Geneva[a]			11 119	6 278		3 399		23 657
Neuchâtel	4	32	144 959	8 375		2 045	19	
Constance	1 081	7 152	227 864	2 034	1 364	289	796	263
Lucerne[a]	87	1 186	265 447	2 089	44	21 078	184	42
Zurich	102	568	85 415	2 744	82	386	70	103
Thun[a]			41 250	205		1 198	210	2
Maggiore[b]	444	386	116 737	3 011		101		1 119
Biel[a]		134	52 920	149				67
Zug		1 335	21 241	444		2 727		
Lugano[b]	450	527	5	1 517		10		526
Brienz[a]			28 628	130		143	13	1
Walenstadt		12	30 483	1 302	73	1 223	41	5
Murten	47	11	170	881		2		
Sempach	3	70	57 586	180	4	30		22
Hallwil	27	17	16 634	8				3
Joux			13 303	1 010				263
Sarnen	1	217	14 727	55				
Aegeri		37	4 090	107		486		
Baldegg	87	362	3 538	67	2			
Lungern			7 808	28				
Total	2 333	12 046	1 143 924	30 614	1 569	33 127	1 333	26 073

[a] Without sport fishery

[b] From 1982 on, without sport fishery

Source: Müller (1988) after Bundesamt für Umweltschutz (1988)The Swiss Federal Office of Statistics (Europa, 1985) states that the total Swiss catch in 1980 was 3.5 thousand tons and 3.7 thousand tons in 1981. It will be noted that the FAO figures (Table 6) agree with these figure totals for these years. It is the confusion concerning "whitefishes" and the apparent lack of a record of aquacultural production which makes the table inadmisable. Once again, the reader seeking catch figures for Switzerland is advised to consult only official Swiss statistics.

Both the coregonids and the perch are desired species, as are trout, char, and pike. Cyprinids, such as bream and roach, sometimes caught in large quantities especially as by-catch, are generally disliked by the public.

7.1.1 Commercial fishing

Müller (1988) points out that the Swiss commercial fishery harvest (as evidenced by official tables) is about 90 percent of the total catch. Following Staub (1987a), he also indicates that circa 1987 there were 292 full-time fishermen and 193 part-time commercial fishermen in Switzerland. Using gillnets (both drifting and bottom) and traps, these men shared a total lake area of about 1 400 km^2, including the Swiss portions of international waters. All of the 352 fishing establishments concerned with commercial net fishing in 1985 were located on lakes, except for a few professionals who fished on a section of the Rhine.

In order to limit fishing intensity and to support the existence of full-time fishermen, the number of commercial fishing permits per lake is closed, their number depending upon the size and productivity of the lake. Fishing pressure is also limited by the number and size of the nets and by closures during the spawning season of important species. Each fisherman has need of from 300 to 600 ha. It may be noted that the number of full-time fishermen has varied little during the 1968–87 period, having remained at about 300 (Staub, 1987a). There has been a diminution of the number of part-time fishermen and also in the number of fishing establishments, but fishing effort is still believed to be rather constant.

Fishery management in Swiss waters is the province of the cantons, 17 of which have lakes exploited commercially today. Only in international and privately owned waters does the Federal government have a hand. Aside from such regulations as have been cited above, fishery management is also carried out through stocking. Both the cantons and some of the commercial fishermen participate in this endeavour. Trout, coregonids, and pike are stocked extensively, but the catch of perch relies entirely on natural reproduction.

Although there have been some great fluctuations in catch, the net fishery of the great lakes of Switzerland produces about 2 600 t annually (Staub, 1987). The value of the 1984 harvest has been estimated at about Sw F 17 million (Staub, 1987a).

Commercial fishing is relatively unimportant in the entire Swiss economy, but locally caught fish do supply a considerable percentage of local needs, perhaps 15 percent.

7.1.2 Sport fishing

Widely distributed sport fish in Switzerland include: both brown and rainbow trout, grayling, char, pike, perch and eel. American brook trout (Salvelinus fontinalis) are found in some waters (e.g., the Areuse), and the American lake trout (S. namaycush) in some lakes.

Switzlerland/EIFAC (1974) estimated the annual sport catch in lakes and rivers to be about 950 t to 1 140 t.

Gaudet (1977) estimated the number of sport fishermen in Switzerland to be about 250 000. Müller (1988) has estimated that about 200 000 sport fishermen (about 3 percent of the total population) fish in Swiss lakes. He also estimates that sport fishing yields about 10 percent of the lake catch.

Management of sport fishing relies on regulation such as size limits, stocking, and stream and lake improvement. Fishing in private waters may require a fee and there is some free fishing.

Table 8

Average annual yield and important fish species of 20 Swiss lakes, 1981–86

Lake	Yield kg/ha/year	Percentage of important fish categories
Geneva	11.7	Perch 48%, cyprinids 41%
Neuchâtel	24.0	Cyprinids 43%, whitefish 28%, perch 26%
Constance	34.6	Perch 46%, whitefish 38%
Lucerne	33.4	Whitefish 70%, cyprinids 17%
Zurich	32.8	Cyprinids 45%, whitefish 29%, perch 21%
Thun	9.1	Whitefish 95%
Maggiore	40.8	Whitefish 68%, cyprinids 14%
Biel	29.9	Whitefish 45%, cyprinids 40%
Zug	27.7	Cyprinids 63%, Whitefish 20%
Lugano	10.6	Cyprinids 69%, perch 18%
Brienz	10.0	Whitefish 98%
Walenstadt	18.2	Whitefish 69%, perch 10%
Murten	26.5	Cyprinids 73%, perch 17%
Sempach	53.6	Whitefish 74%, cyprinids 15%
Hallwil	20.3	Whitefish 80%
Joux	22.3	Whitefish 62%, pike 12%, cyprinids 10%
Sarnen	33.1	Whitefish 58%, cyprinids 31%
Aegeri	13.3	Whitefish 43%, cyprinids 18%, pike 17%
Baldegg	21.4	Cyprinids 42%, Whitefish 31%, perch 17%
Lungern	52.1	Whitefish 75%, cyprinids 17%
Total	23.4	Whitefish or coregonids 39%, cyprinids 30%, perch 25%

Source: Müller (1988) after Bundesamt für Umweltschutz (1988)

7.2 Aquaculture

The principal species of fish cultivated commercially in Switzerland are rainbow and brown trout. Its total aquacultural production circa 1974 was 300 t, mostly of rainbow trout, according to Switzerland/EIFAC (1974). Brown (1977; 1983) also stated that the total production of both rainbow and brown trout in 1974 was about 300 t, and that a generally accepted estimate was about 270 t of rainbow and about 30 t of brown trout achieved by about 30 fish farmers[1]. Although most of the recent authors listing trout production in European countries do not mention Switzerland. Shaw, Shaw and Thomas (1981) have a table showing that annual production of rainbow trout in Switzerland was 400 t during the 1976–79 period, jumping to 1 500 t in 1980 and 1981.

[1] Brown's table 9.1 differs in showing that the estimated production of rainbow trout alone in Switzerland (no figures for brown trout are shown) was 300 t in 1974, a rise from 200 t in 1971

The rainbow trout spawn in February and March and the brown trout in November–January. After spawning they are usually reared in concrete tanks to about 6 cm and then placed in earthern ponds or concrete raceways. Between one and two years are required to raise the trout to market size between 180 and 200 g. Pelletized food is used. All domestic production is sold alive and generally directly to the consumer. There are no exports.

There is also a considerable import of trout (far exceeding the local production), especially from Denmark, Italy and France.

In addition to commercial trout culture, there is a limited production for food of common carp (Cyprinus carpio). Following spawning in the spring, the fry are reared in earthen ponds with little feeding. It requires three or four years to attain the market size of 1.5 kg. The production, which is centered in western Switzerland, is sold live directly to the consumer. In 1975 there were only five farms in the country with a total yearly output of 2 t.

The above information (mostly from Brown, 1977; 1983) can be supplemented by statistics from Switzerland, Bundesamt für Statistik (1979). These indicate that in 1975, Switzerland had about 100 ponds for the cultivation of fish, totalling 4 814 ha, and employing (on full and part-time basis) about 1 854 people.

By 1984 there were 87 installations in Switzerland where fish were reared for consumption and about 124 devoted to rearing fish for repopulation. Most of the fish cultural units are on the Midland Plateau where the water quality is best for them. Aquacultural establishments utilized a surface of 550 000 m^2 in natural waters and 110 000 m^2 in artificial installations. The artificial installations for fish destined for consumption used 50 000 m^2. In 1984, 1 023 t of trout and 138 t of other species of fish were produced in Switzerland for food: their value was about Sw F 15 million (Staub, 1987)[1].

[1] FAO Fish.Info.Data and Stat. (1989) says that the aquaculture production in Switzerland, listing only rainbow trout, varied between 272 t in 1984 and 252 t in 1987. In view of Stabu's account (using the official Swiss census of 1985) this is clearly incorrect

All of the commercially important fish, except European perch, are stocked to support the fisheries. In 1984 about 666 million alevins were stocked. Of these, 606 million were coregonids whose production is aided by the use of net cages equipped with lamps to attract zooplankton. About 28 million fish were raised to pre-summerling and summerling stage before stocking. Of these 9.8 million were brown trout.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[2]

8.1 Ownership and Availability

No information on ownership and availability of fishing rights (other than that given below) is available to the author.

[2] This section is derived primarily from Gaudet (1974) and material received by EIFAC from Switzerland in 1979

8.2 Administration and Management

8.2.1 Federal level

The Department of Interior is the competent Federal authority with respect to Swiss fisheries. Within this administration, fisheries is handled by the Federal Office for the Protection of the Environment (OFPE), more particularly by the latter's Office of Fishery Inspection which is responsible for much of the Federal work in this sphere. This latter office ensures that laws and regulations laid down by the cantons in accordance with the Federal fishery law of 14 December 1973, as well as agreements on fishing in inter-cantonal waters conform to Federal law.

Fishing in Swiss border waters is under the jurisdiction of international commissions staffed by fishery experts and plenipotentaries from the bordering countries which ensure that international agreements are respected. (These international waters are those of the Rhine, the Bodensee and Untersee, and Italo-Swiss and Franco-Swiss waters. See also section 8.5.) Switzerland is represented by the Chief of the Division of Natural Sciences and Fisheries (which has a Fisheries Section) under the OFPE in collaboration with the authorities in the riparian cantons.

The Federal Office of Fishery Inspection is also responsible for organizing refresher courses for the cantonal fish wardens, and issuance of information for the cantonal fishery inspectors.

8.2.2 Cantonal level[1]

Under the Federal fishery law of 1973, the cantons are required to enact the laws and regulations necessary for the application of Federal laws concerning fisheries.

The cantons exercize sovereignty with regard to fisheries. Fishing is regulated by a system of permits or leases; the cantons are free to choose the system.

The cantonal departments in charge of fisheries set up fishery inspectors within their administration. According to Federal law they are required to appoint fish wardens for law enforcement and management. There is a Service Chief for each canton.

[1] Switzerland is composed of 20 cantons and 6 “half cantons”

8.3 Investigation

The Federal Institute for the Management, Purification and Protection of Waters (EAWAG), also within the Department of Interior, has set up a section on fishery research. The section is charged with research and methodology concerning fisheries and collaboration in instruction of the fish wardens.

There is also a laboratory under the Federal Office of Veterinary Medicine to investigate fish diseases. It is also concerned with the controls regulating fish imported from other countries as well as those originating in Switzerland.

8.4 Other Concerned Agencies

8.4.1 Commercial fishing

The Swiss Association of Professional Fishermen is the leading association of commercial fishermen. In 1979, there were about 580 professional fishermen in Switzerland. About 325 (56 percent) of these practised fishing as their only occupation.

8.4.2 Sport fishing

Sport fishing in Switzerland is regulated by two large organizations: (i) Swiss Federation of Fishing and Fish Culture, and (ii) Swiss Association of Sports Fishermen.

Within the cantons there are also diverse cantonal and regional societies whose members are sometimes affiliated with these two leading groups.

8.5 International Agreements

Switzerland has a bilateral agreement with France concerning water quality in Lake Geneva, and another covering hydropower on their boundary streams. With Italy, it has a bilateral agreement covering the water level in Lake Lugano, one covering hydropower on the River Spoll, and one covering water quality in their boundary waters. It has a trilateral agreement with Austria and the Federal Republic of Germany on water quality in Lake Constance, belonging to the Internationale Gewässerschutz Kommission für den Bodensee. Since 1893, fish management of Lake Constance (Bodensee) has been regulated by the Internationale Bevollmächtigen Konferenz für die Bodensee Fischerei.

Switzerland is a member of the International Commission for the Protection of the Rhine against pollution, given legal authority by a treaty, together with France, the Federal Republic of Germany, Luxembourg, the Netherlands, and the European Economic Community (EEC). This Commission is charged with drawing up permit and discharge standards and will fix the maximum tolerable levels of pollution in the Rhine.

Switzerland also belongs to the Central Commission for Navigation on the Rhine to guarantee freedom of navigation on this river, and signed by interested countries in 1868. Other members include: France, the Federal Republic of Germany, the Netherlands, and the UK.

9. STATE OF THE FISHERY

9.1 Yield

Reference to Table 6 shows no great rise or fall in total commercial catch during the 1965–87 period - except perhaps for the perch and cyprinids catches - but, as has been stated before, it is best to look at original Swiss statistics. Here we find that in a representative group of 18 lakes, the average annual catch rose from 2 231 t in 1967–71 to 3 187 t in 1972–75, and then declined to 2 206 t in 1980–82 (Brown 1983, after OFPE, Bern; Statistisches Jahrbuch der Schweiz 1979).

The annual yield in small high mountain lakes in Switzerland is in the nature of only 1 or 2 kg/ha; in some lakes at low elevation the annual yield may be at least 300 kg/ha (Switzerland/EIFAC, 1974, 1979). With respect to individual lakes, Table 9 shows some annual yields in some large Swiss lakes representing about 70 percent of the country's static waters. Later information on yield is shown in Table 8. During the 1981–86 period, the group of lakes represented there (about 90 percent of Switzerland's lake area) had an average yield of 23.4 kg/ha/year, ranging from 9.1 to 53.6 kg/ha/year.

It is thus apparent that yields in the large lakes of Switzerland vary widely, e.g., the complete catch in the Swiss portion of Lake Geneva varied from only 24 t in 1981 to 1 024 t in 1975 (Staub, 1985). Shifts in fish population dominance, eutrophication, fishing pressure, changes in catch regulations, and enhancement of the populations through stocking may be the reasons for changes in harvest and thus in yield. Müller (1988) says that the strongly fluctuating yields stem from “unknown causes”, sometimes even followed by a population collapse.

With respect to aquaculture, there has been a gradual increase in production, but it is still not high.

Table 9

Annual yield in some large Swiss lakes, kg/ha[a]

Lake	1967–71	1972–75	1982

Geneva (Lac Léman)	13.9	23.2	10.1
Neuchâtel	14.4	20.3	19.8
Bodensee and Untersee	33.9	37.9	26.9
Lucerne (Vierstättersee)	17.9	29.9	31.0
Zürichsee	19.2	26.3	--

[a] Based on Swiss catch in Swiss waters

Source: Period of 1967–71 from Brown (1977) based on information from OFPE, Bern
Period of 1972–75 and 1982 calculated from tables in Switzerland, Bundesamt für Statistik (1979; 1983)

9.2 Factor Affecting the Fishery

Switzerland's abundant water resources, including the presence of many large lakes, favour inland fishery production. The country possesses a variety of fishing waters ranging from its great sub-Alpine lakes to high hydroelectric reservoirs, mountain tarns, and a network of rivers and smaller streams. Furthermore, the small demand for abstraction by irrigation and comparatively small demand for domestic supply from surface sources serve to keep these resources intact.

The prevailing cold water temperatures are conductive to the production of high-valued species in both lakes and streams; thus there is emphasis on trout and coregonid fisheries.

Such favourable factors are, however, offset by others which tend to decrease both the quantity and quality of the fisheries. The Alpine streams are subject to heavy runoff, are inconstant often filled with debris and tend to overflow their channels. The relative infertility and short growing season of high mountain lakes are basic limits to production. At low levels, eutrophication, pollution, and multiple-use have degraded more naturally productive waters as fishing areas. There is a dense population near many Swiss lakes and a host of fertilizing elements reach the waters. Continued eutrohication will replace salmonoid and coregonoid populations with fish of lesser value, although the coregonid catch still appears to be holding up well.

Despite eutrophication, the general picture of water quality in Switzerland is quite good. Manufacturing here is relatively clean and there is a traditional national ethic to provide good care for land and water. In 1983, Switzerland became the first European country to announce that the use of phosphates in detergents would be banned. Other highly specific measures are also being taken to reduce the effects of eutrophication, e.g., in the eutrophic Baldeggerrsee, a mesomictic lake of 5.2 km^2 which has received loadings of over five times its critical P-loading of 2 t/year. Destratification by bubbling compressed air and oxygen has changed anoxic conditions to aerobic ones (Stadelmann, Joller and Imboden, 1984).

The average annual surface runoff is about 7 828 m^3 per caput (well above the European average) thus affording a relatively high degree of effluent dilution.

The cantonal system insures a great deal of local control of fisheries, hence, management may vary considerably in different parts of the country. It has also made collection of fishery statistics somewhat difficult in the past.

There has been a desire on the part of the Federal Government to further commercial fishing as an enterprise, including a Federal decree of 30 September 1970 concerning steps to promote professional fishing. Annual subsidies are borne by the cantons and the Confederation for this purpose.

The yield from aquaculture is not great. Lack of good sites, including the high cost of land, and the well established system of importing trout from Italy, France and Denmark hinder its development.

9.3 Prospect

Although there will be construction of some additional pumped storage, some reservoirs for drinking water, and some to supply water for nuclear plants, the period of grand construction of dams is now over in Switzerland. There should be comparatively little effect on its fisheries by future construction. Hydroelectric reserves in Switzerland are now very low; 95 percent had been used 15 years ago. The Swiss have now turned toward use of nuclear power.

One can envision a continuing eutrophication of the sub-Alpine lakes together with a gradual increase in cyprinid stocks rather than in the colder water stocks. One can also visualize diminishment of the productive commercial fisheries and a growing increase in sport fishing.

The yield from aquaculture, primarily of trout, will increase. Brown (1983) estimated that an annual production of 1 000 t might be its limit, but trout production had already risen to 1 500 t by 1980 (see section 7.2).

The quantity and quality of fishing in Switzerland (as in most countries) is largely dependent on the preservation of water quantity and quality. In this respect, "Switzerland is probably closer than most other countries to the 'limits of growth'" (Weiss, 1978), and it has a strong tendency to maintain its quality of life, including an environment favourable for fisheries. Nevertheless, both aquaculture and capture fisheries will continue to be minor elements in this small country devoted as it is to manufacturing, tourism and services.

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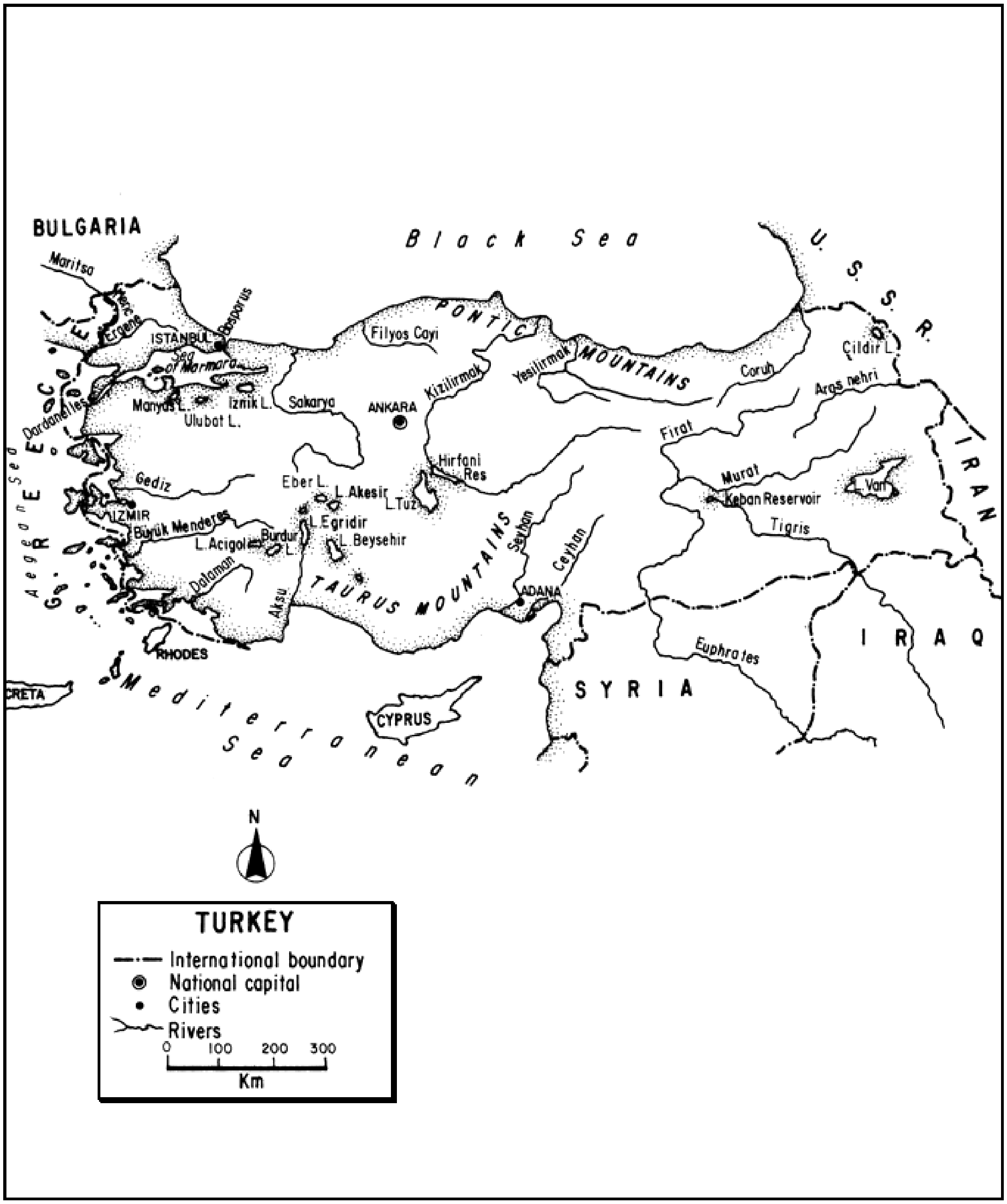

BULGARIA
Black Sea
U. S. S. R.
Maritsa
Meric
Ergene
ISTANBUL
Bosporus
Sea of Marmara
Dardanelles
Manyas L.
Iznik L.
Ulubat L.
Sakarya
ANKARA
Filyos Cayi
PONTIC MOUNTAINS
Kizilirmak
Yesilirmak
Coruh
Cildir L.
Aras nehri
IRAN
Firat
Murat
Keban Reservoir
L. Van
Tigris
Hirfanl Res
L. Tuz
Eber L.
L. Akesir
L. Egridir
L. Beysehir
Burdur L.
L. Acigol
Gediz
IZMIR
Büyük Menderes
Dalaman
Aksu
TAURUS MOUNTAINS
Seyhan
Ceyhan
ADANA
Aegean Sea
GREECE
RHODES
CRETA
Mediterranean Sea
CYPRUS
SYRIA
IRAQ
Euphrates
N
TURKEY
International boundary
National capital
Cities
Rivers
0 100 200 300
Km

TURKEY

The Republic of Turkey is a passage-land between the Balkans and the Middle East: 3 percent (Thrace) lying in Europe and 97 percent (Anatolia) in Asia. Bounded by six countries, and with a long coastline on the Black, Aegean and Mediterranean Seas, it consists of a narrow coastal belt backed by mountains which enclose a great plateau.

The arid plateau contains numerous lakes, many of which are alkaline and some so saline that they will not support fish. The coasts have a considerable number of lagoons which support traditional fisheries for euryhaline species.

Although primarily agricultural (albeit much of the farming is on poor terrain) Turkey's growing industrialization and urbanization has created demands on its limited water resources, and increased its pollution. With a great need for irrigation, the construction of new reservoirs, which are also used to produce hydroelectric power, has created many new static water fishing areas.

Most of the inland commercial fisheries derive from the lakes and reservoirs on the Anatolian plateau, the remainder is principally from lagoons and other coastal areas. Crayfish, carp, and eel are the major inland fishery exports. Aquaculture is developing slowly, and sport fishing is little developed, although the potentialities are there.

The future for Turkey's inland fisheries is one of expansion which will come about through adoption of more modern methods of capture, processing and transport, investigation and management.

1. AREA: 779 452 km^2

2. POPULATION: 54 647 000 (est. 1990) Density: 70 inh/km^2

3. PHYSICAL GEOGRAPHY

Turkey, situated in the Eastern Mediterranean region, both within Europe and Asia, lies between 35°51' and 42°06'N latitudes and 25°40' and 44°48'E longitudes.

European Turkey, which is called Thrace, holds about 12 percent of the population and has an area of 23 764 km^2 (3 percent of the country). Asiatic Turkey, called Anatolia or Asia Minor, has an area of 755 688 km^2 (97 percent of the country). The two are separated by the Dardanelles, Sea of Marmara and Straits of the Bosphorus, a route of about 361 km.

Roughly ovate, the country is about 1 750 km (NW-SE) and 670 km wide (NNE-SSW) and has a periphery, including seas and islands, of 11 086 km. The median altitude of Turkey is 1 128 m; the range in elevation is from sea level to 5 166 m, the summit of Mt. Ararat. Of more importance is the fact that in Asiatic Turkey flat or gently sloping land is very rare, and moderately sloping land is limited mainly to Thrace whose highest point is 1 030 m.

The European portion is bordered on the west by Greece for 212 km and on the north by Bulgaria for 269 km. Anatolia is bordered on the east by the USSR for 610 km and Iran for 454 km, and on the south by Iraq for 331 km and Syria for 877 km[1].

[1] Length of all boundaries from Türkiye Istatistik Yilligi, 1987

The lengths of the coastal boundaries are as follows: Thracian coast 786 km, Anatolian coast 6 480 km, and island coast 1 067 km. The mainland coastlines comprise: 1 695 km on the Black Sea (north), 2 805 km on the Aegean Sea (west), and

1 677 km on the Mediterranean Sea (south). The combined coastline of the Sea of Marmara and its entrance and exit totals 1 169 km.

In general, Turkey consists of a central massif of uplifted blocks and downfaulted troughs (the plateau region), surrounded on all but the west side by a chain of high folded mountains which edge the coastal strips along the Black Sea and Mediterranean. These mountains merge into a mass of jumbled peaks in eastern Turkey close to the USSR and Iran. The mountains act as a barrier to rain-bearing winds leaving the plateau arid. The plateau is treeless, has salt marshes and desert, and becomes less productive as one proceeds eastward. The mountains fall off rapidly to the sea, where they border fertile wooded coastal belts which range from sea level to about 150 m. Part of the great Alpine-Himalayan belt, Turkey is still subject to extensive faulting, making it an earthquake zone.

Turkey consists of five natural regions: the three coastlands, the central plateau, and the eastern highlands[1].

[1] For geographical analysis, these have been broken down into seven “official” geographical regions: Black Sea, Marmara, Aegean, Central Anatolia, Mediterranean, East Anatolia, and Southeast Anatolia

(i) Black Sea Coastlands (10 percent). Stretching completely across northern Turkey is a steep and rocky coast below the faulted Pontic Mountains. Most of the strip is a narrow ribbon widening here and there into a fertile delta. Short rivers cascade through gorges in the well-forested mountains, and a few larger ones have cut back into the mountains. The western part of this area is the centre of Turkey's heavy industry.

(ii) Aegean Coastlands (16 percent). Including Thrace and Marmara, and stretching from the Greek border south for 2 805 km, this is mostly rolling plateau country well suited for agriculture. The 60-km Strait of the Dardanelles, averaging 4 km in width, leads inward from the Aegean to the 11 137-km^2 sea of Marmara, 80 km at its widest, 247 km long, and 1 327 m deep. This Sea in turn opens to the Black Sea through the 27-km Bosphorus which averages about 1.5 km in width, narrowing to less than 500 m in spots. Both the Dardanelles and the Bosphorus are old river channels drowned by the sea. The Aegean region has fertile soils and typically Mediterranean climate. The lowland contains about one-half of the country's agricultural wealth and is its most densely populated area. The shoreline is greatly indented and the Aegean is studded with islands, mostly Greek.

(iii) Mediterranean Coastlands (8 percent). This southern area has a much more regular coastline than its Aegean counterpart. With warm, subtropical climate and fertile soils, it is rich agriculturally (citrus, cotton, rice, grapes, etc.), but is subject to drought. The backland is mainly karst and the rivers have not cut many valleys to the sea. It has few major cities.

(iv) West and Central Plateau (35 percent). Arid and plateau-like, with elevations ranging from 600 to 1 200 m, west to east, a sub-desert or steppe, ringed by mountains, Central Anatolia is the heartland of Turkey. On the north, the Pontic Mountains, mainly 1 600 to 2 000 m, separate the plateau from the Black Sea region. On the south, the Taurus Mountains, up to about 2 800 m, separate it from the Mediterranean region. The two mountain systems converge in the east in the Eastern Highlands. Wooded areas are confined to the northwest and northeast, and cultivation on infertile soils and with low rainfall is mainly restricted to river valleys. For the most part, the plateau is bare and monotonous with rough terrain and poor soil, used primarily for grazing. Rainfall is limited, the summers are hot, and winters harsh and cold with heavy lasting snows.

Although irrigation is practised, the deeply entrenched river courses make it difficult to raise water to the surrounding lands.

(v) Eastern Highlands (31 percent). This is an area of very rugged country with many volcanic peaks rising to 3 000–5 000 m. It is also the Turkish area with the severest climate (down to -40°C), and having more rain than the Central Plateau. Although it contains some fertile basins and river corridors at the foot of lofty ranges, much of it is a wild, barren wasteland with a sparse population, some of it nomadic. Hydrographically, it is notable in being the headwaters of the famed Tigris and Euphrates rivers.

About 40 percent of Turkey's soils are acidic red and grey-brown podsols and brown forest soils found mainly in mountain areas. Brown and reddish steppe soils (20 percent) and large saline areas are found on the plateau. About 40 percent of the soils are terra rossas, alluvial, and bare rock. Some areas are covered with recent lava flows. More productive soils comprising clay and lime materials underlain by sand-silt and clay are found in coastal and lowland areas such as European Turkey. The richest soils are found on alluvial plains in the wider valleys and in volcanic regions, but soils fertility is generally low, and about 20 percent of Turkey's soils are considered non-arable. Most Turkish soils are deficient in organic matter and plant nutrients and have been harmed by centuries of deforestation, over-grazing, and erosion.

The original vegetative cover in Turkey has been greatly modified by man. Basically, there are four types:

(i) Mediterranean on the periphery (oak, pine, laurel and maquis at low elevations);
(ii) steppe-type grasslands on the plateau with trees and shrubs only along rivers;
(iii) hardwood and pine forests in the mountains, and
(iv) Alpine vegetation at high altitudes.

Settlements are heavily concentrated in European Turkey and in the fertile valleys of the Marmara, Aegean and Black Sea coasts. Thrace alone has about 12 percent of the population.

4. CLIMATE

Most of Turkey's climate is a dry semi-continental variation of the Mediterranean type, or alternatively is transitional between Mediterranean and temperate continental regimes. Coastal Turkey has mild wet winters and moderately hot summers. The interior plateau has a wide range of temperatures with hot summers and severe winters, as has the inhospitable eastern part of the country.

The mean annual temperature varies from about 20°C on the south coast (11–29°C), falls to about 15°C on the west and Black Sea coasts (7–23°C), and in the interior varies between 4° and 18°C. In summer, all but the higher mountain areas are hot. July means are above 20°C for the whole country, rising above 25°C in western and central Anatolia, and above 30°C in the southeast where over 40°C has been recorded. In winter, the means are between 0° and -10°C in the interior becoming much colder toward the east. Extreme minima in the interior vary from -20°C in the west and -40°C in the east. The peripheral coasts have January means above 5°C.

The average annual rainfall is about 670 mm, but varies in each region with a minimum of 63 mm and maximum of 4 045 mm. The highest rainfall generally occurs on the slopes of the mountains facing the sea, with 1 000–1 500 mm annually on the Aegean slopes and over 2 500 mm on the eastern Black Sea slopes. Rainfall is about 200 mm at lower coastal levels. In the central and southwest interior, the rainfall averages 300–400 mm. The Black Sea coast receives rain throughout the year. On the other coasts, the rainy season starts in autumn and continues until spring. In the interior and southeast, rain occurs mainly in the spring.

The western continental area does not experience much frost, but it may occur more than 200 days annually in parts of the interior plateau. On an average, the number of days with frost varies from 13 to 16 on the west and south coasts and 103 to 107 on the eastern Central Plateau. Prolonged snowfall is typical of the interior and snow may last for four months in the higher east.

5. HYDROGRAPHY AND LIMNOLOGY

According to the source of Table 8, the extent of inland water in Turkey is 9 820 km^2 or almost 1.3 percent of the country's total area. Another estimate is 9 243 km^2 or 1.2 percent of the total area (Encyclopedia Britannica, 1974). Far surpassing both of these estimates is one made by FAO/World Bank (1975) which says that “Turkey has large extensions of inland waters as follows”:

	No.	Area (ha)
Natural lakes	42	925 000
Dam reservoirs[a]	62	175 000
Lagoons		66 000
Paddy fields		65 000
Rivers	148 000 km	60 000
Ponds		560
		1 291 560

[a] Including those under construction

The derivation of most of the above figures appears to be as follows: lakes (over 10 km^2), lagoons, rivers, and ponds from TUMAS (1972); dam reservoirs include only those owned by the State Hydraulic Department. Such an estimate would be about 1.6 percent of Turkey's total area, but if we include only the estimates of areas of natural lakes and rivers, which total 9 850 km^2, the estimate is more in line with the others, i.e., only 1.3 percent of the total area. Turkey/EIFAC (1989), basing its statement on DSI, 1989. Türkiye eki Barajlar ve Hidroclektrik Santrallar, increases the FAO/World Bank (1975) figures to a total inland water area of 1 508 072 ha by saying that there are 183 dam reservoirs with an area of 391 512 ha. Specific remarks on some of these components of “inland waters” will be made below, particularly the fact that the lake area cited contains much saline water, which in some cases will not support any fish life, and in others almost no species of economic importance.

The approximate annual runoff from rainfall for the entire country is 167 thousand million m^3, but after use and evaporation there is a runoff to the oceans of 143 thousand million m^3 (Noyen et al., 1967, in Van der Leeden, 1975). In the European portion of Turkey alone, the annual runoff from rainfall is 3 300 million m^3 with 6 800 million m^3 entering the country, the total runoff leaving Thrace is 9 100 million m^3 (Van der Leeden, 1975).

Turkey has four major drainages: Atlantic (Mediterranean), Caspian Sea, Indian Ocean, and interior (see section 5.1). These can be further divided into 26 major river basins as shown in Table 1 which shows their area, main precipitation, runoff and discharge.

Table 1

Turkish water resources by river basins

River basin	Area	Mean precipt	Available surface water resources			
	km^2	mm	10^9m^{3a}	mm	m^3/s	$l/s/km^2$
Meric-Ergene	14 560	500	1.06	72.5	33.5	2.3
Marmara	24 100	800	5.85	242.6	185.6	7.7
Susurluk	22 399	600	4.16	185.9	132.0	5.9
North Aegean	10 003	650	1.74	173.2	55.2	5.5
Gediz	18 000	600	2.27	126.0	72.0	4.0
K.Menderes	6 907	650	1.04	151.2	33.15	4.8
B.Menderes	24 976	600	3.15	126.0	100.0	4.0
W. Mediterranean	20 953	900	6.86	327.6	217.0	10.4
Antalya	19 577	1 100	14.33	491.4	454.9	23.2
Burdur Lakes	6 374	600	0.9	141.8	28.7	4.5
Akarcay	7 605	500	0.91	119.7	28.9	3.8
Sakarya	58 160	450	4.1	69.3	130.0	2.2
W. Black Sea	29 598	800	9.32	315.0	296.0	10.0
Yesilirmak	36 144	500	4.57	126.0	145.0	4.0
Kizilirmak	78 180	400	5.66	72.5	179.8	2.3
Int.basin Konya	53 850	400	3.91	72.5	124.0	2.3
E. Mediterranean	22 048	900	9.03	409.5	286.6	13.0
Seyhan	20 450	880	5.92	289.8	187.9	9.2
Asi	7 796	900	1.47	189.0	46.8	6.0
Ceyhan	21 982	950	7.25	330.8	230.0	10.5
Euphrates (Firat)	125 540	700	28.35	220.5	900.0	7.0
E.Black Sea	24 077	1 400	11.34	469.4	360.0	14.9
Coruh	19 872	600	4.88	245.7	155.0	7.8
Aras	27 548	500	3.71	207.9	181.38	6.6
Int. basin Van	19 405	700	3.54	182.7	113.0	5.8
Tigris (Dicle)	57 614	850	19.49	337.0	618.8	10.7
Total	777 688	670	166.81	214.0	5 300.0	6.8

[a] One thousand million cubic metres

Source: Van der Leeden (1975) after Cecen, Wasser und Boden (1968)

5.1 Rivers[1]

The total length of Turkey's rivers is about 148 000 km with an estimated area of about 60 000 ha (TUMAS, 1972). Petr (1983) says that 33 major rivers in Turkey cover 175 715 ha; this is probably a lapsus calamus and km should be substituted for ha.

The major rivers of the country are listed under their respective river basins in Table 2. The seasonal discharge of some of the country's major rivers is shown in Table 3.

[1] In Turkish, akarsu, irmak and nehrir are words for river. Cay and su are words for smaller streams

Table 2

Some principal rivers of Turkey

Basin and River	Length (km) Within Turkey	Outside Turkey
Black Sea (W to E)		
Sakarya	824	
Porsuk cayi	488	
Ankara cayi	186	
Aladag cayi	139	
Göksu	118	
Filyos cayi (Yenice irmagi)	228	
Gerede cayi	260	
Arac cayi	119	
Kisilirmak	1 355	
Delice irmagi	426	
Devrez cayi	186	
Gökirmak	221	
Yesilirmak	519	
Çecerek cayi	331	
Kelkit cayi	373	
Coruh	442	
Oltu cayi	151	
Sea of Marmara		
Susurluk (Simav) cayi	321	
Kocabas cayi	108	
Gonen cayi	134	
Aegean Sea (N to S)		
Meric	211	279
Ergene	281	
Gediz	401	
Alasehir cayi	115	
Gordes cayi	152	
Kücük Menderes	175	
Büyük Menderes	584	
Akçay	157	
Sag Menderes	185	
Sol Menderes	88	
Cine cayi	99	
Dalaman	229	
Mediterranean Sea (W to E)		
Aksu cayi	162	
Göksu nehri	308	
Seyhan	560	
Göksu	201	
Zamanti suyu	308	
Ceyhan	509	
Goksu	138	
Asi nehri (Orantes)	97	283
Persian/Arabian Gulf (W to E)		
Euphrates (Firat)	971	1 829
Çalti suyu	143	
Murat nehri	722	
Munzur suyu	144	
Tigris (Dicle)	523	1 377

Batman cayi	170	
Garzan cayi	122	
Ulucay (Botan cayi)	268	
Caspian Sea		
Aras nehri	548	511
Arpaçay	174	

Source: Primarily from Türkiye Istatistik Yilligi, 1987

Table 3

Discharge of five principal rivers in Turkey

	Sakarya	Kizilirmak	Euphrates (Firat)	Büyük Menderes	Ceyhan
Basin area km^2	5 320	75 120	63 835	23 889	19 767
Mean monthly discharge, m^3/s					
January	242	174	308	167	265
February	328	234	380	190	324
March	350	308	723	168	421
April	354	260	1 990	124	446
May	273	190	1 780	83.7	326
June	162	172	792	53.7	153
July	101	89.5	361	28.1	66.9
August	73.8	62.0	246	23.8	47.6
September	92.1	87.1	217	31.6	48.3
October	115	98.9	248	38.9	61.2
November	123	97.7	300	67.7	70.9
December	213	132	304	103	265
Year	202	159	639	90.0	199
Period of record	1961–66	1962–66	1937–66	1951–66	1954–66

Source: Unesco (1969)

A major divide between Turkey's river basins runs obliquely through eastern Anatolia separating the Atlantic (Mediterranean) drainage from that of the Indian Ocean and Caspian. East of this divide, a large area drains through Iraq to the Persian Gulf through the two greatest rivers of Western Asia, the Euphrates (Firat) and Tigris (Dicle) rivers; and a smaller eastern area drains to the Caspian Sea through the Kuracay and Aras rivers. (The later forms part of the border between Turkey and the USSR.) There are also two areas of interior drainage comprising about one-seventh of the country: (i) the Lake Van drainage, and (ii) drainages from the southern part of Central Anatolia and adjacent sectors of the Taurus Mountains (Konya Drainage). Most of Turkey's drainage is, however, Mediterranean, either directly in the the Sea or into its component, the Aegean, or circuitously through the Black Sea and Sea of Marmara.

Notes on the major rivers of Turkey follow:

(i) Black Sea drainage: The country west and north of the main divide drains to the Black Sea, principally (west to east) through the following rivers: Sakarya, Filyos (Yenice), Kizilirmak (Halys), Yesilirmak (Iris), and Coruh which passes through the USSR to the Black Sea. Most of the Black Sea coast is steep, often with cliffs, backed by wooded mountains except for short torrential streams. The Kizilirmak, the longest river entirely in Turkey, runs in a great arc generally southwesterly and then northeasterly to the Sea. It and the Yesilirmak bear heavy silt loads which have built up deltas in the sea, and the Sakarya has a large alluvial plain.

(ii) Aegean drainage: The Thracian boundary with Greece follows the Meric River, the largest river in European Turkey, for 211 km. Originating in Bulgaria as the Maritza it is called the Evros in Greece and discharges into the Aegean Sea in the Gulf of Enez, with lagoons at its mouth. Flood control on the Meric has necessitated the exchange of land with Greece to strengthen flood control. The main tributary of the Meric is the Ergene flowing from east to west across Thrace and constituting its major basin. The northern part of the Aegean shore is drained mainly by inconspicuous torrents, but from just north of Izmir (Smyrna) proceeding south, there are some larger leisurely rivers: the Gediz (Hermus), Kuçuk (or lesser) Menderes, Büyük (or greater) Menderes, which gave the word "meander" to the English language, and then the Dalaman, the most westerly of the Taurus streams.

(iii) Sea of Marmara drainage: Streams emptying into this Sea mostly follow direct channels with gentle gradients from source to coast, although some streams first enter coastal lake or swamp areas. The Susurlak (Simav or Macertus) is the Sea's principal river.

(iv) Mediterranean drainage: The principal Mediterranean rivers are the: Aksu cayi or outlet of Egirdir Lake, Göksu (Calycadnas) which picks up much of the drainage from the Taurus slopes south of the lake district, the deeply incised Seyhan or Sarus, and the Ceyhan (Pyramus) which have large deltas, and the lower course of the Asi (Orantes) which originates in Syria.

(v) Persian Gulf drainage: The Euphrates, known in Turkey as the Firat, is formed in East Central Turkey by the junction of the 460-km Western Euphrates or Kara Su and the 722-km Murat which rises southwest of Mt. Ararat. The combined streams flow 511 km to the Syrian border and thence through Iraq to join with the Tigris in the Shatt al Arab which flows 193 km farther to the head of the Persian or Arabian Gulf. The Tigris, known in Turkey as the Dicle, rises in Gölcük, a mountain lake in East Central Turkey, flows southeast, forming about 32 km of the Syrian border before entering Iraq, after 523 km in Turkey, and finally joining with the Euphrates, a total length of 1 900 km.

(vi) Caspian Sea drainage: Both the Kuraçay and the Aras nehri rivers drain eastward to the Caspian Sea. The latter river flows eastward from Bingol Mt. for 548 km to the USSR boundary and forms part of it. Meanwhile it is joined by the Arpa cayi, the outlet of Cildir Lake. Its entire course is 1 059 km.

Compared with the rest of the Middle East, Turkey has a considerable number of streams, but considering its size it is not rich in rivers, and those other than the Tigris and Euphrates are relatively small.

Except for the Black Sea Coastal area, precipitation is unevenly distributed throughout the year. As a consequence of this factor as well as their usually barren watersheds, many Turkish rivers frequently flood in spring and become reduced to stagnant ponded beds in the autumn. The rivers of southern Anatolia, which receive little rain, are made even dryer by the porous limestone surface that permits rapid percolation.

5.2 Lakes (Göller)

The country's irregular topography has given rise to many lakes, some fresh and some saline. Official statistics in 1960 listed 61 natural lakes which had been surveyed in Turkey as having a total area of 9 061.18 km^2. TUMAS (1972) lists 46 natural lakes having a surface area of over 10 km^2 which have a total area of 9 257 km^2, and FAO/World Bank (1975) states that there are 42 lakes with a total area of 9 250 km^2. In both cases, it is known that a number of the lakes included in the summary are “salt” lakes.

Table 4, based on up-to-date Turkish statistics, lists 48 Turkish lakes with a surface area of 5 km^2 or over, having a combined area of 8 903 km^2. Again it is known that some of these are “salt” lakes and some of them are better classed as “lagoons” rather than lakes (see section 5.5).

Petr (1983) states that Turkey has some 200 larger natural lakes covering 9 061.18 km^2, and that there are also a number of inland salt lakes. One might judge from his statement that the 200 natural lakes were freshwater. However, one should note that his figure for their area is identical with the Turkish statistics of 1960 for 61 Turkish lakes and that it is definitely known that the latter included salt lakes.

It is apparent that the preceeding statistics are misleading from the standpoint of judging fish production in Turkey, since some of the lakes contain such large quantitites of salts such as NaCL, Na_2CO_3, or $MgSO_4$, that they cannot support fish life. For example, Tuz Gölu, which is listed by TUMAS (1972) and following it by FAO/World Bank (1975) and also in the 1981 source for Table 4, is a salt lake, with an area of about 1 500 km^2 and a depth of less than 1 m, which does not support fish. Aksiray (1961) says that the number of Turkish lakes where fish life cannot be supported total 6 363.9 km^2.

Under the circumstances, until the subject is better clarified, I return to the 1960 statistics which said there were 2 048.94 km^2 of inland lakes capable of supporting fish life plus 6 483.4 km^2 of shore lakes or lagoons, i.e., static waters having a connection with sea. Turkey/EIFAC (1977) indicated that static waters capable of supporting fish life could be grouped into about 2 900 km^2 of inland lakes and 660 km^2 of lagoons.

Although the largest lake in European Turkey is the 25-km^2 Terkos, most Turkish lakes are situated in the western half of Anatolia. There is a group of larger lakes, including the shallow coastal lakes of Kus and Ulubat and the deep low-altitude lake of Isnik, just south of the Sea of Marmara. Farther inland on the Plateau there is an extensive “lake district” including heavily saline lakes such as Burdur (200 km^2) and Aegol or Bitter Lake (153 km^2), the remains of the Tuz Gölu, and lakes with fresher water which support economic fisheries. Among the latter are: the largest truly freshwater lake in Turkey, Beysehir (656 km^2), and the second, third and seventh freshwater lakes, Egridir, Aksehir and Eber, respectively. Far to the east at an altitude of 1 646 m is Lake Van, the largest lake in Turkey (3 713 km^2), and another large high-altitude lake, Cildir, at 1 969 m in the extreme northeast.

The general limnological character of the nine largest natural lakes in Turkey (all over 100 km^2 in extent) which support fisheries are shown in Table 5.

As has been pointed out, many of the Turkish lakes, especially those lying on the Anatolian Plateau are characterized by high alkalinity and are rich in dissolved solids. Of such lakes that support fish, Lake Van can be taken as an extreme example. With its own interior drainage, a basin of 19 405 km^2, with no outlet, its waters are heavily sodium-carbonated. Only one species of fish, a bleak, the bleak or inci kefali (Chalcarburnus tarichi) is reported to live in the lake, and here only in the mouths of its tributaries or in areas around underground springs. This cyprinid is caught during the upstream migration in the spring. It is used fresh or salted and its eggs made into caviar. Production reported in 1971 was 2 100 t (FAO/World Bank, 1976). Another lake, the 676-km^2 Beysehir, often called the largest freshwater lake in Turkey, is also saline, but supports several species of economically valuable fish: common carp (Cyprinus carpio), various other cyprinids, especially Alburnus sp. and the chub Leuciscus cephalus, pike-perch (Stizostedion lucioperca), and the crayfish (Astacus leptodactylus). Yields are low (see section 9.1), but there are active fisheries. Egridir, the second largest freshwater lake, also in the “lake district”, is also high in dissolved solids, but supports crayfish, the introduced pike-perch, common carp, and Vimba vimba. Aksehir also in the Plateau's lake district, has exceptionally high conductivity, is rich in reed beds (especially Phragmites) which is used commercially, and has fish of economic importance including crayfish, common carp, and pike (Esox lucius), in this order. Eber Lake, just northwest of Aksehir, is an example of a large (126 km^2) shallow (5 m) lake with much aquatic vegetation, both emergent and submergent, and high load of dissolved solids, but also with a high yield of economically valuable fishes. In 1980, the catch of just three species (pike, crayfish and carp) was 118.5 t, a yield from the free-water area alone (37.8 km^2) of 31.3 kg/ha/year.

In addition to these plateau lakes, Turkey has a number of lowland lakes which are close to lagoons in physical attributes, and being open to the sea may have faunal elements such as pipefishes (Syngnathidae), clupeids (e.g., Clupeonella), gobies, and migrating eels (Anguilla anguilla). In fact, Table 4 includes a number of lakes classified by the Turkish Government as “natural lakes” which might better be termed “lagoons” (see section 5.5).

Among these shallow coastal lakes are Kus (Manyas) near the sea of Marmara, which with an area of 166 km^2 is the fifth largest freshwater lake in Turkey. Carp dominate the catch, followed by crayfish, pike, European catfish (Silurus glanis) and various cyprinids. Nine cooperatives of about 800 fishermen use gillnets, beach seines and crayfish traps in the fishery. Another shallow coastal lake near Marmara is the 134-km^2 Ulubat (Apolyont) only 5 m above sea level, with a diverse fauna of freshwater and brackishwater forms. In 1981 it produced a catch of 1 405 t, primarily of crayfish, carp and pike, which dropped to 679 t in 1982.

Also near the Sea of Marmara, but of a quite different type is the Lake of Isnik, the fourth largest freshwater lake (298 km^2) in Turkey, situated at an altitude of 85 m. Like so many Turkish lakes, it is alkaline but since it is deep (90 m) it has low water temperatures at depth. Its natural fauna is one of crayfish, cyprinids and European catfish, but it has also been considered to be suitable for coregonids (Coregonus sp.) (see section 7).

In addition to these lakes, which are primarily cyprinid in character, there are Turkish lakes of a more oligotrophic character which can support trout (Salmo trutta) populations. Some of these at low altitudes are deep, e.g., Abant. The crater lake of Gölcük, 35 m deep at 1 300 m, also supports trout, and one of the largest trout waters is Cildir Lake (125 km^2) situated in the Aras River drainage in the extreme northeastern area of Anatolia. Although it has an average depth of only 13 m it lies at 1 925 m and is fed by many small rivers and springs. Said not to exceed 21°C at the surface and to be iced over for three months, it supports brown trout (Salmo trutta), as well as carp and karabalik or Vimba vimba. Trammel nets are used for the trout, gillnets for the carp, and lines are used for winter ice-fishing. Total fish production is about 120 t annually or a yield of 9.6 kg/ha/year.

5.3 Reservoirs (Barajlar, baraj gölleri or göletler)

In 1975 there were reported to be 154 700 ha of dams and artificial lakes by UNDP/FAO (1975). In 1978, a total of 69 large dams (over 15 m in height) were reported in Turkey (CIGB/ICOLD, 1979). In terms of such dams, this accorded Turkey a rank of twelfth highest in Europe and twenty-third in the world. The FAO/World Bank (1975) reported 62 reservoirs owned by the State Hydraulic Works Department with a water surface of 174 515 ha of reservoirs and dams. Petr (1983) stated that there were 74 large reservoirs in Turkey with an estimated area of 185 000 ha. Turkey/EIFAC (1989) states that, according to DSI (1989) Türkiye deki Barajlar ve Hidroelektrik Santrallar, Turkey had 183 reservoirs with a total area of 391 512 ha by the end of 1988. A map issued in 1989 by the same group shows approximately 112 reservoirs in operation, 65 under construction and 74 in the planning stage.

Table 6 shows the official Turkish figures for 1987 on the principal reservoirs in Turkey: 36 with a surface area of 5 km^2 and over, totalling 1 645.1 km^2 in area.

In addition to the large reservoirs, there are many small reservoirs or ponds. Circa 1972, 77 ponds (ranging from 0.1 to 51.5 ha) had been constructed by the General Directorate of Forestry (TUMAS, 1972). Petr (1983) stated that there were 350 small reservoirs with an area of 9 000 ha, but also stated that there were about 600 smaller reservoirs (dams).

The largest reservoirs in Turkey listed above is Keban, formed by a 207-m rockfill gravity dam on the Euphrates (Firat) and its tributary the Murat. When completed in 1974, its hydroelectric plant doubled the electrical capacity of Ankara and Istanbul. The reservoir has an area of 675 km^2, a maximum depth of 167 m, average depth of 40 m, and volume of 31 thousand million m^3. Water temperatures vary from 4° to 21°C with a bottom temperature constant at 8.5°C. Keban has a native cyprinid fauna, plus European catfish, brown trout and several species of Asian catfishes (Mystus sp. and Glyptothorax sp.) and spiny eels (Mastacembelus). The second largest operating reservoir in Turkey is Hirfani, also on the Plateau but on the Kisilirmak River tributary to the Black Sea. With an area of 263 km^2, it has a volume of 6 thousand million m^3.

Table 4

Principal "natural lakes" (5 km^2 and over in area) in Turkey[a]

Lake	Area km^2	Altitude m	Province
Acigöl	153	836	A. Karahisar-Denizli
Akdogan	11	2 153	Erzurum
Aksehir	353	958	A. Karahisar-Konya
Akyatan (Bati)	35	4	Adana
Akyatan (Dogu)	15	0	Adana
Amik	60	81	Hatay
Arin	13	1 658	Bitlis
Avlan	8	1 024	Antalya
Bafa	60	2	Aydin-Mugla
Balik	34	2 250	Agn
Balik-Uzun	12	0	Samsun
Beysehir	656	1 121	Isparta-Konya
Boluk (Acituz)	11	940	Konya
Burdur	200	854	Burdur
Büyükcekmece	11	0	Istanbul
Cavuslu	9	1 019	Konya
Cildir	115	1 959	Kars
Colgolu	32	1072	Kayseri
Dil (Karine)	24	0	Izmir
Düdengölü	8	961	Konya
Eber	126	967	A. Karahiser
Egridir	468	916	Isparta
Ercek	98	1 803	Van
Gala	8	10	Edirne
Hacli	16	1 583	Mus
Hazapin	14	1 794	Kars
Hazar	86	1 248	Elazig
Iznik	298	85	Bursa
Isikli	49	816	Denizli
Karatas	6	1043	Burdur
Kestel	25	779	Burdur
Köycegiz	52	8	Mugla
Kus (Manyas)	166	15	Balikesir
Kücükcekmece	16	3	Istanbul
Marmara	34	71	Manisa
Mogan	6	972	Ankara
Nazik	48	1 816	Bitlis
Nemrut	12	2 247	Bitlis
Salda	45	1 139	Burdur
Sapanca	47	40	Kocaeli
Seyfe	15	1 110	Kirsehir
Terkos	25	5	Istanbul
Tuz	1 500	925	Konya-Nigde
Tuzla	23	1 138	Kayseri
Ulubat	134	5	Bursa
Van	3 713	1 646	Bitlis-Van
Yarisli	16	950	Burdur
Yay	37	1 071	Kayseri

[a] Some of these at low elevation are better classed as lagoons (see section .5.).

Source: Türkiye Istatistik Yilligi, 1987

Table 5

Limnological data for the nine largest Turkish lakes with fisheries

	Van	Beysehir	Egirdir	Aksehir	Isnik	Kus (Manyas)	Ulubat (Apolyont)	Eber	Cildir
Area (km^2)	3 713	676	468	353	298	166	134	126	115
Elevation (m)	1 646	1 121	916	958	85	15	5	907	1 959
Depth (m)									
Maximum	90[a]	10	16	5	90	-	2–7.5	5	22
Mean	-	-	6.7	3	-	2	2–7.5	-	13
Conductivity uS cm^{-1}	-	297–321	-	2 330	-	-	19.6–56.8	434	-
pH	-	8.9	7.2	8.4–9.6	8.4	7.7	8.0–8.2	6.9–8.7	-
Oxygen (mg/1)	-	8.1–8.3	8.0	7.6–8.1	10.4	10.5	9.0–9.6	-	-
Temperature (°C)	-	-	12.7 (av.)	25 (max)	24 (summer)	25 (max)	-	-	21 (max)
Total hardness, CaCO3 (mg/1)	-	-	21.19	33–58	327	142	230–279	-	-

[a] USSR (1978) says that Lake Van is 145 m deep

Source: Table 4 for areas and elevations
FAO/World Bank (1976a) for Cildir and Egirdir
Petr (1983) for all except Cildir

Table 6

Principal reservoirs (5 km^2 and over in area) in Turkey

Reservoir	Area km^2	Province	Reservoir	Area km^2	Province
Afsar	5.3	Manisa	Kayaliköy	10.2	Kirklareli
Almus	31.3	Tokat	Keban	675.0	Elazig
Apa	12.6	Konya	Kemer	14.8	Aydin
Arpacay	41.8	Kars	Kesikköprü	6.5	Ankara
Aslantas	49.0	Adana	Kozan	6.2	Adana
Berdan	6.7	Icel	Kurtbogazi	5.0	Ankara
Büyük Cekmece	43.0	Istanbul	Mamasin	11.7	Nigde
Caygören	7.3	Bahkesir	May	7.8	Konya
Camlidere	32.0	Ankara	Omerli	23.1	Istanbul
Demirköprü	47.7	Manisa	Porsuk	23.4	Eskisehir
Devegecidi	32.1	Diyarbakir	Sanyar	83.8	Ankara
Gökcekaya	20.0	Eskisehir	Selevir	5.0	A. Karahisar
Güzelhisar	5.8	Izmir	Sevisler	6.1	Manisa
Hasan Ugurlu	22.7	Samsun	Seyhan	67.8	Adana
Hirfanli	263.0	Kirsehir	Suat Ugurlu	9.7	Samsun
Kadiköy	8.0	Edirne	Sürgü	5.1	Malatya
Karaidemir	15.0	Tekirdag	Tahtaköprü	23.4	Gaziantep
Kartalkaya	11.3	K. Maras	Yedikir	5.9	Amasya

Source: Türkiye Istatistik Yilligi, 1987

However, the new Ataturk Dam on the Euphrates, scheduled to start power production in May 1991, will have an area of about 815 km^2. Its closure in January 1990 caused the flow to be reduced in both Syria and Iraq. It is part of the Southeast Anatolia project which will harness the waters of both the Euphrates and Tigris with a series of 12 dams and 13 hydroelectric plants. Scheduled for completion in 2006, this project will not only increase hydroelectric production in Turkey, but will irrigate about 1.6 million ha through thousands of kilometres of irrigation canals. (San Francisco Chronicle, 13–14 January 1990.)

New reservoirs in Turkey are multi-purpose, constructed both for irrigation and the production of hydroelectric power. The need for reservoirs for irrigation is unquestioned, and the potential for their further development remains high.

5.4 Canals

There are no navigation canals in Turkey, but there are many kilometres of irrigation canals which may contain fish. They will increase in number.

5.5 Lagoons

As in other sections of this review (see especially Italy and Greece for details), the term lagoon refers to a coastal body of water in permanent or intermittent connection with the sea by either natural or artificial means. Lagoons are mostly shallow and contain mixohaline or brackish water and are usually quite productive biologically. In the Mediterranean area, lagoons characteristically have a mixed population of brackish or euryhaline fishes which enter in the spring and attempt to return to the sea in autumn. Where considerable fresh water enters the lagoon, it may have a permanent population of fluvial fishes. Man has taken advantage of this natural inward migration by cutting off the exit of the migrants during the time of growth, and trapping or otherwise harvesting the fish when they attempt to return to the sea as the season cools. Although this process is often termed “lagoon culture”, it is generally merely a form of capture fishery facilitated by the erection of fixed traps or bordigues.

FAO/World Bank (1975) states that Turkey has 66 000 ha of lagoons. Kiener (1978) states that there are 19 lagoons in Turkey totalling 36 520 ha.

Table 7 gives the name and general location of 19 principal lagoons in Turkey totalling 41 514 ha. Both Amanieu and Lassere (1981) and Kapetsky (1984) are in general agreement as to the areas and yields (differences are indicated in the table).

Most of the catch statistics shown in Table 7 are rather old, and, as is well known, many inland fishery catch statistics, particularly those of lagoons, are suspect (see the review of Greece).

Table 7

Ninteen principal lagoons in Turkey

Lagoon	Finfish annual production/yield: Area ha	Calculated total kg	Yield kg/ha	References
Black Sea Area				
Karabogaz/Tuzlu/Liman/Balik	3 726	201 204	54	Uyguner and Gozenalp (1959)
Koca	355	40 115	113	Uyguner and Gozenalp (1959)
Aegean Sea Area				
Güllük	259	-	-	Amanieu and Lassere (1981)
Bafa	6 581	177 687	27	Uyguner and Gozenalp (1959)
Karine	2 867	40 138	14	Uyguner and Gozenalp (1959)
Homa[a]	6 000	78 000	13	Cataudella (1983)
Pamuklu/Gala/Dalyan/Bücür mene[b]	1 533	249 879	163	Cataudella (1983)
Marmara Area				
Tuzlu Azmak/Hoyrat/Tahir	297	19 899	67	Cataudella (1983)
Poyraz[c]	303	19 998	66	Amanieu and Lasserre (1981)
Büyük Cekmece[b]	1 073	69 745	65	Uyguner and Gozenalp (1959)
Kücük Cekmece[b]	1 522	15 220	10	Uyguner and Gozenalp (1959)
Tuzla	95	15 010	158	Uyguner and Gozenalp (1959)
Hersek	164	40 016	244	Uyguner and Gozenalp (1959)
Rhodes (Mediterranean) Area				
Ova	1 412	19 768	14	Uyguner and Gozenalp (1959)
Köycegiz	5 500	324 500	59	Cataudella (1983)
Adana (Mediterranean) Area				
Yumurtalik/Yelkoma/Bogazi	2 833	31 163	11	Uyguner and Gozenalp (1959)
Karatas/Akyatan	4 694	98 574	21	Uyguner and Gozenalp (1959)
Tuz	1 102	-	-	Amanieu and Lasserre (1981)
Paradeniz	1 198	20 366	17	Uyguner and Gozenalp (1959)

[a] Amanieu and Lasserre (1981) stated that Homa had an area of 1 415 ha and a yield of 35 kg/ha/year
[b] Yield includes both freshwater and marine fishes according to Amanieu and Lasserre (1981)
[c] Probably synonymous with the Arap-Ciftligi of Kiener (1978)

Source: All areas, yields and the references, except those for Güllük, Poyraz and Tuz, taken from Kapetsky (1984). Locations from Amanieu and Lasserre (1981) and Kiener (1978).

Some of the most recent information on two Turkish lagoons from Cataudella and Ferlin (1984) follows. The Lagoon of Homa with an area of 6 000 ha and a maximum depth of 1 m connects with the sea through eight channels and a large channel equipped with a fixed installation or bordigue of reeds. Its salinity is about 25–35 ppt with a maximum of 40 ppt in summer, and water temperature ranging from 9°C in the winter to 26°C in the summer. The channel is open from February to June to provide entry of fish from the sea. Annual production, in what is essentially a capture fishery, is about as follows: topenkefal (Mugil cephalus), 20 t; other grey mullets (Liza spp. and Chelon labrosus), 30 t; gilthead (Sparus auratus), 25 t; sea bass (Dicentrarchus labrax), 7 t; yilan or European eel (Anguilla anguilla), 20–25 t.

Another system, the Koycegiz Lagoon of 5 500 ha, has a freshwater lake area of 2 000–3 000 ha plus a network of brackish waters with an opening to the sea. Salinity varies from 0 to 35 ppt, so that it has a freshwater fauna of common carp and other species as well as brackishwater species. Fishing is practiced both in the lake and the deltaic channels. The annual production in 1975 was 400 t and in 1980, only 250 t. It is divided as follows: grey mullets 200 t; common carp 35 t; gilthead and sea bass 5 t; European eel 10 t. Mullet eggs (6.5 t) and carp eggs (1.5 t) are also collected.

These "lagoon farms" are operated by cooperatives with assistance from the Government in provision of funds, channel dredging, water control and weir construction. In about 1985, lagoon fisheries were granted more importance in Turkey and in 1986 improvements were completed on six lagoons. Among these were the Büyük Menderes River estuary, Bodrum on the Aegean Sea and Tuzla Lagoon (OECD, 1986, 1987).

According to ADCP (1979), there is no true aquaculture in the lagoons of Turkey, only the traditional lagoon fishing described above.

5.6 Coastal Areas

Inward extensions of coastal waters in Turkey have already been discussed under section 5.5, but a few remarks on the Black Sea, forming 1 695 km of Turkey's northern border, may be of interest.

The Black Sea, with an area of 424 760 km^2, maximum depth of 2 123 m, and average depth of 1 191 m, is the largest meromictic basin in the world. With a permanent halocline, below a depth of 130 to 200 m it is filled with stagnant anoxic water containing hydrogen sulphide which limits fish production.

The Sea receives far more fresh water from rain and rivers (mainly northern) than it loses by evaporation. The surface water is of low salinity, 15–18 ppt, and is usually warmer than at depth. It drains off through the Bosphorus while an under-current of salt water from the Aegean flows inwards.

The other European countries bordering on the Black Sea are Bulgaria and Romania. See Zenkevitch (1963) for a further description of this Sea.

6. LAND AND WATER USE

Table 8

Pattern of land use in Turkey (1986)

	Percent
Arable and permanent crops	35.2
Permanent pasture	11.3
Forests and woodland	25.9
Other land	26.3
Inland water	1.3
Total	100.0

Source: 1987 FAO Prod.Yearbook, 41 (Publ. 1988)

Turkey is essentially rural (about 52 percent). It is a country of villages and only Istanbul and Ankara have over one million people. The restricted development of lowlands and dominance of steep slopes and rough terrain are major factors in determining land use.

Over 80 percent of the land is rough, broken or mountainous and of limited agricultural value. Nevertheless, agriculture, mainly on small farms and using rather primitive methods, is the country's primary economic activity, supporting a wide variety of crops because of the diverse climate and topography. Fertlizer use is very low. Plant cultivation is about two-thirds of agricultural production with wheat, barley, cotton, sugarbeets, tobacco, fruit, hazel nuts, and vegetables as major crops. There are also about 65 000 ha of rice-paddy, and some of this area can presumably be used for fish production. Turkey is one of the few countries authorized by the United Nations to grow opium poppies for legitimate pharmaceutical needs (see section 9.3). The production of livestock has a long history in Turkey, but old methods such as grazing goats, sheep and cattle on unproductive areas prevail.

Expansion of cultivation in this century has resulted in a reduction of meadows and grasslands and destruction of tree cover through plowing on marginal lands and on steep slopes. Erosion has resulted in dustbowls and harmed streams. There has also been a good deal of drainage of wetlands both for malarial control and to create agricultural lands. For example, the silt-laden streams often create deltas, where only reclamation can provide good agricultural land. Flood control and river regulation have also altered the nature of the original aquatic state.

Irrigation is most important in Turkey since most of the country does not have enough moisture during the crop-growing season, and the bulk of the cultivated land is on the Anatolian Plateau where large areas have inadequate and variable rainfall. It is often difficult to practice simple diversion from streams by means of weirs because many of the interior streams are deeply incised. This form of irrigation is used, therefore, mainly on the Aegean and Marmara flatlands, and pumping is necessary on many Black Sea streams. Most public irrigation is primarily from impoundments, secondarily from streams, and a small amount taken from wells. Irrigation in Turkey is now practised on about 2.2 million ha, more than doubling since the sixties, but still furnishing water to only about 9 percent of the arable land.

Although Turkish forest lands, about one-half conifers and one-half hardwoods, occupy onequarter of the area, about half of these are scrub, and centuries of inroads by wood-cutters, charcoal burners, and goats, and general neglect have diminished their importance. Nevertheless, Turkey ranked about fifth in European roundwood production in 1982. By 1952, the State had taken over all forest areas from private owners, accompanying this takeover with reforestation and institution of better forest practices.

Turkey is rich in mineral deposits, but the deposits which are often scattered or in remote areas, are not well exploited. Hard coal as well as lignite is abundant, and coal washing causes pollution. Major minerals are iron, chromium and copper. Other important ones are: zinc, antimony, bauxite, boron, asbestos, sulphur, magnesium and magnesite. Oil reserves are not great, but there are some uranium resources.

Of the total installed electric power in Turkey in 1987 of 12 493 000 KW, hydroelectric power represented 40 percent (5 004 000 KW) and thermal power 60 percent. The extensive mountainous terrain provides many hydroelectrc sites, although most are far from the main population centres. In 1978 it was estimated that about one-fifth of Turkey's feasible hydroelectric potential, one of the highest in Europe, had been utilized.

Government policy is now focused on the development of industry which is concentrated in the Istanbul area. The biggest industrial growth sectors include textiles, clothing, food processing, iron and steel chemicals, and petrochemicals. Among the industries producing polluting effluents are sugar, dairy, meat processing, paper, and breweries.

Much of the country is inaccessible and the roads are poor. There were only about 10 000 km of railroads in 1987. Auto road density was only 0.4 km/km^2 in 1986, and passenger car ownership one of the lowest in the world, only about 21 per 1 000 people in 1986. There is some downstream rafting on the Euphrates, and a ferry on Lake Van.

Compared with most of the Middle East, Turkey has a good many permanent streams and considerable ground water, although it is often difficult to use these resources. Circa 1967, about 48 percent of the total surface water (167 thousand million m^3 annually) was diverted to be used as follows: irrigation 62.5%; industry 34%; domestic use 3.5%. Of this amount, 42% was consumed, leaving (counting residual water and return) 134 300 million m^3 in the rivers (Noyan et al.; Water for Peace, 1967 in Van der Leeden, 1975). Almost ten years later (1976) the percentages with respect to use and consumption were as follows: irrigation 76%; industry 10%; domestic use 14% (ECE, 1978).

Fishing is not a major economic activity in Turkey, which in 1987 ranked twenty-eighth in world catch. Ninety-three percent of the total commercial catch (625 722 t) was marine, mainly from the Black Sea and Sea of Marmara. In general, fish does not play an important part in the Turkish diet, accounting for only about 9 percent of the animal protein supply or a per caput supply of about 5.8 kg/year. Over the country as a whole, local freshwater fish do have a considerable importance as marine fish are not distributed widely.

Tourist travel is becoming of increasing importance in Turkey (nearly three million in 1987), but the visits are mainly to coastal cities and sites of antiquity, and inland fishing is not an attraction.

7. FISH AND FISHERIES

During the 1955–64 period, the commercial inland fishery catch in Turkey varied from a low of 3 471 t in 1956 to a high of 7 853 t in 1962 (Anon., 1967).

More recent catches of the principal inland fish of economic importance in Turkey are listed in Table 9, which shows the catch in its inland waters as compiled by FAO during the period of 1965–87. During this period the total inland water catch attained its highest amount (46 497 t) in 1984.

Although the original data used for compilation of this table were obtained from the Turkish Government, it should be noted that there is not complete agreement between the statistics in Table 9 and those in other reports. Table 10 has therefore been included which shows the "freshwater fish" catch in Turkey during the period 1971–86 as listed in Turkey's own statistical yearbooks. It will be noted that the totals (including those for both finfish and total catch) in both tables are identical or almost identical during most of the 1971–86 period. (Rounding could easily account for small differences, and it is really only during the years of 1982 and 1983 and those in 1986 that these totals in Tables 9 and 10 differ very much.) One assumes, therefore, that the two tables are reasonably accurate. However, it would also appear that FAO and the Turkish Government have used different methods to either lump or differentiate between different species or species groups. Furthermore, there may be a complete misunderstanding of what species or group is meant when only a common name is used. Note especially, the differences in catch of "mullet" which are invariably larger in the FAO-compiled statistics. This appears to be a complete confusion of names on the part of FAO. The Turkish Yearbooks use the words "Kefal-Mullet" in both sea and inland catch statistics. Blanc et al. (1971) say that the Turkish name "Tatlisukefali baligi" refers to the chub (a cyprinid), Leuciscus cephalus; and FAO/World Bank (1975, 1976a) reports use the Turkish name of "kefal" or "kofal" and the English name "mullet" for Leuciscus cephalus. (Unfortunately, these papers of the FAO/World Bank also use the term "kefal" for grey mullet (Mugilidae), and many of their other common names seem to be used quite indiscriminately or are at least difficult to understand.) Of most importance, however, is the fact that Turkey/EIFAC (1989) has clearly explained that the "mullets" shown in the FAO-based Table 9 are positively not Mugil or Mugilidae but that for the entire period of 1965–87 these statistics actually stand for the catch of chub or Leuciscus leuciscus.

The fact that Turkish common names are unfamiliar to most Europeans has undoubtedly caused difficulty in interpretation of their submissions. For this reason, another table is included (Table 11) which lists the inland water catch for Turkey during the 1984–87 period as sent to EIFAC by Turkey/EIFAC (1989). This table probably represents the true composition of the present catch better than any of the other tables.

Other tables of the freshwater catch in Turkey may be found in FAO/World Bank (1975) for the period 1967–72, derived from TUMAS (1972) and an economic survey of the Turkish Fisheries (1972) mad by the General Directorate for Turkish Fisheries (1972). These differ so much, however, from Tables 9 and 10, both in the quantities caught and the names used, that it is felt that their inclusion would not clarify, but merely complicate the situation.

Table 9

Nominal catch in the inland waters of Turkey, 1965–87 (in tons)

	1965	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987
Freshwater breams (Abramis spp.)	-	-	-	0	0	0	1 535	-	-	-	-
Common carp (Cyprinus carpio)[a]	2 500	4 800	6 668	9 413	9 886	14 045	14 923	18 655	16 957	19 290	19 684
Roaches (Rutilus spp.)	100	100	155	83	140	98	174	189	166	95	100
Cyprinids, n.e.i. (Cyprinidae)	100	300	1 531	1 067	1 697	1 512	1 635	1 917	1 599	841	806
Pike (Esox lucius)	300	600	296	626	796	667	463	642	927	608	692
European catfishes (Siluridae)[b]	500	1 300	760	1 663	588	410	347	523	581	424	403
Pike-perch (Stizostedion lucioperca)	100	500	753	1 590	1 770	1 461	1 429	1 525	1 533	1 442	1 506
Freshwater gobies	-	600	301	222	249	203	164	186	142	318	855
Freshwater fishes, n.e.i.	2 200	2 300	4 892	1 919	758	972	1 646	1 116	1 641	1 932	2 004
Sturgeons (Acipenseridae)	-	0	10	0	0	0	0	0	0	0	0
European eel (Anguilla anguilla)	200	400	448	224	374	424	588	616	583	517	562
Trouts (Salmo spp.)	100	100	307	798	527	602	769	1 200	1 102	2 253	2 428
Mullets (Mugil spp.)[c]	300	1 800	2 249	8 662	8 800	8 800	9 696	10 816	11 195	10 577	11 257
Silversides (sand smelts) (Atherinidae)	-	400	102	221	44	47	270	274	364	255	255
Total finfish	6 400	13 200	18 472	26 488	25 629	29 241	33 639	37 659	36 790	38 552	40 552
Freshwater molluscs	-	-	-	0	0	765	0	850	166	3 131	3 230
Freshwater crustaceans	-	0	0	5 767	6 131	6 534	6 792	7 936	6 244	1 585	1 565
Total catch	6 400	13 200	18 472	32 255	31 760	36 540	40 431	46 445	43 200	43 268	45 337

[a] Includes other "Cyprinus spp."
[b] Also listed as Silurus glanis
[c] This is not correct. The catch is actually that of the chub (Leuciscus cephalus). See text.

\- This category not listed this year
0 Probably nil, negligible or insignificant, or less than 50 t during the 1965–70 period, or less than half a ton during later years

Source: 1965 - Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970 - FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1984–87 - Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

Table 10

Catch of freshwater fish in Turkey, 1971–86 (in tons)

	1971	1972	1973	1974	1975	1976	1977	1978
Alabalik - trout	209	256	213	274	307	308	320	329
Karabalik[a]	303	528	664	330	346	205	312	311
Kizilkanat - roach[b]	181	636	174	176	1 185	1 254	256	258
Kefal - mullet	504	857	819	803	693	572	604	609
Sazan - carp	4 479	5 436	5 019	5 339	6 678	6 702	5 638	6 905
Turna - northern pike	426	802	1 038	758	296	356	187	188
Yayin - catfish or wels	914	1 564	932	743	760	826	802	821
Yilan - snake fish (eel)	460	220	315	589	448	499	282	283
Diger - others	6 966	5 319	4 443	4 914	7 769	8 263	9 919	12 102
Total	14 442	15 618	13 617	13 926	18 482	18 985	18 320	21 806
	1979	1980	1981	1982	1983	1984	1985	1986
Alabalik - trout	290	798	527	602	769	1 200	1 102	1 263
Karabalik[a]	434	732	1 452	1 299	1 537	1 663	1 321	638
Kizilkanat - roach[b]	328	335	245	213	100	254	278	203
Kefal - mullet	684	1 767	1 846	1 521	1 408	1 553	1 517	1 277
Sazan - carp	8 498	9 413	9 886	11 658	14 875	18 656	16 957	17 290
Turna - northern pike	395	625	796	667	463	642	927	608
Yayin - catfish or wels	536	1 663	588	410	347	523	581	424
Yilan - snake fish (eel)	396	224	374	424	588	616	583	517
Diger - others	10 683	16 698	16 046	16 822	18 608	21 391	22 205	18 060
Total	22 244	32 255	31 780	33 616	38 695	46 497	45 471	40 280

[a] The source says “Local water product. English equivalent is not known”. FAO/World Bank (1976a) uses this Turkish name for Vimba vimba, but see Table 11

[b] FAO/World Bank (1975) uses the Turkish name “Kizilkanat” for “roach”, but FAO/World Bank (1976a) uses this name for Scardinius erythrophthalmus, as does Blanc et al. (1971). Turkiye Istatistik Yilligi 1987 uses this Turkish name to denote “cyprinids”. Turkey/EIFAC (1989) uses the Turkish name to mean “rudd”

Source: 1971–72 Turkiye Istatistik Yilligi, 1979
1973–79 Turkiye Istatistik Yilligi, 1981
1980–86 Turkiye Istatistik Yilligi, 1987

Table 11

Catches in the inland waters of Turkey, using Turkish names, 1984–87 (in tons)

	1984	1985	1986	1987
Capak - bream	223	239	71	79
Sazan - common carp	18 655	16 957	17 290	17 584
Akbalik - roaches	189	166	95	100
Gökce[a]	472	485	283	308
Inci kefali - Chalcarburnus tarichii	9 263	9 678	9 300	10 205
Tatlisu kefali - chub	1 553	1 517	1 277	1 052
Siraz[a]	68	310	881	862
Kizil kanat - cyprinids	254	278	203	206
Turna - pike	642	927	608	597
Yayin - wels	523	581	424	403
Kara balik[a]	1 663	1 321	638	600
Levrek (sudak) - pike perch	1 525	1 533	1 442	1 501
Kayabaligi - freshwater gobies	186	142	318	571
Yilan - European eel	616	583	517	562
Alabalik - trout	1 200	1 102	1 263	1 323
Gümüs - dace[b]	274	364	255	255
Salyangoz - snail	850	2 436	3 132	3 231
Kerevit - crayfish	7 937	6 244	1 585	1 565
Diger - others	403	606	696	755
Toplam - Total	46 497	45 471	40 280	41 760

[a] Turkey/EIFAC (1989) says that this is a local sea (aquatic) product whose English equivalent is unknown. The author believes that: "gökce" may be Alburnus sp., "siraz" may be Varicorhinus sp., and "kara balik" may be Clarias gariepinus (C. lazera)

[b] Turkey/EIFAC (1989) terms "gümüs" "dace" but it may well be an Atherina

Source: Turkey/EIFAC (1989) probably following Su Ürunleri Istatistikleri. The original figures have been rounded.

About 100 species or subspecies of fish are found in the inland waters of Turkey. Of these, and despite the difficulties of recording their exact catches, it is apparent that the common carp (Cyprinus carpio), taken as a wild fish, is by far the most important economic species. During the ten-year period of 1978–87, common carp constituted 47 percent of the catch of finfish. Most of these carp are caught in central Anatolia. Other important cyprinids in the catch include members of the following genera: Abramis, Alburnus, Leusciscus and Scardinius. The European catfish (Silurus glanis), pike (Esox lucius), European perch (Perca fluviatilis), pike-perch (Stizostedion lucioperca), European eel (Anguilla anguilla), and brown trout (Salmo trutta) are also important wild fish. Brown trout are found throughout the country in mountain streams and in some of the lakes. Southeast Turkey is particularly rich in trout which are caught both commercially and by anglers. Coregonids are naturally lacking in Turkish waters, and various foreign scientists have recommended their introduction. Aksiray (1979) describes one such experiment which proved only partly successful. The role of euryhaline fishes such as the gilthead (Sparus auratus), the sea bass (Dicentrarchus labrax), and the various grey mullets has been discussed in section 5.5. Sturgeon (Acipenseridae) of several species used to move up the Black Sea streams such as the Sakayara, Kizilirmak and Yesilirmak to spawn in early summer, but their numbers are now greatly diminished (Carp, 1949).

Waters such as the Euphrates and Tigris which flow out the Persian Gulf, and are dominated by Cyprinidae, contain not only typically European fishes, but Asiatic genera such as Mystus, Heteropneustes, and Mastacembelus (see Banister, 1980).

In addition to these and other finfish, there is some take of freshwater molluscs, and a large take of the crayfish (Astacus leptodactylus), which is indigenous to or has been introduced to many lakes in Anatolia. Although this species is considered to be inferior in taste by some and sells below the price of Astacus astacus, it is exported extensively to other European countries, especially France and Sweden, because of the decimination of A. astacus stocks by the crayfish plague (Aphanomyces astaci). In 1978, for example, 98 percent of France's imports of crayfish were from Turkey (Arrignon, 1981). Prices for crayfish in Turkey are higher than for other fish products, and the species is given protection through imposition of size limits and restriction on the sale of berried females. The sources for Table 9, as well as the FAO Fishery Yearbooks before Volume 52, do not have any numerical catch for “freshwater crustaceans” (crayfish) during the 1965–76 period. However, Turkey/EIFAC (1977) lists Turkish catches of A. leptodactylus for this period, ranging from 100 t in 1965 to 4 500 t in 1973 and 1974.

7.1 Capture Fisheries

7.1.1 Commerical fishing

The major commercial capture fisheries in Turkey appear to be concentrated in the interior lakes and in the lagoons along its sea coast. Circa 1960 (admittedly old figures), it was estimated by Aksiray (1961) that of a static water catch of 7 195 t, 60 percent came from lakes and 40 percent from lagoons. FAO/World Bank (1975) estimated that 45 percent of the Turkish inland catch came from Central Anatolia and 80 percent from Anatolia as a whole. Petr (1983) says that the most important inland fishery exports of Turkey are crayfish, carp and eel. OECD (1982, 1987) says that crayfish is the main product from Turkey's inland waters.

In most cases, cooperatives control the commercial fisheries. Methods of capture are still rather primitive. For example, the bordigues of the lagoons are generally constructed of reeds rather than of metal. Beach seines, gillnets, trammel nets, and longlines are used for fish capture, and crayfish are caught in both baited and unbaited traps. Boats with either inboard or outboard motors are used on the lakes.

Inland capture fisheries once employed 8 000 full-time commercial fishermen (Petr, 1983). In most cases, cooperatives control the commercial fisheries. For example, in 1983 the 134-km^2 Lake Ulubat had five cooperatives with 1 374 members using 1 037 boats, 384 500 m of gillnets and 1.7 million crayfish traps. At the 166-km^2 Kus Lake, there were 800 fishermen using 330 boats, 1 000 000 m of gillnets, 4 500 m of beach seines and 149 000 traps. At the 468-km^2 Egridir Lake, there were 1 900 fishermen, 1 700 boats and 2.55 million traps.

7.1.2 Sport fishing

Sport fishing is not touted in Turkey although the country has a number of species desired by sportsmen, and offers some excellent fishing especially for brown trout in high and rather inaccessible country.

Little is known of the quantity of the sport catch in Turkey. Petr (1983) states that in 1982, 4 000 t of fish were taken in the inland sport fishery. It is not known whether these were included in the overall records. In one of the few records available to the author, about one-third of the catch at the 250-ha Mogan Lake near Ankara was taken by sport fishermen in 1982. Approximately 2 000 recreational fishermen were estimated to average 10 kg of fish/year. The remainder of the fish (41.5 t) were taken by two cooperatives employing 31 part-time fishermen and 20 labourers using 51 boats (Petr, 1983).

7.2 Aquaculture

ADCP (1979) lists an "estimated aquaculture production" of finfish of 930 t annually for Turkey: 500 t of mullet, 250 t of eel, 100 t of gilthead, 60 t of sea bass, and 20 t of sole (Solea vulgaris). The report emphasized, however, that this is "lagoon culture", and it is also emphasized here that this is really a modified form of capture fishing, not even involving the refinements of valli culture as is practised in the Adriatic (see section 7.2 inthe review of Italy). However, there has recently been emphasis on aquaculture in the lagoons along the Argean and Mediterranean coasts of Turkey with the joint aid of Italy (OECD, 1989).

True aquaculture in Turkey seems to be confined mainly to some inland trout and carp culture, and in comparison with that of many European nations, is not far advanced. Petr (1983) says that there are over 500 private fish farms operating throughout Turkey. Some of these have good sites for fish production, e.g., at Kepez on the Mediterranean coast, rainbow trout (Oncorhynchus mykiss) reach 500 g in eight months and carp 1 kg in a year.

The only figures on aquacultural production in Turkey available to the author are those of the recent FAO Fish.Info.Data and Stat.Serv. (1989) which during the 1984–87 period estimates a production of common carp ranging from 1 624 t (1984) to 2 050 t (1987), and of "Salmo sp." (probably rainbow trout) from 602 t (1984) to 950 t (1987). It also estimates an aquacultural production of 1 t of Diplodus sargus in 1986 and again in 1987, and 34 t of gilthead in 1986 and in 1987. It also estimates the value of the total aquacultural production (finfish) of Turkey during the 1984–87 period to range from US$ 4 679 million (1984) to 7 589 million (1987).

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership and Availability

8.1.1 The Turkish Constitution provides for natural wealth and resources to be vested in the State, but the ownership regime of water resources in Turkey is complex. Although surface waters may be considered as falling under private ownership, they are subject to the threefold limitation that they will not be appropriated, or be of public interest, or exceed the beneficial use of the landowner. (Springs, however, are appurtenant to the land on which they arise.) With the exception of spring water and of such surface waters being subject to private interest and beneficial use exclusively, all water resources are public and thus not subject to private appropriation but to rights of use only.

8.1.2 Fishing

With specific reference to fishing, all fishing waters, streams, lakes, and lagoons are the property of the Government with the exception of a few privately owned fishing traps in some lakes.

Under the Fisheries Act of 1971, all fishing enterprises are subject to a permit system and fishing rights are rented by the State. Fishing permits are issued by the Office of the Governor upon consultation with all interested governmental agencies within the applicant's province of residence.

Recreational fishing by citizens or tourists outside prohibited areas are exempted from permit requirements, subject to general limitations on the process.

The regulations concerning the lease of fish producing areas are complex (see especially, Türkös, 1979).

[1] Based primarily on Gaudet (1974), material received by EIFAC from Turkey in 1979, Petr (1983) and Turkey/EIFAC (1989)

8.2 Administration and Management

The Ministry of Agriculture, Forestry and Rural Affairs is the responsible Ministry for fisheries, and most questions relating to Turkey's inland fisheries with the exception of its economic aspects are dealt with in the General Directorate or Department of Fisheries, founded in 1971, and other organizations within this Ministry. The Department of Fisheries in Ankara coordinates 10 regional directorates situated throughout the country. Pending establishment of an organization under the Ministry of Agriculture for the conservation of fisheries, execution of the fisheries law lay with the General Police Command affiliated with the Ministry of the Interior and the Customs Guard Organization of the Ministry of Customs and Monopolies.

Any enterprises which may modify fish production areas (such as water diversion and land reclamation) must be approved by the Ministry of Agriculture, Forestry and Rural Affairs. All constructions and works across water courses which are likely to obstruct the movement of aquatic life require authorization from this Ministry, and the construction of fishways at dams, weirs and diversions is compulsory.

Enterprises to establish commercial fish ponds or farms must receive permission from the Ministry. The Ministry also has wide powers to control not only the catch but the processing and sale of fish.

8.3 Investigation

Research on inland fisheries is carried out by four institutes at Ikizce, Iznik, Kepez and Bodrum plus others planned for the Black Sea, Eastern Anatolia and Aegean regions (Petr, 1983).

The Hydrobiological Research Institute of the Faculty of Sciences of the University of Istanbul once carried out extensive research covering all aspects of fisheries throughout Turkey, but has now lessened this role.

The Turkish Scientific and Technical Research Centre provides funds for research on water pollution control, as does the Ministry of Education on water research.

8.4 Other Agencies

Various governmental agencies concerned with highways, water, energy, natural resources, village affairs, planning, finance, marketing, etc., are, or have been concerned with various aspects of fishery conservation and development. The 1971 Fisheries Law provided that inland fisheries administration be transferred to its present Ministry.

8.5 International Agreements

Turkey has bilateral agreements with Bulgaria and the USSR concerning uses of boundary streams, and one with Greece concerning flood control and boundary stabilization on boundary streams. It also has a trilateral agreement concerning uses of boundary streams with Bulgaria and Greece.

9. STATE OF THE FISHERY

9.1 Yield

According to Table 9 the reported catch of finfish in Turkish inland waters is more than five times as great in 1987 than it was in 1965, rising from 6 400 t to 35 502 t. The catch of crayfish also increased, from 3 885 t in 1977 to 7 936 t in 1984, but has declined since then. None of the other components of this table really show a decline during the 1965–87 period, except perhaps the sturgeons which, as in other parts of Europe, have positively declined. Some of the rather dramatic increases in catch may, on the other hand, simply be due to better reporting.

Table 12 shows the yields, all but one from commercial fishing, from eleven natural lakes in Turkey based upon two reports on Turkey's inland fisheries. There is obviously a wide range in the reported commercial yields, from 4.2 kg/ha/year in Lake Aksehir in 1982 to 166 kg/ha/year in the much smaller Lake Mogan with a much higher fishing intensity. (In 1982, there were a minimum of 12.4 fishermen/km^2 on Lake Mogon and only 1.1/km^2 on Aksehir.) The discrepancies in yields are due not only to limnological differences in the individual lakes which range in elevation from near sea level to 1 959 m, from 2 to over 90 m in depth, and differ in both water temperature and chemistry. The differences may also be due to their individual fish faunas or changes in them due to both introductions and changes in competition, and, of course, fishing intensity.

The yield of finfish from Turkish lagoons has already been shown, in Table 7, where annual commercial yields ranging from 10 kg/ha/year to 244 kg/ha/year are shown for 17 lagoons. The average yield for these 40 153 ha of lagoons during the periods studied was 36.4 kg/ha/year, i.e., below the levels for well-tended Italian or Grecian lagoons.

Aksiray (1961) stated that the average Turkish yield for inland lakes was 21 kg/ha/year and that for lagoons to be 43.7 kg/ha/year. In a worldwide study, Kapetsky (1984) found the average annual finfish production of lagoons to be close to this latter figure, 47 kg/ha/year.

9.2 Factors Affecting the Fishery

Despite the size of Turkey, the number of natural waters of suitable quality for fish production are not comparatively great. Turkey is not rich in rivers, and many of them are very inconstant in character and frequently muddy. The natural lakes include many that are saline and some (like Lake Van) apparently support fish only in the tributaries or close to their mouths. Furthermore, some of the natural lakes are used for irrigation and the drawoff of water increases their concentrations of dissolved salts leading to more strenuous conditions for fish. Encroachment of aquatic weeds or reed beds also diminishes static fishing water. However, there is a good complement of lagoons, and since the potential for hydropower and irrigation is still high the amount of reservoir area is growing and thereby increasing the potential for inland fisheries. In 1973, when only about 15 percent of the water resource of Turkey had been utilized, 473 dam sites had already been selected. In addition, the nonarability of much of Turkey, may well contribute to the intrinsic value of inland fisheries.

The fish fauna is diverse, although coregonids (which contribute greatly to many lake fisheries in Europe) are naturally lacking. There are inward migrations of lagoon fishes from the sea and eels are present but no other important diadromous species.

Pollution control has been long in coming to Turkey. As late as 1956 there was no treatment of effluents, no standards of water quality, no river authorities, and no general pollution law. Even in mid-1979 there was only one sewage treatment plant for Istanbul, a city of 3.6 million. When shut down, raw sewage was dumped into its harbour, the Golden Horn, an inlet of the Bosphorus, so thick that it impeded the route of small boats (Nyrop, 1980). Water pollution is now receiving attention. The Government recognizes that much more stringent protective legislation is needed (ECE, 1978) but much action is required.

The average annual runoff from rainfall per caput in the country is 3 054 m^3, but calculated on the basis of water loss, the runoff is only 2 615 m^3.

Travel in this country of poor roads and relatively few passenger vehicles is difficult either for fishermen or for product transport. Transport in summer is especially difficult due to scarcity of ice. The inland fisheries tend to be localized and commercial, and in the hands of cooperatives. There is comparatively little sport fishing.

9.3 Prospect

Turkey does not consider that her water needs will be adequate after the year 2000, and plans more reservoirs and canal systems to meet these needs (ECE, 1978). Provided that the reservoirs are managed carefully, the fishable area will therefore be increased to advantage. Government ownership and control of fisheries (see section 8) in lakes and reservoirs could be a favourable factor in that a considerable control might be exercized over management of the resource. The development of inland fisheries has been considered favourably in Turkey's Five-Year Plans. The 1973–77 Plan, for example, considered the possibility of developing the fisheries of the lakes of southwest Anatolia as an alternative to the income derived from growing poppies.

There is a good potential for extending the present traditional lagoon system to other areas and in improving the present system by adapting a form of valli culture as is practiced on the Adriatic shore of Italy. This will require holding fish over the winter in specially constructed enclosures and perhaps supplemental feeding in the spring.

There is also an opportunity to culture various euryhaline species (sea bass, gilthead, mullet, etc.) in ponds, and also to increase production through traditional freshwater culture of pond and cage trout, carp, and other species. A considerable number of ideas on this subject are suggested by ADCP (1979).

Other ideas on increasing Turkish inland fish production include the introduction of new species, especially coregonids to deep cold lakes, and the distribution of other species to various waters. Weed control, either by chemicals, or phytophagous fishes is apparently needed.

Prediction of fishery production is always difficult. In 1961, Aksiray felt that the annual catch from “shore and inland lakes” could be raised to about 10 000 t. Turkey probably attained such a catch by 1969. Turkey's third Five-Year Plan (1973–77) estimated that the catch of inland fish in 1977 would be 25 000 t plus 10 000 t from aquaculture. As shown in Table 9, such a total production was not achieved until about 1982. Since then, the highest total production has been 46 497 t in 1984. The Fifth National Plan for Turkey (1984–89) envisaged a 7.7 percent annual increase in fishery production and a 20.7 percent annual increase in fisheries products exports. Envisioned as an export-oriented activity, aquacultural production was expected to rise to 15 000 t in 1989, 20 000 t in 1993 and 40 000 t in 2000.

Overall, Turkey does possess a good deal of potential for further development of inland fisheries. It will require, however, a great deal of concerted investigation, adoption of modern methods, and training of personnel, and greater attention to water quality.

Table 12

Yields from commercial fishing in eleven lakes in Turkey

Lake[a]	Period	Major species	Yield Kg/ha/yr	Remarks	Source
Aksehir	1982	Crayfish, pike, carp	4.2	Crayfish are 75% of catch	Petr (1983)
Iznik	1982	Crayfish, cyprinids	4.3		Petr (1983)
Van	1971	*Alburnus* sp.	5.6	Only part of the lake produces fish	FAO/World Bank (1976a)
Beysehir	1982	*Alburnus*, crayfish, carp, pike-perch	9.2		Petr (1983)
Cildir	ca 1975	Carp, trout	9.6		FAO/World Bank (1976a)
Sapanca	1982	Crayfish, carp, pike, catfish, perch	13.6	Area 46–60 km^2depth 61 m	Petr (1983)
Kus (Manyas)	1982	Crayfish, carp, pike	24.9		Petr (1983)
Eber	1982	Pike, crayfish, carp	31.3	From free-water surface only	Petr (1983)
Egridir	1958–69	Carp, var, cyprinids, pike-perch, crayfish	13.1–18.2	Yield of finfish only	FAO/World Bank (1976a)
Egridir	1974	Carp, var, cyprinids, pike-perch, crayfish	40.6	92% crayfish	FAO/World Bank (1976a)
Egridir	1977	Crayfish, pike-perch, carp	67.6		Petr (1983)
Egridir	1981	Crayfish, pike-perch, carp	43.2		Petr (1983)
Ulubat (Apolyont)	1981	Crayfish, carp, pike	90.6		Petr (1983)
Ulubat (Apolyont)	1982	Crayfish, carp, pike	43.5		Petr (1983)
Mogan	1982	Crayfish, tench, carp	166	Area 250 ha; sportfish yield, 80 kg/ha/yr	Petr (1983)

[a] See Table 4 for areas, if not specified

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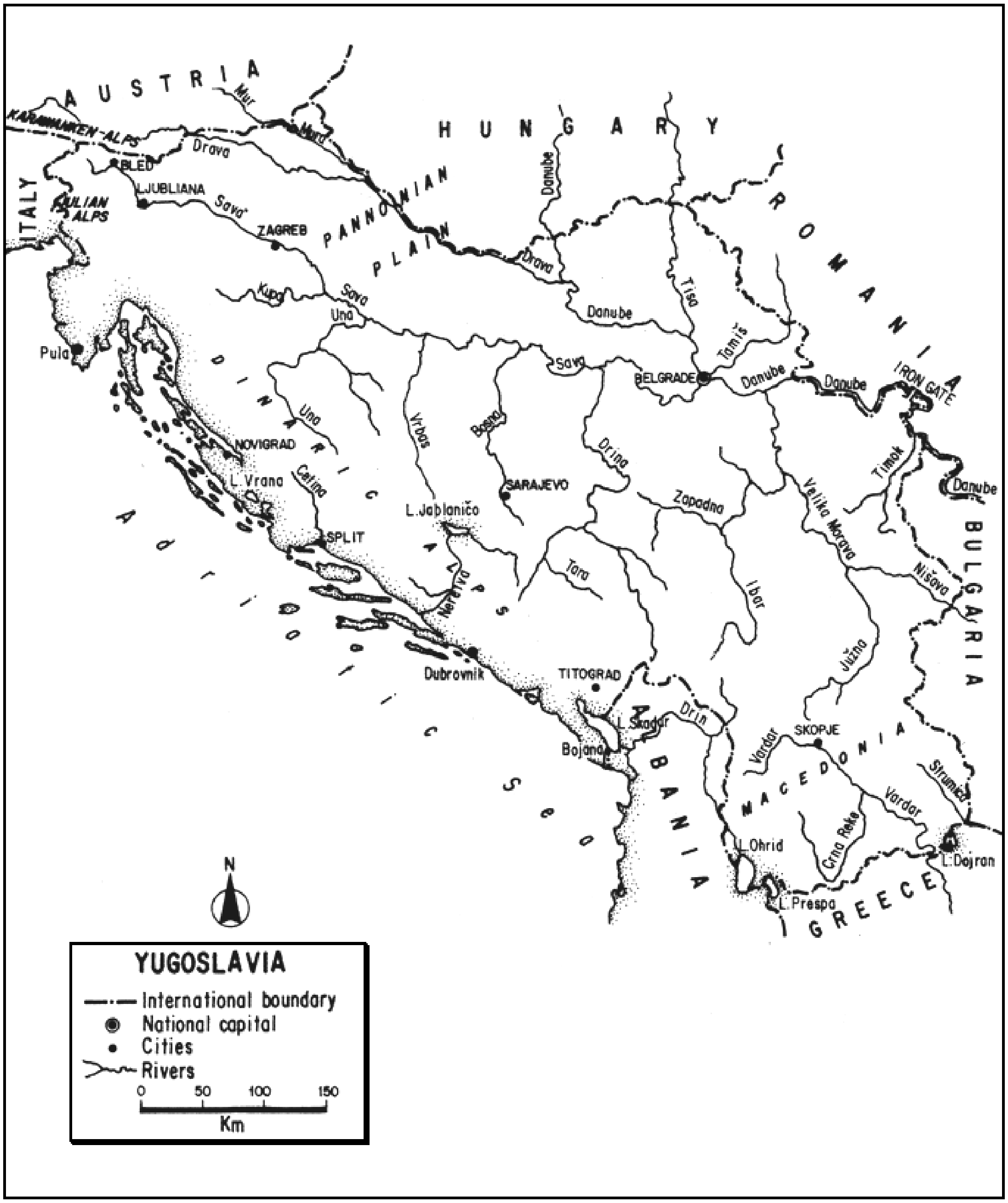

AUSTRIA
HUNGARY
ROMANIA
BULGARIA
GREECE
ALBANIA
ITALY
KARAWANKEN-ALPS
JULIAN ALPS
PANNONIAN PLAIN
DINARIC ALPS
MACEDONIA
Adriatic Sea
Mur
Mura
Drava
Danube
Sava
Kupa
Una
Vrbas
Bosna
Drina
Tisa
Tamiš
Timok
Velika Morava
Zapadna
Ibar
Tara
Neretva
Cetina
Nišava
Južna
Drin
Vardar
Strumica
Crna Reke
BLED
LJUBLIANA
ZAGREB
Pula
NOVIGRAD
L. Vrana
SPLIT
L. Jablaničo
SARAJEVO
BELGRADE
IRON GATE
Dubrovnik
TITOGRAD
L. Skadar
Bojana
SKOPJE
L. Ohrid
L. Prespa
L. Dojran
N
YUGOSLAVIA
International boundary
National capital
Cities
Rivers
0
50
100
150
Km

YUGOSLAVIA

The Socialist Federal Republic of Yugoslavia, ninth largest country in Europe, occupies the northwestern portion of the Balkan Peninsula, fronting on the Adriatic Sea. Its six constituent republics (Bosnia and Herzegovina, Croatia, Macedonia, Montenegro, Serbia and Slovenia) and two autonomous provinces (Kasoro and Vojvodina) are centralized at Federal level.

Primarily mountainous, Yugoslavia has a long indented coastline, an area of great plains and slow rivers, and four large international lakes, as well as many smaller mountain lakes and streams. Transitional in position and climate between continental and Mediterranean Europe, it has drainage to three seas: the Adriatic, Aegean and Black. Much of the terrain is limestone, the country is well forested, and has abundant water resources. Traditionally an agricultural land, it is rapidly progressing into industrial development utilizing its hydroelectric and thermal (coal) resources.

The traditional capture fisheries of its lowland rivers and floodplains are declining with river regulation, drainage, and pollution, but still continue, albeit at slackened pace. Aquaculture for warmwater species continues to advance rapidly, and trout culture is also important. The opportunities for sport fishing, some of it excellent, attract both local and foreign sportsmen.

1. AREA: 255 804 km^2

2. POPULATION: 23 895 000 (est. 1990) Density: 93 inh/km^2

3. PHYSICAL GEOGRAPHY

Yugoslavia is situated between 40°51' and 46'53"N latitudes and 13°23' and 23'02"E longitudes.

Roughly ovate, its greatest length (ESE-WNW) is 978 km, and its greatest breadth (NNE-SSW) is about 425 km. Its altitudinal range is from sea level to 2 864 m (Mt. Triglav).

Yugoslavia is bounded by seven countries: on the extreme northwest by Italy for 202 km, on the north by Austria for 324 km and by Hungary for 623 km, on the northeast by Romania for 557 km, on the east by Bulgaria for 536 km, on the south by Greece for 262 km, and on the southeast by Albania for 465 km. Its total boundary with other countries totals 2 969 km of which 2 173 km is land, 711 km is river, and 85 km is lake. (Length of boundaries from Statistički Godišnjak Jugoslavije, 1987.)

In addition, it is bounded on the west by the Adriatic Sea for 2 092 km (or 628 km bee-line). This highly indented coast is fringed with about 1 050 islands whose inclusion raises the length of the coastline to 6 116 km. Thirty-seven of these islands are over 7 km^2 in area and eight are over 100 km^2.

Three-quarters of the country is mountainous and hilly. The remainder consists of plains and river valleys. About 30 percent is less than 200 m in elevation, 25 percent between 200 and 500 m, 27 percent between 500 and 1 000 m, and 18 percent above 1 000 m.

Yugoslavia has three large physiographic regions (Western, Central and Eastern) subdivided into smaller sub-regions.

(i) Western Region

(a) Adriatic or Coastal Belt. Bordering the Adriatic is a narrow strip of mainland constituting about three percent of the country. Submergence has created many gulfs, bays, coves, peninsulas and islands. Primarily limestone and flysch, some parts of the littoral are very barren, others fed by spring-backed streams are fertile, and there are some marshes. This belt is well separated from the other sub-regions by the steep Dinaric Mountains along the coast.

(b) Alpine Sub-region. This small area in the extreme northwestern part of the country, between its boundaries with Italy and Austria, contains spurs of the Karawanken and Julian Alps, including the highest part of the country. It is well forested, has a rugged terrain and contains some attractive trout lakes and streams.

(c) Dinaric Sub-region. Occupying about 40 percent of the country, this extensive mountain area extends from the Alpine area southeasterly into Albania and Greece in a series of transverse ridges parallel to the coast and ranging from 750 to 2 000 m in height. On the southwest it towers above the Adriatic or Dalmatian littoral, on the northeast it borders the Pannonian Plain. One of the most rugged mountain masses in Europe, much of it is a central plateau of thick permeable limestone with thin soil, known as the High Karst. It is highly distinctive because of its underground drainage channels formed by seepage through soluble limestone leaving the surface dry and forming many large tectonic-karstic depressions, called poljes. (There are about 1 800 poljes in the entire country.) The Neretva is the only river in this sub-region to have its entire course on the surface. Largely barren, unproductive and formidable, the Dinaric area has served to seal off the coast from the interior.

(ii) Central Region

(a) Pannonian or Danubian Plain. This southward extension of the Great Hungarian Plain lies east of the Dinaric and south of the Alpine sub-region and Hungarian and Romanian borders. Partly hilly in the west, most of these well-cultivated lowlands are flat and monotonous along the Danube and the lower reaches of its tributaries. With loess and lacustrine soils, this is the most fertile area in the country, supporting staple grains and root crops. The Sava and Drina drain its western plain; the Tisa, entering from Hungary, bisects the eastern plain. Its major rivers, more than 150 m wide and almost 2 m deep on broad floodplains are usually rimmed by low bluffs. Alders, willows, and marshes often fringe the rivers.

(b) Rhodope or Morava-Vardar Sub-region. East of the Dinaric sub-region and south of the Pannonian Plain is an area of rugged crystalline mountain blocks and enclosed basins cut from north to south by the valleys of the Morava (flowing north to the Danube) and the Vardar (flowing south to the Aegean). The depression broadens northward into the Pannonian Plain and broadens southward into the plains of Macedonia. The main part of the sub-region lying east of these river valleys is occupied by high mountains containing some glacial cirques and lakes.

(iii) Eastern Region. Lying to the northeast of the Rhodope sub-region, east of the Morava and along the Bulgarian border, are the Balkan Mountains or Stara Planina, extensions of the Carpathians. These highlands (to 2 169 m) are cut by several rivers.

In general, about 20 percent of the country is karst. The western zone of Yugoslavia is composed of limestone, dolomite, slate and marl. The Danubian plain is alluvial soil and loess. The eastern zone is primarily limestone, sandstone and granite.

There are a great variety of soils. Grey podsols cover over 50 percent of the country especially in the western humid regions. Terra rossas (insoluble limestones) cover karst depressions along the littoral and in the Dinaric Mountains. Fertile chernozems are found on grasslands with low precipitation especially on the Pannonian Plain.

Lying at the southern end of the European wooded belt, most of the country is covered by a central forest region in which deciduous trees are predominant below 1 500 m with conifers above this elevation. Pasture lands lie in inter-mountain basins or above the tree line. The coastal or Mediterranean woodland areas support macchia, and brush and scrub types are also found in the highlands. A parkland region between the Drava and the Sava has now been cleared of most of its forest, and the great region of grassy steppes along the Danubian Plain is now the chief arable area of the country where cultivated plants now cover a larger area than uncultivated ones.

The geography has dictated population density to a large degree. Thus, much of the barren Karst has a very low density, only 10 inh/km^2, while the density may be 200 or more in the valleys along the large watercourses.

4. CLIMATE

Yugoslavia, lying in the southern part of the north temperate zone, has three basic types of climate.

The narrow coastal area and lower Vardar Valley have a moderate Mediterranean climate with mild rainy winters and hot and dry summers. Mean temperatures of 7.5°C in January and 26.4°C in July are typical. Most of the mountain areas have a moderate continental climate with moderate summers but very cold winters, and are more humid than the interior plains. Most of the inland area such as the Pannonian has a more rigorous continental climate with warm dry summers (July averaging 23°C) and cold winters (February 1.5°C). Overall, the average temperatures in Yugoslavia are about -2° to 2°C in January and 21° to 23°C in July.

Two types of rainfall are common: (i) continental with the heaviest rain in May and June, and (ii) modified Mediterranean with the heaviest in autumn and winter and very dry summers. The average annual rainfall over all of Yugoslavia is 975 mm but its distribution throughout the country and the year is very irregular. Thus, in the Alps and Dinaric chain, the average is over 1 500–2 000 mm. On the Pannonian Plain it is 500–700 mm, and in the Vardar Valley it is only 400 mm. Although most areas experience drought in most years, an area near Titograd has a rainfall of 5 000 mm per year, one of the highest averages in Europe.

In the more elevated areas, long snowy winters prevail. Snow may fall 30–50 days a year. On the northern plains, snow is light but frequent and sections of the large streams are frozen.

In the western and highland areas the growing season is 6 months or less. In the Pannonian area it averages 7 months. On the southern littoral it lasts almost all year.

5. HYDROGRAPHY AND LIMNOLOGY

Table 6 indicates that the total area of inland water in Yugoslavia is only 400 km^2 or 0.16 percent of the country's total area, a figure unaltered for at least 15 years. This ridiculously low figure is obviously incorrect. Reference to Table 5 shows that the Yugoslavian lake area shown there is almost three times the Table 6 figure for its inland waters. (See the chapter for Italy; the situation may be similar.) Meschkat (1956) stated that the total surface of inland waters in Yugoslavia “exploited for economic fishing” covered about 2 500 km^2. Fijan (1976) stated that the country had 2 460 km^2 of inland waters, and Yugoslavia/EIFAC (1979) stated that the area exploited for economic fishing was almost 2 570 km^2, composed as follows: Danube system (1 300 km^2), other rivers (200 km^2), and lakes and reservoirs (1 070 km^2). Fabijanić (1980) says that the inland waters of Yugoslavia are 1.4 percent (i.e., about 3 581 km^2) of the country's total area. Bojčić (1986) says that the total area of streams and lakes in Yugoslavia is about 2 900 km^2. It seems apparent that at least one percent of the country's total area is composed of inland waters.

According to Van der Leeden (1975) and ECE (1978), the average annual runoff from rainfall on Yugoslavian territory is 430 mm or 110 000 million m^3, to which can be added about 117 000 million m^3 received from upstream countries. This results in a total annual river discharge leaving the country of 227 000 million m^3. Higher figures are given by Kuzmanovski (1977) and Miloradov and Djordjevic (1978) of 129 000 million m^3 from rainfall in Yugoslavia and 115 000 million m^3 from upstream countries: a total of 244 000 million m^3 annually.

The origin and runoff of the waters rising in Yugoslavia are shown in Table 1. Of the 115 000 million m^3 from upstream countries (47 percent of Yugoslavia's water balance), 84 percent is brought in by the Danube (72 000 million m^3) and Tisa (about 25 000 million m^3), and the remaining 16 percent by the Drava, Mura and some smaller rivers (Kuzmanovski, 1977).

Table 1

Origin and runoff of waters originating in Yugoslavia

Drainage basin	Basin area km^2	Annual average Discharge m^3/sec	Annual average Runoff Million m^3/year
Sava	96 400	1 685	53 138.2
Morava	37 470	255	8 041.7
Beli Drim	4 360	60	1 892.2
Vardar	22 258	174	5 487.2
Strumica	1 370	6	189.2
Adriatic rivers	46 354	1 642	51 782.1
Other watercourses	44 546	209	6 591.0
Total	255 804	4 088	128 919.1

Source: Kuzmanovski (1977) (additions as given in source)

Of the total area of Yugoslavia, 70 percent drains into the Black Sea via the Danube, 21 percent into the Adriatic Sea, and 9 percent into the Aegean Sea, almost entirely through the Vardar River. The actual quantity of water dispersed through each drainage area is shown in Table 2.

Table 2

Quantity of water flowing through Yugoslavia

Drainage basin	Average annual runoff in 1 000 million m^3 From within Yugoslavia	From outside Yugoslavia	Total outgoing river discharge
Black Sea	67.77	115	182.77
Adriatic Sea	55.47	-	55.47
Aegean Sea	5.68	-	5.68
Total	128.92	115	243.92

Source: Kuzmanovski (1977) and Vujanac-Borovnica and Krstič (1981)

5.1 Rivers (Reke)

Yugoslavia may have more rivers for its size than any other European country according to the Encyclopedia Britannica (1974) which gives their total length as 118 371 km. Another estimate of similar magnitude states that there are about 1 900 streams over 10 km long totalling over 115 000 km in length (see Dill, 1966). Vojnović (1975) states that the average density of rivers in Yugoslavia is 462 m/km^2, indicating that the total length of its rivers is about 118 181 km. Similar figures of total length are given by Fabijanić (1980), 118 370 km, and Vujanac-Borovnica and Krstić (1981), 118 371 km. On the other hand, Mellen (1957) and Framji and Mahajan (1969) say that Yugoslavia has about 1 850 streams over 10 km long, and the latter authors, as well as Yugoslavia/EIFAC (1979) indicate their total length as 43 326 km. Kuzmanovski (1977) states that the average density of rivers in the country is only 100 m/km^2 (i.e., a total length of 25 580 km), while at the same time says that their total length is over 43 000 km. Such discrepancies cannot be explained by the author, but he is inclined to accept the higher figures.

Table 3 shows the principal rivers in Yugoslavia: their length, basin size, and mean annual discharge. Table 4 shows the seasonal flows in four major Yugoslavian rivers.

Despite the large annual discharge, the spatial and temporal distribution of precipitation and consequent discharge is unfavourable to water consumers in the heavily populated agricultural or industrial areas. Specific runoff varies from 0 to 8 1/sec/km^2. The ratio of average stream flow in wet and dry years is often greater than 3 to 1. Thus, for example, in a medium dry year, the discharge of domestic waters falls from its average of 129 000 million m^3 to only 60 000 or 70 000 million m^3. Seasonal discharge fluctuations are also considerable. Runoff in most catchment areas has a markedly torrential nature. In the dry periods of summer and autumn, most rivers have little water; the ratio of minimum to maximum annual stream flow on small rivers is 1:1 000, and there are said to be 13 000 torrential streams in the country.

Drainage on the western slopes of the Karst is provided by underground drainage and by short surface streams, often rapid and turbid and often dry in summer. Here, only the Neretva is a real stream. On the eastern rough mountainous slopes the rivers often flow through steep gorges. Most have swift currents, rocky beds and sharp twists. On the northern plains, where all the drainage is to the Danube, the major tributaries are large broad rivers usually over 150 m in width. High water is usually from March/April to May/June, low water from mid-July to late October. This plains area also has many levees and connecting canals. In the southeast, the rivers which generally flow through broad valleys are shorter than the northern plains rivers, but their regime is similar: usually high and swift from March until June and low from July to October.

Table 3

Principal rivers in Yugoslavia[a]

River	Length (km) Within Yugoslavia	Length (km) Total	Drainage basin (km^2) Within Yugoslavia	Drainage basin (km^2) Total	Mean annual discharge at mouth (m^3/sec)
Danube/Dunav	588[b]	2 857	210 180	817 000	5 750
Tisa	168[c]	966	17 300	157 200	945
Sava	945	945	95 719	96 328	1 690
Drava	437[d]	707	12 033	40 150	620
Mura	143[e]	438	-	13 800	-
Vardar	300.5	420	22 387	28 410	146
Drina	346	346	19 445	19 712	371
Tamiš	111	340	4 816	13 386	-
Južna Morava	304	304	14 232	15 469	-
Kupa	292	292	10 032	10 032	283
Bosna	273	273	10 457	10 457	174
Ibar	272	272	8 059	8 059	-
Zapadna Morava	268	268	14 721	14 721	-
Begej (Plovni)	75.5	244	2 095	6 565	-
Neretva	225	225	11 798	11 798	378
Nišava	151	218	2 737	3 974	-
Una	212	212	9 368	9 368	202
Crna	207	207	5 582	5 582	-
Timok	202.7	202.7	4 682	4 682	39
Lim	197	197	5 936	5 936	-
Vrbas	192	192	5 023	5 023	102
Morava	185	185	37 444	37 444	232

[a] Those over 180 km, arranged in order of total length
[b] Danube: 359 km in Yugoslavia plus 229 km along boundary
[c] Tisa: 164 km in Yugoslavia plus 4 km along boundary
[d] Drava: 342 km in Yugoslavia plus 95 km along boundary
[e] Mura: 70 km in Yugoslavia plus 73 km along boundaries

Source: Statistički Godišnjak Jugoslavije 1987 for lengths and area. Discharge from Van der Leeden (1975) after Pecinar, Water Power of Yugoslavia, Serbian Academy of Science, 1968.

There is usually floating ice on the Danube, Tisa, Sava, and Drava from December until February, although no ice may form in some years.

Otherwise, with respect to water temperatures, the following records for 1985 indicate the annual range for seven representative Yugoslavian rivers (Statistićki Godišnjak Jugoslavije 1987):

	Temperature °C		
	Maximum	Mean	Minimum
Danube at Zemun	24.5	10.8	0.0
Tisa at Senta	25.2	-	0.0
Sava at Slavonski Brod	26.2	12.7	0.1
Drina at Bajina Bâsta	17.1	9.6	1.0
Vrbas At Delibašino selo	20.0	11.0	2.0
Velika Morava at Cúprija	26.2	11.9	0.0
Vardar at Skoplje	25.0	11.1	0.0

Some of the major rivers of Yugoslavia are described below.

Table 4

Seasonal discharge of four major rivers in Yugoslavia

	Drava, Donji Miholjac	Sava, Sremska Mitrovica	V. Morava Ljubicevski most	Danube, Veliko Gradisto
Basin area km^2	8 880	7 222	7 342	6 217
Mean monthly discharge, m^3/s				
January	391	1 830	262	5 460
February	396	1 980	396	6 000
March	482	2 320	450	7 120
April	558	2 440	438	8 100
May	775	2 080	362	7 780
June	846	1 460	246	6 730
July	691	977	133	5 720
August	589	630	82.7	4 670
September	502	589	78.4	4 080
October	487	900	93.0	4 000
November	578	1 760	147	2 250
December	472	2 070	201	5 500
Year	561	1 590	240	5 870
Period of record	1921–66	1941–66	1941–66	1921–66

Source: Van der Leeden (1975) after Unesco (1971)

Danube drainage

Danube. The Dunav as it is called in Yugoslavia, has a total length of 588 km in Yugoslavia and as its border stream[1]. Entering from Hungary, it proceeds southeasterly for 359 km. It then becomes the Yugoslav/Romanian boundary for another 229 km, and leaves the country at the boundary between Yugoslavia, Bulgaria, and Romania about 80 km below the Iron Gate.

1 Known as the Duna in Hungary, Dunav in Bulgaria, and Dunarea in Romania

Throughout the Yugoslavian section, the Danube has a river bed width of 1 to 2 km, a depth of 2.5–7 m and an average flow of about 2 800–5 400 m^3/sec. At low water it may have a width of only 180 m in some places; at other times it may widen to 3 km or deepen in places to 45 m. High water is generally in spring and early summer and low water in autumn.

Like the Hungarian section above it, the Yugoslavian Danube belongs to the cyprinid zone and is a true plains river, formerly with extensive overflow areas supporting good fisheries. When it reaches the Romanian border it cuts a swift course through the defiles of the West Transylvanian Alps, and below Orsova passes through the Iron Gate, long a deterrent to shipping until by-passed by canal and now dammed and equipped with navigation locks (see section 5.3).

The Danube's major tributaries in Yugoslavia are the Drava, Sava, Morava, and Timok from the right, and from the left the Tisa and Tamiš. These are interlaced with canals and the Danube is fully navigable (see sections 5.5 and 6).

Although the Danube receives a pollution load from upstream countries and receives big loads at Novi Sad and Belgrade and from its tributaries, it is still only moderately polluted due to high oxygen saturation and dilution from its affluents. The pollution has, nonetheless, diminished its fisheries as have river training, canalization, and drainage.

Drava. This swift, strong river flows east from Austria (known there as the Drau) into Yugoslavia and thence for 437 km east southeast to the Danube. For 95 km of this course, it forms a boundary with Hungary. Its tributaries bring in much water during the spring snowmelt, and it has a higher water level in summer than most other Yugoslavian rivers. Throughout the section it varies from 120 to 245 m in width, and there is an extensive floodplain area between the Drava and its junction with the Danube.

Mura. Originating in Austria as the Mur, the major Yugoslavian tributary of the Drava forms part of the Austrian/Yugoslav boundary for 32 km and part of the Yugoslav/Hungarian boundary for 41 km of its 143-km course through the country.

Sava. Formed in the northwest Alpine area, the Sava, the largest river entirely within Yugoslavia, flows southeasterly for 945 km to join the Danube near Belgrade. It has a gentle gradient, dropping only 45 m in its lower course below Zagreb. The Sava has two periods of high water, one in the spring and one in the autumn. It has a low in winter and another in late summer. It is an important river, picking up much of the drainage from the northeastern slopes of the Dinaric range, being navigable with a draft of 2.5 m for 543 km, and providing a river fishery. Its major right hand tributaries proceeding downstream are the: Kupa, Una, Vrbas, Bosna and Drina. Circa 1981, it was considered one of the most polluted rivers in Yugoslavia, having deteriorated throughout its course.

Velika Morava. Next below the Sava, entering the Danube from the right, is the Velika or Great Morava River. Formed by the junction of the 318-km Južna (southern) Morava and 268-km Zapadna (western) Morava, it continues for 185 km to a deltaic mouth, draining much of southeastern Yugoslavia[1].

1 There is also another Morava, tributary to the Danube, which is a boundary between Czechoslovakia (there called the Morava) and Austria (there called the March)

Tisa. The longest tributary of the Danube entering Yugoslavia is the sluggish Tisa which enters from Hungary (known there as the Tisza) and courses south through the eastern Pannonian Plain for 164 km to its mouth. This well-embanked river is subject to great floods caused by melting snows in spring and rains in summer and autumn. It has a new dam with locks about 63 km above its mouth.

Tamiš. The only other important left hand tributary of the Danube to enter Yugoslavia is the Tamis which originates in Romania as the Timis. After entering Yugoslavia, it flows generally south for 111 km to enter the Danube below Belgrade.

Adriatic Drainage

Neretva. The Neretva, the only Yugoslavian Adriatic river of importance, has cut a deep canyon to below the level of the water table in the Dinaric chain. Rising north of Gacka, it flows northwest and then southwest for 225 km to the Adriatic, receiving the Rama and Bregara en route.

Two other Adriatic rivers, both international, should be mentioned. One is the Bojana, an international boundary between Yugoslavia and Albania (there known as the Buenë), and the outlet of Skadar Lake (see section 5.2). The other river, which drains a small portion of Yugoslavia, is the Drin or Drim, an Albanian river formed by the junction (in Albania) from the south by the Crna (Black) Drin from Lake Ohrid, and from the north by the Beli Drim (White Drin) which also originates in Yugoslavia (see Albania).

Most of the other Yugoslavian drainage into the Adriatic comes from short, impermanent streams or underground drainage which sometimes enters the sea below sea level.

Aegean Drainage

Vardar. The major river of southernmost Yugoslavia and northeastern Greece is the Vardar River. Rising in the mountains it flows north-northeast and southeast to enter Greece (where it is called the Axios) and proceed to the Aegean Sea. With a total length of 420 km, 300 of these are in Yugoslavia. Its principal Yugoslav tributary is the 207-km Crna Reke.

Strumica. The Strumica which drains southeast into Bulgaria to the Struma, which proceeds through Greece (as the Strymon), is the only other major Yugoslavian stream in the Aegean drainage.

5.2 Lakes (Jereza)

There are about 220 lakes and reservoirs in Yugoslavia with a total area of about 1 600 km^2 (Kuzmanovski, 1977; Vujanac-Borovnica and Krstić, 1981) of which 11 are over 1 000 ha in area. The lake area exploited for commercial fishing totals about 107 000 ha (Yugoslavia/EIFAC, 1979). Table 5 lists 28 of the largest lakes totalling over 1 129 km^2 in Yugoslavia alone. Four of these are shared with other nations.

Table 5

Principal lakes of Yugoslavia[a]

Name	Total area km^2	Altitude m	Maximum depth m
Skadarsko/Skadar[b]	391	6	44
Ohridsko/Ohrid[c]	348.8	695	286
Prespansko/Prespa[d]	274	853	54.2
Derdapsko/Djerdap[e]	253	69.5	92
Buško	55.8	716.5	17.3
Dojransko/Dojran[f]	43	148	10
Bilećko	33	400	104
Vransko (kod Biograda)	31.7	0.1	3.9
Modračk (kod Tuzle)	17.1	200	17
Tikveško	14	-	95
Jablaničko	13.3	270	70
Debarsko	13.2	580	92
Perućko (na Cetini)	13	360	64
Perućačko (na Drini)	12.4	290	70
Mavrovsko	12	1 197	48
Vlasinko	12	1 208	22
Gasivode	11.9	692.7	105
Prokljansko	11.1	0.5	25
Ribnjak (Našice)	11	103	2.5
Zvorničko (na Drini)	8.1	140	28
Zlatarsko (na Uvcu)	7.25	885	75
Vrana (na Cresu)	5.8	16	74.4
Belo	4.8	75	2.5
Palić	4.2	101	3.5
Bohinjsko/Bohinj	3.28	523	44.5
Plavsko	1.99	906	9.1
Plitvicka (I.G. jereza)	1.98	503–636	46
Bledsko/Bled	1.45	475	30.6
Plivsko (Veliko)	1.148	424	36.2
Durmitorska (io jezera)	0.98	1140–1788	49.1

[a] Includes some reservoirs, e.g., Derdapsko
[b] Shared with Albania. Yugoslav portion is 243.1 km^2 (62 percent)
[c] Shared with Albania. Yugoslav portion is 229.9 km^2 (66 percent)
[d] Shared with Albania and Greece. Yugoslav portion is 177 km^2 (65 percent)
[e] Reservoir shared with Romania. Yugoslav portion is 178 km^2 (70 percent)
[f] Shared with Greece. Yugoslav portion is 27.4 km^2 (64 percent)

Source: Statistički Godišnjak Jugoslavije, 1987

Glacial lakes are fairly numerous but small in size. Most of these are located in cirques in high mountains, but the most famous (e.g., Bled and Bohin) are in mountain valleys. Some of the lakes are fluviatile, created as oxbow or overflow lakes on the Pannonian floodplain. The largest and most interesting Yugoslavian lakes are, however, developed in poljes or tectonic karstic depressions, e.g., the series of graben lakes which stretch eastward from Lake Skadar into Macedonia. Generally monomictic or "subtropical", they are known as the Balkan or Aegean lakes. There are also some simpler karstic or solution lakes, periodically flooded polje lakes (e.g., Bŭsko), and coastal or lagoon-type lakes.

Some of the most prominent lakes are described below.

Skadar/Scutari/Shköder. The largest lake in the country, Skadarsko, as it is known here, lies at the southern end of the Yugoslavian littoral on the Albanian border. It is fed by a number of mountain streams, including the 97-km salmonoid river Moracă. It is tributary to the Adriatic through the Bojana (Buenë) River which has a link with Lake Ohrid through a connection with River Drim. The outlet has silted up so that the lake is almost cut off from the sea, but has some marine migrants including sturgeon (Acipenser spp.), European eel (Anguilla anguilla), grey mullets (Mugil spp.), shad (Alosa fallax), and sea bass (Dicentrarchus labrax).

Due to annual flooding, the lake's area has varied from 360 km^2 in summer to 690 km^2 in winter/spring. At an area of 391 km^2, 62 percent (243.1 km^2) lies in Yugoslavia, the remainder in Albania. At an area of 372 km^2, it has an average depth of 4.4 m; at higher elevations it may still only be 7–8 m in average depth. Despite its shallowness, it has a number of crypto-depressions up to 63 m in depth, which, at least in Yugoslavia, yield almost half of the lake's commercial harvest, even though they occupy only about one percent of its area.

Surface water temperatures of this warm, polymictic lake exceed 30°C in summer and decrease to about 7°C in winter. It is well oxygenated, has a pH of 7.5 to 8.4, and a morphoedaphic index of 45.

It contains 15 families of fish of 37 species but cyprinids make up 96 percent of the fish biomass. The largest freshwater fishing grounds of the Balkan Peninsula, Skadar has an annual yield of 800 to 1 200 t of fish. Of this harvest, common carp (Cyprinus carpio) and bleak (Alburnus albidus) are the most valuable food fish but considerable quantities of “scrap” fish such as Pachychilon pictus and Rutilus rubilo are also taken.

Skadar Lake has lately been subjected to intensive industrial and agricultural development including pollution of its tributaries.

Lake Ohrid/Oridsko. Ohrid, the most famous and second largest lake in Yugoslavia, is a permanently inundated karstic polje, a tectonic depression or graben lake on the Yugoslav/Albanian border. Fed almost entirely by underground water from karstic sources, some of them from effluents of Lake Prespa, it has a superficial outlet to the River Drim/Drin. It has a total area of 348.8 km^2 of which Yugoslavia owns 229.9 km^2 or 66 percent. It has a length of 30.8 km, width of 14.8 km, mean depth of 145.2 m, maximum depth of 286 m, and volume of 50.53 km^3.

Thermically, it is a warm monomictic or “subtropical” lake; its water mass always remains above 4°C. It can also be considered a productive oligotrophic lake, with an annual productive rate of 108.3 mg/C/m^2/year (Ocerski and Allen, 1978).

Biologically, Ohrid is of extreme interest in having an archaic fauna including more endemic organisms than any other lake in Europe (see the extensive studies summarized by Stankovič, 1960). Of its 17 species of fish, 10 are endemic, including the cyprinid Pachychilon pictus, and the salmonids Salmo letnica and Salmothynnus ohridanus. During the 1930–57 period, the catch in the Yugoslavian part of the lake averaged 226 t annually (Stankovič, 1960). Salmo letnica accounted for 43 percent of the catch and bleak (Alburnus albidus) for 27 percent of its catch during the 1929–73 period (Točko, 1975). An eel population is being sustained through stocking with elvers from France.

Prespa Lake/Prespansko. Also known as Lake Prespë or Megali (Big) Prespa, this 274-km^2 international lake is shared as follows: Yugoslavia (176.8 km^2 or 65 percent), Albania (49.4 km^2 or 18 percent), and Greece (47.8 km^2 or 17 percent). (The source of Table 5 (1987) states that the area of this lake is 274 km^2. However, a study by Ocevski and Allen (1984) says that its area is 313.6 km^2.) It is an oligo-eutrophic lake with karstic features whose waters disappear into sinkholes. It has a maximum depth of 54.2 m, an average depth of 20 m, and a volume of about 4 km^2. Its catch is primarily of cyprinids.

Dojran/Dojransko. The last in this series of international Balkan lakes is Dojran, shared with Greece where it is known as Doiranis. Yugoslavia's share of this 43-km^2 graben lake is 27.4 km^2 or 64 percent. In the Aegean lake zone, this eutrophic lake has a mean depth of 6.5 m and a maximum depth of 10 m. Like Prespa, it is a cyprinid lake and is quite productive.

Dojran is rather unique in being the site of a fishery where diving birds (especially mergansers, grebes, cormorants, and loons) are used to drive fish into traps where they are captured by fishermen (Apostolski and Matvejev, 1955; Meschkat, 1957).

Other lakes. Typical large salmonid lakes in the Alpine zone of Yugoslavia are the glacial lakes of Bled (1.45 km^2) and Bohinj (3.28 km^2) in Slovenia. The most striking of the karstic lakes are the 16 beautiful lakes, totalling 1.98 km^2 in the Plitvice group. Situated at about 500 m in Croatia, they are fed by springs or underground streams and drain by potholes. Other mountain lakes include seven Triglav lakes in Slovenia, and 30 lakes in the Dinaric ranges of Montenegro. Coastal lakes are represented by Lake Vrana (see section 5.4).

5.3 Reservoirs

In consideration of its size and number of waters, Yugoslavia's watercourses are still not intensively regulated, and most of its static water consists of natural lakes. Most of its storage reservoirs have been constructed for power generation and there are still comparatively few multipurpose reservoirs. Nevertheless, by 1978 there were 102 large dams (over 15 m in height) in the country: 94 constructed after the second world war and 21 during the 1970–77 period. At this point, Yugoslavia ranked tenth in Europe and twentieth in the world in number of large dams.

Of the resulting reservoirs, the largest is the Djerdap (Derdapsko) at Iron Gate on the Danube, the greatest hydroelectric project in Yugoslavia and Romania. Formed in 1971 by a concrete dam, 59 m high and with a crest of 1 228 m, the water level has been raised 34 m and there is a two-flight lock on each bank. The ship chamber lock is 310 m long, 34 m wide, and 4.5 m deep. Two hydropower plants use 270 km of the Danube with a power capacity of 2 050 MW. The spillway provides for release of 16 500 m^3 of water. With a total area of 253 km^2, 70 percent (178 km^2) of the reservoir is in Yugoslavia and 30 percent (75 km^2) is in Romania. At high water, differences between the flowing river water and the reservoir are very slight, and there is only a brief retention time without real stratification. Daily water fluctuations of about 8 m are not conducive to a good fishery.

A number of new dams are under construction, and more will follow. The tendency now is to construct multi-purpose dams, not just for hydroelectric power but to provide domestic, industrial and irrigation water and recreation. Some have been constructed to hold spoil, mine tailings, and other wastes.

5.4 Lagoons

Levi and Troadec (1974) reported, without being specific as to location, that there were three major basins or brackish water complexes in Yugoslavia, totalling 14 200 ha in extent, ranging from 1 to 18 m in depth, and with salinities ranging from 0.5 to 8 ppt. Amanieu and Lasserre (1981) also said that there were 14 200 ha of lagoons in Yugoslavia which produced 360 t in 1971.

In an earlier paper, Krstinić (1956) stated that there were only two areas on the Yugoslavian coast characterized by lagoons. The first of these is Lake Vrana (Vransko Jezero) with an area of 31.7 km^2, average depth of 2 to 2.5 m and maximum depth of 4 m, and salinity of 2 to 8 ppt. It has a subterranean connection with the sea as well as by an artificial canal, and is fed by two principal freshwater affluents. Water temperature in the lagoon varies between 0° and 30°C and in harsh winters the lake may be ice-covered. The species fished are grey mullets, European eel, Atherina, and a blenny (Blennius fluviatilis). Common carp have also been reported from here. Krstinić (1956) stated that the fishing, performed with fixed gear, and production, without artificial feeding, was 20 to 25 kg/ha/year.

The second area described by Krstinić (1956) was a lagoon area at the mouth of the Neretva River, the most important Yugoslavian river debouching directly into the Adriatic. Here several lagoons are found with a total area of 1 200 ha, depths ranging from 0.3 to 1 m, salinities ranging from brackish in the summer to completely fresh in the winter, and temperatures rising above 30°C. The water does not freeze but there is a lack of oxygen in the summer which may cause mortalities. Communication with the sea is direct and fresh water enters from the river and subterranean channels. The species entering the lagoons are grey mullet, eel, sea bass, gilthead (Sparus auratus), and sole (Solea vulgaris).

In addition to Lake Vrana and the Neretva complex, Krstinic (1956) stated that there were several thousand hectares of semi-enclosed canals or bays along the Yugoslavian coast which support populations of mullets, sea bass, gilthead, etc. These areas include: the sea of Novigrad, the lake of Prokljan, and bay of Jadrtovac. Capture of fish in these areas is possible in the narrow channels connecting them with the open sea when the fish leave in the late year.

Despite the existence of these lagoons or lagoon-like areas, brackish water fishing or aquaculture has never been developed in Yugoslavia to the extent that it has in Italy across the Adriatic. However, there has been a considerable activity here in recent years (see section 7.2).

5.5 Canals (Kanala)

Yugoslavia has a canal system used for navigation, irrigation, and to alleviate water congestion. The basic one, the Danube-Tisa-Danube Hydro-system, totalled 644 km of navigable waters alone circa 1977. Among the many connections are the Veliki Canal connecting the Tisa with the Danube, the Mali connecting the Veliki with the Danube, the Tisa with the Begej River, and the Begej with the Danube. (Both Yugoslavia and Romania are affected by Begej regulation.)

Many large schemes for new waterways have been considered. These include: linking the Danube with the Aegean Sea via the Morava and Vardar, connecting the Danube and the Sava, and canals linking the Sava with the Adriatic.

In addition to navigational canals, Yugoslavia has over 3 000 km of main irrigation canals and a network of drainage ditches (see section 6).

Yugoslavian canals are usually less than 60 m wide and average about 1.5 m in depth. They are important for fisheries although constantly being dredged to remove silt.

6. LAND AND WATER USE

Table 6

Pattern of land use in Yugoslavia, 1986

	Percent
Arable and permanent crops	30.4
Permanent pasture	25.0
Forests and woodlands	36.5
Other land	8.0
Inland water	0.16
Total	100.0

Source: 1987 FAO Prod.Yearbook, 41 (Publ. 1988)

Yugoslavia has a rural population (of about 50 percent) and despite its generally maintainous terrain, over 50 percent of Yugoslavia is used for agriculture. Three-quarters of its arable land is used for cereals; maize, wheat, sugar beets, tobacco, potatoes, fruit, and the vine are principal crops. Waterdemanding sub-tropical crops, such as cotton, are grown in the extreme southern section. Livestock raising is of smaller proportions. Sheep and goat grazing affects vegetational cover and runoff in some areas. Although climatic conditions demand intensive irrigation in Yugoslavia, only about 2 percent of the cultivable land was irrigated in 1986. Land drainage and diking along the main lowland rivers, especially the Danube and Sava, have reduced the floodplain fisheries. There has also been reduction of marshes and swamps, and there are periodic attempts to lower water levels in lakes such as Skadar to provide additional agricultural land. Although fertilizer production is now a very large segment of the Yugoslav chemical industry, application to crops has lagged far behind that of most European countries, being one of the lowest on the continent. (Effects of agriculture on water and fisheries are summarized at the end of this section and in section 9.)

With about one-third of the country under forest, a higher proportion than any other European country except Austria and in Scandanavia, there is considerable lumbering, and in 1985 Yugoslavia ranked eighth in roundwood production in Europe. Deciduous trees such as oaks and beech are dominant; conifers are secondary. Preserved forests, the bulk in the highlands, account for about 65 percent of the wooded area, 20 percent is degraded, 14 percent is coppice, and I percent is macchia. A number of rivers are used to float logs. There is a programme of afforestation.

Mineral resources are varied, abundant, and well distributed. Important deposits include: copper, lead, zinc, low grade coal (especially lignite), petroleum, gas, and oil shales, iron, bauxite, chromite, antimony, mercury, magnesite and some uranium. The effluent resulting from mining and processing has often resulted in pollution of fisheries, e.g., the total fish fauna in 80 km of the River Pek was destroyed by copper mine pollution.

Yugoslavia has a large potential for hydroelectric power, ranking among the highest countries of Europe, because of its relief, level of rainfall, river slopes, and river density. It is estimated at about 66 000 million kWh/year. In the past, most of the reservoirs in Yugoslavia were constructed to furnish hydroelectric power, and there is still much of the water resource to be utilized. Circa 1981, only about 37 percent of the potential was exploited by 71 hydroelectric power dams (Vujanac-Borovnica and Kristič, 1981), and it was still only about 40 percent exploited by 1985 (Durié, 1985). In 1987, of a total installed power capacity of 16 150 000 kW, hydroelectric power represented 43 percent (7 000 000 kW). The remainder of the power was thermal (7 900 000 kW) using Yugoslavia's abundant supply of lowgrade coal for most of it, nuclear (650 000 kW) and geothermal (600 000 kW).

Industry, now over half of the labour force, is largely concerned with the production of steel and other metals, chemicals, wood products including pulp and paper, cement and textiles. These, as well as distilleries, flax and hemp retting, packing and slaughterhouses have produced large amounts of effluent. Although the northwest was traditionally the industrial zone, the Governmental policy of economic equality for all republics has engendered the dispersal of economic enterprises and therefore, extended the zones of heavy pollution.

Land transport (1986) with about 10 000 km of railways, and 127 000 km of roads with a road density of 0.5 km/km^2 is only reasonably good in Yugoslavia. Rugged terrain and poor surfaces hold down transport and many areas of the country remain inaccessible. Furthermore, passenger car ownership is low, only 103 vehicles per 1 000 circa 1982, and their manufacture in Yugoslavia did not begin until 1954.

Most of the domestic water supply comes from ground water, (Vujanac-Borovnica and Kristić, 1981, say there are 5 000–7 000 million m^3), but use of river water is increasing. Sewerage has been slow to develop and there are still few single large discharges. Similarly sewage treatment has lagged.

There are about 2 410 km of navigable waterways in Yugoslavia. Rivers constitute 1 745 km of this total: Danube (588), Drava (75), Tisa (164), Sava (653), Kupa (75), Tamiš (53), and the lower reaches of the Adriatic streams, Neretva (20), Krka (15), Zrmanja (11), and Rijeka Crnojevica (12) (S.F.R.J., 1987). In addition, there are 664 km of canal in the Danube-Tisa-Danube system, and two navigable lakes, Ohrid and Prespa. In the largest segment, the Danube, barges to 5 000 t can ascend to Belgrade and those of 1 500 t can traverse the remainder (Kuzmanovski, 1977). Traffic is increasing on all these waterways with consequent problems to the fisheries accrued by channelization, dredging and pollution.

All of these water uses (for irrigation, drainage, flood control, production of hydroelectric and thermal power, industrial and domestic supply, and direct use for effluent disposal) have inflicted drastic changes in the hydrographic network and in its quantity and quality of water, with consequent changes in the fisheries. The many river training projects include (through 1977) over 1 030 km of meander cuttings (895 in the Danube basin alone), plus 1 000 km of bank reinforcement, and 300 km of other river training structures (Yugoslav Survey, 1977a). The flood-protected areas in Yugoslavia total over 2 million hectares and there are 5 650 km of levees. There are, in addition, about 3 000 km of main irrigation canals and over 7 000 km of distribution ditches.

Water quality is greatly affected by erosion in this country with many torrential streams. Palošević (1988) says that 90 percent of the farm land is eroded. The overall annual sediment yield is estimated at more than 176 million m^3 or an average of 690 m^3/km^2/year.

Water pollution from domestic and industrial sources is also a growing concern in Yugoslavia. Of the total streamflow in 1976, only 22 percent was considered as first class quality waters (i.e., it could be used for drinking and for fish farming), 39 percent was second class (also suitable for fish farming, for bathing and with treatment for drinking), 32 percent was third class (suitable for irrigation and industrial use), and 7 percent was fourth class (requiring special treatment before use), Vujanac-Barovnica and Kristić (1981). In 1975, the rate of effluent discharge was about 192 m^3/sec of which about 11 percent (21 m^3/sec) originated from communities, and the remainder from industries and steam power stations. Thermal plants are considered the highest polluters of both water and air in Yugoslavia. Of the total waste water, aside from steam power plants, the bulk comes from ferrous metallurgy and the chemical, pulp and paper, and food industries. Pollution is also growing with increased use of pesticides and fertilizers in agriculture although their use is still minor compared with that in most European countries.

The amount of water required for different uses in Yugoslavia has been outlined by Kuzmanovski (1977) as follows.

With respect to overall water use, domestic and industrial consumption is about 2 500 million m^3 annually. Of this amount, public water supply uses about 25 percent, steam power plants 30 percent, and other industries use about 45 percent. Most of the domestic supply comes from ground water; most of the industrial supply from surface water, 80 percent from the Black Sea drainage, 10 percent from the Adriatic and 10 percent from the Aegean. Irrigation uses about 644 million m^3 annually, of which about 598.6 million (93 percent) comes from surface water, 281.5 million m^3 directly from streams and 317.1 million m^3 from reservoirs. (Almost 90 percent of this surface water is used in the single republic of Macedonia, and over 6 percent in Serbia.)

Surprisingly enough, the annual water requirement for fish farms (primarily for 13 000 ha of carp ponds) is about 430 million m^3, mostly, of course, flowing, non-consumptive use (see section 9.2).

Although Yugoslavia has a long indented coastline, its marine fisheries have been of minor importance. Confined to the Adriatic, the Sea's comparative unproductivity, unsuitable bottom for trawling, and unfavourable weather conditions, have been factors in this. During the 1975–80 period, the Yugoslav marine fisheries averaged only 34 784 t annually, while the inland fishery averaged 24 260 t or 41 percent of the country's total. Furthermore, at least at one time, the inland catch was more important in terms of value than the marine catch (see Pažur, 1966). The inland “catch”, which includes the production from fish culture, and commercial fishing in the large lakes, rivers and overflow areas, will be discussed in section 7. The per caput consumption of fish increased from 1.5 kg in 1960 to 4.3 kg in 1981, but has decreased to 3.4 kg circa 1986.

Tourism itself (8.9 million tourists in 1987) is now an important source of foreign currency with the leading role played by the coastal area and its hinterland. Mountain areas attract hikers and hunters, but angling has not been stressed as a tourist attraction despite its potential. In fact, Marković (1988) considered fishing in Yugoslavia an “overlooked form of tourism”.

7. FISH AND FISHERIES

Dudich (1967) lists 49 species of fish belonging to 15 families as resident in the Yugoslavian Danube. (Djerjap Dam has, however, barred five species of anadromous sturgeons and two clupeids from ascending from the Black Sea.) Of these, about eight families are of commercial or recreational importance. There are also 15 families of fish including 47 species in Skadar Lake which has a close connection with the Adriatic Sea.

Among the Yugoslavian fishes of commercial and recreational importance are the: European eel (Anguilla anguilla), pike (Esox lucius), common carp (Cyprinus carpio), bleak (Alburnus sp.), roach (Rutilus sp.), European catfish or wels (Silurus glanis), European perch (Perca fluviatilis) and pike-perch (Stizostedion lucioperca). The sturgeons (Acipenseridae), shad (Alosa fallax), and grey mullets (Mugil spp.) are important in situations where they can ascend from the sea, as at Skadar Lake. There are also large catches of so-called “scrap fish” such as the cyprinids: Barbus sp., Gobio sp., and Pachychilon sp. The salmonoid fauna of Yugoslavia has attracted considerable attention in that a number of endemic species or subspecies have been described from here. Outstanding among resident species are the famous Lake Ohrid trout (Salmo letnica), the marble trout (Salmo trutta marmoratus), the giant huchen (Hucho hucho), and the unique Salmothynnus. The commoner brown trout (Salmo trutta), the rainbow trout (Oncorhynchus mykiss) introduced in 1890, char (Salvelinus alpinus), and grayling (Thymallus thymallus) are also important fish in Yugoslavia.

Table 7 shows the “catch” in the inland waters of Yugoslavia during the 1965–87 period as reported to FAO by Yugoslavia. They are very similar to those in Statistički Godišnjak Jugoslavije. No distinction is made in these statistics between fish derived from capture fisheries and aquaculture, or between individual species except for common carp. Other information clearly shows, however, that the bulk of the fish shown in the table are cultivated fish, primarily carp, and that cultivated trout may also be included. For example, a report from Yugoslavia (Fijan, 1972) shows that in 1970 only about 3 273 t or 17 percent of the total inland catch of wild fish and pond fish harvest (which he records as 19 105 t) came from the capture fishery in natural waters and reservoirs. Similarly, Yugoslavia/EIFAC (1976) shows that the combined commercial and sport capture fishery from rivers, lakes and canals in 1974 was only 5 256 t (22 percent) of the total inland fish production/catch of 23 983 t (Table 8). Yugoslavia/EIFAC (1979) indicates that of the 25 552 t “caught” in 1978, only 7 002 t (27 percent) came from capture fisheries, and reference to Table 8 clearly indicates that during the 1980–84 period, capture fisheries and reference to Table 8 clearly indicates that during the 1980–84 period, capture fisheries never succeeded in more than 21 percent of the total catch and production, and was generally closer to only 10 percent of this figure. (Relatively small differences between these total figures and those in Table 7 are to be expected. Figures in both yearbooks are sometimes provisional, and those in the earlier FAO Yearbooks are rounded.) However, Bojčić (1986), who at the time was Director of the Yugoslav Business Community for Freshwater Fisheries, has provided some statistics, shown in Table 8, which are in general higher than those shown in Table 7. He states that his figures have been brought “into accord with the real situation”.

All told, there were in 1986 about 90 organizations concerned with freshwater fisheries in Yugoslavia, employing about 4 550 workers.

7.1 Capture Fisheries

It is apparent that Table 7, derived from the FAO fishery statistical system, is not a valid measure of the harvest from the commercial capture fishery, since it includes the overwhelming production from pond fish culture, and, at least in some years, the (what must surely be roughly estimated) sport fish catch. Reference to Table 8 which summarizes some of this information, provides a much more accurate picture of the derivation in recent years of both captured and cultivated stocks in Yugoslavia.

Table 7

Nominal catches by species in the inland waters of Yugoslavia, 1965–87 (in tons)

	Common carp (Cyprinus carpio)[a]	Freshwater fishes, n.e.i.	Total
1965	8 400	7 500	15 900
1966	10 800	7 400	18 200
1967	10 100	7 800	17 900
1968	9 200	5 800	15 000
1969	11 800	5 100	16 900
1970	12 200	7 300	19 500
1971	11 800	6 600	18 400
1972	12 400	6 400	18 800
1973	13 600	6 900	20 500
1974	16 753	7 246	23 999
1975	16 191	8 178	24 369
1976	14 864	9 134	23 998
1977	16 081	9 614	25 695
1978	15 400	10 122	25 522
1979	13 406	9 140	22 546
1980	13 354	10 074	23 428
1981	15 639	11 593	27 232
1982	14 744	11 508	26 252
1983	14 405	12 122	26 527
1984	13 568	11 530	25 098
1985	13 531	12 153	25 684
1986	12 917	13 156	26 073
1987	13 042	12 132	25 174

[a] Includes other cyprinids during 1965–69 period and probably thereafter also

n.e.i. - not elsewhere included

Source: 1965–69 Yearb.Fish.Stat.FAO, 36 (Publ. 1974)
1970–83 FAO Fish.Dept.Fishery Statistical Database (FISHDAB)
1984–87 Yearb.Fish.Stat.FAO, 64 (Publ. 1989)

<u>Table 8</u>

Origin of Yugoslavian inland fishery catch and pond fish production, 1945–84 (in tons)

Year	Capture fishery			Aquaculture production					
	Commercial	Sport	Total	Carp ponds	Trout ponds	Consumable[a]	Fry production[a]	Total	Grand Total
ca 1945[b]	-	-	5 000	-	-	-	-	2 000	7 000
1963[c]	-	-	5 158	8 378	206	-	-	8 584	13 742
1964	5 697	-	5 697	7 360	156	-	-	7 516	13 213
1968[c]	-	-	4 969	11 311	446	-	-	11 757	16 726
1970	4 209	-	4 209	-	-	15 841	2 869	18 710	22 919
1973	1 691	-	1 691	17 370	1 382	-	-	18 752	20 443
1974	2 871	2 385	5 256	17 395	1 332	-	-	18 727	23 983
1978	-	-	7 022	15 400	3 100	-	-	18 500	25 522
1980	3 140	-	3 140	-	-	20 288	6 092	26 380	29 520
1981	4 502	-	4 502	-	-	23 006	6 892	29 898	34 400
1982	2 965	-	2 965	-	-	23 387	6 194	29 581	32 546
1983	6 792	-	6 792	-	-	19 735	5 230	24 965	31 575[d]
1984	3 000	-	3 000	-	-	25 200	6 300	31 500	34 500

[a] Carp and trout
[b] 3 000 t from rivers, 2 000 t from lakes and 2 000 t from fishponds
[c] Capture fishery listed merely as "catches". Note that Statistički Godišnjak Jugoslavije (1970) records the grand total for 1963 as 12 878 t, and for 1968 as 15 007 t
[d] Addition as in source

\- Not give or unspecified as to whether consumable (marketable) or total production (including fry)

Source: 1945 - Naval Intelligence Division (1945)
1963, 1968, 1973 - Fijan (1976)
1964 - Dill (1966)
1974 - Yugoslavia/EIFAC (1976)
1978 - Yugoslavia/EIFAC (1979)
1970, 1980–84 - Bojčić (1986)

7.1.1 Commercial fishing

From Table 8 we see that in the last Yugoslavian statistics available to the author the annual commercial catch of inland fish in Yugoslavia may amount to only about 3 000 t. This catch can be compared with earlier statistics showing that between 1938 and 1964, the annual capture fishery from Yugoslavia's open waters only varied between 4 492 t in 1938 and 6 340 t in 1957 as reported to Dill (1966). Table 8 does show a highly increased commercial fish catch in 1983 (6 792 t) but this appears to be an anomaly, and no explanation can be provided.

Commercial fishing is now very limited in Yugoslavia's inland waters, as natural conditions have deteriorated, being carried out only on the major lakes (see below), some of the major rivers such as the Danube, Sava, Drava and Tamiš, and on some canals and floodplain areas. The composition of the catch is dependent upon the area fished. Thus, the deep Lake Ohrid produces a large percentage of trout, while in shallow Skadar, Prespa, and Dojran the cyprinid catch is predominant (see section 5). Boejĉiĉ (1986) estimated that in 1984, about 30 percent of the commercial catch, totalling 3 000 t, came from the Danube, about 12 percent from Skadar Lake and 58 percent from other waters. The catch is utilized in a fresh state (for many years much of the catch was transported in special boats and sold alive), or as at Apatin on the Danube, the cyprinid catch may be canned. In addition to finfish, both crayfish (Astacus astacus) and frogs may be caught. Slovenian streams were once rich in crayfish, but have been affected by crayfish plague (Aphanomyces astaci) since 1880.

There are now only about 500 professional inland fishermen in Yugoslavia, and almost none of them have fishing as their sole occupation since they cannot make a living of it (Bojčić, 1986).

A variety of fishing gear is used: trawls (as at Skadar), seines, gillnets, hoopnets, labyrinth traps, and hook and line. As in the other Danube countries, much of the original fishing gear was constructed of local materials and often unique to the area fished. The older systems are, however, being replaced with gear constructed of synthetic materials.

In addition to the strictly inland catch, Yugoslavia reports separately on its catch in the Mediterranean (Statistical Area 37) of two major fishes which enter fresh water: European eel and striped mullet (Mugil cephalus). During the 1970–87 period, the Yugoslavian catch in the Mediterranean of these two species was as follows: an average yearly catch of eel of 51 t (annual range about 35 to 56 t), and an average yearly catch of 255 t of striped mullet (annual range 200–535 t). (Data from FISHDAB and Vol.64 of the FAO Yearbook of Fishery Statistics.)

7.1.2 Sport fishing

There are some excellent trout waters in Yugoslavia including rough or freestone waters in Slovenia, Bosnia, and Macedonia, chalk streams in Croatia and mountain lakes. Among the good streams are the upper Sava, Krka, Gacka (a famous chalk stream), Neretva, Buna, Una, Unica and Moraca. The presence of some unique salmonoid stocks has been mentioned, and other fish such as carp, pike, perch, pike-perch, and eel are also fished for sport.

Circa 1972, there were about 158 000 fishermen in Yugoslavia. This was only about 0.7 percent of the total population, an extremely low percentage of sport fishermen, and it was estimated that the number of tourist anglers equalled the number of Yugoslavian anglers (Gaudet, 1973). In 1980, the number of sport fishermen was still given at around 150 000 (Yugoslavia, 1980), but Bojčić (1986) stated that there were about 320 000 Yugoslavian anglers organized in about 500 organizations, and that they catch about 1 500 t a year or about one-half of the total catches.

Despite the potentialities, sport fishing has been slower to develop here than in many other European countries. For example, as late as 1969, there was no manufacture of sport fishing equipment in Yugoslavia (Vojnović, 1969).

7.2 Aquaculture

Carp: Although "carp farms" represent the commonest form of aquaculture in Yugoslavia, an increasing percentage of the fish reared in these farms are species other than common carp. The common carp is still, however, the principal fish cultivated, but the Chinese carps, the bighead (Aristichthys nobilis), grass carp (Ctenopharyngodon idella), and silver carp (Hypophthalmichthys molitrix), have been constantly gaining importance since 1963, and now form about 20 percent of the harvest (Turk, et al., 1987). The bighead now occupies the leading place of these three species because of its high growth rate and bighead/silver carp hybrids are increasing in number (Fijan, 1986). The tench (Tinca tinca) has been a secondary species since the early days of pond culture in the country. European catfish or wels and pike-perch are cultived as "police fish", i.e., as species that eat trash fish in the ponds. During the 1984–85 period, the market-sized fish from pond culture in Yugoslavia consisted of about 73 percent common carp, 20 percent Chinese carps, and 7 percent an assortment of tench, pike-perch, European catfish, and other species (Fijan, 1986).

The American channel catfish (Ictalurus lacustris) was introduced as a pond fish, but conditions on traditional carp farms have not been suitable for its production.

Table 8 shows some of the pond fish production during the 1945–84 period, and Table 9 shows the area devoted to pond culture, pond fish production, and yield in 1970 and 1984.

Carp culture, the best developed sector of the industry has had a constant expansion dating back to its introduction in the latter part of the last century. A production of 8 378 t in 1963 doubled in ten years to 17 370 t in 1973 (Fijan, 1976), and by half again as much in the next five years to 27 322 t in 1978 (Yugoslavia/EIFAC, 1979). In 1984, it totalled 31 500 t of which 22 480 t was consumable (Table 9). (There is some danger in the use of comparative figures on pond fish "production" since the term itself is usually not defined in the source. Note, for example, in Table 9 that only 85 percent (14 997 t) of the total carp pond production in 1970 was marketed, i.e., was consumable, and that in 1984 the consumable harvest of 22 480 t from carp ponds represented 80 percent of their total production. Similar examples will be found in the chapters on Hungary and Poland.)

Table 9

Pond area and cultivated fish production in Yugoslavia 1970, 1978 and 1984[a]

	Area (ha)		Production (t)				Yield
	Total	Production	Marketed	Fry	Total	Marketed	(kg/ha/year)[b] Total
Carp							
1970	19 520	-	14 997	2 691	17 688	768	906
1978	22 850	21 471	15 400	11 922	27 322	674	1 196
1984	27 000	-	22 480	5 620	28 100	833	1 041
Trout							
1970	15.23	-	844	178	1 022	55 417	67 104
1978	26	15.1	3 100	400	3 500	119 231	134 615
1984	25	-	2 720	680	3 400	108 800	136 000
Total							
1970	19 535	-	15 841	2 869	18 710	692	958
1978	22 876	-	18 500	12 322	30 822	809	1 347
1984	27 025	-	25 200	6 300	31 500	932	1 166

[a] Any discrepancies between Table 8 and Table 9 are those of the source

[b] Yield is based on total pond area. If in 1978, one had used only the "production" area given for carp ponds, the yield of marketed (consumable) carp would have been 717 kg/ha/year and the total yield would have been 1 272 kg/ha/year

Source: 1970 and 1984 Bojčić (1986)
1978 Yugoslavia/EIFAC (1979)

Constructed at the beginning of the century, the area of the large commercial carp ponds increased to about 8 000 ha by 1939 (Fijan, 1971). The area devoted to carp ponds then rose from 8 860 ha in 1966 (Dill, 1966) to 22 850 ha in 1978 (Yugoslavia/EIFAC, 1979). In 1980, carp ponds in Yugoslavia had an area of 24 550 ha, a net pond area of about 22 000 ha and a production of about 25 100 t of fish (Bojčić and Bunjevac, 1982). By 1984, carp farms totalled 27 000 ha (Bojčić, 1986). The largest carp breeders are in Croatia and Vojvodina.

Carp ponds in Yugoslavia are large. In 1976, the largest single pond was 600 ha and the maximum pond depth was 4.5 m (Fijan, 1976).

Carp in Yugoslavia are reared to a market weight of about 1 200–1 500 g in a two-year management cycle (Matenâ and Berka, 1987).

The dominant part of carp production in Yugoslavia is now from controlled reproduction in modern hatcheries, using hypophysation, artificial spawning, and incubation of eggs and larvae. Higher stocking densities, intensive feeding, aeration, genetic selection, disease control, and improved pond management including polyculture, are other factors which have improved warm-water aquaculture here. Rapid acceptance and spread of intensive fingerling production in small ponds received an initial impetus from a commercial experiment with an average yield of 5 515 kg/ha in 1981 (Petrinec, et al., 1983). The present yields of 10 to 14 t/ha/year at pilot scale production of two-summer fingerlings and market-size fish exert a strong influence on developmental trends in carp farming (Petrinec and Dordević, 1989).

Trout: Trout culture, the second important form of aquaculture in Yugoslavia, which is devoted mainly to the production of rainbow trout in fresh water, has developed more slowly. In general, trout ponds vary in area from a couple of acres to 2 ha, and total pond area has not increased much. There were about 25 ha in 1966, 26 ha in 1978, 25 ha in 1984, and 27.6 ha in 1987. Production, however, has risen from only 96 t in 1962 (Yugoslavia/EIFAC, 1979) to 206 t in 1963, increasing almost seven-fold to 1 382 t in 1973 (Fijan, 1976), and more than doubling in the next five years to 3 500 t (3 100 t marketed) in 1978 (Yugoslavia/EIFAC, 1979). In 1982, commercial trout farms had a production area of 20 ha and a total production of 4 400 t, 80 percent of which was marketed as table fish (Bojčić and Bunjevac, 1982). In 1984 there were 25 ha of trout farms with a total production of 3 400 t of which 2 720 t or 80 percent were consumable. In 1987 there were about 100 trout farms with 27.6 ha of rearing facilities producing 5 395 t of fish (Milinkovic, 1988; Teskeredzic, et al., 1989). Cage culture of trout in reservoirs of SR Macedonia (Dzurovski and Stefanovski, 1987) and of other republics will have an increased importance for production in near future.

Most cultivated Yugoslavian trout are portion-sized, i.e., 200–300 g. Raising trout to this size requires 18–26 months, while the rearing of big trout of over 1 000 g requires four to five years. The latter rearing is, therefore, not practised (Teskeredžić, et al., 1989). Trout farmers in Yugoslavia have relied on artificial feeding for some years and have gradually installed modern methods. Most of the trout is consumed within the country, but export markets are also important.

Aside from commercial culture, salmonids including the huchen are reared to stock open waters for sport fishing.

The largest trout breeders using fresh water are in the southern and western part of the country, but a new development in Yugoslavian trout culture is the use of salt water as a cultural medium (see below).

Brackishwater and seawater culture: In some coastal waters of Yugoslavia (Adriatic) opportunities also exist for brackishwater aquaculture of finfish. An ADCP team which spent a week in Yugoslavia in 1978 reported that there was no commercial culture of "marine" fish in the country, but that it was possible. The team stated that cage culture for sea bass (Dicentrarchus labrax) was planned in deep protected bays such as Novigrad, Telascica on Dugi Otok, and Limski Kanal. They also proposed valliculture (see the review of Italy) in the lagoons in the delta of Neretva and Bojana, and at Portorož and Pomer where mullet (Mugil spp.) are now fished, as well as commercial mullet culture in abandoned salt pans in Portorož. Potential for fish culture in Lake Vrana was also postulated (ADCP, 1979). Trials using sea bass and gilthead (Sparus auratus) were made near Zadar in 1976, where ten years later there were both cages and an area using heated and recirculated sea water (Lisac, 1986). Cage culture has also been tested at other locations (Teskeredžić and Fijan, 1977). Girin (1989) says there are two hatcheries in Yugoslavia for sea bass and gilthead. Brackish waters of the Krka estuary are successfully utilized for cage culture of rainbow trout and silver salmon (Oncorhynchus kisutch) (Teskeredžić and Edwards, 1986, 1987). The latter species was introduced to Yugoslavia in 1981. Several hundred tons of salmonids and sea bass are now being produced at this location. Teskeredžić, et al. (1989) are highly enthusiastic about using floating cages in Yugoslavia's salt water to raise salmonids. They believe that an Adriatic production of about 1 000 t/year is possible, and that waters from Pula to south of Dubrovnik are suitable for this purpose. This belief, it may be noted, is contrary to that of Girin (1989) who said "…the high summer temperatures of coastal waters in the Mediterranean region are not favourable to a great development in salmonid culture in saltwater…"

Experimental culture has also been carried with eel using recirculated water and with the cichlid, Oreochromis mossambicus (Yugoslavia, 1980) but these attempts have been impracticable.

8. OWNERSHIP, ADMINISTRATION, MANAGEMENT, INVESTIGATION AND AGREEMENTS[1]

8.1 Ownership and Availability

According to the Constitution of the Socialist Federal Republic of Yugoslavia, and the constitutions of the socialist republics, all the open fresh waters (rivers, lakes, etc.) as well as fish and other aquatic animals are under the ownership of society. (In Croatia, for example, even leeches fall within the provisions of the inland fishery act.) There is no private ownership of water. (Under the Yugoslavian Constitution, waters are treated and protected not only as natural resources, but also as goods of general use or general interest. Waters, watercourses, the sea and seashore are goods in public use, enjoy special protection, and may only be used under conditions and in the way specified by law.) Land by the water's edge can, however, be a private property but its use is limited.

Open fresh waters are managed by communes, which are legally authorized under established conditions to open them for exploitation to sport fishing organizations or individuals engaged in commercial or sport fishing. Under these and other conditions, organizations and individuals acquire the right of ownership, namely the utilization of fish and other aquatic animals that are caught.

The administration, management, and regulation of Yugoslavia's open water fisheries will be discussed below. With respect to commercial fish ponds, which are capital assets of the organizations, the regulations for freshwater fishing apply only insofar as the control of fish diseases is concerned.

[1] This section is derived primarily from Gaudet (1974), material sent to EIFAC by Yugoslavia in 1979, Pietrogianna and Sturm (1983), and Yugoslavia/EIFAC (1989)

8.2 Administration and Management

8.2.1 Federal level

The Federal Committee for Agriculture (Development Department) is responsible for fishery administration at a national level, but only for questions of national importance when the responsibility lies with the Federation.

The Development Department deals with administrative economic matters in agriculture and forestry. The livestock section within the agricultural part of the Department also deals with fishery matters.

Within the Federal Committee for Agriculture, there is also a Legislation Division responsible for legal affairs in fisheries, but only those within the competence of the Federation or having an interest for the country as a whole. These include mainly international relations.

The Federal Committee for Agriculture is, among others, responsible for the control of infectious animal diseases threatening the country as a whole, for release of veterinary drug sales, and for transfer of animals, including fish and other aquatic animals, across the state borders.

8.2.2 Republic level

Since 1950, Federal fishery administrations have been decentralized and fishery matters turned over to the Republic and from them to districts and communes. The six republics have kept only matters of importance for the Republic alone. Fishery administration within a republic is dealt with by its Secretariat for Agriculture (except in the case of Montenegro where it is the responsibility of the Secretariat for Economic Affairs which includes agriculture).

The sea and inland fishery administration, which is the responsibility of the Republic as a whole or of the autonomous provinces, includes the following studies:

(i) drafting laws and regulations concerning fishing and conservation of fish and other aquatic animals;

(ii) analysis and study of certain legal/economic fishery problems;

(iii) commenting on, suggesting, and explaining federal and provincial draft regulations and other technical documents that are related to the fields of sea or inland fisheries;

(iv) performing administrative/legal affairs, e.g., decisions of secondary importance, explanations as to the application of Republic or provincial regulations, the supervision and expert assistance to commune administrative authorities as to application of regulations, etc.;

(v) fishery inspection within the limits of responsibility of the Republic or province, namely supervision of the communal organizations responsible for fisheries, i.e., direct supervision of the work of communal organizations for fishery inspection; training of personnel concerned with fishery inspection, etc., and

(vi) cooperation with Federal and Republic organizations on fishery problems.

8.2.3 Commune level

Following progressive decentralization (from the Federal to the Republic, Republic to province, and province to commune), the major part of administrative matters in the field of fisheries has been dealt with by the commune authorities responsible for economic affairs (inspection).

In some communes where marine or inland water fishing is of special economic importance, there is a section for fisheries and/or a service for fishery inspection responsible for fishery administration and supervision of enforcement of fishery regulations. However, in those communes where fisheries are of no particular economic importance, administrative responsibility lies within the agricultural administration or inspection service.

Communal assemblies and their organizations are obliged to deal with fisheries administrative matters, particularly in:

(i) management of open waters in their territory, i.e., granting the rights of exploitation of these waters by commercial fishery or sport organizations, or to individual commercial or sport fishermen;

(ii) regulation of particular fisheries in certain areas or for a definite period of time;

(iii) issuance of permits for commercial and sport fishing to individuals;

(iv) direct supervision for the enforcement of Federal, Republic and local fishing regulations;

(v) issuance of special permits for fishing or taking other aquatic animals;

(vi) undertaking measures for improvement of fisheries in the area, and

(vii) keeping a fishery register of open waters, fishing gear and craft, and records of commercial fishing and sport organizations and individual fishermen engaged in commercial fishing in the areas, when it is so provided by regulations.

8.2.4 Fishing permits

(i) Commercial fishing

Under Republic laws, commercial fishing in open fresh waters can be carried out by enterprises inscribed in the register of commercial enterprises at the district economic courts. After registation, the organization can fish commercially in waters designated for exploitation under contracts with the communes responsible for the concerned fishing area.

Under the same regulations, commercial fishing in open waters can be practiced by individual fishermen who are issued an annual permit by one of the organs of the commune responsible for fishing. (Conditions to be fulfilled to obtain a permit are: the individual must be a Yugoslav national, capable of running an enterprise, fishing must be the main or one of his main occupations, and he must not have any court prohibition to pursue this occupation.)

(ii) Sport fishing

Sport fishing in fresh waters can be practiced by members of fishing associations and other persons for the purpose of personal recreation.

For sport fishing in open waters which are the responsibility of communes and are not for exploitation by commercial fisheries or sport organizations, the organization of the commune responsible for fisheries issues: (a) annual permits for sport fishing to members of sport associations, and (b) daily permits for sport fishing valid not longer than 30 days.

However, in waters open for exploitation by sport fishing associations, its members can fish without the commune permit, and need only an association card.

Sport fishing in Yugoslavia's open waters involves only angling, and sport fishermen cannot sell or barter their catch.

8.2.5 General protection

There are many measures for the protection and improvement of inland fishing. For example, it is forbidden to pollute fishing waters by discharge of substances that destroy fish or have harmful effects on their habitat, to catch fish by underwater gear, to erect deterrents to fish migration, etc.

8.3 Investigation and Education

Biological and technological research to improve inland fisheries (yields, decrease of production costs for pond culture, etc.), and to suggest measures for conservation and improvement of fisheries in open waters (rivers, lakes, etc.) are carried out at institutes for freshwater fisheries or faculties of agriculture in the republic centres of Belgrade, Zagreb, Skopje, Titograd, Novi Sad, Sarajevo and Ljubljana.

8.4 Other Concerned Agencies

Professional institutes and business associations (members of communal and Republic chambers of economy and of the Chamber of Economy of Yugoslavia) are also engaged in the promotion of inland fisheries. They cooperate closely with the Yugoslav business association for the improvement of freshwater fisheries of which the members are fishery enterprises and cooperatives.

In addition to groups actively interested in the promotion or improvement of inland fisheries, there are many agencies in Yugoslavia and much legislation concerned with land and water use that can affect fisheries. Both the agencies and the legislation are at several levels of government, and the autonomy of the socialist states adds to this complexity. The paper on water law in Yugoslavia by Pietrogianna and Sturm (1983) provides a detailed review of this subject.

8.5 International Agreements

Yugoslavia has bilateral agreements concerning uses of common boundary streams or international waters with: Albania, Austria, Bulgaria, Greece, Hungary, Italy, and Romania. See, for example, Yugoslav Survey (1976, 1976a). It has a quinque-lateral agreement concerning the Tisa (Tisza) River with Czechoslovakia, Hungary, Romania and the USSR.

It belongs to the Danube Commission, along with the other Danube countries, concerning navigation and related matters. It adheres to the Convention on Fisheries of the Danube together with Bulgaria, Czechoslovakia, Hungary, Romania and the USSR, to take joint action to protect the river's fish stocks.

It also has a bilateral agreement with Italy concerning the Adriatic Sea.

9. STATE OF THE FISHERY

9.1 Yield

As has been shown in section 7, Table 7 which lists the total “catch” of inland fish in Yugoslavia for the 1965–87 period cannot be taken as indicative of the harvest of wild fish. Other evidence indicates, however, that the harvest from the commercial fishery may be at least holding its own, although there may be a decline in the catch of the more valuable fish such as pike-perch, wels, and common carp.

The yields reported from some major Yugoslavian waters are shown in Table 10. Since the total area devoted to inland fisheries can only be estimated roughly (see section 5), little dependence can be placed on the figures in the table for countrywide yields. More credence can be placed in the figures for the large lakes. Fijan (1986) believes that the catches in these lakes in 1973–82 were less than those of 1945–55. Conversely, he states that both the commercial and sport catches in Croatia are increasing. Differences in reported yields can be attributed not only to the relative richness of the waters or the fish stocks, but to the manner in which they are exploited and the area (in the case of fluctuating lakes) used for calculation.

The yield from production of cultivated fish has increased decidedly. With respect to cultivated carp ponds, the average annual yield increased from 342 kg/ha in 1938 to 738 kg/ha in 1960, jumping to 987 kg/ha in 1961 (Dill, 1966). By 1978, there was a yield of 1 196 kg/ha/year for overall production in carp ponds, and 674 kg/ha/year for marketed production. In 1984, the total yield in carp ponds was 1 041 kg/ha/year while the marketed production was 833 kg/ha/year (Table 9). Experimental production has succeeded in yields of over 10 000 kg/ha/year.

9.2 Factors Affecting the Fishery

Yugoslavia has a wide variety of fishing waters, including its meandering and anastomosing plains rivers with backwater and overflow areas, both rocky and meadow trout streams, large tectonic-karstic lakes and smaller glacial lakes and tarns. Most of the country has some inland waters of consequence, and there is a high density of fluvial water per unit area. The karstic nature of a large segment of the country does result in diminishment of surface waters, but limestone terrain furnishes enrichment for aquatic life.

The fish fauna is also diversified. Although coregonids are lacking, it contains most of the common commercial and sport fishes of Europe as well as some unique Balkan species and the rare but highly prized huchen.

Rock and soil types, climate, and the long growing season in much of the country are favourable to both cold- and warm-water fishes.

Land and water uses have been very important in determining the direction of Yugoslavian fisheries. The original endowment of large rivers with low gradient, and a hydrological regime which flooded fertile overflow areas, guaranteed abundant spawning and nursery areas. It also promoted the development of a variety of local fishing methods. But, as in the other middle and lower Danube countries, river regulation has shortened, diked and channelized the larger rivers, and, along with drainage, has diminished the good spawning and nursery areas.

The climatic conditions, including dry summers and frequent droughts, definitely require irrigation for good crop production. Its development, which is still well below the European average, will further diminish the amount of water available for fish as well as take a toll through their diversion into ditches and fields. (Circa 1986, only 2 percent of Yugoslavia's arable land was irrigated.) The European average was 13 percent. In the other Balkan states, Romania irrigated 30 percent, Bulgaria irrigated 32 percent, Greece irrigated about 38 percent, and even Albania irrigated 66 percent of its arable lands. The practice will, however, have compensatory advantages in some areas by increasing the amount of static water through impoundment.

Table 10

Yields from open waters in Yugoslavia

Water	Kg/ha/year	Source
Total inland waters	40[a]	Meschkat (1956)
Cyprinid waters	80–120	Fijan (1976)
Trout waters	35	Fijan (1976)
Skadar Lake	45	Meschkat (1956)
Skadar Lake	50	Stein, Mecom and Ivanović (1975)
Ohrid Lake	8	Meschkat (1956)
Ohrid Lake (1930–57)	9	Stanković (1960)
Ohrid Lake	10–12	Yugoslavia/EIFAC (1979)
Prespa Lake	6.8	Meschkat (1956)
Prespa Lake (ca 1952–72)	5–7	Apostolski (1972)
Dojran Lake	227	Meschkat (1956)
Dojran Lake	170–290	Yugoslavia/EIFAC (1979)
Major brackishwater complexes	20–30	Levi and Troadec (1974)
Lake Vransko	23	In Dill (1966)
Lagoons	25	Amanieu and Lasserre (1981)

[a] Based on a catch of 10 000 t annually from 2 500 km^2

Similarly, the continued growth of the hydroelectric industry will affect fisheries through its regulation of water. The construction of dams on the Danube has already affected its runs of anadromous fishes, e.g., of the sturgeons, only Acipenser ruthenus is now found above the Djerdap dam (Janović, 1978). Yugoslavia is well fitted for the construction of hydroelectric reservoirs, not only on its lowland rivers but in the highlands outside the Karst area where rivers high in slope and with valley suitable for damming will be subject to development. New dams, especially with pumped storage, in dry valleys will increase static water for fisheries but will be subject to constant fluctuation.

The steep relief in Yugoslavia promotes erosion accompanied by degradation of forest and pasturelands in both mountain and coastal areas. Over 1.5 million ha have been eroded by torrents and up to 3.5 million ha exposed to milder erosion. The Velika Morava and its two main tributaries alone wash away about 33 million m^3 to be deposited at its mouth and in Derdapsko (Janković, 1978). Accompanied by poor forestry practices and overgrazing by livestock, such erosion has directly destroyed aquatic habitat, altered flow patterns, and silted the waters.

Pollution from industrial mining, and domestic wastes is also serious, e.g., over 100 factories dump waste into the Yugoslavian Danube and its tributaries, and 100 km of the Una River was once destroyed by papermill wastes. Not only the drastic fish kills, however, are of importance. In some areas, such as the Danube and Morava, there has been a degradation of the quality stocks accompanied by increase and spread of more resistant forms like Chondrostoma nasus and the chub, Leuciscus cephalus. However, industry is somewhat scattered in Yugoslavia (it lacks the great industrial complexes found in countries with extensive deposits of high-grade coal), and the amount of surface water available for effluent dilution is quite high. The average annual runoff per caput is 9 500 m^3 well above the European average. (This calculation uses the mean annual discharge cited by Van der Leeden (1975) of 227 000 million m^3. If the higher figure of 244 000 million m^3 given by Miloradov and Djordjevic (1978) is used, the average annual runoff per caput is 10 211 m^3.) Much of this runoff, however, leaves through the Danube, and some areas have very little surface water for dilution of effluent.

Th Government has an avowed policy to diminish pollution. The control of pollution in inter-republic or inter-state waters is regulated by Federal law. Construction of new industrial and other plants obligatorily includes the design and construction of water purifying facilities. However, the principal polluters are facilities which were built earlier, where stimulation to change may be afforded by increases or decreases in the level of the water rate that is levied.

Yugoslavia's position on the border of seven countries affords other problems which concern its fisheries. It is a recipient of polluted water from upstream countries and a donor to those downstream. Thus, the Danube enters carrying considerable effluent. It is also confronted with a need to manage several international fisheries in its border rivers and lakes and those waters which pass from one country to another. For example, the proper management of Yugoslavia's several lakes shared with Albania and Greece entails agreements with these countries to insure protection and use of their common stocks. This applies not only to regulation of mixed stocks, but to the effect of barriers on connecting streams. For example, the supply of mullet, eel and shad migrating from the Adriatic to Skadar Lake has been cut down following construction of a harvesting weir on its outlet, the Bojana River, by Albania. Yugoslavia also has international agreements concerning water use and management. It belongs to the international Danube Commission, formed in 1948 to ensure free navigation and management on this river from Ulm (Germany) to its mouth. It also has individual treaties creating Water Exploitation Management Commissions with Albania, Bulgaria, and Hungary; belongs to a Yugoslav-Romanian Hydrotechnical Commission; and has standing Yugoslav-Austrian Commissions on the rivers Drava and Mura (see Section 8.5).

Commercial fishing, long traditional on Yugoslavia's larger lakes and floodplains using rather primitive and locally constructed gear, is changing to the use of modern equipment. One reason for the importance of using a large percentage of freshwater fish in the interior has been the difficulty of reaching this area from the Adriatic, but improved transport, preservation, and storage is changing this picture.

With respect to sport fishing, the predominantly agrarian population and relatively undeveloped transport system (including low ownership of private automobiles) have been among the reasons which have kept sport fishing among resident Yugoslavians at a low level.

Warm-water fish culture was introduced into Yugoslavia at the beginning of this century and after the first world war developed rapidly. Carp culture is considered an integral part of agricultural development, and trout culture has fared well in recent years. Yugoslavia has been fortunate in having good local advice and in enlisting the aid of foreign experts to develop its fish farms. The use of large ponds has sometimes made their management difficult, and the country has, of course, the usual pond farm problems concerned with fertilization, feeding, water pollution with oxygen loss, and weed control. With no tradition of using its lagoons for culture, as in Italy, brackishwater finfish culture has not developed rapidly but it now seems to be on its way.

9.3 Prospect

Although the traditional fisheries for warm-water floodplain fishes have persisted, they are inevitably declining as regulation, irrigation, drainage, navigational and hydroelectric development, and pollution continue. Commercial fishing in natural lakes will have greater persistence, the yields being dependent largely upon the extent to which pollution is minimized and good management procedures are agreed upon by the participating countries. In general, the number of professional fishermen and their use of traditional gear will decline, and sport fishing in these lakes will achieve greater importance.

Reservoir fishing will achieve more importance in Yugoslavia as the number of multi-purpose units increases, and transfers from water-rich to water-poor areas will further influence the fisheries.

Sport fishing, ranging from simple recreational fishing for coarse fish to very attractive angling for salmonoid fishing, has a great potential in Yugoslavia. There will be a decided growth in angling for both residents and tourists.

Pond fish culture for both warm- and cold-water species can continue development. The potential in available land and water areas still exists, and the use of introduced fishes will increase the yield. There are indications that the production can double. In 1966, some Yugoslav fish culturists believed that the pond area could be increased (from the then 8 860 ha) to 30 000 ha with a yield of about 1 000 kg/ha/year. Ten years later (Kuzmanovski, 1977) it was estimated that by 1987 these ponds could be increased to a total of 45 000 ha with an annual fish harvest of 70 000 t. If accomplished, the water requirement would rise to 1 430 million m^3 annually, with 86 percent of the water returned to water courses. Bojčić (1986) has estimated that another 40 000 ha of carp ponds and another 10 ha of freshwater trout farms could be created. Furthermore, the development of lagoon fisheries and the production of salmonids in the saltwater of the Adriatic would greatly increase the harvest of finfish in Yugoslavia.

The overall prospect for inland fisheries in Yugoslavia depends largely upon the execution of plans for water development. The avowed governmental aim is for: emphasis on long-range planing, development of complex multi-use systems, and basic water planning within the republics for the use of river basins (water management units) as the units for basic water planning. If fish are given due consideration in such planning, the prospects for both continued capture fisheries and aquaculture are good. (For example, a water plan for the Sava River involves construction of 33 new reservoirs, pollution control, river training, increase in irrigation and hydropower, cutting off some canals, and expansion of fish farms from 6 600 to 15 000 ha.) On the other hand, as has been emphasized in this report, the preservation and development of fisheries are often unrealized unless these aims are specifically emphasized in such wide-reaching programmes. In this respect, it may be noted that a “Draft Outline of a Common Policy for Long-term Development in Yugoslavia (until 1985)” mentions: food production, water development, water quality, recreational activity, and tourism, but makes no mention of fish, fisheries or angling (SFRI Assembly, 1975).

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