FAO Fisheries Synopsis No. 36 FRI/S 36
(Distribution restricted) SAST - *A. brama* – 1,40(02),001,02

SYNOPSIS OF BIOLOGICAL DATA ON THE BREAM

Abramis brama (Linnaeus, 1758)

Prepared by
T. Backiel and J. Zawisza

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1968

DOCUMENTS OF THE FISHERY RESOURCES AND EXPLOITATION DIVISION OF FAO DEPARTMENT OF FISHERIES

Documents which are not official FAO publications are issued in several series. They are given a restricted distribution and this fact should be indicated if they are cited. Most of them are prepared as working papers for meetings, or are summaries of information for use of member governments, organizations, and specialists concerned.

FAO Fisheries Report FR/R (No.)
FAO Fisheries Circular FR/C (No.)
FAO Fisheries Synopsis FR/S (No.)

Special groups of synopses are identified by symbols followed by classification numbers based on indexed code of "Current Bibliography":

- SAST Data concerning certain species and fish stocks.
- MAST Information on methods and subjects.
- OT Oceanographic data.
- IT Limnological data.

and

- CART Information concerning fisheries and resources of certain countries and regions (FID/S).

FAO Fisheries Technical Paper FR/T (No.)

Special groups of Technical Papers are identified by:

- RE Indexed lists of experts and institutions drawn from Registers maintained by the Fishery Resources and Exploitation Division.
- CB Lists of periodicals, special sections of "Current Bibliography for Aquatic Sciences and Fisheries," special bibliographies and papers concerning documentation problems.
- MFS Provisional editions of "FAO Manuals in Fisheries Science."

Some documents also have another identification, if, for example, they have been contributed to a meeting for which papers have been numbered according to another system.

DOCUMENTS DE LA DIVISION DES RESSOURCES ET DE L'EXPLOITATION DES PECHES DU DÉPARTEMENT DES PECHES DE LA FAO

Des documents qui ne figurent pas parmi les publications officielles de la FAO sont publiés dans diverses séries. Ils font seulement l'objet d'une distribution restreinte, aussi convient-il de le préciser lorsque ces documents sont cités. Il s'agit le plus souvent de documents de travail préparés pour des réunions, ou de résumés d'information à l'intention des gouvernements des pays membres, ainsi que des organisations et spécialistes intéressés. Ces séries sont les suivantes:

Des catégories spéciales de synopses sont identifiées à l'aide de symboles suivis des chiffres de classification basés sur le code d'indexation de la « Current Bibliography »:

- SAST Données sur certaines espèces et populations de poissons.
- MAST Renseignements sur des méthodes et des sujets.
- OT Données océanographiques.
- IT Données limnologiques.

et

- CART Renseignements sur les pêcheries et les ressources de certains pays et régions (FD/S).

Des catégories spéciales de documents techniques sont identifiées à l'aide des symboles suivants:

- RE Listes indexées d'experts et institutions tirées des registres tenus à jour par la Division des ressources et de l'exploitation des pêches.
- CB Listes de périodiques, des sections spéciales de la « Current Bibliography for Aquatic Sciences and Fisheries », des bibliographies particulières et des articles sur les problèmes de documentation.
- MFS Editions provisoires des « Manuels FAO de science halieutique ».

Certains documents portent d'autres numéros d'identification, par exemple, s'ils ont été préparés pour une réunion dont les documents ont été marqués à l'aide d'un autre système.

DOCUMENTOS DE LA DIRECCION DE RECURSOS PESQUEROS Y EXPLOTACION DEL DEPARTAMENTO DE PESCA DE LA FAO

Esta Subdirección publica varias series de documentos que no pueden considerarse como publicaciones oficiales de la FAO. Todos ellos tienen distribución limitada, circunstancia que debe indicarse en el caso de ser citados. La mayoria de los titulos que figuran en dichas series son documentos de trabajo preparados para reuniones o resúmenes de información destinados a los estados miembros, organizaciones y especialistas interesados.

Grupos especiales de sinopsis se distinguen con las siglas siguientes, seguidas por números de clasificación que se basan en las claves de los indices de la « Current Bibliography ».

- SAST Datos relativos a ciertas especies y poblaciones.
- MAST Sinopsis sobre métodos y materias.
- OT Sinopsis sobre oceanografia.
- IT Sinopsis sobre limnologia.

y

- CART Información sobre los recursos acuáticos vivos de algunos paises y regiones (FID/S).

Grupos especiales de documentos técnicos se identifican por las siglas siguientes:

- RE Listas indices de expertos y de instituciones tomadas de los registros que se llevan en la Dirección de Recursos Pesqueros y Explotación.
- CB Listas de periódicos, secciones especiales de la « Current Bibliography for Aquatic Sciences and Fisheries », bibliografías especiales y trabajos relativos a los problemas de documentación.
- MFS Ediciones provisionales de los « Manuales de la FAO de Ciencias Pesqueras ».

Algunos documentos tienen también otra identificación si, por ejemplo, son contribuciones a una reunión cuyos documentos han sido marcados con arreglo a otros sistemas.

SYNOPSIS OF BIOLOGICAL DATA ON THE BREAM

Abramis brama (L.)

Prepared by

T. BACKIEL and J. ZAWISZA

Inland Fisheries Institute
Poland

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, February 1968

PREPARATION OF THIS SYNOPSIS

This synopsis of biological data on the bream has been prepared to fulfil the Program of Work established at the Second Session of EIFAC, Paris, May 1962.

The authors have the pleasure of acknowledging the cooperation of Dr. M. Gasowska, Zoological Institute, Pol.Ac.Sci., who helped in writing chapters 1 and 2, and Dr. J. Grabda, Center for Combating Fish Diseases, Olsztyn, who prepared section 3.35. Special thanks should go to the persons listed below who have supplied valuable data, not published elsewhere, summarized in Tables XXII and XXVII.

Mr. K. Apostolski,	Fisheries Institute of S.R. Macedonia, Yugoslavia
Mr. J. Dahl,	Denmarks Fiskeri - og Havundersgelser, Denmark
Dr. W. Einsele,	Bundesinstitut für Gewässerforschung und Fischereiwirtschaft, Austria
Dr. Entz Bela,	Biologisches Forschungsinstitut, Hungary
Mr. A.E. Hofstede,	Inland Fisheries Inspection, Netherlands
Prof. M. Huet,	Station des Recherches des Eaux et Forêts, Belgium
Dr. L. Ivanov,	Institut za Rybarstvo i Rybna Promyshlennost, Bulgaria
Mr. K. W. Jensen,	Fisheries Research Officer, Norway
Mr. E.D. LeCren,	Freshwater Biological Association, England
Dr. H. Mann,	Bundesforschungsanstalt für Fischerei, Hamburg, F.R. Germany
Mr. H.V. Mentzel,	Institut für Binnenfischerei, Berlin, D.R. Germany
Mr. K.A. Pyefinch,	Freshwater Fisheries Laboratory, Scotland
Mr. I. Sasserson	Institute Freshwater Research, Sweden
Mr. V. Sjöblom,	Bureau of Fisheries Investigations, Finland
Dr. F.W. Tesch,	Biologische Anstalt, Helgoland, F.R. Germany
Mr. P. Tombleson,	"Angling Times", Peterborough, England
Mr. E.D. Toner,	Fisheries Division, Eire
Dr. W.B. Ziemiankowski,	Statiunea Experimentala Stuficola Delta Dunarii, Maliûc, Roumania

Our appreciation of Mr. and Mrs. W. Rumszewicz's translation must be expressed.

We also extend our thanks to Dr. D.I. Williamson of the Marine Biological Station, Port Erin, Isle of Man, for his help in the technical editing.

Distribution

Author
FAO Department of Fisheries
FAO Regional Fisheries Officers
Regional Fisheries Councils and Commissions
Selector 2

"Current Bibliography" entry

Backiel, T. & J. Zawisza 13-6F084
(1968)
FAO Fish.Synops., (36): pag.var.
Synopsis of biological data on the bream *Abramis brama* (L.)

Taxonomy. Morphology. Distribution.
Life history. Population structure.
Exploitation. Management. Culture.

CONTENTS

---

* As no information was available to the author, these items have been omitted from the text.

1 IDENTITY

1.1 Nomenclature

1.11 Valid names

Cyprinus brama Linnaeus, 1758, Systema Naturae, 10th Ed.

Abramis brama (Linnaeus): Cuvier, 1817, Regne Anim., II

1.12 Objective synonymy

There are no junior objective synonyms of the name.

Abramis brama (L). An objective synonym of one of its subspecies is given in section 1.23.

1.2 Taxonomy

1.21 Affinities

Suprageneric

Phylum Vertebrata
Subphylum Craniata
Superclass Gnathostomata
Series Pisces
Class Teleostomi
Subclass Actinopterygii
Order Cypriniformes
Suborder Cyprinoidei
Family Cyprinidae

Generic

Abramis Cuvier, 1817

The generic concept adopted here is that of Berg (1949).

Body laterally strongly compressed. Pharyngeal teeth in one row 5-5, sporadically 6-5 or 5-6, their crowns compressed and oblique with a groove on the masticating surface. A scaleless keel on the belly; a scaleless furrow along the edge of the back, from head to dorsal fin; no keel behind the dorsal fin. Dorsal fin begins behind the vertical line drawn from the base of ventral fins, ray formula D III 8-10; anal fin long, begins before a vertical line drawn from the end of the dorsal fin, ray formula A III 15-44. Scales strongly attached to the skin. Lateral line slightly convex ventrally, without sharp curves. Mouth small, upper jaw protractile.

According to Berg (1949), this genus contains the four species: A. brama (L.), A. sapa (Pallas) A. ballerus (L.) and A. melanops Heckel. However Karaman 1924 (in Berg, 1949; in Drenski, 1951) put the last species in the genus Vimba; if this is done, the generic definition should be modified to Anal fin III 21-44.

Specific

Abramis brama (Linnaeus, 1758) (Fig. 1)

Type locality: Gulf of Finland

Diagnosis: Fin formula D III 9(10), A III (23) 24-30; L.l. 49-60; gillraker count 17-25, vertebral count 38-46. Body deep, maximum height 35-40 percent of standard length. (Tables I and II).

Subjective synonymy

Cyprinus farens Linnaeus, 1758, placed in synonymy in Siebold (1863) as description of young specimens.

Abramis microlepidotus Agassiz, 1835, and

Abramis argyreus Agassiz, 1835, both placed in synonymy in Siebold (1863); reasons discussed.

Abramis vetula, Heckel, 1835, placed in synonymy in Siebold (1863) and Blanchard (1880); reasons discussed.

Abramis gehini Blanchard, 1880, placed in synonymy in Moreau (1881) as a "variety" of A. brama.

Key to the species of Abramis simplified (from Berg, 1949).

1 (6) Anal fin more than 20 soft rays.

2 (3) Anal fin less than 30 soft rays. Lateral line less than 60 scales ...

A. brama (L)

3 (2) Anal fin more than 30 soft rays.

4 (5) Lateral line less than 60 scales ...

A. sapa (Pall.)

5 (4) Lateral line more than 60 scales ... A. ballerus (L.)

6 (1) Anal fin 20 or less soft rays.

7 (8) Dorsal fin usually 9-10 soft rays ... hybrid of bream and roach

8 (7) Dorsal fin usually 8 soft rays. Balkan Peninsula ... A. melanops Heckel.

1.22 Taxonomic status

This is a well defined species by morphological as well as by breeding data (cf. hybrids, section 2.4). It seems to be polytypic. No published analysis of this subject is available.

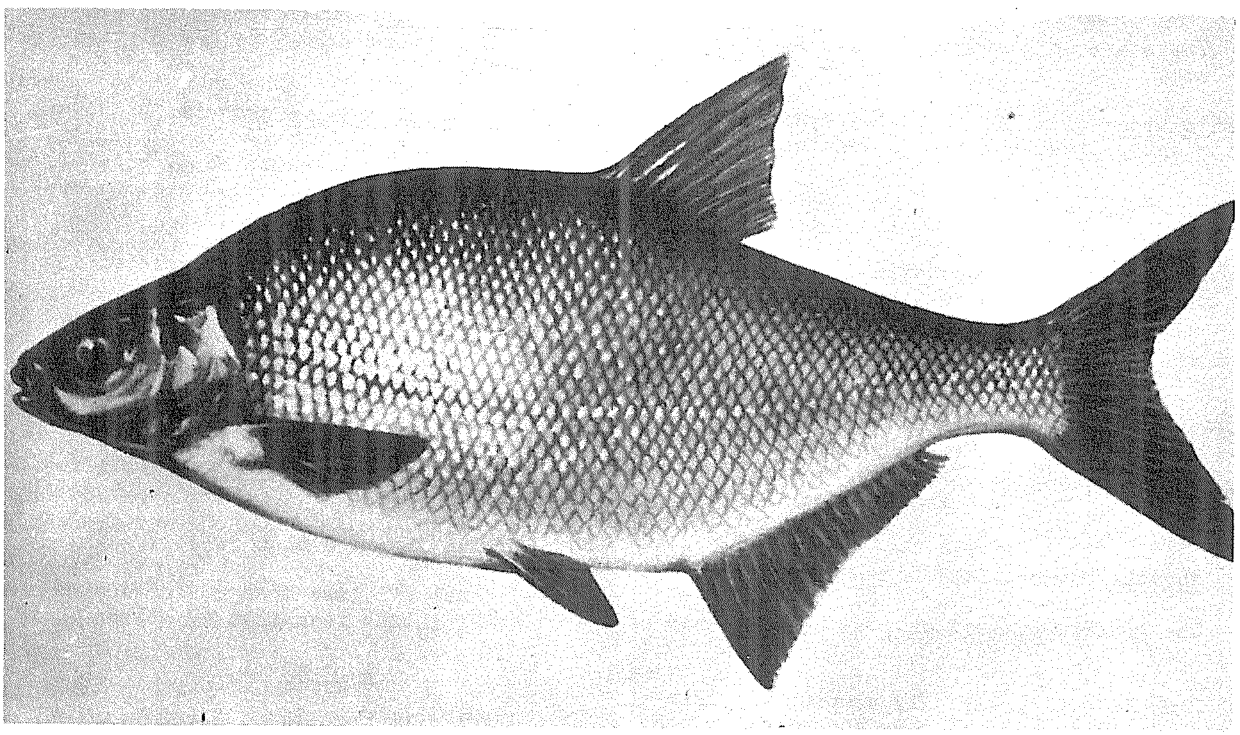

Figure 1. The bream, *Abramis brama* (Linnaeus).

Table I

Meristic features of the subspecies of Abramis brama

Abramis brama brama (Linnaeus, 1758)

Fin D range	Fin D mean	Fin A range	Fin A mean	lateral line range	lateral line mean	gill-rakers range	gill-rakers mean	vertebrae range	vertebrae mean	authors, regions
III 9(10)	-	III (23)24-30	27.4	51-60	55.2	19-24	22.5	(44)45-46	45.0	Berg (1949) Gulf of Finland
-	-	22-28	25.1	52-57(59)	54.2	(22)23-25	23.6	(43)44-45	44.1	Markun (1929) Pskovskoe Lake
III (8)9(10)	9	III (22)23-27(28)	24.9	50-58	54.1	17-25	19.8	41-44	44.0	Potapova (1954) Sjamozero
III (8)9-10	9.5	-	23.4	-	52.5	20-27	23.5	-	44.0	Pavlov (1956) Dnepr River
III 9	9	-	25.7	-	54.9	-	25.2male 22.2female	-	44.5	Klimova, after Berg (1949) Yaskjärvi
III 8-10	9.3	III (22)23-27(28)	25.1	(49)50-57	53.3	21-25	23.27	(41)42-45	43.05	Zhukov (1958) Nemen River
10-12	-	26-32	-	49-57	-	-	-	42-45	-	Ladiges (1960) Nordmark
III 9	9	III 23-28	-	51-56	-	-	-	43-45	-	Bauch (1963) Germany
III 8-10	9.0	III 23-29	25.7	(50)51-57	53.86	21-25	23.12	43-45	44.46	Gasowska (MS) Vistula River
				Abramis brama orientalis Berg, 1949						
III 9-10	9.1	III 23-28	25.7	(49)50-55(56)	52.3	(20,21,22) 23-30	26.0	(42)43-44	43.4	Markun (1929) Aral Sea
-	-	-	25.9	-	53.45	-	25.22	-	44.5	Shaposhnikova (1948) Volga River
				Abramis brama danubii Pavlov, 1956						
III 9-10	-	III/23,24/ 25-28	25.8	50-56	52.7	18-26	22.5	38-43	40.5	Pavlov (1956) Yalpukh Lake, Danube Estuary
III 9	9	III/24/ 25-26	25.5	52-55(56)	53.2	20-26	22.9	-	-	Pavlov (1956) Kitai Lake, Danube Estuary

Figures in brackets refer to one case only.

Table II

Morphometric characters of Abramis brama (L.), expressed as percentages of standard length; values in upper row for males, in lower row for females

(After Shaposhnikova, 1948, and Pavlov, 1956)

Features	Abramis brama brama (L.) Gulf of Finland	Abramis brama orientalis Berg Aral Sea	Abramis brama danubii Pavlov Yalpukh Lake (males and females combined)
Depth of body	37.00 37.62	38.84 39.58	34.77
Depth of caudal peduncle	9.68 9.56	10.72 10.36	9.79
Antedorsal distance	56.63 58.28	58.62 58.50	56.57
Distance P - V	24.13 24.95	22.96 24.30	22.57
Length of P	19.37 19.04	21.08 20.14	20.31
Base of D	12.54 12.28	13.54 13.25	13.30
Height of D	20.05 20.56	26.16 24.92	22.43
Length of head	21.37 21.38	22.20 22.06	21.76
Length of caudal peduncle	15.19 15.14	13.52 13.68	13.72

1.23 Subspecies

Abramis brama orientalis Berg, 1949.

Synonym (objective): Abramis brama bergi Grib and Vernidub, 1935, placed in synonymy in Berg (1949) as nomen preocupatum.

Type locality: Aral Sea.

It occurs in the basins of the Caspian and Aral Seas.

Abramis brama danubii Pavlov, 1956.

Type locality: Yalpukh Lake and Kitai Lake in the Danube Estuary.

It occurs in the Danube Estuary. Balon (1961, 1962, 1964), Banarescu (1964) and Pacák (1962) used the name of this subspecies for the bream of the Danube River.

The statistical analysis of bream's characters applied by Pavlov (1956) may raise reservations. He used Pravdin's (1939) methods, but, on the criteria of Mayr, Linsley and Usinger (1953), a number of features cannot be considered different enough to be subspecific (Gasowska, MS).

For subspecific characteristics see Tables I and II.

1.24 Standard common names, vernacular names

Table III

Standard common and vernacular names

(After Antipa, 1909, Steinmann, 1948, and others)

Country	Standard common names	Vernacular names
Austria	Brachsen	Brasse, Scheibpleinzen
Belgium	Brème	
Bulgaria	Platika	Diverika
Czechoslovakia	Cejn velký	Pleskác vysoký, lešč
Denmark	Brasen	
England	Bream	
Finland	Lahna	
France	Bréme commune	Brame, Bramme, Brasem
Greece	Lestia	Lestika
Germany	Bracksen	Blei, Brassen, Breitling
Hungary	Dévér Keszeg	Durda
Netherlands	Bley	
Norway	Brasme	Brase
Poland	Leszcz	
Roumania	Platica	Platicuta, Carjanca, Carjencuta, Albitura, Ciabac, Leşt
Sweden	Braxen	
Switzerland	Brachsmen	Steibrachse, Blei, Breiteln, Braese, Blagge Brème, Cormontant, Platton, Bracsele
Turkey	Ciapac balac	
U.S.S.R. (in Russian)	Leshch	Tsebak, Liashch, Laskir

1.3 Morphology

1.31 External morphology

Some morphological data are given in Table II.

Geographic variation small (Shaposhnikova, 1948).

Morphological changes with growth: in juvenile and adolescent phases length/depth ratio decreases with growth. Quantitative data not available (cf. section 3.2).

1.32 Cytomorphology

Lieder (1954) studied chromosomes of roach (Rutilus rutilus) and of the hybrid roach x bream (male): since the hybrid had a similar chromosome count ($2n = 52$) to the roach he concluded that bream also had 52 diploid chromosomes.

1.33 Protein specificity

Schumann (1959) made use of electrophoresis to study haemoglobins of some fish species including bream. He found that bream Hb was dual and that the migration velocity of Hb fractions was specific.

2 DISTRIBUTION

2.1 Total area

Bream occurs in fresh and brackish waters of Europe, off the northwestern part of Asia Minor and in the drainage areas of Caspian and Aral Seas. (Berg 1949; Bănărescu, 1964; Stephanidis, 1937; Ladiges, 1960; Nümann, 1962). The natural distribution area has been enlarged eastwards by transplantation (see section 6.52) Fig. 2.

2.2 Differential distribution

2.21 Spawn, larvae and juveniles

Demersal eggs, adhesive, deposited on hydrophytes in shallow waters, mostly at the depths of 20-80 cm. (for detail see section 3.16).

Larvae remain in shallow water near their hatching place. When they are about 20 mm, juveniles start feeding at the bottom and move away from the shore. At that time (June and July) A. brama orientalis starts its downstream runs to brackish waters (cf. section 3.22).

2.22 Adults

Feeding individuals remain dispersed at the bottom, far from shores. Before winter they gather in schools. Early in spring A. brama orientalis and the bream of the Sea of Azov begin their spawning migration upstream (cf. sections 3.5 and 5.31).

2.3 Determinants of distribution

The lethal temperature for southern bream is 33-34°C (Shkorbatov, 1964). For larvae, 2 weeks old, raised in aquaria at 30°C, the lethal temperature was 37-39°C (Horoszewicz, unpublished data). During embryonic development the temperature of 28-31°C proved to be lethal (cf. section 3.21). Alabaster (1964) recorded 50 percent survival for 1000 min at 30.2°C and 100 min at 31.8°C, (Backiel) in bream acclimatized at 20°C.

Oxygen. Lethal oxygen contents are 1.8 - 1.9 mg O_2/1 for larvae (Kuznetsova, 1958) and 5 mg O_2/1 for embryos (Iurovitskii, 1961). In the case of mature bream, according to Privolnev and Koroleva (1953), it is 0.3 mg O_2/1 at a temperature of 20°C. Alabaster and Robertson (1961) observed pronounced restlessness among bream at an oxygen content of 1-1.5 mg/l.

Salinity. The highest salinity at which bream occur in the Sea of Azov is 12.9°/oo (Karpevich, 1955). Bream eggs can be fertilized in the Aral Sea at a salinity of 10.2°/oo (cf. section 3.21).

Water flow. Bream are not found in the rivers with strong currents (Backiel, 1956; Berg 1949; Shaposhnikova, 1950). Aslanova (1952) found that bream 24-35 cm long could resist a current of 16 cm/sec for up to 3 h 30 minutes when immature but only up to 30 minutes when fully mature.

It seems that the natural distribution of bream is limited by the conditions necessary for their reproduction and embryonic development: maximum temperature not higher than 28°C, high oxygen content, salinity up to 2.8‰ and up to 10‰ in the case of the A.b. orientalis, gentle water flow.

2.4 Hybridization

2.41 Hybrids

- frequency of hybridization; species with which hybridization occurs; methods of hybridization.

Rutilus rutilus (L.) x Abramis brama (L.)

This cross was described by Heckel as Abramis leuckartii; junior synonyms are Abramis heckelii Selys Longchamps, 1842, and Leuciscus buggenhagii (Valanciennes, 1844 (Nikoliukin, 1952). Siebold (1863) named this cross Abramidopsis leuckartii (Heckel) but he was aware that it was a hybrid of the roach and bream. Berg (1949) described it as a cross and gave its characteristics. Nikoliukin (1952) thoroughly examined specimens of this hybrid from natural waters and from artificial fertilization.

Characteristics: D III(IV) 9-10(II), A III(IV?) (13)14-20, P I 15-16, V II 8, C 19, L.1 44-55 $\frac{9-12}{5-6}$, pharyngeal teeth in one or two rows, vertebrae usually 41-44. Keel complete or only half of it is present. Females preponderate over males among sexually mature individuals (Nikoliukin, 1952).

Abramis brama (L.) x Scardinius erythrophthalmus (L.)

Nikoliukin (1952) stated that Longchamps found the above cross in ponds in 1887. Regan (1908) described this hybrid

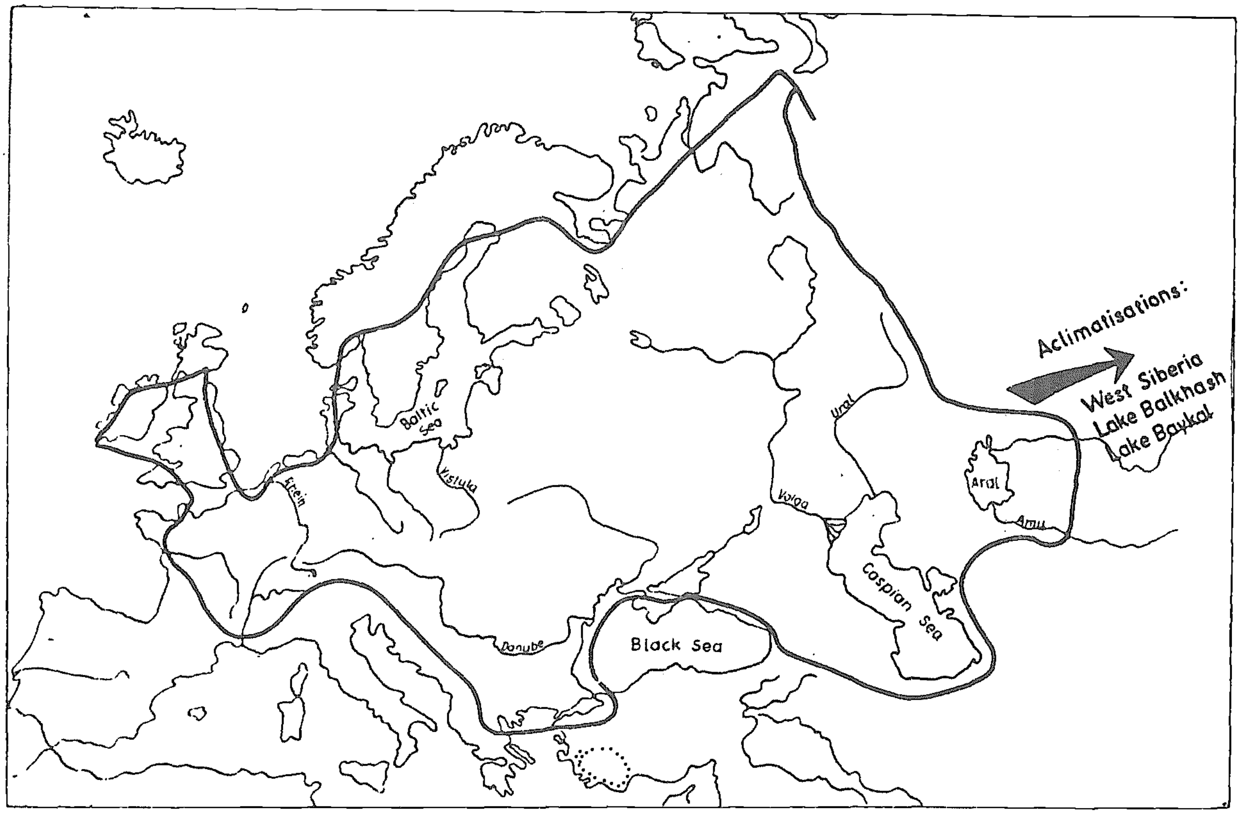

Figure 2. Geographical distribution of bream (after Banaresou, 1960, supplemented by data in Nümann, 1962, and Ladiges, 1960 - dotted line).

from 12 individuals from Ireland and England. Nikoliukin (1952) reared specimens of this cross to an age of five years. The characteristic features given by him are similar to those described by Longchamps and Regan.

Characteristics: externally the hybrid resembles something between the rudd and bream. D III (7)8-9(10), A III(IV) 15-18, L.l 45-51 $\frac{9-11}{4/5-6}$, vertebrae 41-43, pharyngeal teeth usually in two rows.

Blicca bjoerkna (L.) x *Abramis brama* (L.)

According to Nikoliukin (1952) this hybrid was described by Knaute in 1896. Nikoliukin (1952) raised individuals from artificial fertilization until they were 5 years old. Zhukov (1958) obtained one specimen from the Nemen River. According to Nikoliukin (1952) the characteristics of the hybrid are: D 8(9), A (20) 21-25, L.l 48-53, gill rakers 18-22, vertebrae 43, pharyngeal teeth 1.5-5.1. In contrast to the bream, there is no scaleless furrow on the back.

Alburnus alburnus (L.) x *Abramis brama* (L.)

Specimens obtained by Nikoliukin (1952) from artificial fertilizations survived for up to two years. This hybrid can hardly be distinguished from that of

A. alburnus x *Blicca bjoerkna*.

Nikoliukin (1952) also crossed the bream with *Gobio gobio* (L.), *Tinca tinca* (L.), *Cyprinus carpio* (L.) and *Carassius carassius* (L.) but in each case either the embryos or larvae did not survive. He also unsuccessfully crossed the bream with *Perca fluviatilis* (L.), *Lucioperca lucioperca* (L.) and *Acerina cernua* (L.).

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.11 Sexuality.

The bream is heterosexual. No information on hermaphroditism, even as an anomaly, is available. Sexual dimorphism of the secondary sexual characters is weak: pearl organs of males can be distinct in autumn (Oliva, 1952), and males have longer paired fins (Vladykov, 1931, quoted by Oliva, 1952). On the spawning grounds, males can be distinguished by colour, spawning tubercles and injured fins, especially the dorsal fin (Fabricius, 1951).

3.12 Maturity.

The following data supplement Table IV. Differences in the age at which first maturity is reached can be considerable. In the Caspian Sea, 85 - 100 percent of four-year old bream are mature, in the Sea of Azov 52 percent of four-year old, 32 percent of five-year-old and 14 percent of six-year-old bream are maturing for the first time (Dementeva, 1952a, 1955). On the other hand, immature bream of ten years or older have been found by Neubauer (1926) and Pęczalska (1963) in the Szczecin Firth (Lagoon) and by Ostroumov (1956) in the Ribinskoe Reservoir. There are considerable differences in the length of the sexual activity period. Driagin (1952) quotes the data of Tereshchenko concerning the Volga Delta (Caspian Sea) where male bream older than eight years and females of 12 years appear to be sterile, whereas according to Potapova (1954) female bream of 20-26 years from the lakes of the Karelo-Finnish SSR are still sexually active, and in the Volga (Shaposhnikova, 1948) 13-year-old males and 16-year-old females showed no signs of sterility. A male bream of the Kama River (Griazeva, 1936) could still spawn at the age of 15 years.

The bream of the southernmost waters (the Dnepr Delta, Volvi Lake, Fertö Lake) mature earliest, i.e. at the age of three-four years. In the remaining area no clear-cut regularity could be observed. The maturing period ranges from three to ten years, and, according to numerous observations, males frequently reach maturity one year earlier than females.

The geographic position and climate do not influence pronouncedly the size at which maturity is reached. The data of Table IV do not confirm the assumption of Laskar (1948) that the climate affects the size at which bream reach maturity. In the Aral Sea, according to Morozova (1952), two populations of bream occur together and reach maturity at the same age, but they differ considerably in size.

The bream of the Aral Sea transferred to Lake Balkhash (Kazakh SSR) reaches maturity at the same age as in its native waters although the fish are much smaller (Petkevich, 1953; Ivanov and Pechenikova, 1960).

Geyer (1939) pointed out the interdependence of growth rate and maturity. He was of the opinion that, under conditions of rapid growth, males and females mature at the same time, and one year later than in lakes where growth is slow. On the contrary, Shaposhnikova (1948) linked earlier maturity with faster growth in the first years of life. These differences result largely from regional variations, as stated by Wundsch (1939), who confirmed the findings of Geyer (1939) for the lakes studied by him.

Though the age of sexual maturity varies from 3 to 10 years, the length at which maturity is reached is less diversified and lies between 14 cm and 30 cm (ratio 1 : 2). Perhaps, as suggested by Alm (1959), maturity is affected by "physiological age", which is determined by absolute age and growth rate. Zemskaia (1958) expressed a similar opinion.

3.13 Mating.

Male and female bream spawn repeatedly with different partners. Mating is therefore promiscuous.

3.14 Fertilization.

Fertilization is external. At a temperature of 19-21°C sperm motility lasts for eight minutes in fresh water and for 10-13 minutes in brackish water (8.6-10.1‰). (Data for bream of Aral Sea, Gosteeva, 1957). According to Dziekońska (1958), sperm motility lasts for 45-75 seconds in the Vistula Lagoon.

3.15 Gonads.

The quantity of eggs produced annually by one female may differ considerably and it depends mainly on body size. Berg (1949) reported 941,000 eggs as the highest fecundity of the bream; according to Bauch (1963) the lowest is 2,000. Different fecundities are recorded for different districts: for the middle reaches of the Don, the range is 98,000-713,000 and the average 218,000 eggs per female (Syrovatskaia, 1949); for the middle reaches of the Volga, 40,500-654,000, average 176,500 (Shaposhnikova, 1948); for the Aral Sea, 92,000-

Table IV

Age and size at first maturity

Bream from	age 1/ (years) males	age 1/ (years) females	standard length 1/ (cm) males	standard length 1/ (cm) females	Approximate weight (gram)	Growth rate 3/ 4/	Author
Norfolk Broads, England	(4)6	(4)6	(22)24 2/	(18)24 2/	250	average	Hartley, 1947
River Welland, England	5		23		-	average	Leeming, 1963
Grosser Plöner See, Germany	7	7	30	30	500	good	Geyer, 1939
Vierer See	(5)6	6	25	25	250	good	Geyer, 1939
Oberer Ausgrabensee	(4)5	(4)6	(13)16	(13)16	100	poor	Geyer, 1939
Mügel See	6	7	(18)20	20	160	poor	Wundsch, 1939
Langer See	6	6	(15)	(15)	120	poor	Wundsch, 1939
Ammersee	8	8	25	25	-	good	Laskar, 1948
Simssee	7-8	7-8	30	30	-	good	Laskar, 1948
Lake Volvi, Greece		3		16	-	good	Laskar, 1948
Lake Fertö, Hungary	2-3		14			good	Geyer and Mann, 1939
Danube, Czechoslovakia	(2)3	(3)4	(16) 17-23	20-24		good	Balon, 1963
Danube Delta	2-4	3-4	12-22	23-26			Pavlov, 1956
Toften, Sweden	6-7	6-7	25	25	-	good	Alm, 1919
Hjälmaren, Sweden	8	8	25	25	-	average	Alm, 1917
Yxtasjon, Sweden	6-10	6-10	16-20	16-20	-	poor	Alm, 1922, in Laskar, 1948
Haderslev-Dam, Denmark	7	8-10	19	20-21	-	poor	Otterström, 1932, in Geyer, 1939a
Tuusula, Finland	(3)5	(4)6	9	12	5-12	poor	Järnefelt, 1921
Vistula Lagoon, Poland	(5)6	(5)6	28	30	400	good	Filuk, 1962
Szczecin Firth, Poland	(5)6	6	(22)28	(23)30	400	good	Pęczalska, 1963
Goldopiwo Lake, Poland	6	7	25	28	300	good	Inland Fish. Inst., Poland (unpublished)
Aral, USSR	(3)4	(4)5	25	28	400	good	Morozova, 1952

Azov, USSR	4-5		4-5	30		30	500	good	Dementeva, 1955
Ilmen Lake, USSR	6		6-7	26		27	400	good	Morozova, 1952
Volga, USSR	(5)	6-7	7-8	(22)28		30		good	Shaposhnikova, 1948
Rybinsk Reservoir, USSR	(7)9		(7)10	30		30	500	average	Ostroumov, 1956 Poddubnyi, 1960
Caspian Sea, USSR	(3)4		(3)4	(19)23		(20)24		good	Dementeva, 1952a
Siamozero, Karel SSR	7-8		8-9		27-30		600-900		Potapova, 1954
Niukozero, Karel SSR		8-10			28-30		600-800		Potapova, 1954
Ubinskoe, Novosibirskaia obl.			5-6					average	Petkevich, 1953
Balkhash, Kazakhstan			(3)5					average	Ivanov and Pechnikova, 1960

1/ Figures in brackets give the youngest age and the smallest length of sexually mature bream. The remaining figures give the age and size when a considerable part of the population reaches sexual maturity.

2/ The length of Norfolk Broads bream is fork length, while for other water bodies it is standard length. When calculating standard length (lc) from total length (lt) the ratio lc/lt = 0.78 - 0.80 has been accepted (Bauch, 1963).

3/ Growth rate scale is according to Geyer (1939).

4/ When no data on length and body weight were available, publications on the growth rate of bream in a given water body were made use of.

338,500, average 205,000 (Morozova, 1952); for the lakes of the Karelo-Finnish SSR, 25,000-501,500 (Potapova, 1954); for Lake Mamry, Poland, 45,000-520,000 (authors' material).

Taking into account a small number of studies and differences in the methods applied, the data concerning the average fecundity of weight classes, as presented in Fig. 3, should be treated as tentative.

The number of eggs per gram of body weight and the relative weight of gonads are presented in Table V. Attention is drawn to the great variability of the relative weight of female gonads from the same body of water, e.g. from 10 to 23.8 percent for the Aral Sea. After spawning this index diminishes in the case of females to 2.2 - 2.3 percent (Morozova, 1952). Seasonal changes in gonads were studied by Butskaia (1955) and Shilov (1962).

The quantity of eggs which remain in the ovaries after spawning is inconsiderable; according to Dementeva (1952a) it is 1.4 percent.

The potential quantity of eggs which could be produced by one female depends on the duration of its sexual activity and its rate of growth. From data referring to the middle reaches of the Volga (Shaposhnikova, 1948), it appears that a female which matures at the age of six years, weighing 680 g, may spawn for the last time at the age of 16 and a weight of 4,380g; such a fish could produce about 2.5 million eggs during these 10 years. Shpet (1964) gives an absolute potential fecundity of one pair of bream during nine years of life as 6×10^5 pairs of progeny.

Griazeva (1936) carried out a histological analysis of changes occuring in bream gonads.

3.16 Spawning.

Some orientative data concerning the spawning of bream are presented in Table VI.

In most water bodies bream spawn only once a year, but there are populations known in which females spawn twice or even three times (Papadopol, 1963). In the spawning period, the ovaries contain eggs of two or three different sizes. (Driagin, 1949; Morozova, 1952; Syrovatskaia, 1949; Sych, 1955). Quantities of small eggs found in bream from the Aral Sea and River Don make up 30 and 32 percent respectively of the total number of eggs.

Repeated spawning can occur in the whole population or in part of it. According to Zakharova (1955) females with two egg fractions occasionally occur in the Rybinskoe Reservoir. In Lake Ilmen only seven percent spawn repeatedly but in the Don and in the Danube Delta the great majority of females spawn more than once a year. The fact should be stressed that repeated spawning occurs more frequently among the semi-migratory populations which spawn in the areas inundated by spring floods.

In the water bodies where female bream spawn only once a year, the population may often be divided into groups which spawn at various times; sometimes these groups are related to the size of the spawners. According to Järnefelt (1921) younger and smaller bream spawn first in Lake Tuusula, while according to Pęczalska (1963) bigger and older individuals spawn first in the Szczecin Lagoon. In several water bodies the periods at which particular spawning groups appear are regular enough to have local names given by fishermen, e.g. in Lake Ilmen (Driagin, 1949), in Szczecin Lagoon (Neubaur, 1926). They are often connected with phenological observations. According to Bernatowicz (1962) the first period of spawning in Mazurian Lakes coincides with full blooming of apple trees (Malus domestica) and lilac (Syringa vulgaris); the second period begins with the flowering of Stratiotes aloides.

Males are ready to spawn first and they remain longer on the spawning grounds; they are therefore in a majority in the spawning schools (Pęczalska, 1963; Shaposhnikova, 1948; and others).

Table VI also shows the spawning season. The data refer to different years of observation, and the season can differ by two-three weeks in successive years, depending on the weather.

The main factor influencing the beginning and course of spawning is temperature. Driagin (1949) stated 12-13°C to be the lowest temperature, at which bream have observed to spawn. The corresponding highest temperature is 27°C, recorded in the Aral Sea (Shaposhnikova, 1948). The most commonly reported spawning temperature is 16-18°C. A sudden cooling may stop spawning (Zakharova, 1955). During warm and calm weather, bream spawn in masses in a short time (two-three days); under bad conditions spawning lasts longer. The maximum water level reached in spring and the time when it occurs are important factors influencing the populations of estuaries, rivers and retention reservoirs. These factors affect the area of the

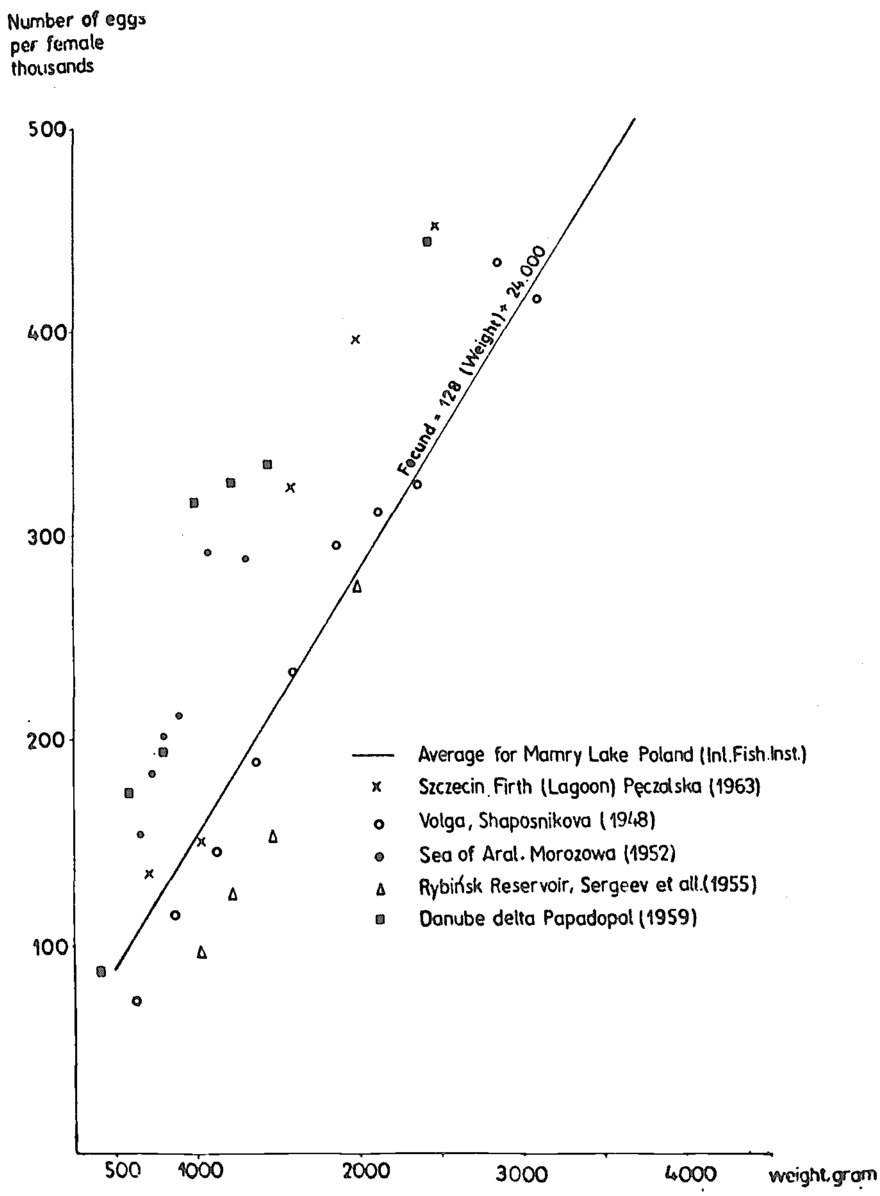

Figure 3. Fecundity of bream in relation to individual weight.

Table V

Number of eggs per gram of body weight and gonad weight as percentage of body weight in some bream stocks

Stock from	No of eggs		Gonad weight, percent				Author
			Females		Males		
	average	range	average	range	average	range	
a/Spawning once a season							
Volga River	125	102-156					
- age: 6-7		102-105					Shaposhnikova (1948)
- age: 12-14		151-156					
Szczecin Lagoon		150-200		13.3-19.4	2.8		Pęczalska (1963)
Lake Mamry	150	140-170					authors' data
b/Spawning repeated							
Dnepr River	113	97-138					Velikokhatko (1947)
Danube delta	246		21				Papadopol (1962, 1963)
Aral Sea	260		16.8	10.0-23.8	3.4	2.4-4.6	Morozova (1952)
Lake Ilmen				8.4-16.8		2.0-3.9	Driagin (1949)

Table VI

Data on bream spawning

Water body	Repeated spawning	No of spawning groups	Beginning of spawning	Temperature (°C)	Spawning duration (days)	Author
Aral Sea, USSR	+	few	15.IV	15	120	Morozova, 1952
Caspian Sea, USSR		few		17-20		Dementeva, 1952a
Don River lower course, USSR	+	3	20.IV	15	40-45	Syrovatskaia, 1949
Dnepr River lower course, USSR	+	2-3	25.IV	10-18	20-25	Velikokhatko, (1947)
Volga River middle course, USSR	-	1	10.V	12-18	4-6	Shaposhnikova, 1948
Siamozero, Karelo-Finnish ASSR	-	3	10.VI		15-20	Shaposhnikova, 1948
Ilmen Lake, USSR	-+	3	20.IV	12	40	Driagin, 1949; Ponedelko, 1958
Volgogradski Reservoir, USSR	-	-	5.V	8-15	25	Elizarova, 1962
Rybinskoe Reservoir, USSR	-	1	20.V	12.5-15	14	Zakharova, 1955
Glubokoe Lake, USSR	-	2	1-2.VI	17-18	14	Dmitreva, 1960
Harsz Lake, Poland	-	1	25.V	16-18	3-4	Pliszka, 1953a
Mazurian Lakes, Poland	-	2	10.V	16	30	Bernatowicz, 1955, 1962
Vistula River, Poland	+	2	10.V	17-20	20	Sych, 1955
Vistula Firth, Poland	+	2	1-10.V	18	45	Dziekońska, 1956
Szczecin Firth, Poland	-	3-4	25.IV	15-17	30	Żukowski, 1962; Pęczalska, 1963
Holstein Lakes, Germany	-	-	26.V		14	Geyer, 1939
Tuusula Lake, Finland	-	2	5.VI	18	10	Järnefelt, 1921
Norfolk Broads, England	-	-	5.VI			Hartley, 1947
Malären Lake, Sweden	-	-	5.VI-10.VI	14.5-18		Svärdson, 1949; Fabricius, 1951

spawning ground and the spawning season e.g. in the Volga (Shaposhnikova, 1948), in the Vistula (Sych, 1955), in the Rybinskoe Reservoir (Zakharova, 1955; Elizarova, 1962).

According to the observations of Sych (1955), spawning lasts day and night, becoming more intensive at night. Fabricius (1951) and Svärdson (1949) observed bream spawning in Lake Mälaren by day. According to Shaposhnikova (1948), most intensive bream spawning lasted from 10.00 to 11.00 and after a break at noon from 16.00 to 17.00 hours.

- Location and type of spawning ground.

Bream deposit eggs in sheltered places, where the water is either still or the current is weak. Depths at which eggs have been found vary from 9 cm (Sych, 1955, Vistula) to 3-3.5 m (Driagin, 1949) and even 17 m in the Kakhovskoe Retention Reservoir (Belyi, 1962). The most common spawning depths are from 20 to 80 cm (Shaposhnikova, 1948; Zukowski, 1962; Zakharova, 1955). When bream spawn at various times in the same body of water, the earliest spawning takes place on shallow grounds, and later spawnings are on deeper grounds (Driagin, 1949); the temperature of the water is probably important. Sych (1955) observed that during calm weather eggs are laid at the minimum depth (9 cm), when there are waves they are laid at a greater depth (30 cm). One body of water can have both shallow and deep spawning grounds (Driagin, 1949; Morozova, 1952; Dziekońska, 1956).

There is considerable variation in the areas of different spawning grounds. Shaposhnikova (1948) described particular spawning areas in the Volga as occupying about 100 m^2; Pliszka (1953a) reported a spawning area of 0.5 ha in a lake of 200 ha; Zakharova (1955) stated the area of a spawning ground in the Rybinskoe Reservoir to be about 50 ha. In many Mazurian lakes fishermen know the main spawning grounds which are relatively constant (Pliszka, 1953a) and the same is true of the Szczecin Lagoon (Pęczalska, 1963). In retention reservoirs, rivers and estuaries, where bream spawn on inundated areas, the locality and size of the spawning ground are changeable and they depend on the hydrometeorological conditions (Zakharova, 1955; Morozova, 1952; Dementeva, 1952a, and others).

The bream is a "generatively phytophilous species", a term applied by Kryzhanovskii (1949); its eggs adhere and develop on plants. The plant substratum may be quite diverse: flooded land plants, the remains of the previous year's aquatic vegetation, tree leaves, stems and roots of emergent plants, algae (Cladophora), submerged hydrophytes. From among the latter the following are often mentioned: Myriophyllum sp., Chara sp., Stratiotes aloides, Elodea sp., etc. In the Vistula, Sych (1955) found the eggs of bream on Rorippa amphibia, Butomus umbellatus, Sagittaria sagittifolia and Glyceria aquatica. Bream eggs are deposited also on "artificial" spawning grounds, where the branches of conifers are used as a substratum (cf. section 6.26).

The spawning of bream may coincide with the spawning of other species of fish. In the Szczecin Lagoon a part of the bream population spawns on the same breeding grounds and simultaneously with Blicca björkna (L.). The eggs of bream, pike-perch and ruff were found at the same time on the artificial spawning grounds in the Don delta.

At time of spawning, bream are alert and shy. A splash of an oar or voices frighten them away, and they swim to deeper water (Shaposhnikova, 1948).

According to lake fishermen, bream spawn in great masses during calm weather. The spawning is stormy; the fish splash water with their tails, making characteristic noises which can be heard from afar. The water of the spawning ground is turbid and vegetation torn out by the fish can be seen.

According to Svärdson (1949) and Fabricius (1951), who observed the spawning of bream in Lake Mälaren, the spawning ground consists of a number of plots occupied by big males which are on the move. Their movements attract females and scare away males. The male defends its territory and when another male appears there is intensive splashing. According to Svärdson one territory is about 5 m^2; Fabricius observed smaller territories. Males did not abandon their territories during the whole time of observation (8 h.).

The data of Zakharova (1955) suggest that the spawning of bream may follow a similar course in other water bodies. In the Rybinskoe Reservoir she found bream eggs deposited in patches, each covering about 1 m^2 and containing about 1,200 eggs. The fact should be stressed, however, that eggs are often not evenly distributed (Shaposhnikova, 1948; Pliszka, 1953a) and their great quantities suggest that many fish may spawn in the same area. Thus according to Potapova (1954) from 60,000 - 2,300,000 eggs were found on 1 m^2 in Lake Vygozero. In the Vistula Lagoon, Dziekońska (1956) found 30,000 - 738,000 eggs per m^2 on the shallow spawning grounds and, on the average, 2,000 eggs per m^2 on the deep grounds. In Lake

Harsz, Pliszka (1953a) found 20,000 - 400,000 eggs per m^2.

3.17 Spawn.

The polyplasmatic eggs show various shades of yellow and contain little perivitelline space. The diameter of a mature egg is 1.62 - 1.82 mm, without membrane it is 0.97 - 1.30 mm. The blastodisc is from 0.325 to 1.30 mm high depending on the stage of development, in width it almost equals the diamter of the yolk sac. The membrane is transparent, and the filaments which attach the egg to the substratum are minute and thinly spread. The egg membrane is delicate and it breaks easily (Kryzhanovskii, 1949). Other authors give the egg size as follows: Driagin (1949): 1.3 - 1.9 mm, av. 1.5 mm, after swelling av. 2.1 mm; Morozova (1952): 0.9 - 1.2 mm, av. 1.0 mm; Sych (1955): av. 1.3 mm.

The average weight of a bream egg varies between different populations from 0.75 - 1.35 mg. The differences in average weight of eggs of particular females may amount to 100 percent. Maximum egg weight of 1.25 g was found in females seven years old; younger and smaller females as well as older and heavier ones had lighter eggs (Privol'nev, 1964).

The biochemistry of bream eggs and spawners has been studied by Maliarevskaia and Birger (1965).

3.2 Pre-adult phase

3.21 Embryonic phase.

Developmental stages of bream eggs are presented in Fig. 4. The rate of embryonic development depends clearly on temperature (Table VII). Kryzhanovskii (1949) stated that the incubation period lasts from 3 - 13 days and data from other works are in agreement with this.

A temperature of 28°C was found to be lethal during cleavage and it caused heavy losses at other stages of development, 24°C was responsible for heavy losses during cleavage and before hatching, 10 - 18°C gave similar results to the control (14 - 15°C), and the temperature of 6°C caused considerable losses only at cleavage (Volodin, 1960). The same author quotes the lethal temperature for the developing bream eggs from the Don River as 29 - 31°C. Dziekońska (1958) took developing bream eggs from the Vistula Lagoon at five defined developmental stages and placed them in water of 35, 32, 8 and 4°C for 5 minutes. At the temperature of 35°C all eggs, irrespective of the developmental stage, perished, while at 32°C and 4°C, 10 - 20 percent of eggs survived. At the temperature of 8°C the results were similar as in the control at 17°C.

- Oxygen.

According to Iurovitskii and Rosnichenko (1961) the critical oxygen content for bream egg development at 15°C is 5 mg/l. At 3 mg/l losses were 100 percent, at 5 mg/l they amounted to 11 percent and there were 67 percent of abnormally developing embryos. At the control at 10 mg/l the losses were 7 percent and 7 percent of embryos were developed abnormally. According to Kuznetsova (1958) the critical oxygen content is 1.9 mg/l.

- Salinity.

Morozova (1952) and Gosteeva (1957) reported that in the Aral Sea, some bream spawning grounds, far from the shore and 4 - 5 m deep, show a salinity of 9 - 10‰. Under experimental conditions (Gosteeva, 1954, 1957) bream eggs from the Aral Sea developed normally at a salinity of 10.12‰. At 11.5 - 11.6 ‰ the development was abnormal, at 11.7 ‰ embryos perished at the beginning of segmentation and at 12 ‰ the development stopped at the blastula stage. Changes in salinity from 5.4 - 10 ‰ did not impair the development.

The survival of Bream embryos at different salinities is also given by Cherfas (1956) after Konovalov:

Bream eggs from the Sea of Azov:

Salinity (‰)	0	2.7	4.5	5.4
Survival (%)	60.1	32.3	21.5	15.1

Bream eggs from the Aral Sea:

Salinity (‰)	0	4.3	5.7	7.1	10.2
Survival (%)	88.4	86.3	80.0	67.3	38.4

Bream eggs from the brackish water of the Vistula Lagoon, do not develop at such a high salinity. Fertilization could be carried out only at 2.8 ‰ but fertilized ova could develop at a salinity of 5.6 ‰.

CO_2 is harmful to the eggs of bream only at the concentration of 50 mg/l or greater (Volodin, 1960).

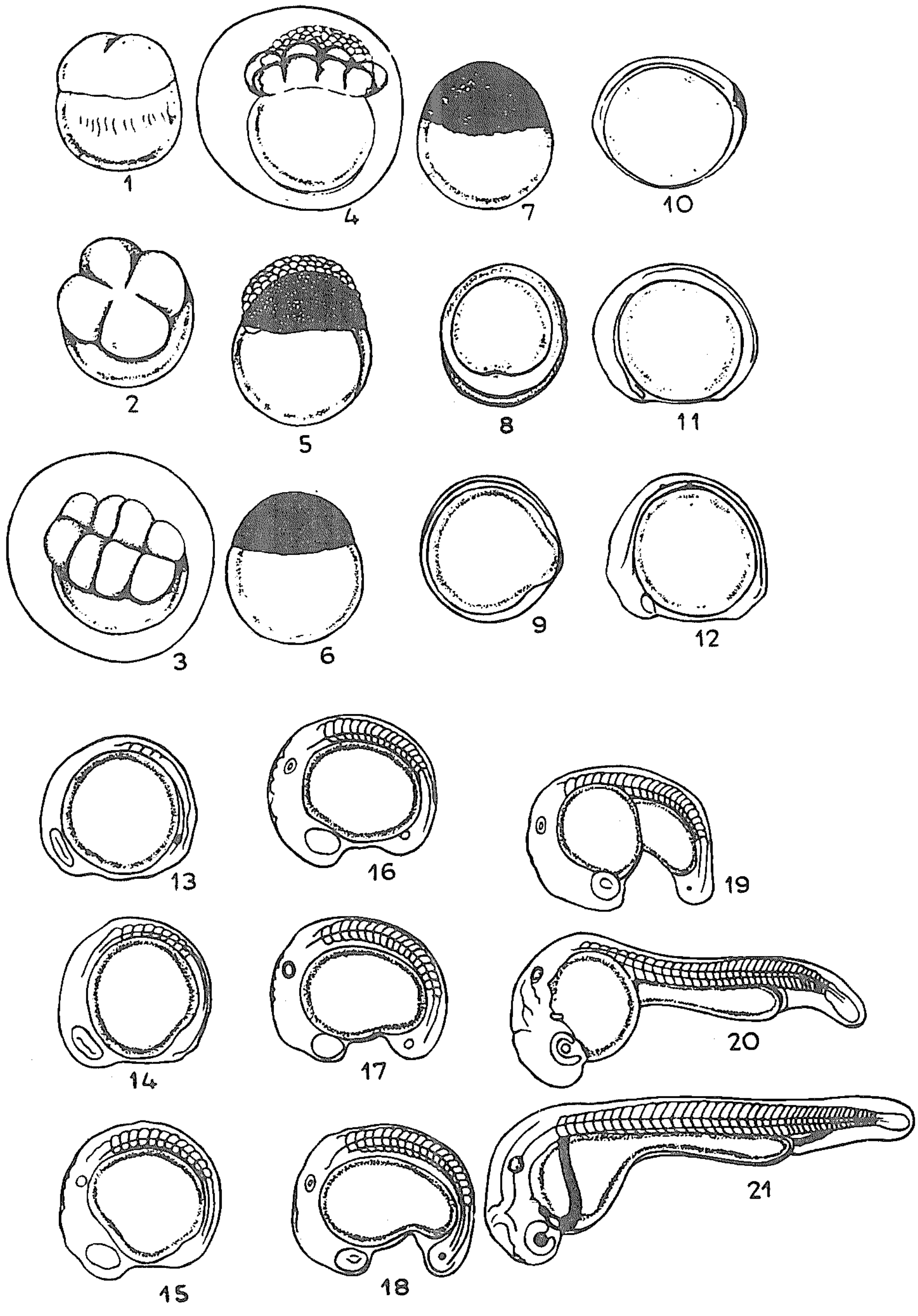

Figure 4. Embryonic development of bream, after Kryzhanovskii (1949).

Explanation of Fig. 4

1/ Stage of two blastomeres; age 1 h 5 min, yolk sac diameter 0.97 mm.

2/ Stage of four blastomeres, from above; age 1 h 27 min.

3/ Eight blastomeres, from above; age 1 h 48 min.

4/ Two superimposed drawings of the same egg, at the stage of eight blastomeres(age 1 h 48 min.) and at the stage of early morula (age 4 h 5 min).

5/ Two superimposed drawings of the same egg at the age of 4 h 5 min and 5 h 55 min.

6/ Transitional stage between morula and blastula; age 6 h, temperature 22°C.

7/ Blastula; age 6 h 30 min, temperature 22°C.

8/ Beginning of gastrulation; age 8 h 15 min, temperature 22°C.

9/ End of gastrulation, blastopore still partially open; age 16 h 40 min, temperature 19.2°C.

10/ Blastopore closed but still visible; age 2 days 3 hrs, temperature about 16°C.

11/ Cephalic mesoderm still linked with body mesoderm; age 21 h, temperature 20.8°C.

12/ Cephalic mesoderm rudiment separated from body mesoderm, the latter beginning to divide into segments; age 2 days 17 h, temperature about 16°C.

13/ Three segments: rudiments of eyes and Kupffer's vesicle visible (the latter is situated in the future eleventh segment); age 22 h 40 min, temperature 20.8°C.

14/ 8 segments; age 24 h 18 min, temperature 21°C.

15/ 12 segments: encephalomeres and ear vesicles can be seen; age 26 h 40 min.

16/ 15 segments: gall bladder differentiating, Kupffer's vesicle has increased in size and its location now corresponds to that of 12 segment; age 28 h 10 min.

17/ 18 segments: the location of Kupffer's vesicle corresponds to that of 24th segment; age 29 h 40 min.

18/ 20 segments; elongated head, encephalomeres have disappeared, Kupffer's vesicle has moved towards caudal kidney and its location corresponds to that of 27th segment, embryo moves slightly.

19/ 22 segments: Kupffer's vesicle is very small, its location corresponds to that of 31st segment; age 31 h 40 min, temperature 20.4°C.

20/ 35 segments (9 segments in the tail): gall bladder pear-shaped, otoliths visible in ear vesicles; age 42 h 24 min, temperature 19.4°C.

21/ 17 segments in tail; heart starts beating, beginning of blood circulation; age 48 h, temperature 20°C.

Table VII

Number of "degreehours" of embryonal development, from fertilization to hatching

Temperature	No of degreehours	Source
11°C	2950	Kryzhanovskii, 1949
18°C	1300	Pliszka, 1953a
18°C	2600	Shaposhnikova, 1948
19°C	1501	Dziekońska, 1956
20-22°C	1430-1890	Kryzhanovskii, 1949
23°C	2208	Dementeva, 1952a

Developing bream eggs can withstand short (60 minute) periods of exposure to the air (without water). This does not disturb the process of development but irregularities during hatching must be mentioned (Dziekońska, 1958).

The percentage of fertilization of bream eggs on the natural spawning grounds is high (Driagin, 1949; Dmitreva, 1960). Pliszka (1953a) reported 98 - 100 percent fertilization in Lake Harsz, of which 70 - 90 percent hatched. Sych (1955) estimated the fertilization on the Vistula spawning grounds to be 91.2 - 96.7 percent and the losses to be 65%. Zakharova (1955) described the losses on the spawning grounds of the Rybinskoe Reservoir as 32 percent, Dziekońska (1956) estimated the losses in the Vistula Lagoon, depending on the character of the spawning ground, to be 6.8 - 19.6 percent. Potapova (1954) reported that 75 - 90 percent of eggs are fertilized in Karelo-Finnish lakes.

Different causes are responsible for losses in bream eggs on natural spawning grounds. According to Dmitreva (1960) and authors quoted by Zakharova (1955) and Gosteeva (1957), they are (a) oxygen deficiency in poor water circulation, caused by decaying organic matter or, at night, by plant respiration; this can check the development of eggs deposited on the bottom, on vegetation near the bottom, or on decaying leaves (shallow inshore grounds of the Volga Delta, Aral Sea); (b) eggs not fertilized; (c) drying out due to a fall in water level (rivers, retention reservoirs); (d) infection with the mould *Saprolegnia*; (e) predation by invertebrates and fishes. Zakharova (1955) found up to 400 bream eggs per fish in perch caught on a spawning ground, and Gosteeva (1957) mentions *Pungitius pungitius* L. as a predator. It seems that fish can cause considerable losses in bream eggs. In the lower reaches of the Don River, Mikheev and Meisner (1954) observed bream eggs deposited on artificial grounds, where pike-perch had spawned earlier. The bream eggs were protected by the male pike-perch. On those spawning grounds the losses in bream eggs were very small when compared with those on natural spawning grounds.

- Mode of hatching.

Glands containing a substance which weakens the egg membrane can be found on the head and back of the embryo. They are conspicuous and full in larvae taken from the egg-capsule before hatching (Kryzhanovskii, 1949). From bigger eggs hatch bigger larvae, from 4.57 to 5.30 mm, (Dmitreva, 1960).

3.22 Larval phase.

General features of development. The post-embrionic development of the bream has been worked out in detail in a number of papers from the A. N. Severtsov Research Institute of Animal Morphology in Moscow (Vasnetsov, 1948; Vasnetsov *et al.* 1957; Eremeeva, 1960, 1960a; Dmitreva, 1960; Kryzhanovskii, 1949; Sablina, 1960).

Those works distinguish a number of developmental stages in the pre-and post-larval phases. These stages are illustrated in Fig. 5, and a summarised description is given in the accompanying explanation.

The rate of development depends on temperature, hence the rate of development may change, but in principle the course of larval development is similar in lake bream, estuarine bream (semi-migratory) and in those of retention reservoirs (Dmitreva, 1960; Eremeeva, 1960, 1960a). The main difference is in the fact that at stage G, bream in estuaries, such as the deltas of the Volga, Don and Kuban, gather in schools and begin their migration towards the sea.

According to Vladimirov (1964), mortality at this phase resulting from hereditary factors may be very high and may differ greatly between the progeny of different females. His experiments lasted 30 days, under good environmental and feeding conditions; mortality among the progeny of 60 percent of the females was less than 20 percent, but among the progeny of 12 percent of females it was 90-100 percent. Vladimirov observed the highest mortality of larvae on the 13th - 15th and 20th - 23rd days after hatching. Larvae shorter than the mean length perished. Abnormalities of the alimentary tract were the cause of losses. The results of breeding bream in ponds for the purpose of stocking (Nikolskii, 1955) show that at low densities, i.e. 200,000 pike-perch eggs and about 1.5 million bream eggs per 1 ha, the mortality of bream amounted to 95 percent in 60 days, and when the density was 2 - 3 times greater it rose to 98.5 - 99.6 percent in 30 days. In Poland, in fish-ponds near lakes where bream larvae were raised together with tench, the mortality of the bream amounted to 99 percent in 90 days, but the survivors grew excellently, and on average they measured 7.5 cm and weighed 4 g after three months, i.e. 2 - 3 times higher gain than in the adjacent lakes.

According to Berg *et al.* (1949) frogs sometimes do considerable damage to bream larvae.

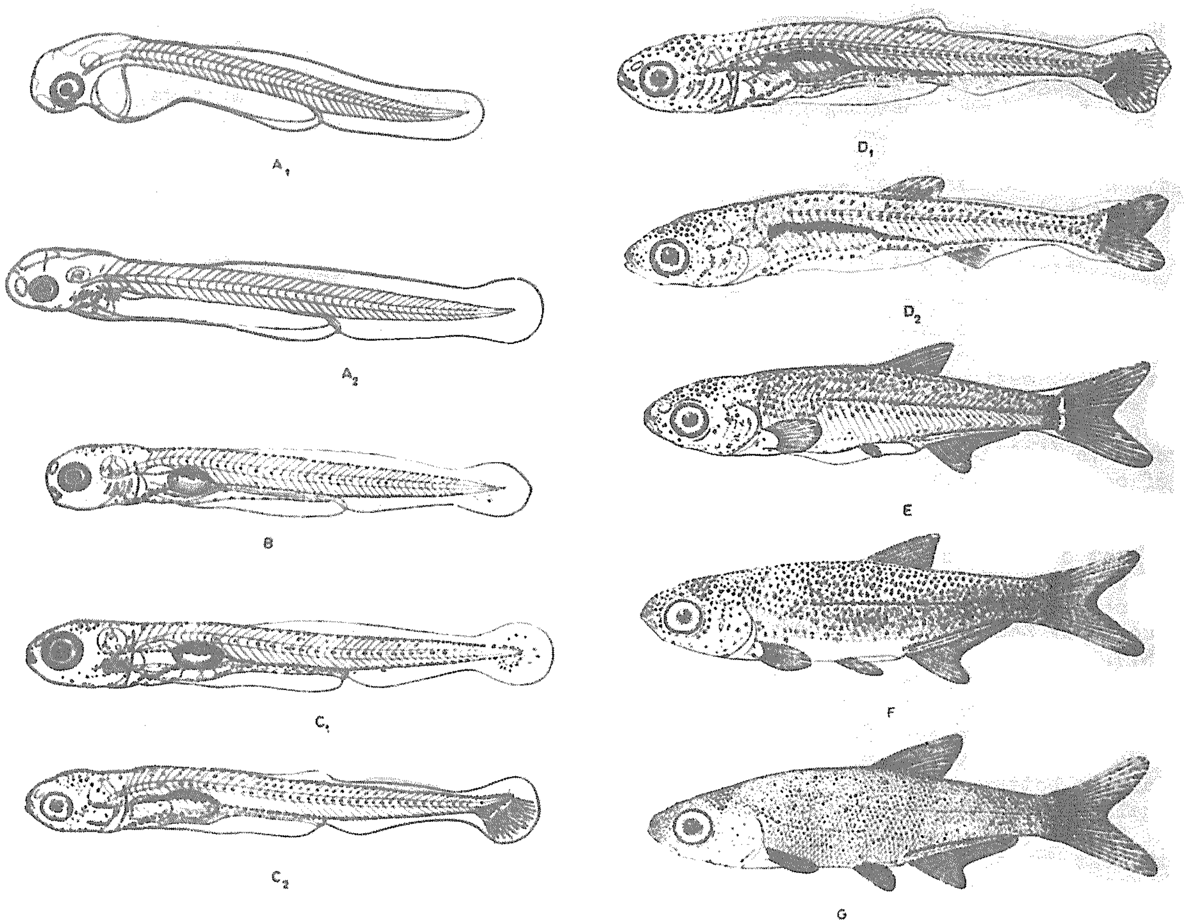

Figure 5. Stages of bream development (after Dmitreva, 1960).
See explanation on following page.

Explanation to Fig. 5 (after Vasnetsov *et al.*, 1957, and Dmitreva, 1960)

Stage	Length (mm)	Age (days)	Structure	Behaviour, Food
A_1	4.5-5.3	3	Yolk sac pear-shaped, head slightly bent down. Body surrounded with larval fin. Mouth inferior, immobile. Eyes slightly pigmented. Pectoral fin bases horizontal. Rudimentary gill cover. Glutinous glands under eyes for attachment of larva.	Larvae motionless, attached to vegetation or resting on bottom. Feed only on yolk.
A_2	up to 6	2-3	Yolk sac cigar-shaped. Head straight. Mouth inferior, lower jaw movable. Pectoral fin bases oblique. Membranous gill cover reaching first gill arch only. Few melanophores on yolk sac.	
B	5.2-6.4	3-4	Filled air bladder. Yolk sac small. Tail fin develops from larval fin. Mouth inferior, not completely closing. Membranous gill cover leaves last three gill arches uncovered. Chorda straight. Pectoral fin bases vertical. Intestine resembles a straight tube.	Stay near shore, in vegetation. Swim obliquely, head upwards. Feed on yolk and small sluggish organisms such as rotifers and their eggs.
C_1	6.4-7.5	3	Yolk disappears. Chorda straight. Dorsal and anal fins develop. Mesenchyme concentration can be seen in caudal fin.	Swim well and fast, chasing food. Feed on rotifers, diatoms, nauplii, copepodids and small copepods.

C_2	7.5–8.6	3	Chorda end bent slightly upward, cartilaginous hypural beneath it. Heterocercal tail. Mesenchyma concentration in dorsal and anal fin lobes. Membranous gill cover leaves last three gill arches uncovered.	Stay near shore (depth 0.5m), in surface layer of water; agile. Feed on rotifers, nauplii and copepodids.
D_1	8.6–10	3	Anterior cavity of air bladder fills with air. Posterior chorda end bending slightly upward. Tail almost homocercal. Bony fin rays in tail fin. Mesenchymal rays in dorsal and anal fins. Operculum still membranous, not covering last two arches. Mouth slightly protractile.	Stay among plants. Feed on small copepods, Cladocera, rotifers and diatoms.
D_2	10–13.5	4	Bony finrays developed in dorsal and anal fins. Tail homocercal. Caudal fin forked. Ventral fins developed as two horizontal folds without fin-rays.	Stay near shore in vegetation. Feed on large Cyclops and on rotifers and diatoms.
E	13.5–16	4	Bony finrays developed in all fins. Olfactory cavity resembles figure of eight, septum starts forming. First two intestinal ansae developed. Gills covered.	Stay a little further from shore. Feed on zooplankton and periphyton.

... 3

F	16–20	7	Scales develop. Preanal fin lobe disappears. Body height increases. Upper profile line almost straight, lower one convex. Finrays start branching. Olfactory cavity double, although septum not complete.	Stay far from shore, in places without vegetation, not shallower than 1.5 m; swim in upper water layers, feeding on zooplankton (large Daphnia, Cyclops, rotifers, larvae of Chironomidae).
G	20		Whole body covered with scales. Mouth semi-inferior. Two nostrils. Second pair of intestinal ansae developed.	Stay at bottom, feed on larvae of Chironomidae, larger zooplankton, green algae and diatoms.

At a temperature of 17 - 20°C, the yolk sac resorbs between the sixth and eighth day, and the larvae then start feeding on minute organisms. The information on feeding habits is summarized in Table VIII.

A concentration of food organisms of 500 per liter provides good feeding conditions for larvae at stage C_1 (lc = 7 mm, weight 1.5 mg) according to the experiments of Panov (1960). Zheltenkova (1964) states that 227 - 275 organisms/liter is a sufficient food concentration. A plankton biomass of 30 - 40 mg/liters, i.e. about 1,000 organisms/liter, secure proper feeding conditions for bream larvae at stage D_2 (length 12 mm, weight 15 mg) according to Panov (1960). Karzinkin (1952) gives the following data on the amount of food eaten by larvae in a day:

16-day-old, weighing 7.7 mg: 101.9 percent of body weight,

32-day-old, weighing 38.8 mg: 57.0 percent of body weight,

48-day-old, weighing 85.0 mg: 35.0 percent of body weight.

Larvae were fed on tiny Cladocera in aquaria.

- Growth.

Body length reached in the first year of life is exemplified by the following data: (Table IX).

Shaposhnikova (1948) expressed the opinion that the growth of juvenile bream responds readily to a number of factors and therefore it may be different in particular parts of a bigger water body and in particular years. This is illustrated by her data in the table IX, showing widely different growth rates for different parts of the Ural and Dresna rivers.

3.23 Adolescent phase.

Depending on the population, the adolescent phase lasts from two to eight years (Table IV).

The basic period of development and organogenesis ends at the length of 75 - 107 mm (Sablina, 1960). The bream attains its final body shape when longer than 14 cm (Vasnetsov, 1948).

- Predators.

Bream is seldom eaten in large quantities by predatory fish. (Table X). The data of Domanevskii (1964), Hartley (1947), Filuk (1962a), Ivanova (1956, 1960), Makkoveeva (1956), Vashchenko (1958), Romanova (1956) and Balagurova (1963) confirm the small proportion of bream in the food of predatory fish, apart from those exceptional cases where no buffer species are available and bream is practically the only available food for the predators (cf. Dziekońska, 1954). Bream are also eaten by some birds, such as grebes (<u>Podiceps</u> sp.), divers (<u>Colymbus</u> sp.), herons and cormorants. (Authors' material).

Bream longer than 20 cm are attacked rarely and only by big predatory fish. Although detailed information is not available, it seems that, except in the larval phase, predation is rarely a factor controlling the density of bream. In Polish lakes, where predatory fish are protected and common, no decrease in the abundance of adolescent bream has been observed. (Authors' material).

Parasites can probably affect the survival of bream in the adolescent phase (cf. section 3.35).

3.3 <u>Adult phase, mature fish</u>

3.31 Longevity.

Segeståle (1933) published a photograph of a scale of a 32-year-old female bream from Hajka Fjörd, Finland. It was 50.4 cm lc and weighed 2.4 kg. Potapova (1954) found 26-year-old bream. A 23-year-old female bream from Lake Sniardwy, Poland, weighed 5.2 kg and its lc was 57 cm. The oldest bream found during archeological excavations in Central Russia was 20-years-old (Levedev, 1961). Bigger bream and probably the older ones have been caught in Central and Northern Europe. Berg (1949) reported that a bream weighing 11.5 kg was caught in Lake Vestjarvi, Finland. Wundsch (1939) quoted data according to which bream of German waters can be heavier than 10 kg.

Maximum age is not older than 15 years in the case of the populations of the southernmost areas of the distribution of the species (Berg, 1949; Dementeva, 1952; Balon, 1961, 1963). Nümann (1962) reported that he caught bream up to 2 kg in Spanca, an Anatolian lake, Turkey.

The interdependence between longevity and growth rate is not clear. Semi-migratory bream of the estuaries of the Caspian, Azov and Aral Seas are characterized by a fast growth rate and a short life cycle, but at the same time an ecological variety of a slow growing bream with a short life cycle also occurs in the Aral Sea, (Morozova, 1952).

Table VIII

Bream diet in the first year of life

Water body	Size or age of fish	Main food	Author
Volga	6 days	Phytoplankton	Pankratova, 1948
	10-11 days	Small Cladocera and Copepoda found in aggregations	
	2-3.7 cm	Tendipedidae and zooplankton	
Tsimlanskoe Reservoir	4 cm	Zooplankton: Bosmina, Daphnia, Moina, Cyclops	Lapitskaia, 1958
	4.1-6 cm	Forms found at the bottom: Alona sp. Pleuroxus, Harpacticidae	
Mazurian Lakes (Poland)	1.8-4.8 cm	Littoral forms of Cladocera	Pliszka and Dziekońska, 1953a
	2.3-2.9 cm	Cladocera, Copepoda, Nematocera puppae	Leszczyński, 1963
Lake Bolshoi Ivan, (North.) USSR)	Age 0+	60 percent - Alona affinis, 12 percent - Bosmina sp.	Bogatova, 1963

Table IX

Body length of bream in the first year of life

Water body	Date	Length mm	Weight g	Author
Tsimlanskoe Reservoir	Sept.1953	92.0	15.0	Ginzburg, 1958
Tsimlanskoe Reservoir	Sept.1954	86.1	12.6	Ginzburg, 1958
Tsimlanskoe Reservoir	Sept.1955	64.4	4.7	Domanevskii, 1958
Vistula River	Oct.1952-1955	25.0		Backiel and Bontemps, 1958
Mazurian Lakes	autumn	32.0-37.0	0.5-0.8	Zawisza, 1953
Ural River	August	29.0-59.0		Shaposhnikova, 1948
Desna River	August	16.0-40.0		Shaposhnikova, 1948

Table X

Predation on bream

Water body	Predator	Season	Percentage of predators with bream in stomachs	Bream as percentage of total food by weight	Bream as percentage of no. of fish in stomachs	Size of bream most frequently found (cm)	Remarks	Author
Aral Sea	Pike-perch			1.4-13.7			In 2 out of 6 places studied, no bream in pike-perch and skeatfish	Baimov, 1963
Mazurian lakes of common type	Perch	summer			1.5	4-10	Bream abundant	Antosiak, 1963, 1963a
		winter			3.9	4-10		
	Pike	summer			1.4	2-10		
		winter			5.0	5-10		
Mazurian lakes of pond-type	Pike-perch	summer and autumn	66.0				Bream very abundant	Dziekońska, 1954
		winter	12.5			6-21		
		spring	20.0					
Vistula River (middle reaches)	Pike				3		Bream abundant	Horoszewicz, 1964
	Perch				2			
	Pike-perch				4			
	Skeatfish				6	2-12		
	Aspius aspius				2			
	Chub				3			
Tsimlanskoe Reservoir	Pike	summer	38.0					Domanevskii, 1958a
		winter	2.4					

The growth rate of bream has been determined for several hundred Polish lakes, Z. Marciak, unpublished data), but no relation can be established between the longevity of a population and its growth rate.

It is almost a rule that females are more numerous in older year-classes of bream (cf. section 4.41).

3.32 Hardiness.

Wunder (1936) reported that at an oxigen content of 2 - 2.5 mg/l bream show the first signs of aspyxia and at 0.4 - 0.5 mg/l they begin to die. Similar results were obtained by Privol'nev and Koroleva (1953). Lethal temperatures for southern bream are 33 - 34°C, for northern bream they are less than 30°C (Shkorbatov, 1964).

3.33 Competitors.

- Reproduction.

Pęczalska (1963) mentioned common spawning grounds of bream and white bream in the Szczecin Lagoon. In the Don Delta bream spawned together with pike-perch and the males of the latter protected the eggs of both species (Mikheev and Meissner, 1954). Sukhoivan (1959) reported similar observations. The hybrids described (cf. section 2.4) suggest that bream can spawn together with a number of other species of fish, thus competition for spawning grounds cannot be excluded.

- Competitors for food.

In lakes and rivers ruff, eel, white bream, roach, carp, Chondrostoma nasus and tench show common food items with bream (Aristovskaia, 1954; Bogatova, 1963; Podarueva, 1960: Wundsch, 1939; Pliszka and Dziekońska, 1953; Neuhaus, 1934). In the Azov, Aral and Caspian Seas, the food of bream is similar to that of Neogobius fluviatilis (Pallas), N. melanostomus (Pallas), Rutilus rutilus caspius (Yakovlev), Percarina demidoffi maeotica Kuznetzov, Aspius aspius, wild carp, Abramis sapa (L.) and Barbus brachycephalus (Kessler) (Berg et al., 1949; Shorygin, 1952). The latter calculated and compared a number of quantitative indexes referring to the competition for food among the fish of the Caspian Sea (cf. section 4.6).

Vasnetsov (1948) was convinced that the strongest competition between bream, wild carp and roach may take place when they start to feed on benthos (bream about 25 mm long). The older year classes of those species have their own specific feeding grounds and the competition for food occurs only in poorly differentiated water bodies containing not enough food.

Karzinkin (1952) gave a number of data on the availability of Tendipendidae larvae as food for a number of fish species. These observations suggest that under similar conditions carp, crucian carp, tench and ruff are superior to bream in finding food.

3.34 Predators.

Predators were discussed in section 3.23. Large bream are rarely preyed upon by fishes; big fish-eating birds attack them when on the spawning grounds (Berg et al., 1949).

3.35 Parasites, diseases, injuries and abnormalities.

- Parasitic diseases.

Ichthyophthiriosis

A disease caused by Ichthyophthirius multifillis Fouquet, 1876, (Protozoa, Ciliata).

A cosmopolitan parasite occurring in numerous fish species, including bream. The vegetative form of the parasite (up to 1 mm in diameter) is found under the gill epithelium and under the epidermis on the fins but also on the entire surface of the fish body. On heavily infested fish there are found small, whitish nodules. The parasite couses an inflammation of the skin, increased mucus secretion, peeling of the skin, and in more advanced cases even death. The parasite is dangerous to fish of all ages but especially so to fingerlings (Amlacher, 1961; Markevich, 1951; Schäperclaus, 1954).

- Control.

Best results are obtained by keeping the infected fish for some time in a trough with a strong current of water, which washes off the parasites from the skin and also from the bottom of the trough. A thorough disinfection of the pond erradicates the invasive stages of the parasite accumulated on the bottom.

Bucephalosis

A disease caused by an invasion of metacercariae of the family Bucephalidae (Trematoda). In Europe and Asia two species of this family are found in bream: Bucephalus polymorphus Baer, 1827, and Rhipidocotyle illense (Ziegler, 1883).

Sexually mature forms of the parasite are found in the intestine of predatory fish (Esox lucius L., Lucioperca lucioperca L., Perca fluviatilis L. and Acerina cernua L.). Cercariae develop in mussels (Unio and Anodonta), metacercariae are usually found under the gill epithelium, in the eyes, subcutaneous tissue and in muscles of various species of Cyprinidae.

Pathogenic effects of both the species depend on their localization in the fish body. Kozicka (1958) reported fin damage, skin hyperaemia and even large wounds on the body, in bream infested with Rhipidocotyle illense. According to Kozicka metacercariae, by pressure on the blood vessels, cause circulatory disturbances. The resulting blood congestion may result in atrophy of particular parts of the organs.

The presence of metacercariae in the eyes may cause blindness. Grabda and Grabda (1961) observed a massive invasion of Bucephalus polymorphus metacercariae in the eye cornea (some 500 larvae in one eye) causing cloudiness of the cornea and an increase in the amount of fluid in the interior chamber of the eye and exophthalmus.

Parasites pathogenic both to fry and to older bream.

Caryophyllaeosis

A disease caused by Caryophyllaeus laticeps (Pallas, 1781) (Cestoda, Caryophyllaeidae), a parasite of Cyrpinidae, extremely common in bream.

The parasite is common all over Europe and also in the Asiatic part of the USSR. The adult tapeworm is found in the fish's intestine and its larvae develop in the body cavity of various species of Tubificidae.

A heavy invasion of the parasite causes an inflammation of the intestine. The intestine may be blocked by numerous tapeworms and heavy mortality may result. The heaviest infestation occurs in April-May. The intensity of the invation increases with the age of the fish. According to Schäperclaus (1954), the degree of infestation increases markedly from the fifth year onward, when the bream starts to feed at the bottom.

– Control.

Intensive catches of bream with the onset of the disease.

Ligulosis

A disease caused by plerocercoids of the tapeworms (Cestoda, Ligulidae), Ligula intestinalis (L.) and Digramma interrupta (Rud., 1810), living in the body cavity of fish. The first intermediate hosts of the parasite are copepods (Cyclops strenuus, Diaptomus gracilis and others), in whose body cavity develop larvae of the procercoid type which are infectious to fish. The development of the larvae (plerocercoidae) in the body cavity of fish takes about 12 – 14 months (Dubinina, 1957). At this time the parasite attains the length of an adult tapeworm, the gonads develop but there is no egg production as yet. Sexually mature tapeworms are found in the intestine of such piscivorous birds as gulls, grebes, wild ducks and others. The final host may be also the domestic duck. (E. Grabda, 1951). In the intestine of birds, Ligula matures in about two days and begins to produce eggs.

The parasites are very common in Europe and the Asiatic part of the USSR in many species of Cyrpinidae, the main host being the bream. In many lakes the extent of the infection exceeds 50 percent. Single tapeworms are usually found, but sometimes a few or even some dozen are present in the body cavity of a single fish. Adult plerocercoids attain 1 m length and 1.5 cm width. A mixed simultaneous invasion of both species of cestode is sometimes encountered.

Ligulosis is most often found in palm-sized bream. According to Schäperclaus (1954) the heaviest infestation is found among bream under 17.5 cm. According to Zawisza (M.S.), the highest percentage of infestation is found in bream aged 4 – 5 years, which corresponds to the length of 20 – 24 cm. Dubinina (1957) reports that bream aged 1+ to 3+ are subject to the heaviest infestation. After the fish have started bottom feeding the incidence decreases.

Ligulosis causes heavy losses among fish. Reshetnikova (1959) estimated the annual losses in the Tsimlanskoe Reservoir at 1,200 tons.

A heavy invasion is manifested by flatulence. This often results in bursting of the abdominal cavity and the parasites drop into the water. Infested fish become languid and may easily be attacked by predators. In ligulosis there is observed a substantial decrease in fat content of fish muscles, a chronic peritonitis, and frequently there is a serum exudate in the body cavity. The internal organs of the fish are damaged owing to the pressure exerted by the parasites. The development of gonads is inhibited (Willer, 1912). According to Kerr (1948), infested fish show hypophysis changes and disturbances in the secretion of gonadotropic hormones, which results in a decreased fecundity. The investigations of Kosheva (1957) showed a lowering of the haemoglobin content and an increased blood sedimentation rate among infested bream. A slowing down of growth and a reduction in weight of bream infested with Digramma interrupta was found by Reshetnikova (1965).

Affected bream show low survival in tanks and during shipment.

– Control.

Intensive catches of infested fish and checking of the stocking material.

Ergasilosis

A disease caused by Ergasilus sieboldi Nordmann, 1832 (Crustacea: Copepoda parasitica), a gill parasite of numerous species of fresh water fish, frequently found in bream.

The parasite is very common in the lakes of Europe and Asia. The larval stages of the parasite develop outside the fish body, in water. Only the females are parasitic.

E. sieboldi injures the gill epithelium of the fish and causes respiratory difficulties. Heavily infested fish die of asphyxia, especially during summer heat. An emaciation of the fish is frequently observed. The intensity of the invasion is generally milder in bream than in Tinca tinca, the latter being the main host. As many as five hundred parasites have been reported on the gills of a single fish (Gnadeberg, 1948).

Control: an examination of the stocking material as well as intensive catches with the onset of the disease. Neuhaus (1929) recommended intensive catches during the winter season, when no juvenile forms of the parasite are found in the water, thus the females of E. sieboldi hibernating on the gills of fish are eradicated along with the fish.

Tracheliastosis

A disease caused by the parasitic copepod Tracheliastes maculatus Kollar, 1836 (Crustacea: Copepoda parasitica).

Only females which attach to the scales of fish, are known to be parasitic. Males unkown.

T. maculatus is found in Europe, mainly on bream, less frequently on other members of the family Cyrpinidae. It damages scales at the place of attachment and causes dermatitis, local at first and then diffuse. If the fish is heavily infested and the disease is more advanced, wounds form at the places of attachment. These may become portals of secondary infection through bacteria or fungi. Dermatitis is accompanied by a profuse mucus secretion. The disease causes strong emaciation of fish resulting in death (Grabda and Grabda, 1957). According to Geyer (1939a), bream ranging from 14 – 17 cm in length are most frequently subject to infestation. Grabda and Grabda (1957) found the heaviest infestation among fish over 20 cm lt. The intensity of the invasion amounts frequently to 100 percent. Usually only single parasites are found on a fish. When the invasion is heavy several parasites may be present.

– Control.

There are no means of eradicating the parasites themselves. They can be controlled through usual management practices, i.e. the control of stocking material and intensive catches of bream to thin the stock and to diminish the possibility of contact contamination.

Table XI summarizes data concerning the common parasites of bream.

– Infectious diseases.

Bream septicemia

An infectious disease manifested by an inflammation of the skin accompanied by congestions and haemorrhages. Frequently there are local swellings of the skin due to serum exudate in scale pockets. On the skin there may form lesions, sometimes reaching deep into the muscles. The gills are usually pale, sometimes there is protrusion of the eye-balls. Internal anatomicropathalogic changes: serum fluid in the body cavity, a congestion of the intestine, liver, and swim bladder, necrosis of the kidneys.

The investigations of Flemming (1954) proved that in the initial phase of the disease there is an increase in the number of leucocytes of the blood. Among them there are numerous granulocytes. In more seriously affected fish complete destruction of erythrocytes is observed.

Table XI

More frequently occuring parasites of the bream, *Abramis brama* (L).

No.	Species of parasite	Found in	Distribution area	Authors
		Protozoa		
1.	*Cryptobia abramidis* (Brumpt, 1906)	blood	Europe	Markevich, 1951; Kosheva, 1957; Bykhovskii, 1962
2.	*Myxidium pfeifferi* Auerbach, 1908	gall-bladder	Europe, Asia	Markevich, 1951; Bogdanova, 1957; Barysheva and Bauer, 1957
3.	*Myxobolus oviformis* Thélohan, 1882	gills, muscles, viscera	Europe, Asia (Siberia)	Wegener, 1909; Markevich, 1951; Akhmerov and Bogdanova, 1957; Bykhovskii, 1962
4.	*Myxobolus exiguus* Thélohan, 1895	gills, intestine, kidney	Europe	Wegener, 1909; Markevich 1951; Kogteva, 1957; Grabda and Grabda, 1961; Bykhovskii, 1962
5.	*Myxobolus mülleri* Bütschli, 1882	skin, gills, kidneys	Europe, Asia (Siberia)	Markevich, 1951; Bogdanova, 1957; Kogteva, 1957; Grabda and Grabda, 1961, and others
6.	*Myxobolus cycloides* Gurley, 1893	viscera	Europe	Wegener, 1909; Markevich, 1951; Grabda and Grabda, 1961
7.	*Chilodonella cyprini* (Moroff, 1902)	gills, skin	Europe	Kozicka, 1951; Markevich, 1951; Bogdanova, 1957
8.	*Ichthyophthirius multifiliis* Fouquet, 1876	skin, gills	Europe	Kozicka, 1951, 1959; Markevich, 1951; Bogdanova, 1957; Pacak, 1962
		Monogenoidea		
9.	*Dactylogyrus auriculatus* (Nordmann, 1832)	gills	Europe, Asia (Kazakhstan)	Markevich, 1951; Prost, 1957, 1959; Bogdanova, 1957; Vojtěk, 1959; Margaritov, 1959; Bykhovskii, 1962; Agapova, 1962
10.	*Dactylogyrus cornu* Linstow, 1878	gills	Europe	Markevich, 1951; Bogdanova, 1957; Pacak, 1962; Bykhovskii, 1962; Lucky and Dyk, 1964

... 2

11.	Dactylogyrus falcatus (Wedl, 1857)	gills	Europe, Kazakhstan	Markevich, 1951; Prost, 1957, 1959; Bogdanova, 1957; Vojtěk, 1959; Agapova, 1962, Bykhovskii, 1962
12.	Dactylogyrus crucifer Wagener, 1857	gills	Europe	Markevich, 1951; Bogdanova, 1957; Bykhovskii, 1962; Lucky and Dyk, 1964
13.	Dactylogyrus sphyrna Linstow, 1878	gills	Europe	Markevich, 1951; Prost, 1957, 1959; Bogdanova, 1957; Bykhovskii, 1962; Lucky and Dyk, 1964
14.	Dactylogyrus wunderi Bykhovskii, 1931	gills	Europe, Kazakhstan	Markevich, 1951; Bogdanova, 1957; Kogteva, 1957; Vojtěk, 1959; Agapova, 1962; Bykhovskii, 1962
15.	Dactylogyrus zandti Bykhovskii, 1933	gills	Europe	Markevich, 1951; Prost, 1957, 1959; Bogdanova, 1957; Margaritov, 1959; Vojtěk, 1959
16.	Gyrodactylus parvicopula Bykhovskii, 1933	gills	Europe, Kazakhstan	Prost, 1957; Bogdanova, 1957; Margaritov, 1959; Agapova, 1962; Bykhovskii, 1962
17.	Gyrodactylus medius Kathariner, 1893	gills	Europe, North Asia, Kazkhstan	Markevich, 1951; Agapova, 1960; Lucky and Dyk, 1964
18.	Diplozoon paradoxum Nordmann, 1832	gills	Europe, Asia (Siberia, Kazakhstan)	Markevich, 1951; Kozicka, 1951, 1953; Prost 1957, 1959; Vojtěk, 1959; Margaritov, 1959; Pacak, 1962; Agapova, 1960; Bykhovskii, 1962; Lucky and Dyk, 1964
		Trematoda - Digenea		
19.	Bucephalus polymorphus Baer, 1827, larva	gills, eyes, skin	Europe, Asia	Markevich, 1951; Kozicka, 1951; Grabda and Grabda, 1961; Bogdanova, 1957; Vojtěk, 1959; Agapova, 1960; Bykhovskii, 1962
20.	Rhipidocotyle illense Ziegler, 1883, larva	skin, gills, fins	Poland	Kozicka, 1953, 1958, 1959
21.	Phyllodistomum folium (Olfers, 1916)	urinary bladder, ureters	Europe	Markevich, 1951; Kosheva, 1957; Vojtkova, 1959; Bykhovskii, 1962

... 3

22.	Phyllodistomum elongatum Nybelin, 1926	urinary bladder	Europe, Asia	Markevich, 1951; Barysheva and Bauer, 1957; Akhmerov and Bogdanova, 1957; Vojtkova, 1959; Bykhovskii, 1962
23.	Sphaerostomum bramae (Müller, 1776)	intestine	Europe	Markevich, 1951; Kozicka, 1951, 1959; Grabda and Grabda, 1961; Pacak, 1962; Bykhovskii, 1962, and others
24.	Asymphylodora imitans (Mühling, 1898)	intestine	Europe	Markevich, 1951; Kozicka, 1951; Vojtěk, 1959; Wierzbicka, 1964; Bykhovskii, 1962
25.	Diplostomum clavatum Nordmann, 1832, larva	vitreous body of eye	Europe, Asia (Kazakhstan)	Markevich, 1951; Kozicka, 1953, 1958; Bogdanova, 1957; Vojtkova, 1959; Agapova, 1958; Grabda and Grabda, 1961; Bykhovskii, 1962
26.	Diplostomum spathaceum (Rudolphi, 1819) larva	eye lens	Europe, Asia (Kazakhstan)	Markevich, 1951; Kozicka, 1951, 1953, 1959; Bogdanova, 1957; Engelbrecht, 1958; Grabda and Grabda, 1961, and others
27.	Posthodiplostomum cuticola (Nordmann, 1832) larva	skin, fins, gills	Europe	Kozicka, 1953, 1958; Grabda and Grabda, 1961; Pacak, 1962; Bogdanova, 1957, and others
28.	Apophallus muhlingi (Jägerskield, 1899) larva	gills, fins	Europe	Markevich, 1951; Vojtěk, 1959; Bykhovskii, 1962
29.	Metagonimus yokogawai Katsurada, 1912, larva	scales, fins, gills	USSR, Czechoslovakia	Vojtěk, 1959; Zitman, 1960; Bykhovskii, 1962
		Cestoda		
30.	Caryophylleus laticeps (Pallas, 1781)	intestine	Europe, Asia, (Siberia, (Kazakhstan)	Markevich, 1951; Janiszewska, 1954; Kozicka, 1953, 1959; Engelbrecht, 1958; Agapova, 1960; Pacak, 1962, and others
31.	Caryophyllaeides fennica (Schneider, 1902)	intestine	Europe, Asia	Kozicka, 1959; Pacak, 1962; Bykhovskii, 1962
32.	Ligula intestinalis (L., 1758) larva	body cavity	Europe	Markevich, 1951; Kozicka, 1958; Dubinina, 1957; Willer, 1912; Pacak, 1962; Kosheva, 1957, and others

... 4

33.	Digramma interrupta (Rudolphi, 1810), larva	body cavity	Europe, mainly East Europe	Kosheva, 1957; Dubinina, 1957; Bykhovskii, 1962
34.	Proteocephalus torulosus (Batsch, 1786)	intestine	Europe	Markevich, 1951; Kosheva, 1957; Grabda and Grabda, 1961; Pacak, 1962, and others
		Nematoda		
35.	Rhaphidascaris acus (Bloch, 1779) larva	viscera	Europe	Markevich, 1951; Schäperclaus, 1954; Dyk, 1961; Bykhovskii, 1962, and others
36.	Philometra ovata (Zeder, 1803)	body cavity	Europe, Kazakhstan	Bykhovskii, 1962; Agapova, 1962
37.	Philometra abdominalis Nybelin, 1928	body cavity	Europe, Asiatic USSR	Markevich, 1951; Bykhovskii, 1962
		Acanthocephala		
38.	Neochinorhynchus rutili (Müller, 1780)	intestine	Northern holarctic region	Van Cleave and Lynch, 1950; Grabda and Grabda, 1961; Bykhovskii, 1962, and others
39.	Acanthocephalus anguillae (Müller, 1780)	intestine	Holarctic region	Kozicka, 1951, 1953; Pacak, 1962; Lucky and Dyk, 1964; Bykhovskii, 1962, and others
40.	Acanthocephalus lucii (Müller, 1776)	intestine	Europe	Kozicka, 1953, 1959; Pacak, 1962; Bykhovskii, 1962, and others
		Crustacea parasitica		
41.	Ergasilus sieboldi Nordmann, 1832	gills	Europe, Asia	Neuhaus, 1929; Markevich, 1956, Grabda and Grabda, 1961; J. Grabdá, 1962; Schäperclaus, 1954; Pacak, 1962, and others
42.	Caligus lacustris Steenstrup et Lütken, 1861	gills, skin	Europe, Asia (basins of the Baltic, Black, Caspian and Aral Seas)	Markevich, 1956; Kozikowska, 1957; J. Grabda, 1962; Bykhovskii, 1962 and others
43.	Tracheliastes maculatus Kollar, 1835	skin	Central and East Europe	Schäperclaus, 1954; Markevich, 1956; Kozikowska, 1957; Grabda and Grabda, 1957; J. Grabda, 1962; Bykhovskii, 1962, and others
44.	Argulus foliaceus (Linnaeus, 1758)	skin, mouth cavity, gills	Europe, Asia	Bogdanova, 1957; Stammer, 1959; Pacak, 1962; Bykhovskii, 1962, and others

From the affected bream, Schäperclaus (1954) isolated Pseudomonas punctata (Syn. Aeromonas punctata). The disease is quite common in Germany and Poland.

It is frequently found together with carp saepticemia (Abdominal dropsy). Although it has not been established that it is caused by the same germ as in carp, utmost precautions should be taken when stocking lakes with the latter species.

Focal liquefactive necrosis

An enzootic disease of bream found in Poland (Waluga, 1962; Niewolak, 1961).

The disease occurs among lake bream weighing approximately 1 kg, in summer (August - September). Weakened fish swim upside down near the surface. On the body of the fish there are found tumors of a soft consistency.

Histopathologic symptoms: a liquefactive necrosis of the skin and muscles, focal necrosis of the liver, spleen and kidney, fatty degeneration of the liver, peeling of the intestinal epithelium. In extreme cases there is a complete necrosis and loss of the caudal part of the fish (Waluga, 1962).

These changes are irreversible and usually lethal.

From the affected bream there has been isolated Pseudomonas chlororaphis (Guignard et Sauvageau, 1894) (Niewolak, 1961).

- Diseases of unknown etiology.

Epithelioma

In the initial phase of the disease there is a proliferation of the epithelial cells in the form of soft, whitish patches which eventually harden. The disease may affect the gills, causing their degeneration, or the skin. When the patches cover large portions of the surface of the fish body the fish become emaciated, the growth is retarded and death may eventually result.

Epithelioma is a disease common among carp. In bream the symptoms were observed by Schäperclaus (1954) in Germany, by Liaiman (1949) in the USSR, in Poland by J. Grabda, (unpublished observation). In older bream the disease is found sporadically.

The etiology of the disease is not sufficiently known.

- Poisoning.

Water pollution by industrial wastes containing phenol.

Phenol poisoning causes disturbances of the circulatory system (congestions, haemorrhages), necrobiotic changes in the cells resulting in a destruction of the cytoplasm and nucleus, the presence of foci of coagulative necrosis. Phenol affects the central nervous system causing abnormalities of respiration, motion and pigmentation - the bream become pale. Death results from respiratory paralysis (mors per asphyxiam) or from paralysis of the heart (mors per syncopem) (Waluga, 1966).

Low concentrations of phenol, although not lethal to fish, cause changes in the peripheral blood of fish, characterized by an increase in the number of non-typical and juvenile forms of blood corpuscles and a destruction of morphotic elements of blood (Waluga, 1966a).

3.4 Nutrition and growth

3.41 Feeding.

According to Laskar (1948), in lakes, younger bream feed by day and the older ones by day and night. Kogan (1963) and Nebolsina (1962), after studying the daily feeding rhythm of bream in retention reservoirs, came to the conclusion that they feed exclusively by daylight. Feeding is most intensive from 11.00 to 13.00 and then from 15.00 to 19.00 hours if the temperature is higher than 27°C.

Tendipedidae preponderate in the food when the light is strong, and Mollusca at dusk. Younger year classes feed in the littoral zone, the older ones in the sublittoral and profundal regions of lakes (Laskar, 1948; Pliszka, 1953). Feeding places depend on the limnological character of the water body (Table XII, and Pliszka and Dziekońska 1953, 1953a). In the Vistula, bream feed in muddy places, at greater depths, where the current is weak (Pliszka *et al.*, 1951).

Poddubnyi (1959) reported that, in the Rybinskoe Reservoir, one-to-two-year-old bream feed inshore, two-to-three-year-olds on the newly inundated areas, and older bream mainly in the former river bed; bream schools were observed on rich feeding grounds, while, at the same time, single fish or small groups were feeding on the poorer ones.

The mouth of an adult bream is semi-inferior; it makes a long snout directed downward, at an angle with the long axis of the body. The gill covers have strong muscles, which give the mouth considerable sucking power (Eremeeva, 1948, in Vasnetsov, 1948).

Table XII

Feeding grounds of bream in some German lakes (after Laskar, 1948)

Lake type	Abundance of bream	Tendipedidae in food, forms of: Sublittoral	Tendipedidae in food, forms of: Profundal	Feeding ground of mature bream	Growth	Catch	Lakes (Examples)
oligotroph	+	Tanytarsus and other littoral forms		Littoral sublittoral	very good	low	Bodensee
eutroph	++	Tanypini Tanytarsini Polypedilus Limnochir. Cryptochiro-nomus	Bathophilus Plumosus	Sublittoral -Profundal	very good	low middle	Grosser Plöner
eutroph	++++	Tanypini Tanytarsini Polypedilus Limnochir. Cryptochiro-nomus	Bathophilus Plumosus	Sublittoral -Profundal	good-very good	high-very high	Kleiner Plöner
eutroph	++++	Tanypini (not always)	Plumosus	Profundal	middle-low	high	Vierersee
eutroph	++++	-	Plumosus	Profundal	low	middle low (rarely high)	Müggelsee

According to Wunder (1936), the bream uses mainly its taste when looking for food; according to Kogan (1963) sight is most important. Disler (1948) proved that the sense organs of the lateral line may be helpful in finding food.

Bream can search for food in the upper mud layer only. According to Karzinkin (1952), bream 11.5 cm long can penetrate mud layers up to 5 cm thick, 16 cm fish up to 9 cm. Karzinkin (1952) is of the opinion that old bream (6 years old) can find their food even under a 15 cm mud layer. Changes in nutrition in older year classes of bream of the Caspian Sea are presented in Fig. 6, in those of Central European lakes in Fig. 7. Many authors agree with the general rule that as bream grow older they move to deeper feeding grounds and feed on bigger organisms.

A typical pattern of feeding activity is shown in Fig. 8 (after Hartley, 1947). The data of Laskar (1948) for German lakes, Pliszka (1953, 1953a) for Polish lakes and Morozova (1952) for the Aral Sea suggest that bream feed most intensively from June to August. According to Pliszka et al. (1951), however, in the Vistula there are two feeding maxima, in November and May, and two minima, in January and July; the latter is connected with the level of water; feeding is intensive at a low water level.

The data of Hartley (1947), Laskar (1941, 1948), Pliszka (1951, 1953, 1953a) and Nebolsina (1962) suggest that there is a drop in the feeding intensity both during the spawning season and in winter. The observations of Ziemiankowski and Cristea (1961) suggest that bream feed at a temperature of 0.5°C, but in the Gorki Reservoir Zhiteneva (1960) noticed that feeding stopped in October at a temperature of 4 - 5°C and in 1958 bream stopped feeding at a temperature of 8 - 9°C.

- Abstention from feeding.

During the spawning season bream hardly feed (Morozova, 1952; Pliszka et al., 1951). Ivlev (1955) studied the effect of starvation upon the biological reactions in fish. The data (Fig. 9) refer to bream weighing 0.32 g. Starvation clearly diminished the resistance to water pollution (phenol) and infection with mould (Saprolegnia).

3.42 Food.

Data on bream food are numerous. Laskar (1948), Shorygin (1952), Aristovskaia (1954) and Pankratova (1948) made lists of appropriate references. Table XIII and Fig. 7 show the most important food components of bream.

Many authors confirm the pattern of food composition (Egereva, 1962; Volgin and Vertinin, 1964, and others already quoted).

Annual changes in food composition were observed in lakes (Pliszka, 1953, 1953a) and brackish waters (Shorygin, 1952). It is believed that they reflect changes in availability of food animals. This explanation may be applied to differences in the food of bream in diverse biotopes, and in various years in reservoirs (Aristovskaia, 1954; Ivanova, 1960; Kogan, 1958; Zhiteneva, 1960).

Detritus, or mineral particles from the bottom, are almost always found in bream feeding on demersal fauna. They may make up to 80 - 90 percent of the contents of the digestive tract by weight (Bogatova, 1963; Shorygin, 1952). Gomazkov (1959) and Ananitchev (1959) discuss detritus as a source of food for bream. They conclude that detritus cannot be sufficient food for bream although it contains comparatively large amounts of vitamin B_{12}. The part played by bacteria is not clear.

The daily food intake (as percentage of body weight) is 19.5 percent in ponds, 38.4 percent in aquaria for small bream and 5 - 9 percent for big ones. The annual food requirement is the body weight times 15 (Zheltenkova, 1964).

Karzinkin (1952) found in experiments that one-year-old bream had a daily food intake of 5.7 percent of body weight in June, 10.1 percent in July and 6.6 percent in August. During 92 days the bream ate 16.5 times its weight at the beginning of the experiment.

Kogan (1963) estimated the daily food intake of bream in the Tsymlanskoe Reservoir as 2.5 - 3 percent of the body weight during summer. Nebolsina (1962) obtained a similar result of 2.5 percent for the bream of the Volgograd Reservoir. Shorygin (1952) reported the daily intake to be 7.4 percent in the case of bream aged one-plus in Lake Glubokoe; the annual intake was equal to 15 times the body weight.

3.43 Growth rate.

The growth in length and body weight of many bream populations has been established during the last 50 years. Most data were obtained from scale reading and

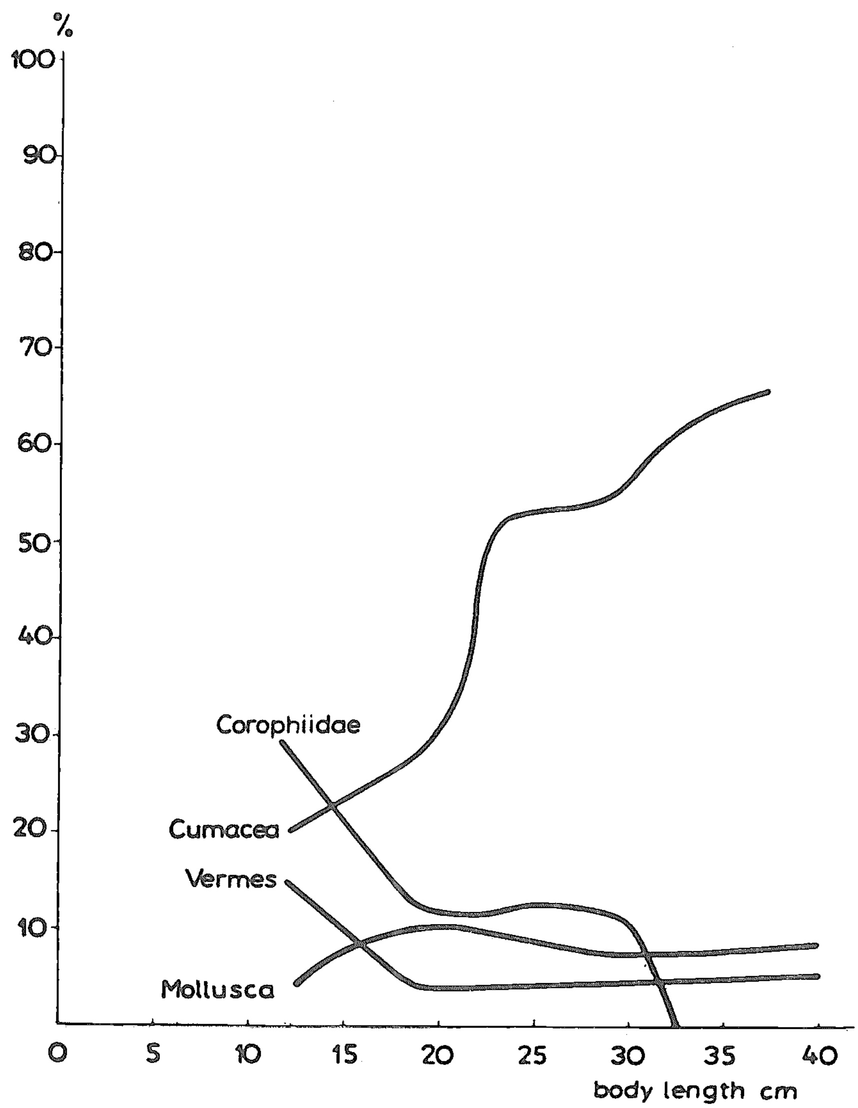

Figure 6. Food composition of Caspian bream, changing with growth (after Shorygin, 1952).

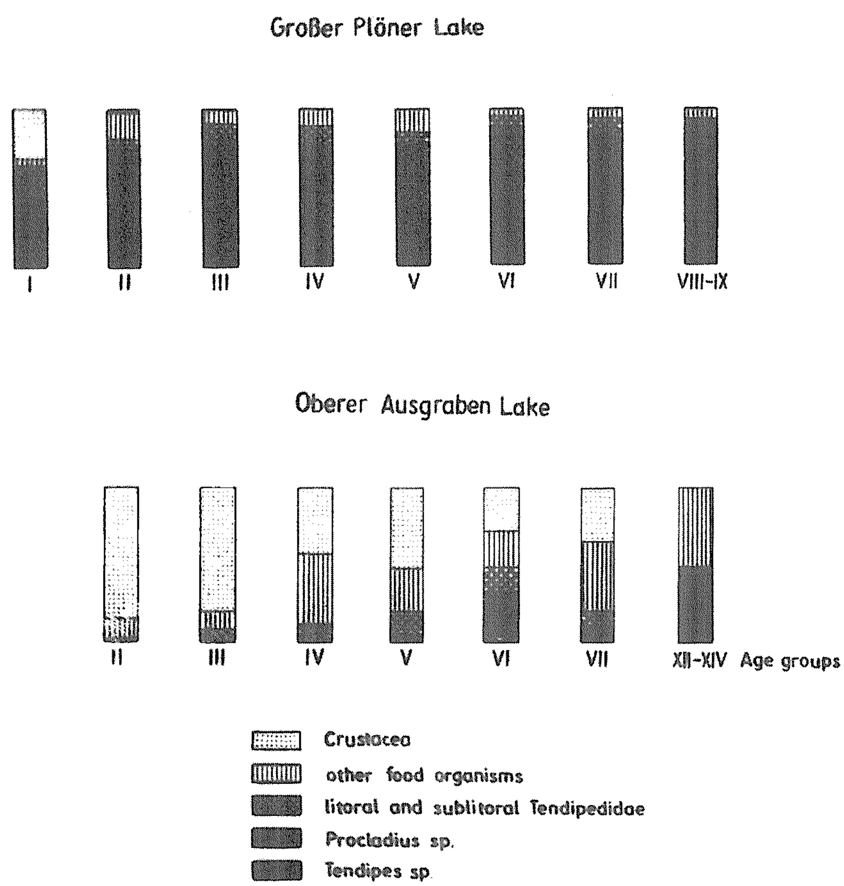

Figure 7. Food composition of bream from two eutrophic lakes (after Laskar, 1948).

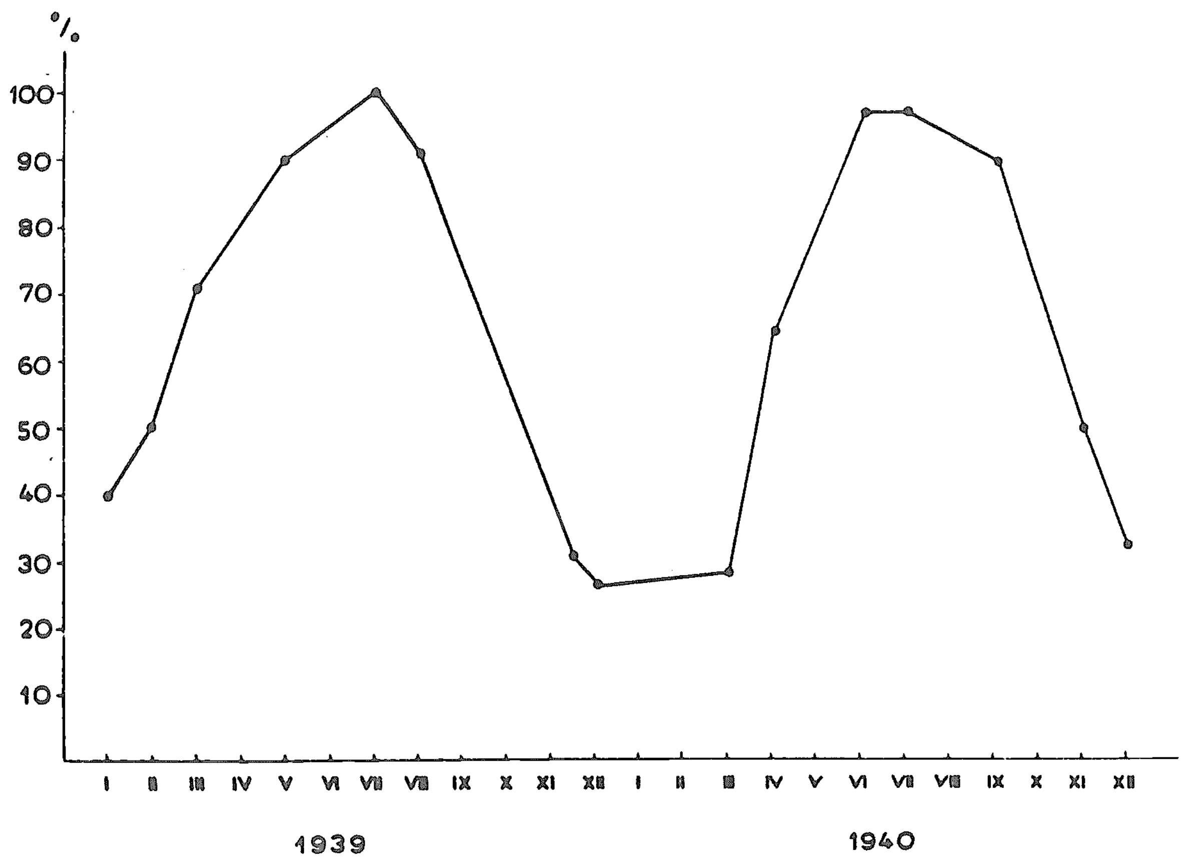

Figure 8. Variation in feeding activity in the course of the years 1939 and 1940. Percentage of fish containing food (after Hartley, 1947).

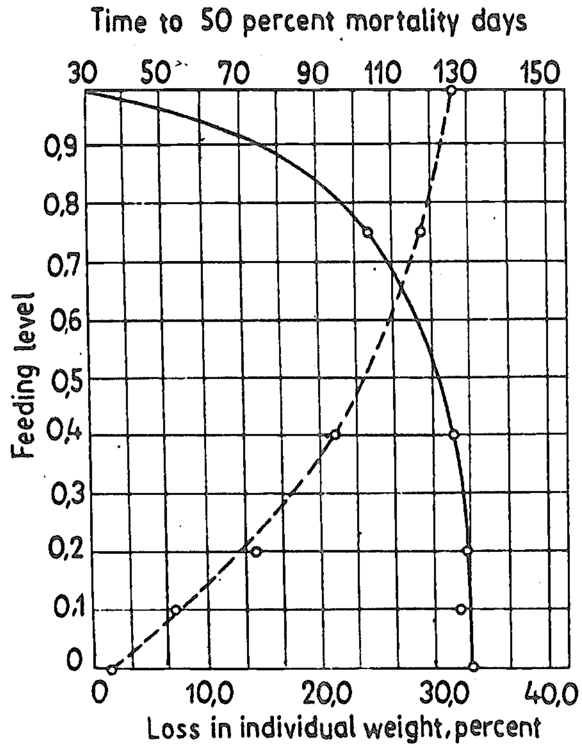

Figure 9. Loss in weight (solid line) and time to 50 percent mortality (broken line) in bream in relation to the "feeding level" expressed as proportion of maintenance food ration (after Ivlev, 1955).

Table XIII

Food of bream

Water body	Food components	Remarks	Author
Northern Caspian Sea	Cumacea, Corophiidae *Adacna* (69 percent by weight) Tendipedidae, Polychaeta Gammaridae, Mysidae *Monodacna*, Oligochaeta		Shorygin, 1952
Volga River	Tendipedidae, Oligochaeta Corophiidae		Pankratova, 1948
Vistula River	Tendipedidae, Oligochaeta Tipulidae		Pliszka *et al.*, 1951
Danube Delta	Tendipedidae	bream	Botnariuc and Spataru, 1963
– flooded areas	Nematoda, Copepoda	6.2–37.5 cm long	
– delta itself	Tendipedidae, Mollusca		
Ivankov Reservoir	*Tendipes* sp. up to 94 percent Mollusca 10–61.8 percent Oligochaeta 10–76 percent	summer food	Zhiteneva, 1958
Volgograd Reservoir	Tendipedidae, Oligochaeta Mollusca		Nebolsina, 1962
Gorky Reservoir	Zooplankton 33 percent in 1957; in other years Tendipedidae, Oligochaeta, Mollusca		Zhiteneva, 1960
Tsymlianskoe Reservoir	Tendipedidae, Oligochaeta Mollusca		Kogan, 1958, 1963

back calculations and they should be treated with caution. Numerous data on the growth rate of bream in European waters can be found in the works of Balon (1962), Bauch (1963), Berg (1949), Geyer (1939), Hartley (1947), Karpińska-Waluś (1961), Segestråle (1932, 1933), Shaposhnikova (1948) and Wundsch (1939).

Table XIV presents some available data to show differences in growth rate of bream. It is possible to distinguish two principal types of bream growth. The first is represented in Fig. 10 by the curve of the growth rate of bream in the Ural River delta and the Sea of Azov; in these cases, a high growth rate during the first 3 - 4 years is followed by a pronounced slowdown at the time of attaining sexual maturity. The second type of growth rate is shown in Fig. 10 by the data referring to Lake Tuusula, Gr. Plöner See and averages for Polish and German lakes; here the growth rate is approximately uniform, and there is no slowing down after sexual maturity is reached. This type of growth is common in the water bodies of Central and Northern Europe.

Vasnetsov (1934) regarded the first type as representative of bream. He defined the relative growth index or "growth characteristic" as

$$\frac{\log l_t - \log l_{t-1}}{0.4343} \; l_{t-1}$$

i.e. the difference between log of length at age t and log of length at age t - 1, times length at age t - 1. He considered the growth of bream to show two periods in most cases: the first, or juvenile, with rapid growth, and the second, after sexual maturity is reached, with low rate of growth. The data of Fig. 11 give the values for the "growth characteristic" index for three bream populations of various growth rates. Sharp differences in the index can be observed most frequently in the populations from the southernmost areas of the species distribution (Balon, 1963).

The relation of weight to age is presented in Table XV for three bream populations. For length/weight relationship, Hartley (1947) gave the formula:

$$W = 0.0065\, L^{3.296}$$

for fork length of bream from English waters. Fig. 12 presents a relationship between body weight and length for bream from Lake Godopiwo, Poland, after Karpińska-Waluś (1961), and data referring to a number of other water bodies. These show a similar trend, although they represent extremely widely separated populations with different growth rates. This confirms the opinion of Geyer (1939) and Wundsch (1939) on a close correlation between body length and weight in bream, irrespective of growth rate.

The Fulton condition index does not show any greater differences in the case of populations from different lakes and of diverse growth rate. For instance, according to Savina et al. (1964) the Fulton index for seven lakes situated in the north-western part of the USSR varies from 1.73 in Lake Tiosto to 1.90 in Lake Ilmen. Shaposhnikova (1948) gave the Fulton index as 2.20 for the Volga, the highest value being for three-year-olds, 1.8 - 2.4 for Lake Itkul, 2.00 - 2.21 for the Dneper delta. Other authors give similar values for bream from a number of water bodies, (in Shaposhnikova, 1948). Starvation forms are, however, also known among bream, when body proportions and condition deviate from the mean (Lühmann and Mann, 1957).

No correlation has been found between growth rate of bream and limnological type of lake (Zawisza, 1961). Wundsch (1939) stated that when comparing the growth rate of different populations of European bream it was impossible to find any dependence on the geographic position or climatic conditions. Shaposhnikova (1948) also reported that the geographic position of a water body and climatic conditions are rather secondary factors, the effects of which may be alleviated by food abundance. The growth rate in different areas is shown in Fig. 13, from the work of Shaposhnikova (1948), supplemented by data from other authors.

The following classification of growth rate of bream follows Järnefelt (1921), Geyer (1939 and Wundsch (1939):

Rate of growth	standard (total) length at age 9 (cm)	Age (years) at which weight of 1 kg and standard length of 37 cm are reached
good	31.5 (37.5)	before 11
medium	25 - 31.5 (30 - 37.5)	before 14
poor	less than 25 (30)	after 14

In addition, a class of "very good" growth rate has been introduced, after Shaposhnikova (1948), to denote those populations which reach the length of 31.5 cm at the age of five-to-six years and the weight of 1 kg and body length of 37 cm at the age of six-to-eight years. Such growth rates have been observed not only in estuaries and brackish waters of southeastern Europe but also in the Bodensee (Haakh 1929, in Wundsch, 1939), the Vistula Lagoon (Filuk, 1957) and among survivors in smaller lakes after winter-kill (Karpińska-Waluś, 1961).

A number of authors, from Järnefelt (1921) to Laskar (1948), have drawn attention to the dependence of growth rate upon the quality and quantity of food. This is very noticeable in retention reservoirs during the first period of their existence (Elizarova, 1962; Iliina, 1960; Marketova, 1958; Shaposhnikova, 1948). But in lakes no clear-cut correlation between the abundance of the profundal fauna food and the growth rate of bream can be established if other factors are not taken into consideration (Wundsch, 1939; Karpińska-Waluś, 1961; Zawisza, 1961).

Some other opinions concerning growth relations may be summarized as follows:

Stock in:	Factors affecting growth:	Author:
Finnish lakes	Temperature	Segestråle, 1932
German lakes	Combination of factors	Geyer, 1939
Polish lakes	Food abundance, combination of factors	Karpińska-Waluś, 1961, Zawisza, 1961
Azov Sea	Food availability, length of growing season	Dementeva, 1955
Caspian Sea	Abundance of bream and food availability	Zemskaia, 1958, 1961

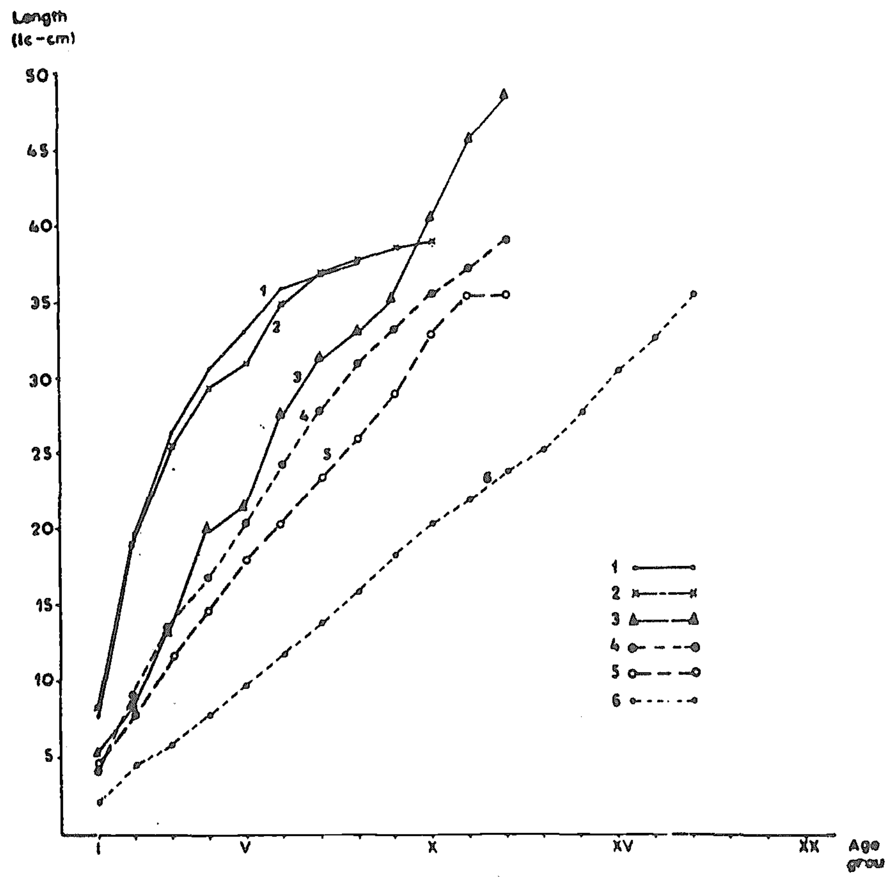

Figure 10. Growth in length of bream from some waters: 1. Ural River, 2. Sea of Azov, 3. Grösse Plöner Lake, 4. Average from 244 lakes of Poland, 5. Average from 36 lakes of Northern Germany, 6. Tuusula Lake, Finland.

Table XIV
Growth of bream (standard length) (cm)

Age group	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	Author Remarks
Lakes																				
Madingley Lake, England	7.63	12.77	14.0	21.4	25.33															Hartley (1947) total length
Bodensee, Switzerland-Germany		15.8	19.5	24.1	30.1	32.8	38.7	39.9	42.4	43.7	45.8	47.0	48.6							Haakh (1929) in Wundsch (1939)
Gr. Plöner, Germany	5.1	8.9	13.3	20.0	21.3	27.4	31.8	32.8	35.0	40.7	45.9	48.0								Geyer (1939)
Ob.Ausgrabensee	4.9	8.2	10.3	12.9	14.7	16.0	18.0	21.2	23.3	27.2	31.4	35.5	35.5		44.5					Geyer (1939)
Müggelsee			11.0	13.3	16.6	17.8	19.4	20.8	23.2	24.7										Wundsch (1939)
Average from 36 North German lakes	4.7	7.8	11.7	14.8	18.0	20.4	23.6	25.9	28.8	32.8	35.2	35.2								Bauch (1963)
Havgardsjön, Sweden	5.9	11.6	16.7	22.0	26.3	29.3	32.1	34.5	37.3	39.0	40.7	42.8	44.1							Alm (1920 in Wundsch (1939)
Hjälmaren, Sweden	2.9	6.1	9.1	12.2	15.0	17.4	20.0	22.3	24.7	26.8	29.6	31.8	32.2							Alm (1917) in Wundsch (1939)
Onkamo, Finland	5.2	9.6	14.8	18.8	22.4	25.9	30.0	33.5	36.0	39.3	42.3	44.2								Järnefelt (1921)
Tuusula, Finland	2.2	4.1	6.0	7.8	9.8	11.8	13.9	15.9	18.5	20.5	22.0	23.7	25.2	27.9	30.5	32.5	35.5			Järnefelt (1921)♀
Average from 14 Mazurian Lakes, Poland	4.8	8.6	11.6	15.0	17.9	20.5	23.5	27.5												Karpińska-Walús (1961)
Oświn, Poland	4.8	11.5	18.0	23.8																(After winter-kill
Wadąg, Poland	4.3	6.3	8.9	11.4	14.0	16.0	19.2	22.4	24.0	25.7	28.0	30.5	32.9							(Data of Inland
Żnin Duży, Pol.	5.7	10.2	15.2	20.3	24.6	28.5	33.4	37.3	39.8	41.5	43.3									(Fisheries Inst. (Poland
Ilmen, USSR	6.5	12.0	16.8	21.3	25.2	29.0	32.7	36.1	39.1	41.8	44.2	46.0	47.7							Berg (1949)
Itkul, USSR			22.5	29.0	33.2	38.0	40.5	44.0	47.0	52.5										Berg et al.(1949)
Samoziero, Karelia	3.4	6.9	9.6	13.6	16.2	22.5	24.9	26.5	29.5	32.6	34.9	37.3	38.9	42.5	43.1	45.0	48.8	50.9		Balagurova (1963)
Ladoga, USSR	6.5	9.8	13.7	18.0	23.8	27.7	29.0	32.0	33.6	37.8	40.0									Balagurova (1963)
Rivers																				
Vistula near Warsaw	5.6	9.8	13.6	17.1	20.0	23.3	27.5	30.5	33.3	35.8	38.5									Zawisza (1951)
Vltava near Praha	6.2	10.3	14.6	16.5	21.4	25.0														Oliva (1958) in Balon (1963)

Danube near Medvedovo	5.3	10.6	16.7	20.8	23.9	26.9	29.4	31.7	33.1	35.5	39.5									Balon (1963)
Danube delta	11.2	18.4	24.7	29.7	34.2															Papadopol (1960) in Balon (1963)
Dneper, middle course	8.1	14.9	21.5	27.6	32.7	35.8	38.1	39.9												Belyi (1948) in Balon (1963)
Dneper delta	8.6	16.4	25.2	30.3	34.7	38.6	41.2	44.6												Belyi (1948) in Balon (1963)
Niemen, USSR	6.7	13.6	20.8	26.9	32.1	36.4	40.3	45.2												Zhukov (1958) in Balon (1963)
Volga near Kuybyshev	4.6	9.3	14.1	19.3	24.3	28.4	31.8	35.0	37.2											Shaposhnikova (1948)
Ural delta	7.6	19.7	27.8	31.6	33.6	37.4	38.5	40.0												Berg (1949)
Reservoirs																				
Rybinsk Reservoir	4.8	9.2	13.0	16.8	20.2	23.5	26.2	28.6	31.3	33.6	35.4	37.3	39.0	42.0						Ostroumov (1955)
Volgograd Reservoir		14.0	18.7	24.9	29.8	33.3	37.3	41.0												Elizarova (1962)
Pskov Reserv.	6.2	11.6	16.7	21.6	25.8	29.4	32.8	35.6	37.8	39.6	41.5	43.5	45.1							Berg (1949)
Brackish waters																				
Aral Sea	9.2	16.1	22.1	26.8	30.0	32.3	34.7													Berg *et al.*(1949)
Caspian Sea	7.1	16.1	22.4	26.2	28.9	31.4	34.6	37.5												Dementeva in Shorygin (1952)
Azov Sea	8.0	18.0	26.0	29.0	32.0	35.0	38.0	40.0	42.0	43.0										Timofeev (1964)
Vistula Firth (Lagoon)		17.1	21.8	26.0	30.5	32.4	34.5	36.7	38.5	46.5	43.0	45.2	47.0	48.7						Filuk (1957) total length
Baltic, Arkona	4.8	11.0	14.1	17.6	21.0	23.0	26.1	30.5	33.6	37.0	37.8	38.8								Bauch (1963)
Hommanäs-Pellinge	2.5	5.7	9.0	11.8	14.2	16.2	18.3	19.6	21.8	23.4	25.1	27.0	28.3	30.0	31.6	33.0	34.4	35.4	36.9	Segestråle (1933)

Table XV
Examples of slow, medium and fast growth of bream

Lakes	Age group	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
Tuusula	length (cm)	2.2	4.1	6.0	7.8	9.8	11.8	13.9	15.9	18.5	20.5	22.0	23.7	25.2	27.9	30.5	32.5	35.2
(Järnefelt, 1921)	weight (g)		5.2			11.5		65	122.5	168.2	217.2	304.5	343.3	375	475	575	683	950
Gr.Plöner	length (cm)	5.1	8.9	13.3	20.0	21.3	27.4	31.8	32.8	35.0	40.7	45.9	48.0					
(Geyer, 1939)	weight (g)		12.5	40.5	170.0	225.0	510.0	700	800	980	1500	2400	2850					
Itkul (Berg <u>et al.</u>, 1949)	length (cm)			22.5	29.0	33.2	38.0	40.5	44.0	47.0	52.5							
	weight (g)			250	595	880	1310	1700	1960	2600	3700							

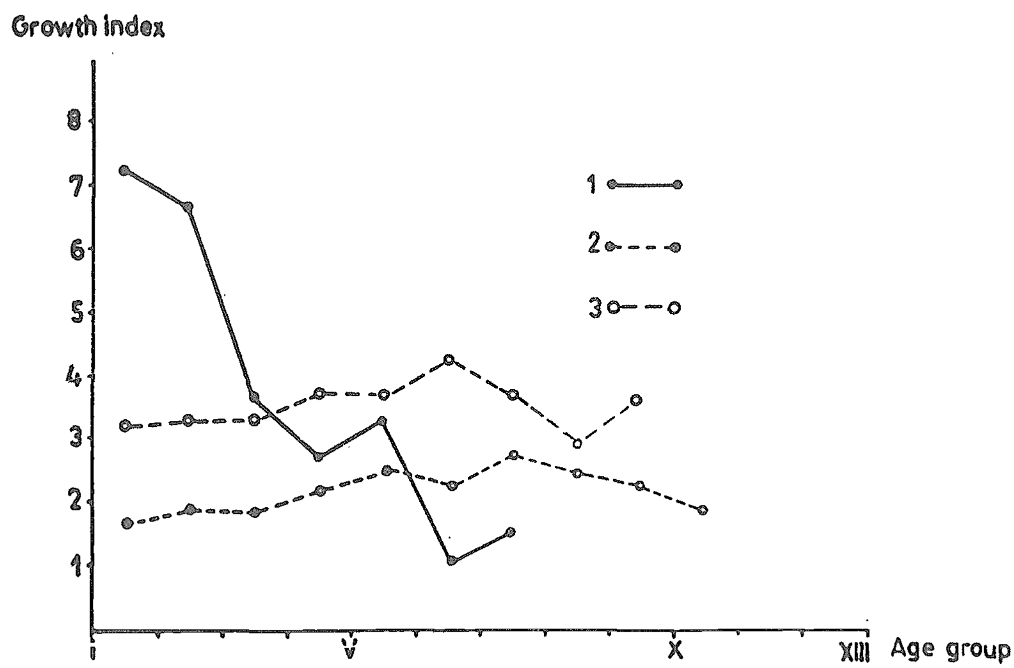

Figure 11. Vasnetsov's growth index: $(\ln l_t - \ln l_{t-1}) \cdot l_{t-1}$
1. Ural River, 2. Tuusula Lake both from Vasnetsov (1934), 3. Charzykowo Lake (Stangenberg, 1950) calculated by Balon (1963).

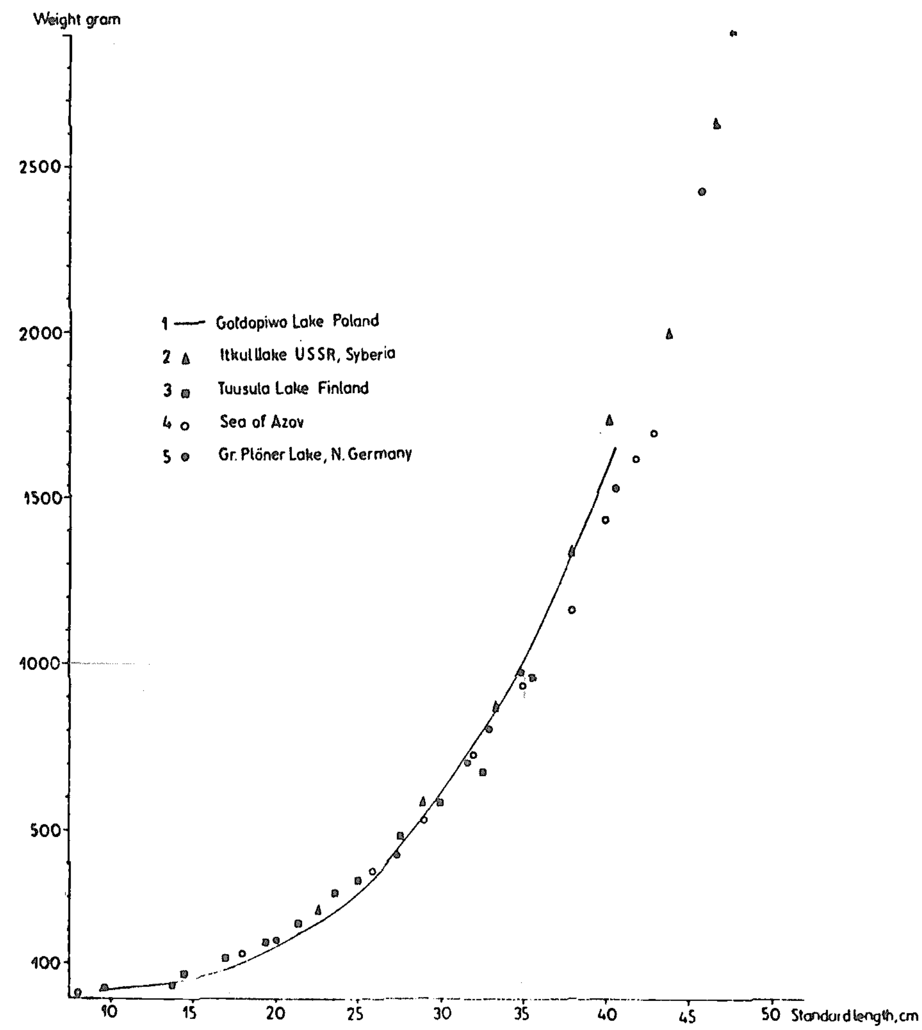

Figure 12. Length/weight relationship in bream

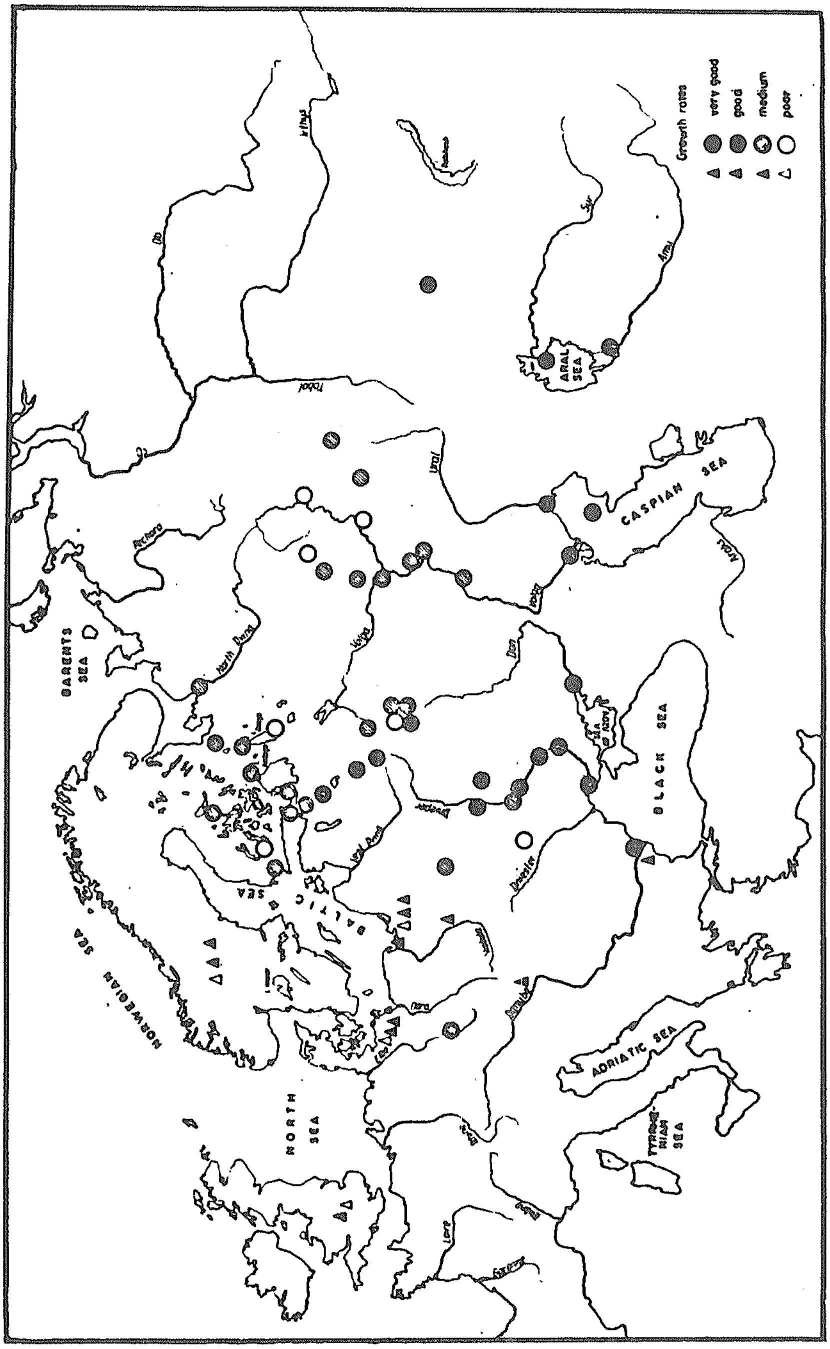

Figure 13. Growth rates of bream in the area of its natural distribution.
Circles - from Shaposhnikova (1948)
Triangles - some data from Table XIV.

3.44 Metabolism.

The available data are presented in Table XVI and Figs. 14 and 15.

Kuznetsova (1958) studied the oxygen requirement of bream from fertilization of egg until the larvae attained a weight of 2 g. According to Vinberg (1956) a rough estimate of the standard metabolism of bream at 20°C can be obtained from the formula:

$$Q_1/\ O_2\ ml/h/ = 0.3\ W^{0.8}$$

or

$$Q_2/calories/day/ = 36\ w^{0.8}$$

where "w" is weight in grams.

No data on active metabolism has been found.

3.5 Behaviour

3.51 Migrations and local movements

Bream from the estuaries of Black, Caspian and Azov Seas have been described as semi-migratory. The spawning and winter grounds of those populations are in the lower reaches and deltas of large rivers, while their feeding grounds are in brackish sea areas. Consequently two periods of mass migration are observed: spring and autumn. The spring migration of the Caspian bream begins with the melting of ice on the sea. The first group of bream start their up-stream migration at the beginning of April, while the second and larger run lasting for 15 - 30 days begins when the water of the river reaches the temperature of 8°C.

After spawning, bream return to the sea and disperse to feed. They school at the end of July and in August. The autumn migration in the northern part of the Caspian Sea begins in August and reaches its peak in October. Bream spend the winter in the deeper parts of rivers, not far from the places where they discharge themselves into the sea (Dementeva, 1952a; Berg in Berg et al., 1949).

Only a part of the bream population of the Aral Sea spawn in rivers, while the rest spawn in the areas surrounding river mouths. In March - April bream appear in coastal areas to breed. After spawning, bream move to marine feeding grounds and return to the shore in September - October. In December bream aggregate near the Syr and Amu-Daria Rivers (Morozova, 1952). Velikokhatko (1941, in Berg 1949) distinguishes two forms of Dneper bream: a "winter" form which migrates up to 100 km upstream and "spring" fish which occur in the lower reaches of the river. The runs of the "winter" form begin in autumn, at the end of September and in October, and they last all through the winter. The "spring" form is not so numerous as the "winter" one and starts its migration in spring. Young bream reaching the length of 25 - 30 mm swim seaward.

The results of tagging carried out in German rivers and in the middle Vistula (Pliszka, 1951) prove that most of the population does not migrate for long distances. Similarly, the observations of Sakowicz and Backiel (1953), on the migrations of fish along canals linking lakes with dense bream populations, did not reveal any clear-cut migratory trends.

Within particular lakes, however, there occur local migrations which in some degree resemble those of semi-migratory bream of the North-European big river estuaries. Driagin (1949) described the spawning migration of bream from Lake Pskovsko, USSR, to adjacent rivers. Tagging was carried out in Lake Sniardwy, Poland, (unpublished data of the Inland Fisheries Institute in Olsztyn) on a spawning ground where they were very abundant. Tagged fish were caught on feeding grounds over the whole lake in summer, and they were found on a gathering ground in winter, when 40 tons of bream were taken in one seine haul.

3.52 Schooling.

Bream school in early stages of their development (Vasnetsov et al., 1957) after reaching the length of 16 mm (Paiusova, 1961). These schools or aggregations, known also as "elementary populations" (Lebedev, 1946), differ in individual size, size distribution, condition factor and degree of infestation with metacercariae. Paiusova (1961) observed separate aggregations of young bream for two weeks. The behaviour of those bream was not observed. Observations on bream in an aquarium suggest that they school when excited and they scatter for feeding. Ohlmer and Schwarzkopf (1959) proved that the swimming velocity of bream studied individually increases with their length, from 0.66 m/sec. when they are 12 - 16 cm long to 0.90 m/sec at the length of 24-28 cm. Bream, when studied in a school, swam 0.65 - 0.68 m/sec irrespective of their length (cf. also section 3.51).

3.53 Responses to stimuli.

Bream are able to see light of wave-length 400-710 mμ, their greatest sensitivity lying between 600 and 630 mμ. At dusk they are most sensitive to rays of 540 mμ. The number of pictures a bream can distinguish in one sec is 55 (Radakov and Protasov, 1964).

Table XVI
Respiration rate of bream

Age (days)	Weight (g)	O_2 consumption	Author
Embryo		0.655 mg/h/g	Kuznetsova, 1958
Larvae		mm^3/h/10 larvae	Nikiforov, 1953
20	0.080	0.84	
25	0.100	0.38	
30	0.120	0.42	
45	0.210	0.42	
60	0.200	0.42	
Older bream at t° = 20°C		mg/h/g	Ivanova, 1939
	38.7	0.177	in Vinberg, 1956
	69.5	0.165	
	102.9	0.114	

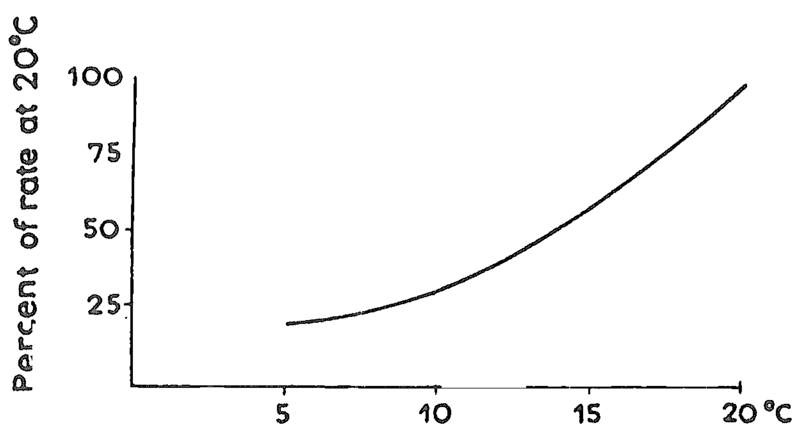

Figure 14. Metabolic rate of bream and temperature (from Vinberg, 1956, after Bogdanova and Strelcova, 1953).

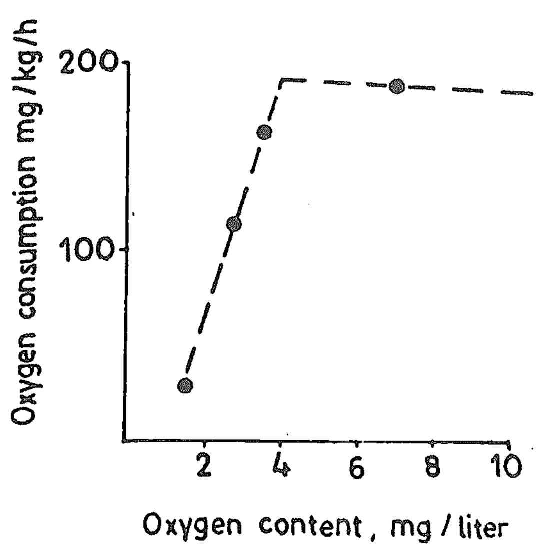

Figure 15. Respiration rate of bream and oxygen content of environment at 20°C (from Vinberg, 1956).

The reaction to light changes with age. Privolnev (1956a) found that bream younger than 15 days shun strong light, from the 15th to the 20th day of their life they get more photophilous, and they again avoid light when they are 40 days old.

A positive rheotaxis was observed by Aslanova (1952) among bream 4.5 - 5.5 cm long, when the water current was 3.32 cm/sec. Bream aged two-to-six years, which were 24 - 35 cm long, took an upstream position in flow rates of 4.54 - 8.46 cm/sec.

A drop in the oxygen content of water to 1 or 1.5 mg/l caused bream to leave that place and search for another where the oxygen content was higher (Alabaster and Robertson, 1961). Privolnev (quoted by Vinberg, 1956) observed restlessness among bream at an oxygen content as high as 2-2.5 mg/l.

Bream of the southern region of its distribution avoid salinities higher than 12.9 ‰ (Karpevich, 1955).

According to Lenkiewicz (1964), young bream of 6-10 cm, studied in November and acclimatized for one-to-five days at 7-8°C, showed a preference for water of temperature 9-19°C (average 13.75°C); but when acclimatized at the temperature of 14-25°C they preferred a higher temperature, from 13-24°C (average 18.9°C). Bream bred in an aquarium at room temperature for 6 months showd a preference for temperatures from 26° to 28°C (Horoszewicz, unpublished data).

The bream is sensitive to direct electric current of field intensity equal to 0.66 V (Bodrova and Kraiukhin, 1959). At the intensity of 3.64 V electronarcosis takes place. The reaction to alternating current (Shentiakov, 1964) begins with fin twitching at about 0.46 - 0.77 V, head-to-tail voltage ("Gestaltspannung" in German, denoted by U_R).

As the electric field strength grows, the twitching of fins increases, there are body jerks, uneasy swimming around, then sudden swimming for long distances and convulsive movements of the body. Shock or tautening of fins and the whole body, twitching and at last complete immobility take place at U_R = 2 to 3.5 V, depending on the body length, at the water resistance 3035 Ohm/cm.

4 POPULATION

4.1 Structure

4.11 Sex ratio

Available data are presented in Table XVII. In the catchable populations females usually predominate. It may be assumed that the same is true of the population as a whole owing to the greater mortality rate among males (Alm, 1959). In older age groups the proportion of females keeps increasing.

During the spawning season far more males are taken and up to 80 percent were recorded by Shaposhnikova (1948). This is because males remain longer on the spawning grounds (cf. section 3.16). In bream aggregations observed in the Sea of Azov, called "elementary populations" by Lebedev (1946), the sex ratio varied widely, ranging from 48 to 80 percent of females. To sum up the available data:

- the ratio among young bream is close to 1 : 1;

- the number of males declines faster than that of females as bream grow older; females predominate in older age groups;

- in the spawning aggregations usually females predominate before spawning whereas males are more numerous during spawning;

- in feeding aggregations the ratio varies.

4.12 Age composition

Table XVIII exemplifies age composition in bream catches. Populations from northern waters (Siamozero) are composed of more age groups than those from southern waters.

The composition of a population varies from year to year, particularly in heavily exploited populations (e.g. Caspian Sea) owing to considerable variations in the abundance of different generations (Fig. 16).

Age at first capture is frequently two-to-three years (Table XVIII). In the lakes of northern Poland it is five-to-six years.

The average age of bream caught in the northern Caspian Sea (Lukashov, 1961) was 4.5 in the years 1937 - '48 and 3.6 in the years 1953-' 58. In the Sea of Azov it ranged from 4.5 to 5.5 in 1939-'47.

The most abundant age groups of bream caught in northern waters are:

Siamozero	7 - 12 years
Vistula Lagoon	3 - 8 years
Vistula River	4 - 6 years
Lakes of Northern Poland	6 - 10 years

In the Danube estuary 76 percent of the bream caught are two years old (Popescu, 1958).

The age composition in the populations caught varies in the course of a year, as shown in Table XVIII for the Caspian Sea. In spring, older individuals are usually taken in spawning aggregations.

Age at maturity - cf. section 3.12

Maximum age - cf. section 3.31

4.13 Size composition

The composition of bream populations in length groups are illustrated by the data of Dementeva (1955), for catches with a gear called "lampara" in the Sea of Azov. The catches comprise individuals ranging from 5 to 51 cm in length (Fig. 17). The variations in the size composition are in agreement with the variations in age composition (cf. section 4.12), so that bream 7 cm long dominated in the Sea of Azov in 1948, while bream 27-35 cm long were predominant in 1952. In commercial catches from various waters the length of bream was as follows:

Nogat River (Vistula estuary)	28 - 57 cm body length (Backiel unpublished)
Vistula Lagoon	15 - 60 cm total length (Filuk, 1957)
Elbe River	22 - 57 cm total length (Bauch, 1958)
Danube estuary	21 - 38 cm total length (Popescu, 1958)

Size at first capture: cf. section 6.12.

The average lengths of bream caught in various waters vary, due to differences in the abundance of generations, variations in growth and also exploitation.

In 1929-'39 the average length of bream caught in the Volga Delta ranged from 24.5 - 31 cm (Dementeva, 1952) due to variations in the abundance of generations. A decrease in the average length of bream caught today, as compared with bream caught during the Middle Ages and in prehistoric times, has been explained by changes in the methods and inten-

TABLE XVII
Sex ratio in bream populations

Locality	Data obtained from	Percent of females	Author
Szczecin Firth, Poland	commercial catch 1956-1959	63.8	Pęczalska,1963
Szczecin Firth	commercial catch, age group:		Pęczalska,1963
	2	43.3	
	3	55.9	
	4	70.5	
	5	59.7	
	6	61.6	
	7	60.0	
	8	65.0	
	9	64.0	
	10	70.0	
	11-15	78.7	
German lakes		abt 50.0	Wundsch,1939
Vistula River Poland	commercial catch age group:		Zawisza,1951
	3	46.0	
	4	39.0	
	5	48.5	
	6-10	55.5	
Danube River, Czechoslovakia	special collection	abt 50.0	Balon,1963
Volga estuary	young bream catch, age 1 and 2	abt 50.0	Berg,1949
Volga estuary	spawning population in autumn	53.0	Berg,1949
Volga estuary and Azov Sea	commercial catch, age group:		Dementeva,1952
	3	28.6	
	4	45.3	
	5	64.0	
	6	78.2	
	7	87.5	
	8	100.0	

Table XVIII
Age composition of bream in catches (percent)

Locality	Age groups 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Author
Lake Siamozero, Karelia, USSR	0.2	0.4	0.2	0.2	2.4	7.8	13.9	25.9	16.9	8.1	6.2	4.6	5.9	2.2	2.5	1.9	0.5	0.2	Balagurova, 1963
Vistula Lagoon, Poland	7.0	25.1	14.1	9.1	10.2	8.8	6.7	6.0	3.7	2.1	0.9	0.7	0.1						Filuk, 1957
Vistula Estuary, Poland			0.6	4.0	49.9	21.9	15.8	2.5	2.2	0.6	1.9		0.5						Backiel, (unpublished)
Elbe River, middle course, Germany		0.8	5.1	24.5	25.5	28.8	8.5	3.4	3.4										Bauch, 1958
Danube River, Czechoslovakia	2.7	39.9	6.8	24.5	8.4	7.3	3.6	2.7	1.6	0.9	0.5	0.5		0.1					Balon, 1963
Vesolovskoe Reservoir on Don River, USSR *																			
1953	3.6	62.7	20.5	11.4															Kruglova, 1961
1954	25.5	64.8	8.3	0.7															
1959	1.0	22.0	67.0	9.0															
Southern Aral Sea																			
1939		5.5	52.9	36.7	4.5	0.3	0.1												
1947			2.0	56.3	31.7	7.9	1.5	0.3	0.3										Berwald, 1956
Estuary of Terek River, Western Caspian Sea, USSR																			
1947		71.2	17.2	10.1	1.1														Demin, 1962
Northern Caspian Sea																			
1933 autumn	2.4	91.0	6.2	0.4															Dementeva, 1952
1934 spring	0.2	82.0	13.9	2.0	0.6	1.2													
1935 autumn		2.3	13.7	81.5	2.5														
1936 spring		0.8	25.2	72.4	1.4	0.1	0.1												
1951 spring	0.3	13.8	12.1	64.5	6.5	1.1	0.6	0.8	0.3										Berdichevskii, 1961
1951 autumn	7.7	49.1	11.1	25.6	4.4	0.9	0.4	0.7											
Lake Yasa, Turkmen SSR	10.0	40.0	31.0	19.0															Nikolskii, 1953

* Note that the total catch increased rapidly:

1953 - 00.2 ton; 1954 - 6.00 ton; 1959 - 120.90 ton

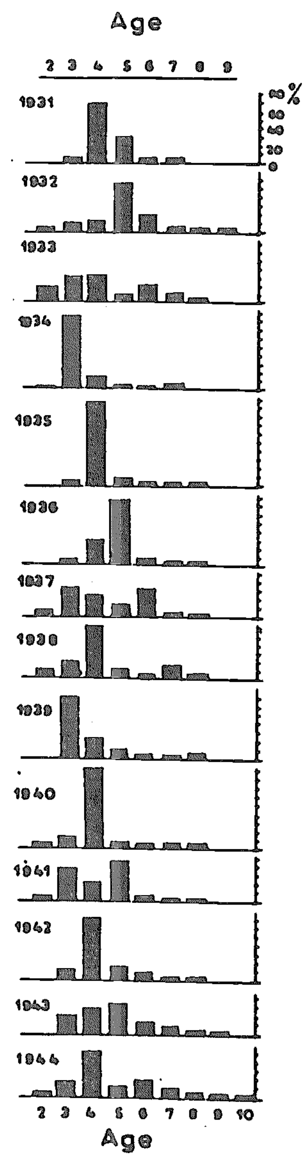

Figure 16. Age composition of bream catches in Volga Estuary (after Dementeva, 1952).

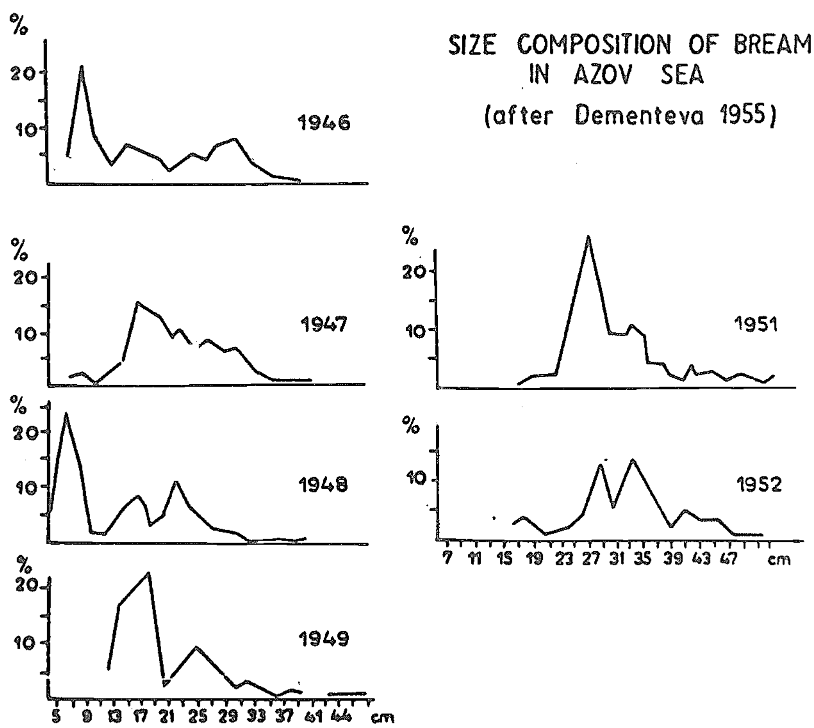

Figure 17. Size composition of bream in Azov Sea (after Dementeva, 1955).

sity of exploitation. So, for example, excavations from the first eight centuries A.D. revealed that the average length of bream from Lake Pskovskoe was 39.6 cm, whereas the average for 1951 is 33.1 cm. Excavations in the vicinity of Lake Ilmen from VII to IX centuries A.D. revealed the average length to be 42.4 cm; today it is 30.5 cm (Nikolskii, 1958). Similar tendencies have been observed in bream from the Sea of Azov (Nikolskii, 1958), the average length being:

5,000 years ago,	about	36.0 cm
in 1925	"	34.3 cm
" 1929	"	31.0 cm
" 1955	"	29.4 cm

According to Tsepkin (1964), bream averaging from 28.9 to 29.5 cm were caught in the VI - XI centuries A.D., in the estuary of the Amu-Daria River, where it enters the Sea of Aral. It must be stressed that 5,000 years ago bream comprised only two percent of all catches, whereas today they amount to some 39 percent.

Size at maturity cf. section 3.21.

In lakes, adult bream inhabit deeper regions. In the shallow coastal waters of lakes only young bream, about 4 cm long, are found, and these occur only in small numbers even in the vicinity of spawning grounds (Backiel, 1953). In running water, larger bream avoid shallow places. They move to deeper waters within one month of hatching (Backiel, 1958).

The same applies to the Volga (Dementeva, 1952a; Tanasiichuk, 1952, 1959), and to the Amu-Daria and Syr-Daria (Berg, 1949) where young bream move to deeper water and to the brackish water of the estuary. As early as July, bream about 2 cm long have been found in brackish waters (Dementeva, 1952a; Paiusova, 1961; Tanasiichuk, 1952). The data concerning the age distribution in autumn and spring catches in the Northern Caspian Sea (Table XVIII) show differences in bream size in various places and seasons, connected with spawning migration.

According to Berg (1949) the maximum weight of bream is 11.55 kg. Toner (personal communication) reported that a 5.3 kg bream has been caught in Ireland. Bauch (1958) gave 8 kg as the maximum weight in the Elbe River. Lebedev (1961) mentioned the length of 74 cm as the maximum for bream, (cf. section 3.31).

4.2 Abundance and density

4.21 Average abundance

No information is available on any attempt to estimate the abundance of bream by tagging or from data on fishing effort and catch. Karpevich (1955) estimated the so-called "Promyslovyi zapas" (available commercial stock) of more than three-year-old bream of the Sea of Azov to be 39.4 million fishes in 1947 and 47.7 million fishes in 1949-'50. The areas where bream occured were 17,000 - 18,000 km^2 and 10,000 km^2 respectively. Therefore it is possible to calculate that average numbers of bream older than three years were 22 per ha in 1947 and 48 per ha in 1949 and 1950.

4.22 Changes in abundance

Changes in abundance caused by hydrographic and other conditions were studied in the Sea of Azov by Maiskii (1955). He established the area where bream were present, and then the relative density was found in various places of that area by means of catches made with a net called "lampara", which can take fish from 5-50 cm long. The numbers of fish caught are an index of relative abundance, according to the author. The results were as follows:

Year	1937	1940	1946	1947	1948	1949	1950	1951
Area where bream were found (thousand km^2)	22	20	15	18	13	12	10	10
Relative abundance (million fish)	161	62	120	96	130	40	40	66

A shrinkage of the area of occurrence, and consequently a drop in abundance, were caused, according to Karpevich (1955) and Maiskii (1955), by an increase in the salinity of the Sea of Azov, as a result of flow regulation of the Don River where retention reservoirs have been built.

Tanasiichuk (1952), Dementeva (1952a) and Koblitskaia (1961) have pointed to the dependence of the abundance of young bream on the water level of the Volga delta. A high, although not disastrous, water level lasting for 12-15 days during bream spawning and egg and larval development and then a lowering of the water level favour the development of a numerous generation. Romanycheva (1958) noticed a similar correlation between the strength of year classes in the Aral Sea and the water level in the Amu-Daria River. His suggested explanation is that a high water level makes bream more difficult to catch and therefore more bream reach the spawning grounds.

Changes in hydrological conditions and an increase in the water area resulting from the building of retention reservoirs generally cause a rise in the abundance of bream, both in absolute and relative numbers (Wundsch, 1949; Backiel, Kossakowski and Rudnicki, 1956; Nikolskii, 1948; Sebentsov and Meisner, Mikheev, 1953; Vasilev, 1956).

The following four reservoirs may serve as an example:

Reservoir	Year of fishery exploitation	Percentage in catches
Möhne, Westfalen (highland)	to 12th year	very low
	12th - 14th years	up to 8.3 percent
Otmuchów, Slask, Poland (lowland)	1st - 4th years	1.0 percent
	13th - 20th years	75.0 - 90.0 percent
Kutuluk, Middle-Volga, USSR (lowland)	1st - 5th years	considerable amounts of young
	8th - 10th years	34.0 - 42.0 per cent
Rybinskoe, USSR (lowland)	1945	9.5 percent
	1951	35.8 percent

In all these water bodies the catches of bream increased with the lapse of years.

Pape (1952) drew attention to the undesirable effects of river bed correction upon the population of bream. He was convinced that a drop in catches (mainly bream) in the Elbe from an average of 56.6 kg fish/ha between 1896 and 1928 to 18.5 kg fish/ha was caused largely by cutting-off or destroying lentic environments and by pollution. Bauch (1958) was of a similar opinion. Hydrographic conditions should be accepted, therefore, as one of the most important factors influencing the abundance of bream.

Nikolskii (1954) drew attention to the effects of climatic changes and stated that 5,000 years ago bream were the main fish in the catches in the drainage basin of the White Sea; and now they are caught there in negligible amounts. The retreat of bream from those waters is connected with cooling down of the climate.

- Biotic factors.

Competition for food is mentioned as an important factor but no reliable data are available (cf. section 3.33). Tanasiichuk (1952) stated that a decrease in the population of Blicca björkna L. in the Volga delta favours a better survival of bream.

Predation on bream is inconsiderable and cannot really affect the changes in abundance (cf. section 3.34).

An invasion of parasites can have serious effects (cf. section 3.35).

- Effects of exploitation.

A break in bream exploitation in the group of "Siamozero" lakes in 1940-'42 caused an increase in the abundance of 1941-'43 generations (Balagurova, 1963). An increase in bream catches in Polish lakes during the years 1958-65 was partly due to greater legal sizes and stocking (Zawisza, in Backiel, 1965).

According to Dahl (personal communication), bream in Danish lakes is underfished and therefore numerous. Hofstede (personal communication) is of a similar opinion concerning Dutch waters.

The importance of exploitation in the changes in the abundance of fish, including bream, is commonly accepted.

4.23 Average density

From the data quoted by Karpevich (1955) it has been calculated that in the Sea of Azov there were 22 individuals/ha in 1947 and 48 individuals older than three years in 1949-'50. The average yield was 6.6 kg/ha (Table XIX).

Data presented in the table show differences in the average density of a bream population. The intensity of catches is not known, and therefore water bodies exploited in a similar way for a long time have been selected. Thus it may be assumed that differences between catches result from differences in population density.

The differences are even more distinct when a group of 238 lakes exploited in Poland is taken into consideration (Leopold, data Inland Fisheries Institute). This species was not taken at all in three of the lakes, and the amount of bream caught in the remaining lakes was as follows: In 27 lakes (11.3 percent) less than 1 kg/ha; in 26 lakes (10.9 percent) 10-20 kg/ha; in 3 lakes it was higher than 20 kg/ha, the maximum yield being 27 kg/ha; in the remaining lakes (76.5 percent) the yield was between 1 and 10 kg/ha. The average yield per ha, which to a certain degree supplies information on the density of bream, does not depend on the area of a lake (Leopold, personal communication).

4.24 Changes in density

Catches per unit of fishing effort with various types of gear are very diverse in the lakes of Northern Poland. Average values are presented in Table XXIV (Section 5.41).

The catches near the Volga delta in the Caspian Sea per 100 gill nets are given by Dementeva (1952); they vary with the region:

Region	Western	Central	Eastern
kg/100 nets	0.9-2.2	3.7-23.4	in single cases up to 5.0

In the Volga delta, the farther from the sea the lower catches per unit of fishing effort were reported, e.g. in 1937:

Delta region	Lower	Central	Upper
kg per Seine haul	218.52	44.61	6.69

Tanasiichuk (1952) included the results of catches made with a fry trawl in the Northern Caspian Sea and information on salinity:

Salinity ‰	No. of Bream per hour trawling
0-1	903
1-2	1051
2-3	1063
3-4	236
4-5	210
5-6	265
6-7	251
7-8	375
8-9	23
9-10	6
10-11	121
11-12	106
12-13	24
13-14	7
14-15	0
15-16	0

The few examples mentioned above illustrate the enormous variability in the bream population density in fresh and brackish waters.

Seasonal variation of available stock is shown in Table XXIII. This variation is a

Table XIX
Amount of bream caught per ha of some water bodies

Water body	Bream in kg/ha	Percentage of bream in total catch	Author
Sea of Azov	6.6	9.1	Bervald, 1952
North-Caspian	4.1	13.0	Bervald, 1952
Aral Sea	1.8	36.0	Bervald, 1952
Siamozero, Karelia, USSR	0.2- 0.3		Balagurova, 1963
Ijssel Lake, Netherlands	1.5	3.0	Hofstede, pers.comm.
North-eastern German lakes:			
Griminitz (data for 2 years)	11.8-24.3	58.0-72.9	Tesch, 1955
Mügelsee (2 years)	12.0	30.0	Tesch, 1955
Sacrowersee (6 years)	0.3-7.7	1.7-50.6	Tesch, 1955
Tallensee (3 years)	3.7-15.0	6.5-18.4	Tesch, 1955
Polish lakes:			
Average for all in 1950-1964	4.73	19.25	Leopold, pers.comm. (Dpt.Economics, Inland Fish.Inst.)
minimum (1957)	3.14	17.55	
maximum (1952)	6.79	23.87	

result of winter or spawning aggregations.

4.3 Natality and recruitment

4.31 Reproduction rate

Zemskaia (1961) estimated annual egg production rates for the bream of the Volga Delta (Fig. 18). She multiplied an average fecundity by the number of females probably reaching the spawning grounds. Numbers of eggs deposited varied from 520 to 3,962 million million in 1936-'49.

For survival in embryonic and larval phases see sections 3.21 and 3.22.

- Forecasting of potential yields.

An estimate of the density of young fish, made during their seaward runs in the Volga delta by Tanasiichuk (1952), has been used to forecast the relative abundance of year classes in catches (Dementeva, 1952; Dementeva, 1952a; Zemskaia, 1961). There is a direct relation between the number of young bream caught during one hour trawling and year class strength calculated by the Derzhavin method, as shown by the approximate formula:

$$\frac{Nx}{Nb} = \frac{a_x}{a_b} \quad \text{or} \quad Nx = \frac{a_x \cdot Nb}{a_b}$$

where: a_x, a_b are number of young per one hour of trawling in the years x and b, Nx and Nb are year class strengths in the years x and b.

As seen from Fig. 19, such calculations may contain considerable errors. It should be mentioned that the correlation between the density of young and the year class strength was close in 1931-'38, the correlation coefficient being 0.91 (Monastyrski, 1952).

4.32 Factors affecting reproduction

The water level in the estuaries of the Volga and Amu-Daria affects decisively the number of larvae hatched (cf. section 4.2). A sudden lowering of the water level in the river after spawning causes drying out of eggs (cf. sections 3.21, 3.22).

The amount of food available for larvae and young fish is mentioned as the main factor influencing the brood strength (Zemskaia, 1961; Dementeva, 1955; Nikolskii, 1953; and sections 3.22, 3.35). According to Karpevich (1955), the survival of four-day-old bream larvas in the Sea of Azov, in water of salinity 0 - 7.5 ‰ and temperature of 17°C, was reasonably high and it did not depend on salinity; an increase in salinity above 7.5‰ caused increased mortality. A similar resistance was shown by 11-day-old larvae to salinities of up to 7.5‰.

4.33 Recruitment

Monastyrskii (1952) proposed to divide the spawning population into two parts on the absence or presence of spawning marks on scales: (a) fishes spawning for the first time and (b) those repeating their spawnings. The spawning population of bream in the inland seas of the southern USSR is the main object of exploitation. Therefore fish which have not yet spawned are to a certain degree recruitment to the fishable stock. The age distribution of that part of population is shown by data referring to the bream of the Northern Caspian Sea (Table XX). In the catchable stock of Caspian bream, the relative numbers of recruits defined as above varied from 42.2 to 87.7 percent, depending on brood strength, in the period 1933-'39. Relative numbers of recruits can be higher in lightly exploited populations. Variations in the growth rate of bream and resulting changes in the average age at which sexual maturity is reached affect the recruitment rate (cf. sections 3.12 and 3.43).

Recruitment may proceed during the entire growing season or only in the warmer period. Fig. 18 shows the ratio of eggs deposited by bream in the Volga delta to the density of young fish. As can be seen, there is no simple correlation. In our opinion it is very characteristic that maximum numbers of young fish developed from eggs deposited in numbers below the average (see year classes 1941, 1942), and this suggests a relation resembling Ricker's reproduction curves. According to Dementeva (1952) the number of spawners, and hence the quantity of eggs laid, has little bearing on recruitment.

4.4 Mortality and morbidity

4.41 Mortality rates

Average annual mortality caused by fishing and natural factors was estimated for the postrecruitment phases of the North-Caspian bream (Lukaskov, 1961) (cf. section 4.5). Balon (1963) from one sample of 256 individuals, estimated total mortality of bream older than four years to be 65 percent annually. It follows from the age composition (section 4.12) that among older age groups, particularly in the northern water bodies, total mortality is less than 50 percent. Tiurin (1962) estimated the survival of the Lake Ilmen bream using Baranov's method. The method assumes that if, in a given sample, maximum age is represented by one in-

TABLE XX

Age composition Percentage of Northern Caspian bream migrating for spawning for the first time (after Dementeva, 1952).

Year	Age (years)				
	2	3	4	5	6
1933	25.8	45.3	27.5	0.9	
1934	0.2	91.2	8.4	0.2	
1935		2.8	94.1	3.1	
1936		2.4	45.9	51.7	
1937	3.5	46.6	36.3	9.8	3.8
1938	0.9	28.3	66.0	2.5	0.7
1939		80.3	17.0	2.7	

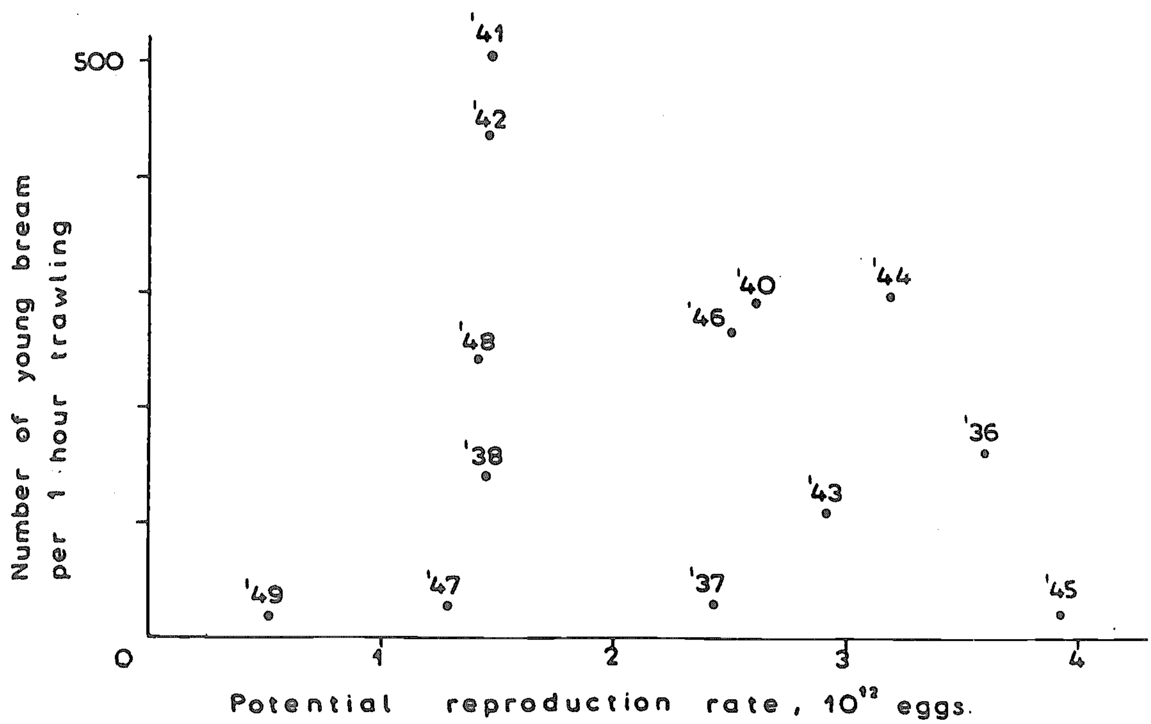

Figure 18. Relative abundance of young bream in the Volga Estuary against potential number of eggs deposited in the same year (data from Zemskaia, 1961).

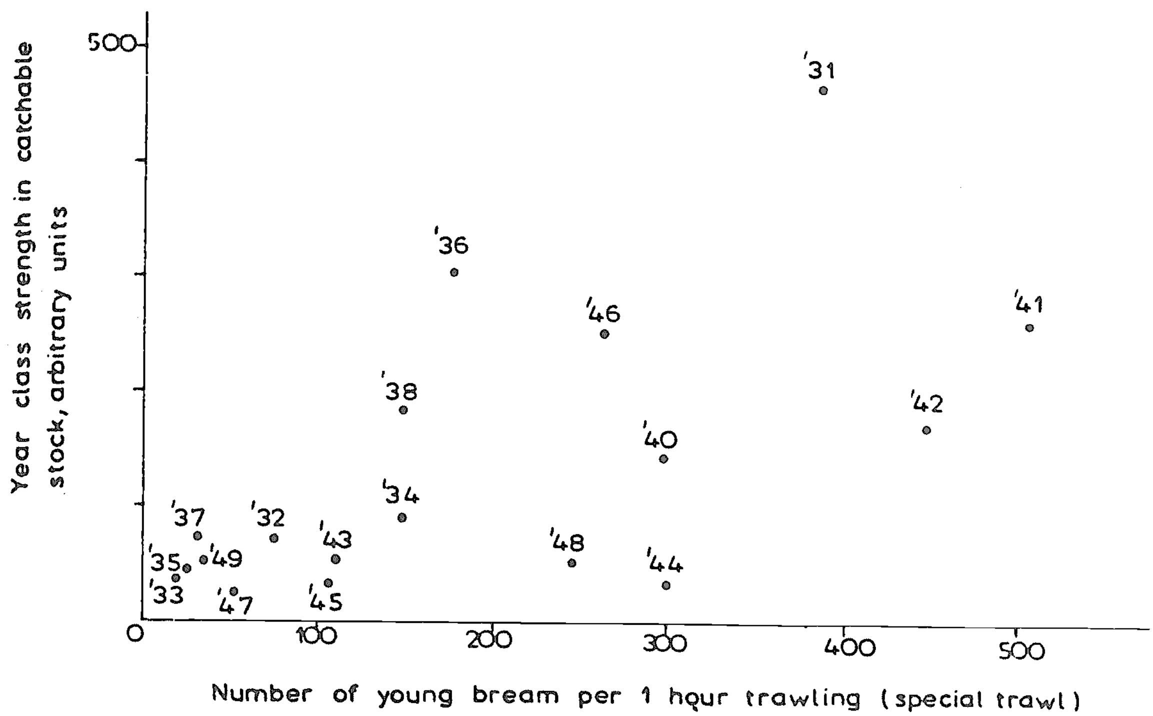

Figure 19. Year class strength in the catchable stock of bream in the Volga Estuary against relative abundance of young of the same year class (Data from Dementeva, 1952, for 1931-1935, and Zemskaia, 1961, for 1936-1949).

dividual then annual survival is a function of maximum age and the size of the sample. Tiurin's sample contained 260 bream in age groups from 2 to 11, from which he estimated the total mortality rate to be 40 percent. His estimate of fishing mortality as 22 percent seems to be not very convincing.

Cherfas (1956) quoted Dementeva's estimate that the proportion of eggs which eventually gave rise to caught fish in the case of North-Caspian bream varied from 0.0006 to 0.0220, or from 6 to 220 fish were caught per 10,000 eggs laid.

These data show variations in mortality rates. As can be seen in Fig. 18, there is a considerable variation in survival in the first year, but a more consistent survival rate in later years of life is suggested by Fig. 19. The oscillation of the fishing return coefficient, expressed by Zemskaia (1961) in arbitrary units, ranged from 0.01 to 0.18 (ratio 1 : 18).

4.42 Factors causing or affecting mortality.

Predation by fish is a factor which usually has little influence on the survival of young bream (cf. section 3.23). When the density of young bream is great, however, competitors or predatory fishes may affect the survival rate (cf. section 6.44).

4.43 Factors affecting morbidity – cf. section 3.35.

4.5 Dynamics of population (as a whole)

Lukashov (1961), in a very short paper, attempted to apply a mathematical model to the exploited bream population in the northern part of the Caspian Sea. The survival rate was estimated after taking into account the year-class composition of the population fished, during two periods of varying intensity of exploitation, i.e. in period I: 1937-48, period II: 1953-58. The total mortality rate in period I was 0.55 and in period II it was 0.80. He estimated fishing and natural mortalities, without describing the method in detail, as follows:

	Natural mortality	Fishing mortality
Period I	0.15	0.40
Period II	0.15	0.65

Growth rate parameters to the Bertalanffy's formula

$$l_t = L_\infty (1 - e^{-k(t-t_0)})$$

were estimated as:

$L_\infty = 42$ cm

$k = 0.233$

$t_0 = 0.62$ years

From the weight/length relation

$$W_\infty = 0.0215 \cdot L^3_\infty$$

the maximum weight was calculated to be 1,593 grams.

In calculating yield per recruit the following values have been accepted:

M (natural mortality coefficient) = 0.165

t_p (age at recruitment) = 2 years

t_c (age at first capture) = 3 years

t_λ (maximum age) = 20 years

Lukashov (1961) was convinced that increasing t_c (age at first capture) by one year and diminishing the intensity of fishing (F) could result in a three- or fourfold increase in yield.

Many Soviet ichthyologists (Monastyrskii, 1952; Dementeva, 1952; Nikolskii, 1950, 1953; Dementeva et al., 1961, and others) view fish population dynamics in a different way, emphasizing the connections between dynamic parameters and environmental conditions and the community, and looking for causality. The latter has been mentioned above (sections 4.2, 4.3, 4.4). According to those authors the size of a population depends mainly on the "feeding base" (the area and richness of feeding grounds) and also on spawning conditions. Monastyrskii (1952) explained variations in the abundance of a bream population in the region of the Volga delta as resulting from the changes in those factors and in the conditions under which young fish live in winter. He stressed the fact that looking for one factor responsible for variations in abundance does not solve the problem.

Nikolskii (1950) pointed to the relationship between food, growth rate and age of sexual maturity, and stated that the strength of fish year-classes depends on the above relationship. For the bream of the Volga Delta region, Zemskaia (1961) found a positive correlation between the food supply index and the growth rate of bream in the 3rd, 4th and 5th years of life.

Factors responsible for variations in abundance may be different in diverse environments. Thus, e.g. changes in the abundance of bream in the Sea of Azov and the Don Delta are connected with variations in salinity (Karpevich, 1955). The water level oscillation in the deltas of the Volga and Amu-Daria are of great importance (Tanasiichuk, 1952; Romanycheva, 1958). Water level was also held responsible for variations in the year-class strengths of bream of the Rybinskoe Reservoir (Ostroumov, 1956).

Numerous authors have drawn attention to exploitation as the main factor controlling abundance (Berdichevskii, 1961; Nikolskii, 1958; Tsepkin, 1964; Zawisza, 1961; Lukashov, 1961).

4.6 The population in the community and the ecosystem

The bream is a generatively stagnophilous fresh-water species, living also in brackish waters of a salinity up to 10 ‰ (cf. sections 2.3 and 3.21). In bigger rivers, it occurs in the middle and lower reaches (e.g. in the Rhine, Elbe, Danube, Vistula, Don, Volga). When the current of a river is strong, as e.g. in the Amu-Daria, it occurs only in its delta (Shaposhnikova, 1950). In small rivers, even those with very weak currents, bream are found in negligible quantities (Backiel, 1964). When a river is divided into zones, the bream is recognized to be a characteristic species of certain physical conditions (Borne, 1877, and Nowicki, 1882, according to Starmach, 1956; Huet, 1949; Bauch, 1963). According to Huet (1949), a bream zone comprises those river stretches of slope less than 1 in 2,000 and which are from 5 m to 300 m wide; according to Starmach (1956), a bream zone comprises river stretches of slope between one in 800 and one in 10,000 and 15 - 200 m wide. Bauch (1963) defined that zone in a different way, namely: besides bream and white bream there are found numerous species which also occur in the lakes of the German Lowlands including sporadically *Barbus barbus*; the bottom is sandy and muddy; lotic environment with abundant vegetation, the banks overgrown with *Typha* and *Phragmites*.

The fishery classification of the lakes in Germany, Poland and USSR also accepts the bream as a characteristic species (Bauch, 1963; Sakowicz, 1952; Cherfas, 1956).

Among bream lakes, Bauch (1963) distinguished four subtypes which differ in certain environmental properties and in quantities and sizes of bream most often caught (Table XXI). Cherfas (1956) defined bream lakes in the USSR as those which are not too deep, with a well developed littoral region, abundant vegetation and a very muddy bottom. During winter and summer, oxygen exhaustion often occurs in the deeper layers of water. Two subtypes have been distinguished: smelt-bream lakes and bleak-bream lakes, according to which of these two species is abundant in the pelagic zone of a lake.

In the bream lakes of Poland, from 17 to 23 fish species are found, but roach, bream and bleak predominate (Zawisza in Backiel, 1965).

It should be stressed that the fishery classification of lakes as described above has not resulted from an analysis of certain properties of water bodies and the coexistance of fish species in those water bodies, and therefore it ought to be looked upon as a working conception. It has been mentioned here since it is very common.

According to limnological typology, bream lakes are b-mezotrophic and eutrophic.

The bream population position in the ecosystem is determined by their abundance, food, predators feeding on bream, and parasites, some of which have a complex life cycle (cf. section 3.35). The abundance of bream in many waters can be comparatively great (cf. section 4.2) and therefore it may be concluded that their part in the ecosystems of lakes and some brackish waters is considerable.

After studying the food of fish of the Northern Caspian Sea, Shorygin (1952) stated that bream feed mainly on Cumacea (more than 25% of daily intake) and that Cumacea are also the main food of some Gobiidae (Fig. 20). A complete list of organisms on which bream feed shows that many of its items are taken by almost all the fish species, but the coincidence is strongest in case of some Gobiidae and *Cyprinus carpio* and less, although still considerable, with *Rutilus rutilus caspius* and Acipenseridae. Taking into account the area of fish occurrence in the Northern Caspian Sea, the biomass of fish and that of food organisms, Shorygin (1952: 203) established the relative intensity of competition for food between the bream and other fish species (in arbitrary units) as follows:

Neogobius fluviatilis pallasi	- 144
Benthophilus macrocephalus	- 32
Rutilus rutilus caspius	- 29
Neogobius melanostomus	- 21
Acipenser stellatus	- 16
Acipenser güldenstädti	- 8
Lucioperca lucioperca	- 6

The food of the carp is similar to that of the bream, but, since the two fish occur in different regions, they do not compete. In fresh waters, the composition of fish species and food is different (cf. section 3.4), but the bream is a demersal fish in these waters too.

Predatory fish attacks upon bream are inconsiderable (cf. section 3.32).

Table XXI
Characteristics of bream lakes after Bauch (1963)

Subtypes	I	II	III	IV
Transparency in summer	1 – 5 m	1.5 – 5 m	0.8 – 2 m	2 – 5 m
Oxygen content in summer	insufficient at the bottom	insufficient at the bottom	insufficient in the hypolimnion	not found at the bottom
H_2S occurrence in summer	not present	frequent under the metalimnion	frequent in the hypolimnion	always present
Bottom fauna in summer	0–12 m, abundant <u>Tendipes</u>	in the deepest places poor; 7–10m, very abundant	comparatively abundant	<u>Soyomya</u> – larvae <u>Tubifex</u> – few Tendipe didae
Depth	15 – 30 m	12 – 35 m	4 m; 25 m in places	6–25 m (depending on size, usually deep)
Shape of lake basin	with relief	with relief	without relief	–
Area	more than 500 ha	less than 500 ha (frequently channel-like)	–	–
Vegetation along shores	abundant		submerged – comparatively dense	submerged – very poor
Fish	<u>Coregonus lavaretus</u>	<u>Coregonus</u>, usually not found	no <u>Coregonus</u>	no <u>Coregonus</u>
	Bream, heavier than 1.5 kg, numerous Roach – very numerous	Bream 1–1.5 kg quite abundant Roach – numerous	numerous smaller bream Roach – not always numerous	small bream, not very numerous Roach – small
	Eel – rather numerous Pike, tench, big perch	Eel – rather numerous Pike – rather numerous Tench – numerous Perch – rather numerous Pike – perch present when transparency is 1.5 m	Eel – usually numerous Pike – numerous Tench – moderately Pike-perch – big	Pike – moderately numerous Tench – usually none Eel – Pike – perch – none Perch – small, usually too numerous
Fishery yield	20 – 50 kg/ha	Bream 20 – 50 percent		

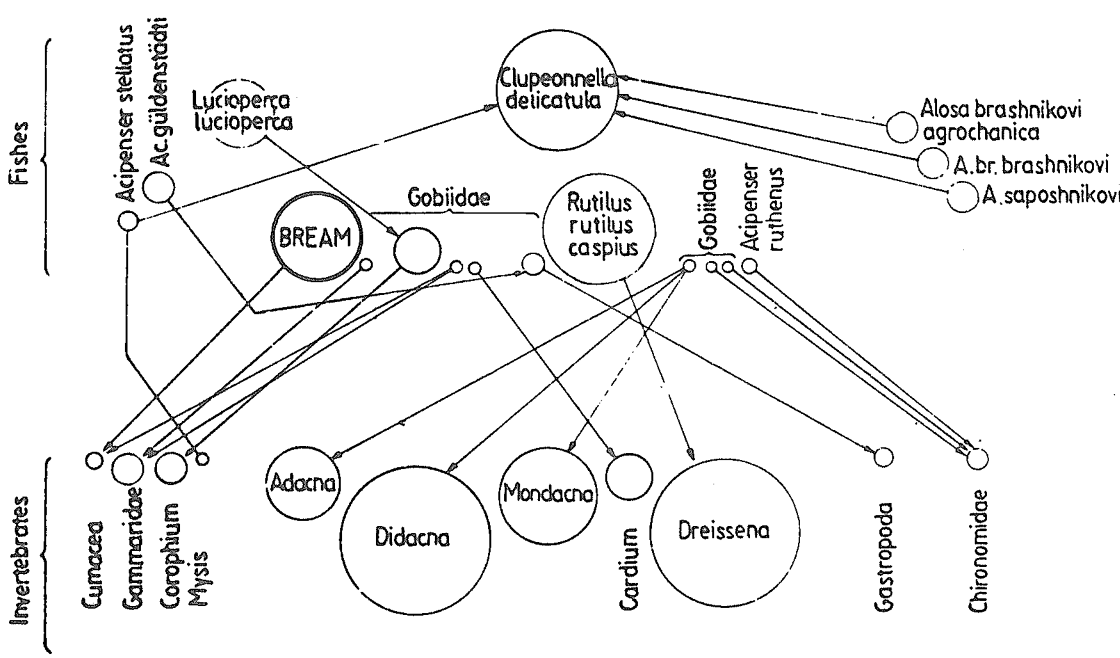

Figure 20. Food interrelations among fishes in Northern-Caspian Sea. Arrows directed towards prey. Areas of circles - relative biomass of groups indicated. The figure includes only food items which constitute not less than 25 percent in food of a fish species (after Shorygin, 1952).

5 EXPLOITATION

5.1 Fishing equipment

5.11 Gears.

Various types of fishing gear, adapted to local conditions and to the behaviour of bream, are used in commercial fishing. In large water basins (Sea of Azov, Caspian and Aral Seas, large retention reservoirs of the USSR) trawls are mainly used but seines, pound nets and gill nets are also employed. Winter seines, for fishing under ice, are used on ice-covered lakes. In summer, beach-seines and various set nets are used.

In Polish lakes, so-called bream gill nets, mesh size 60-90 mm, height 2.5 - 3.0 m, length 40-45 or 90 m, are used. Best fishing results with this gear are obtained in April and in October and November. In the Aral Sea, from 40 to 50 percent of bream are caught with gill nets (mesh size 60-75 mm), from 30 to 35 percent with seines and from 10 to 15 percent with fyke nets (Bervald, 1956). In the Rybinskoe Reservoir, gill nets, mesh size 50 to 90 mm, as well as trawls and seines, smallest mesh size 6 mm, are used (Ostroumov, 1956).

In large rivers, usually river seines without bag are used (lower Danube, Vistula) fyke nets and drifting gill nets, less frequently river seines with bag (Table XXII).

In the Rybinskoe and Tsimlanskoe reservoirs, successful attempts have been made to catch bream with a trawl, the lead line of which was equipped with a system of electrodes supplied with alternating current (Shentiakov, 1964).

5.12 Boats.

Various fishing craft, ranging from simple rowing boats or boats with an outboard motor (lakes, rivers) to trawlers or drifters (e.g. Sea of Azov, Caspian Sea) are used, according to the type of fishing gear.

5.2 Fishing areas

5.21 General geographic distribution.

Bream are taken almost everywhere they occur (cf. section 2.1), although commercial catches are made only in regions of their greater concentrations. The richest bream fishing grounds are situated in the southern seas of the USSR (Table XXII and XXVI), and in the brackish waters of the South-eastern Baltic.

Exploitation and its intensity in various waters also depend upon whether people consider bream as a savoury fish, as do the fishermen of Northern Germany (Bauch, 1963), people in the USSR (Berg *et al.*, 1949) and country people in Hungary (Entz, personal communication). It is considered as a coarse fish by Danish people (Dahl, personal communication), and Dutch people (Hofstede, personal communication), and as of little value in Sweden (Sasserson, personal communication). Bream is believed to compete with other highly valued species in Danish lakes and in the Netherlands.

5.22 Geographic ranges.

See sections 5.21 and 5.43

5.23 Depth ranges.

Adult bream are demersal fish. In lakes, however, they have not been taken by bottom fishing at a depth of over 40 m. Bream fishing grounds in brackish waters usually do not go beyond the 12 ‰ isohaline, i.e. they do not reach any great depth.

5.24 Conditions of the grounds.

An increase in salinity in the Sea of Azov has affected the abundance of bream (Karpevich, 1955). The construction of retention reservoirs has resulted in new fisheries having conditions different from those existing in the river, e.g. the Rybinskoe Reservoir on the upper Volga, where trawls are used in fishing; this gear was formerly limited to the sea (Ostroumov, 1956).

River pollution in Central Europe has affected fishing grounds, e.g. the Elbe (Bauch, 1958). A decline in abundance was noted, and the meat of bream (and of other species) acquired an unpleasant "chemical" flavour and this in turn caused a decline in demand. In the middle Vistula and lower Odra, fish developed the flavour of phenol or its derivatives.

Variations in the abundance in certain regions and the resulting variations in the importance of certain fishing grounds are also related to changes of climate over long periods of time. Nikolskii (1954) found that 5,000 years ago bream was the main constituent of all catches in the White Sea drainage area. Today only single individuals are taken. Thus the conditions on the fishing grounds are subject to rapid changes due to the activities of man, whereas the changes resulting from variations of climate are slow.

TABLE XXII

Summary on data on bream fisheries by countries

Country	Kind of exploitation	Fishing: equipment	Fishing: main areas	Fishing: main season	Utilisation, other remarks	Authority
Denmark	commercial	otter trawls, seines, pound and hoop nets	lakes (the largest lake Arresø)	spring	coarse fish, fish meal, v. little export of fish over 1.5 kg	T. Dahl, p.c. x/
Norway	no exploitation					K.W.Jensen, p.c.
Sweden	little commercial	winter seines gill - and fyke nets	brackish water in the Baltic, some lakes	May to June and winter	coarse fish, little consumption, v.low price appr. 28 percent that of pikes	J.Sasserson, p.c.
Finland	commercial, no sport		brackish waters, lakes		import, food fish	V.Sjöblom, p.c.
Netherlands	commercial; very little sport fishing (released when caught)	gill nets, seines, in fyke nets with eel	lake Yssel	September to March	coarse fish, not consumed	A.E.Hofstede, p.c.
Belgium	sport only	hook and rod	rivers			M.Huet, p.c.
France	v.little sport fishing				not appreciated for consumption	R.Vibert, p.c.
Ireland	little sport occasionally during closed seasons for salmonids	rod and line			not consumed	E.D.Toner, p.c.
Great Britain	sport fishing common in lowland rivers of England (Northern Ireland: little commercial)	rod and line (gill nets)			not appreciated no market value	E.D.LeCren, p.c; P.Tombleson, p.c.
Yugoslavia	little commercial		rivers (Danube, Drava Sara, Tisa)			K.Apostolski, p.c; Disalov, 1964
Greece	no information					
Bulgaria	commercial, of little significance	river seine fyke nets	Danube, coastal lakes			L.Ivanov, p.c.

... 2

Roumania	little commercial and little sport	seines and fyke nets	Danube estuary and proximate lakes		second grade food fish	W.B.Ziemiankowski, p.c; Popescu, 1958
Turkey	commercial (little with other fishes)					Nümann, 1962 Ladiges, 1960
Germany	commercial and sport	water and sead seines, gill nets, fyke nets	northern and central lakes	winter and spring	large specimens appreciated	Bauch, 1963 Tesch, p.c; Menzel, p.c.
Austria	commercial more in lakes, sport more in rivers (ox-bow lakes)	gill nets in lakes fyke nets in rivers and rod and line				W.Einsele, p.c.
Poland	commercial and sport	winter seines beach seines, gill nets, fyke nets	Firths of Vistula and Odra, northern lakes	winter, early spring and autumn	sold at a medium price, large specimens appreciated	authors
Czechoslovakia	little commercial, almost no sport fishing	seines, fyke nets in spring	Danube (low lakes)	spring and autumn		E.K.Balon, p.c.
Hungary	commercial; as sport fish not appreciated	seines, fyke nets in rivers	Balaton lake, Danube		appreciated as food fish by country people, mostly preserved (tinned)	B.Entz, p.c.
USSR	commercial (large scale) and sport	seines, trawls, gill nets, pound nets	North Caspian, Azov, south Aral, big reservoirs, big north-western lakes	spring and autumn	food fish, large specimens appreciated	Nikolskii, 1954; Berg *et al*., 1949; Dementeva, 1952a.

x/ p.c. means personal communication

5.3 Fishing seasons

5.31 General pattern of season(s)

The general distribution pattern of commercial catches throughout the year is very much the same in various regions (Table XXII). Most bream are taken at the time of spawning aggregations in spring, or in winter (in freezing lakes). In the warmest period, i.e. at a time of intensive food intake as well as great dispersion of fish, the catches are very small. A few examples are given in Table XXIII.

5.32 Dates of beginning, peak and end of season(s)

Cf. Tables XXII and XXIII.

5.33 Variation in date or duration of season

According to Dementeva (1952a) a cool spring retards the spawning migration of bream to the Volga estuary, thus shifting the peak of catches (Romanycheva, 1958).

In lakes, winter catches depend on the date on which a sufficiently thick ice cover forms. The duration of the fishing season in turn depends on winter weather. The lakes of northwest Poland frequently fail to freeze and therefore do not permit the use of winter seines.

5.4 Fishing operations and results

5.41 Effort and intensity

It is difficult to estimate the fishing effort in a bream fishery since, in lakes, bream are caught under conditions that vary frequently, and they are usually caught together with several other species. Dąbrowski et al. (1964) and Leopold and Nowak (1964, 1964a 1964b, 1964c) made an analysis of catches in lakes and established, among other data, the average (annual) yield of fish caught per gear per day (Table XXIV). The authors stress, however, that yield per gear per day varies widely throughout the year and with the locality. It can serve only as a comparison for a large number of data.

Catch per h has been accepted as an effort unit when catching young fish with a specially designed fry trawl in the Caspian Sea and in the Aral Sea (cf. section 4.24).

5.42 Selectivity

Baranov (1948, page 207) stated that the optimum mesh size (a) of bream gill nets is given by $a = 0.2\ Lc$ or $a = 7\sqrt{w}$, where Lc is body length in cm and w is weight of fish in gram.

The available data on the selectivity of some fishing gear in relation to the size of bream are presented in Table XXV. In Table XXIV it is worth noticing that the catch of bream varied with the use of different types of fishing gear, constituting a larger or smaller percentage of all fish landed. This depends on the distribution of bream in water bodies and on the fishing technique used. Usually, however, seines and trawls catch smaller fish than other nets.

In the Rybinskoe and Tsimlanskoe retention reservoirs an alternating electric current has been applied to trawls (a system of electrodes at ca. 230 v placed along the lead line, to prevent the fish escaping the trawl). This device was used in selective fishing: the average weight of bream caught with the selective trawl exceeded the average weight of bream taken with a usual trawl by 22 percent in the Tsimlanskoe and by 58 percent in the Rybinskoe Reservoirs (Shentiakov, 1964).

5.43 Catches

The available data on commercial bream catches are presented in Table XXVI. In some countries bream catches are recorded together with the catches of other fresh water species (partially in the Netherlands and Denmark).

In most countries bream is caught by anglers and in some exclusively so. The amounts of bream caught by anglers may be considerable; e.g. in Belgium, annual anglers' catches are estimated to be 37 tons (Huet, personal communication in 1963). According to Rümler (1949), the ratio of commercial to sport catches varied from 1 : 1 to 1 : 11 in Lake Sacrower, near Berlin, in 1923 -1948.

Similarly around Warsaw, Poland, the ratio of anglers' catches to commercial catches has been estimated by tagging, as about 1 : 1.

The number of bream caught by anglers makes an estimate of the total catch in the whole region of their exploitation difficult. From commercial catches only, Table XXVI, the total annual yield amounts to about 70,000 tons, and 80 percent of this quantity comes from the fishing grounds of the Caspian, Azov and Aral Seas.

Table XXIII
Seasonal distribution of bream catches (percent of total annual catch)

Area	Calendar month												Authority
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Don estuary	0.8	8.0	21.4	33.4	22.6	7.7	0.2	0.3	0.8	1.3	2.9	6.0	Berg, 1949
Azov Sea near Kuban estuary	1.6	4.4	16.8	13.6	40.9	13.7	0.8	0.7	2.2	2.7	1.8	0.8	
Aral Sea		23.0			63.0			4.0			10.0		Bervald, 1956
Lakes in Poland (1950–1964)	9.4	14.0	11.6	4.1	10.7	8.5	4.0	5.4	6.1	8.3	11.1	6.8	M. Leopold, p.c.
Vistula Firth	great peak in May and second in October or November												Filuk, 1962
Szczecin Firth	peaks in spring and late autumn												Pęczalska, 1963
Northern Caspian	spring 60 – 70 percent												Dementeva, 1952a
Azov Sea	spring 60–90 percent												Dementeva, 1955
Lake complex "Siamozero", Karelia, USSR	greatest part caught in April, May, June												Balagurova, 1963

Table XXIV
Bream fishing with various gears in Polish lakes
(Data from Dąbrowski *et al*., 1964; Leopold and Nowak 1964, 1964a, 1964b, 1964c)

Gear	Fishing season	Size class of lakes (ha)	Catch of bream as percentage of total catch	Total average catch per gear per day (kg)	No. of lakes considered
Winter seine with bag	January-April	up to 100 100 - 500 500 and more	28.02 41.83 28.38	245.4 323.3 500.6	108
Summer seine with bag	July-December	up to 80 80 - 500 500 and more	22.32 19.57 6.56	157.5 177.9 252.3	206
Fyke nets with rings 37-80 cm	March-October	up to 100 100 - 500 500 and more	6.73 15.07 10.03	1.36 1.78 1.52	101
Fyke nets (traps) height av. 100 cm	March-September	up to 1000 1000 and more	15.19 23.98	1.93 1.72	44
Gill nets, mesh 30-50 mm	April-December	Mamry lake complex (10,000 ha) other lakes	less than 3.1 less than 17.0	2.44 3.26	21

TABLE XXV
Selectivity of some gear in bream fishing

Gear (water body)	mesh size	fish caught	Authority
Seine towed by boat		mostly 20-35 cm	
beach seine		20-35 cm	Filuk, 1957
trammel nets		35-45 cm	
gill nets (Vistula Firth)	60 mm	30-74	Filuk, 1962
Trawl and seine nets (Rybinskoe Reservoir)	cod end 6 mm	2-17 years old	Ostroumov, 1956
	50-90 mm	6-18 years old	
Gill nets in autumn 1956 and spring 1957 (Northern Caspian)		percent of fish under 18 cm	Berdichevskii, 1959
	28	100	
	35	73-90.2	
	38	70.4-93.8	
	43	15.1-54.8	
	50	0-1.3	
Seines and trawls nets (Northern Caspian)		average body length	Berg, 1949
		24.2-36.2 cm	
		32.9-37.9 cm	

Table XXVI (Sheet I)
Bream catches

Country	Catch estimate (per annum)	Authority
Denmark	Coarse fish: total 800-1,100 ton (1955-63), bream is the most abundant. (see editor's note)	Dahl, p.c.
Sweden	Freshwater: total 2,700- 4,000 ton (1956-59), bream 100- 200 ton (1956-60), Brackish water: bream 126 ton (1961) (e.g. in Lake Aspen, bream 15 percent of 10 ton).	Yearbook* Sasserson, p.c.
Finland	Bream 3,300- 4,500 ton, which is 5-10% of total freshwater fish yield.	V.Sjöblom, p.c.
Netherlands	Lake Ijssel: total 10,400-15,800 ton (1955-62), large bream and roach 400-710 ton; "immature fish" 7,600-10,800 ton, includes small bream. Other waters: 250-300 ton.	Hofstede, p.c.
Yugoslavia	Bream not more than 5% of total freshwater catch. Danube: 595 ton (1963).	K.Apostolski, p.c. Disalov, 1964
Bulgaria	Danube: 154 kg-48 ton, average 12.6 ton (1925-58) Coastal lakes: average 2.7 ton.	Ivanov, p.c.
Hungary	Bream, average for all commercial waters, 1,600 ton, which is to 55 percent of total catch	Entz, p.c.
Roumania	Danube estuary: ca 200 to 400 ton (1962-1964), which is 2-3.8 percent of total catch. Danube: 457 ton (1963). Other waters: about same as Danube.	Ziemiankowski, p.c. Disalov, 1964 Popescu, 1958
Germany West	Total freshwater: ca 10,500 ton; Bream, perch etc 10,100 ton.	Yearbook*
Germany East	Total freshwater: 3,200- 4,100 ton (1960-1964), Bream 900- 1,400 ton	Menzel, p.c.
Poland	Lakes: total 5,400- 7,000 ton (1956-60), Bream: 1.3-1.4 th ton. Rivers: total 800- 1,200 ton (1956-61), Bream 0.3 th ton. Szczecin Firth: bream 745 ton (1948-50) Vistula Firth: bream 300-400 ton (1948-60)	 Peczalska, 1963 Filuk, 1962

Table XXVI (Sheet II)
Bream catches

Country	Catch estimate (per annum)		Authority
USSR	Freshwater: total	420,000–489,000 ton (1956–61)	Yearbook*
	bream	46,400– 56,300 ton	
		Bream catch (1936–39)	Nikolskii, 1954
	Caspian Sea:	47,600–105,300 ton	
	Sea of Azov (including very little from Black Sea):	17,800– 47,100 ton	
	Aral Sea:	9,800– 16,700 ton	
	Gulf of Finland:	30– 460 ton	
	Northwestern Lakes:	830– 17,400 ton	
	Onega and Ladoga Lakes:	220– 360 ton	
	Lake Pskovskoe-Cudskoe:	300– 700 ton	
	Lake Ilmen:	1,300– 3,100 ton	

*/ Yearbook of Fishery Statistics, Production, 1961, Vol.XIV, FAO

6 PROTECTION AND MANAGEMENT

6.1 Regulatory (legislative) measures

6.11 Limitation or reduction of total catch.

Limitation on efficiency. No data are available on limitations other than those presented in Table XXVII. Equally no limitations has been imposed on the number of fishing units.

- Quota limitation.

Fishing was prohibited in some of the recently constructed retention reservoirs in the USSR (Sebentsov *et al.*, 1953). In some Polish retention reservoirs there are quantitative restrictions on fish taken with nets, bream included. This measure applies to reservoirs heavily exploited by anglers.

6.12 Protection of portions of populations.

Closed areas, season, legal sizes, etc. are presented in Table XXVII.

Rescue action of fry in the estuaries of the Volga, Ural, Dneper, Amu-Daria Rivers includes bream (Cherfas, 1956). The aim of this action is to rescue fry remaining in shallow basins which lose their connection with the adjacent river as the water level falls. Young fish are rescued in two ways: (i) when the bottom of the cut-off basin is above the low water level of the river, a canal connecting the latter with the basin is dug and the young fish are released with the water; (ii) when the bottom of the cut-off basin is beneath the water level in the river, young fish are caught with fine meshed nets and transferred to the river.

In both cases the number of the rescued fish is estimated. In 1948 in the USSR, 8,272.4 million young fish were rescued, and the percentage of bream amounted to 15.3 percent (Cherfas, 1950); in 1953 2,422.7 million were rescued, including 579.6 million (16.9 percent) bream (Cherfas, 1956).

6.2 Control or alternation of physical features of the environment

6.21 Regulation of flow.

In many countries the construction of dams to regulate the flow of water in rivers has led to changes in the population of bream. This has been mentioned in sections 4.22 and 5.2.

The regulation of flow resulting from the construction of a dam on the Don River affected the abundance of bream in the Sea of Azov (Karpevich, 1955). In rivers after the construction of a dam the bream population increased (Nikolskii, 1948; Backiel *et al.*, 1956; Wundsch, 1949).

6.22 Control of water levels.

The construction of dams alters the water level. The effects are the same as those mentioned above.

6.23 Control of erosion and silting.

That, too, is achieved by building dams.

6.24 Fishways at artificial and natural obstructions.

Although bream use the fishways constructed at the dams, this is of minor importance (Sakowicz and Zarnecki, 1954).

6.25 Fish screens.

No screens specially adapted for bream have been devised. The Soviet electric screens of the E RZ U - 1 type (Strakhov and Nusenbaum, 1959) are used at dams, to direct fish into the fishways, and in front of irrigation canals, to discourage young fish from ascending these canals. The screens are up to 85 percent effective. Bream are also protected by them.

6.26 Improvement of spawning grounds.

In the construction of artificial spawning grounds, use has been made of the fact that bream spawn on branches of coniferous trees placed in lakes (Mikheev, 1951; Sukhovan, 1959). Floating spawning grounds have also been used, consisting of bunches of coniferous tree twigs or bulrush (*Scirpus*) attached every 30-40 cm to ropes hanging 30-40 cm apart from a floating wooden frame. Mikheev (1951) advised the use of this type of spawning ground in reservoirs of oscillating water level, e.g. retention reservoirs. But Antipova *et al.* (1954) found that bream did not use such spawning grounds in the Rybinskoe Reservoir, in spite of unfavourable conditions on natural spawning grounds. Dudin (1954) sharply criticized this method, drawing attention, among other things, to the considerable cost and losses in eggs. Trials in Poland with floating artificial spawning grounds have also not been very successful.

Mention should be made here of the measures taken on the so-called "poimennye ozera", ox-bow lakes in the Volga delta. These are flooded during high water in spring and they serve as the spawning grounds of bream and other fish (Suvorov, 1948; Sukhoverkhov, 1948). Improvement is possible

TABLE XXVII
Protection and management in bream fisheries

Country	General remarks	Legal size	Closed seasons	Closed areas	Other measures	Stocking	Authority
Denmark	lakes overpopulated, considered competitor, intensive fishing recommended.	no	no	no	no	no	Dahl, p.c.
Finland	considered important, fishing is regulated by law.	35 cm total length	no	no		transfered to several lakes with success.	V. Sjöblom, p.c.
Netherlands	intensive fishing, including small fish, recommended.		1 April to 31 May (for all fishes)		some sport fishing associations prescribe length limits		Hofstede, p.c.
Belgium			end March to mid-June				Huet, p.c.
France			2 months in spring				Vibert, p.c.
Ireland				netting is prohibited in inland waters			Toner, p.c.
England		12 inch	15 March to 15 June				Tombleson, p.c.
Yugoslavia	of little importance	in some Republics				no	Apostolski, p.c.
Bulgaria	of little importance		May (Danube fisheries)				Ivanov, p.c.
Roumania		20 cm from eye to end of tail	May (Danube fisheries)				Ziemiankowski, p.c.
Germany West	considered important	25 to 32 cm (in various parts of country)	4 to 6 weeks in spring, dates depending upon local conditions	no			Tesch, p.c.

... 2

Germany East		25 cm	established by local authorities	as in case of closed season			Menzel, p.c.
Austria			spawning time, varying in different regions				
Poland	protected and regulated	25 cm in State Fish Farms, 500g in lake fisheries, 30 cm in Szczecin Firth	15 March to 30 April all kinds of movable gears prohibited	so-called protected spawning grounds established by local fish authorities	local restrictions such as catch limit, no seining etc.	usually transfer from one lake to another	authors
Czechoslovakia		25 cm	16 March to 15 June				E. K. Balon, p.c.
Hungary		50 gram	15 April to 15 May	commercial fishing prohibited in the 100 m wide belt along the shore of Balaton Lake			Entz, p.c.
USSR	considered important food fish, fishery regulated	18 cm	no	no	rescue action (see text)	both maintenance and transplantation (see text)	Berdichevski, 1961 (and many others)

by construction of a sluice in the canal linking a lake with the river and securing a high water level from spring to the end of August or the beginning of September. Such a sluice prevents spawners from swimming into the spawning ground but desirable species may be released in the lake. In the middle of August, 196 kg of fry, weighing on average 1.6 g, was obtained from 1,000 bream spawners released in 95 ha of lake. Sukhoverkhov (1948) reported that with careful management 300-400 kg/ha of carp and bream fingerlings can be obtained from such lakes.

6.3 Control or alteration of chemical features of the environment

6.31 Water pollution control.

Water pollution control exists in all countries where bream occur (Economic Commission for Europe, 1962).

This water pollution control is not carried out from the point of view of the bream's demands only but the criteria of surface water purity are good enough to the populations of this species.

6.32 Salinity control.

In spite of the fact that an increase in salinity limits the occurrence of bream (cf. section 4.2 - the Sea of Azov), not much can be done to prevent the undesirable effects of these changes.

6.4 Control or alteration of the biological features of the environment

6.42 Introduction of fish foods (plant, invertebrate, forage fishes).

Invertebrates are being introduced in the USSR. They are not exclusively organisms present in the natural food of bream but they are accepted as food by bream (Karpevich and Bokova, 1963, 1961; Karpevich and Lokshina, 1965).

6.43 Control of parasites and diseases - cf. section 3.35.

6.44 Control of predation and competition.

In the USSR attempts have been made to regulate the species composition of spawners in ox-bow lakes which have sluices and are periodically flooded (Irinarkhov and Tokarev, 1949). Regulation has consisted in preventing predatory fishes and less valuable species from entering those ox-bow lakes; carp, bream and Caspian roach (R. rutilus caspius) were looked upon as valuable species. Changes in fry species composition were as follows: in the spawning grounds under control 59.4-83.5 percent of fish were valuable while the respective figures were 20.5-67.8 percent on uncontrolled spawning grounds. Nevertheless this method has been criticized (Kuznetsova, 1950) since the production of fry on the controlled spawning grounds proved to be lower than on the uncontrolled ones. Kuznetsova (1950) does not attack the basic idea but she stresses the technical difficulties, laborious control of species composition of spawners and inconsiderable effects.

6.45 Population manipulation (cf. sections 6.1 and 6.5).

6.5 Artificial stocking

6.51 Maintenance stocking.

In the USSR some river deltas are stocked with bream fry reared in the so-called spawning and breeding farms (Cherfas, 1956). Those farms have ponds lying in hollows separated from the river bed by natural elevations or by dams with sluices. Such reservoirs are flooded during high water in the river or by means of pumps. Young fish when two months old are usually released by emptying the pond into the river. Their numbers are estimated (see section 7). Stocking with bream eggs was done in the USSR to strengthen the population in recently constructed retention reservoirs (Mikheev and Meisner, 1954).

Such reservoirs were stocked with spawners, too. Recommendations have been made to release one female and one-to-two males per one ha (Bizaiev, 1952; Mikheev and Prokhorova, 1952).

The transfer of two-to-three year old bream from lakes having an abundant population to lakes and retention reservoirs with a small bream population is common in Poland. Some such transfers have been successful. Wundsch (1949) mentions the stocking of German retention reservoirs with bream.

6.52 Transplantation and introduction.

Bream have been introduced into numerous Sibirian waters (Table XXVIII). These works are being continued on a big scale in the USSR, e.g. in 1960-61 Abramis brama orientalis was introduced into eight lakes and two retention reservoirs and in 1962 into more than 30 lakes and four reservoirs; in most cases spawners were released (Karpevich and Bokova, 1961, 1963; Karpevich and Lokshina, 1965).

The bream is being introduced into those water bodies within its natural geographic distribution where it did not previously occur, e.g. to some lakes of Finland (Sjöblom, p.c. 1965) and Poland. It can be stated that its introduction into the lakes within its natural occurrence area and its acclimatization in Sibirian waters have been successful.

TABLE XXVIII

Acclimatization of bream

Locality	Year of first introduction	Stage of fish introduced	Results	Authority
Ponds and lakes in the Iset' River system (near Sverdlovsk, West Siberia)	1863		Successful, invaded some sectors of middle Irtysh river	Cherfas, 1956; Burmakin, 1963
Lake Ubinskoe (near Novosibirsk, West Siberia)	1929	spawners	In 1950 estimated stock abt. 300 ton of young bream, in 1951 - 30-40 percent of total catch	Petkevich, 1954; Tikhii, 1954; Volgin and Vertinin, 1964
Lake Zajsan (East Kazakh. SSR)	1949	spawners	Spawning and fry observed in many places after 2 years	Goriunova and Serov, 1954
Lake Balkash (East Kazakh. SSR)	1949	spawners	1958 commercial catches about 1.5 ton per trawl	Goriunova and Serov, 1954; Ivanov and Pechenikova, 1960
Lake near Baikal Lake	1954	spawners	young observed in many places in 1955-57	Askhaev, 1958

7 POND FISH CULTURE

Bream have not been reared in ponds until reaching marketable size. Nevertheless, the rearing of young fish has much in common with pond fish culture.

7.1 Procurement of stock

Bream spawners are caught in the waters adjacent to a fish farm during their spawning migration in the spring (in May) (Cherfas, 1956; Syrkov, 1953; Kozhin and Letichevskii, 1953).

7.2 Genetic selection of stocks

Genetic selection of stocks has not been attempted.

7.3 Spawning

Bream spawners are released in a pond having proper spawning conditions, usually together with carp spawners and occasionally also with Caspian roach spawners (*Rutilus rutilus caspius* Jak.) and pike-perch spawners (Syrkov, 1953; Nikolskii, 1955). The sex ratio among spawners should be 1 : 1 (Kozhin and Letichevskii, 1953) and 5-11 females are released per ha. The number of spawning fish released depends on the quantitative relation of fish species, female fecundity and the survival rates of young fish (Cherfas, 1956). According to Kozhin and Letichevskii (1955), survival was between 3.34 and 8.5 percent from fertilization of the eggs until the fish were two-to-three months old.

When necessary, artificial spawning is used (e.g. when there is no suitable submerged vegetation to induce natural spawning). The fertilization is carried out by the dry method (Russian method). The eggs are then placed on a substratum of coniferous tree branches or their adhesiveness is removed by mixing with river mud for one h. (Cherfas, 1956:119; Vernidub, 1953).

Eggs, on a substratum or after unsticking, are put into hatching boxes which are submerged in a pond or river. Green's or Chalikov's apparatus sets are used; these are cases, some or all walls of which are made of fine-meshed netting.

7.4 Holding of stock

The so-called spawning and breeding farms cover an area of about 7,000 ha in the Volga delta (Syrkov, 1953; Letichevskii, 1965, cf. section 6.51). There are also farms in the deltas of the Don, Kuban and Kura Rivers (Syrkov, 1953). Attempts to rear young bream were made in Poland before World War II (Mrugasiewicz, 1931). At present bream are reared in ponds near lakes. Similar attempts have been made in Roumania (Ziemiankowski, personal communication).

Young fish (bream, carp and eventually others) are reared in ponds until the middle or end of August, then released into a river by letting out water through a sluice or similar arrangement. Fishes released are counted (Cherfas, 1956:275; Kozhin and Letichevskii, 1953).

7.5 Pond management

Ponds of 50-500 ha in area are filled in spring, at the time of high water in the adjacent river. These ponds are without water from about the beginning of September until the spring. The importance of early flooding is stressed, since food organisms can then develop.

Emergent plants overgrowing ponds and their control are a serious problem (Kozhin and Letichevskii, 1953). To secure suitable spawning conditions, grasses should be sown in autumn (Letichevskii, 1965).

7.7 Disease and parasite control

The spawners (of bream and other species) should be carefully examined and all individuals either injured or having external parasites ought to be discarded (Cherfas, 1956). Apart from that, the drying out of ponds should be looked upon as a means of controlling diseases and parasites.

7.8 Harvest

Some data on the yields obtained by the farms of this type are presented in Table XXIX.

7.9 Transport

Live eggs deposited on a substratum of coniferous tree branches have been transported in the USSR (Mikheev and Meisner, 1954). Eggs on chopped branches of coniferous trees were put into impermeable cardboard boxes and the twigs were interlaid with wet napkins. After 8.5 h of transportation the eggs were in good condition.

In Poland, young bream for stocking are usually transported in autumn in tanks, trucks or lorries with tarpaulin and barrels. From 20-50 kg of fish is put per 1,000 liters of water, depending on the time required for transportation.

Marketable live bream are rarely transported. Privol'nev (1956) advised in such cases the use of the same appliance as when transporting carp, providing that only 72 percent of carp weight is carried; e.g. in a railway wagon (car) provided with tanks of 24,000 liters capacity and an appropriate system of aeration the following quantities of bream can be transported for two-to-three days:

water temperature (°C):	0-2	2-5	5-10	10-15	15-20
tons of fish (bream):	7.2	6.5	5.8	4.3	2.9

Table XXIX

Harvest from spawning-breeding Farms in Volga Estuary

(after Syrkov, 1953 - selected data)

Year	No of farms	Total area (ha)	No of fish harvested, millions			Harvest (kg per ha)
			Carp	Bream	Other species	
1946	5	1454	46.9	41.4	-	420
1948	7	1874	62.7	83.8	14.2	318
1951	10	4052	215.7	267.9	6.7	160

8 REFERENCES

Agapova, A.I., Osobennosti parazitofauny ryb akklimatizirovannykh v vodoemakh Kazakhstana.
1958 (Peculiarities of parasites of fishes acclimatized in Kazakhstan) (Ru) Trudy Inst. Zool., Alma Ata, 9:25-31

__________, Parazity ryb vodoemov Kustanaianskoi oblasti. (Fish parasites in waters of
1960 Kustanaian District) (Ru) Trudy Inst.Zool., Alma Ata, 12:195-205

__________, Parazity ryb verkhnego i srednego techenia Syr-Darii. (Fish parasites of upper
1962 and middle course of Syr-River) (Ru) Trudy Inst.Zool. Alma Ata, 16:135-44

Akhmerov, A.Kh. and E.A. Bogdanova, Data on the parasitical fauna of fishes from the reservoirs
1957 placed in the zone at the future Stalingrad reservoir. (Ru, En summary), Izv.vses. nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 42:146-159

Alabaster, J.S., The effect of heated effluents on fish. In International Conference on Water
1964 Pollution, 1962. Oxford, Pergamon Press, pp.261-92

Alabaster, J.S. and K.G. Robertson, The effect of diurnal changes in temperature dissolved oxygen
1961 and illumination on the behaviour of roach (Rutilus rutilus (L.)), bream (Abramis brama (L.)) and perch (Perca fluviatilis (L.)). Anim.Behav., 9(3-4):187-92

Alm, G., Undersökningar rörande Hjälmarens naturförhållanden och fiske. Medd.LandtbrStyr.,
1917 Stockh., (3) (quoted in Laskar 1948)

__________, Fiskeribiologiska undersökningar i sjöarna Toften, Testen och Teen. Medd.Landtbr-
1919 Styr., Stockh., (quoted in Laskar 1948)

__________, Connection between maturity, size and age in fishes. Rep.Inst.Freshw.Res.
1959 Drottningholm, 40:5-145

Almacher, E., Taschenbuch der Fischkrankheiten. Jena, G. Fischer Verlag, 286 p.
1961

Ananichev, A.V., Chemical composition of the detritus of Rybinsk, Uglich and Ivankovo Reservoirs.
1959 Biull.Inst.Biol.Vodokhran., 5:37-8

Antipa, Gr., Fauna ichtiologica a Romaniei. Buçuresti, Carel Göbl, 294 p.
1909

Antipova, O.P., V.A. Sakharova and L.A. Shchetinina, Primenenie plovuchikh iskustvennykh
1954 nerestilishch dlia leshcha v Rybinskom vodokhranilishche. (Application of floating artificial spawning grounds for the bream in Rybinskoe Reservoir) (Ru) Ryb.Khoz., 1954 (5):39-40

Antosiak, B., Fishes in the food of older perch (Perca fluviatilis L.) in lakes of Węgorzewo
1963 district. (Polish, En Ru summary), Rocz.Nauk roln.(B), 82(2):273-94

__________, Pike food of some lakes of Węgorzewo district. (Polish, En and Ru summary).
1963a Rocz.Nauk roln.(B), 82(2):296-317

Aristovskaia, G.V., Pitanie ryb bentofagov srednei Volgi i ikh vzaimootnoshenia. (Feeding of
1954 benthophagous fishes and their interrelations) (Ru) Trudy tatar.Otd.vses.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 7:76-132

Ashkhaev, M.G., Rezultaty akklimatizatsii ryb v vodoemakh vostochnoi Sibirii. (Results of fish
1958 acclimatisation in eastern Siberia) (Ru) Ryb.Khoz., 1958, (1):17-20

Aslanova, N.E., Eksperimentalnye izuchenia povedenia ryb v potoke. (Experimental study of fish
1952 behaviour in a stream)(Ru) Dokl.vses.nauchno-issled.Inst.morsk.ryb.Khoz.Okeanogr., 1:13-8

Backiel, T., 1953 Distribution of fry in the littoral of lake Tajty. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 67:257-74

_____, 1958 Fry relations in the shallow sectors of Vistula river. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 73(2):313-62

_____, 1964 On the fish populations in small streams. Verh.int.Ver.Limnol. 15:529-34

_____, 1965 (Ed.), Freshwater fisheries of Poland. Krakow, Polish Academy of Sciences, Hydrobiological Committee. 95 p.

Backiel, T. and S. Bontemps, 1958 The growth and differentiation of length in cyprinid fry populations. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 73(2):363-98

Backiel, T., J. Kossakowski and A. Rudnicki, 1956 Fishery management in basins formed by dams; Outline for planning. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 71(1):65-138

Baimov, U.A., 1963 On feeding of the Aral Sea predatory fish in connection with the introduction of Gobiidae. (Ru, En summary). Vop.Ikhtiol., 3(2):304-11

Balagurova, M.V., 1963 Biologicheskie osnovy organizatsii ratsionalnogo rybnogo khoziaistva na siamozierskoi grupe ozer Karel'skoi ASSR. (Biological principles for rational organization of Siamozero fisheries) (Ru) Moskva - Leningrad, Izdatelstvo Akademii Nauk SSSR, Karel'-skii Filial, 88 p.

Balon, E., 1961 Vergleich der Altersstruktur und der Gesetzmässigkeit des Populationswachstums in drei Donauarten der Gattung Abramis. Zool.Anz., 167(9-12):404-12

_____, 1962 Beitrag zur ökologischen Charakteristik der Ichtyofauna des tschechoslovakischen Donau-Abschnitts. (Czech, Germ summary). Biológia, 17(4):283-96

_____, 1963 Altersstruktur der Populationen und Wachsgesetzmässigkeiten der Donaubrachsen (Abramis brama, Abramis sapa, Abramis ballerus). Sborn.vys.Šk.chem.-technol.Praze, 7(2):459-542

_____, 1964 Verzeichnis und ökologische Charakteristik für Fische der Donau. Hydrobiologia, 24(1-3):441-51

Banarescu, P., 1960 Einige Fragen zur Herkunft und Verbreitung der Süsswasserfischfauna der europäisch-mediterranen Unterregion. Arch.Hydrobiol., 57(1/2):16-134

_____, 1964 Fauna Republicii Populare Romîne. Pisces - Osteichthyes. Vol. 13. (in Roumanian), Buçuresti, Editura Academiei Rep. Populare Romîne, 962 p.

Baranov, F.I., 1948 Teoria i razchet orudii rybolovstva. (Theory and computations of fishing gear) (Ru), 2d edition, Moskva, Pishchepromizdat, 436 p.

Barysheva, A.F. and O.N. Bauer, 1957 Die Fischparasiten des Ladogasees. (Ru, German summary). Izv.vses.nauchno-issled.Inst.rechn.ozern.ryb.Khoz., 42:175-226

Bauch, G., 1958 Untersuchungen über die Gründe für den Ertragsrückgang der Elbefischerei zwischen Elbesandsteingebirge und Boizenburg. Z.Fisch., 7(3-6):161-437

_____, 1963 Die einheimischen Süsswasserfische. Berlin, Neudamm Verlag, 197 p.

Belyi, N.D., 1962 Nerest sudaka - Lucioperca lucioperca (L.), leshcha - Abramis brama (L.), tarani - Rutilus rutilus Heckeli (Nord.) i razvitie ikh ikry na bolshykh glubinakh v Kakhovskom vodokhranilishche. (Spawning of pike-perch, bream, Heckel roach and development of their eggs in deep waters of Kakhovskoe reservoir) (Ru) Vop.Ikhtiol., 2(2):291-4

Berdichevskii, L.S., 1959 Biologicheskie printsipy regulirovaniia Severokaspiiskogo rybolovstva. (Biological principles for regulation of Northern Caspian fisheries) (Ru) Zool.Zh., 38(1):88-102

__________, Biologicheske osnovy ratsional nogo vedeniia rybolovstva. (Biological
1961 foundations of rational fishery) (Ru) Trudy Soveshch., ikhtiol.Kom., 13:42-66

Berg, L.S., Classification of fishes both recent and fossil. Ann Arbor, Mich., J.W. Edwards Co.,
1947 517 p.

__________, Ryby presnykh vod SSSR i sopredel nykh stran, Chast'2. (Fishes of fresh waters
1949 of USSR and of adjacent countries, Part 2) (Ru) Moskva - Leningrad, Izdatelstvo
Akademii Nauk SSSR, Vol. 2:469-926

Berg, L.S., et al., editors, Promyslovye ryby SSSR. (Commercial fishes of USSR) (Ru) Moskva,
1949 VNIRO - Pishchepromizdat, 787 p.

Bernatowicz, S., Development stages of certain vascular plants as an indication of the spawning
1955 time of fish. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 69(4):547-557

__________, Observations on the phenology of fish spawning. (Polish, En and Ru summary).
1962 Rocz.Nauk roln.(B), 81(2):306-33

Bervald, E.A., Ryboproduktivnost' vodoemov i kolebanie chislennosti stad promyslovykh ryb.
1952 (Fishproduction of waters and fluctuations of abundance of commercial fishes) (Ru)
Zool.Zh., 31(1):82-90

__________, Vozdeistvie promysla na producktivnost'stad leshcha Aral'skogo moria. (Effect
1956 of fisheries on productivity of bream populations in the Aral Sea) (Ru) Vop.Ikhtiol.,
7:21-32

Biziaev, F.N., Opyt peresadki proizvoditelei promyslovykh ryb v Tsimlianskoe vodokhranilishche.
1952 (Transfer of bream spawners into the Tsimliansk reservoir) (Ru) Ryb.Khoz., 1952(4):
39-40

Blanchard, E., Les poissons des eaux douces de la France. Paris, J-B. Baillière et Fils, 656 p.
1880

Bodrova, I.V. and B.V. Kraiukhin, K voprosu o vidovoi chustvitelnosti ryb k elektricheskomu toku.
1959 Biull.Inst.Biol.Vodokhran., 5:29-31

Bogatova, I.B., On food relations of lake fishes. (Ru, En summary). Vop.Ikhtiol., 3(2):336-46
1963

Bogdanova, E.A., Parasitenfauna der Blei- und der Wildkarpfenbrut in den Fischzüchtereien des
1957 Wolgadeltas und epizootischer Zustand. (Ru, German summary). Izv.vses.nauchno-
issled.Inst.rechn.ozern.ryb.Khoz., 43(2):3-75

Botnariuc, N. and P. Spataru, Etude de la nourriture naturelle de la brème (Abramis brama L.)
1963 dans le complex d'étangs Crapino-Jila. Věst.čsl.zeměd.Mus., 27(2):130-46

Burmakin, E.U., Akklimatizatsia presnovodnykh ryb v SSR. (Acclimatisation of fresh-water fishes
1963 in USSR) (Ru) Izv.gosud.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 53:5-316

Butskaia, N.A., Ob osobennostiakh funktsii semennika u ryb s razlichnymi tipami neresta. (On
1955 peculiarities of testes in fishes of different type of spawning). Dokl.Akad.Nauk SSSR,
100(4):809-12

Bykhovskii, B.I., (Ed.), Opredelitel prazitov presnovodnykh ryb SSSR. (Ru) Moskva - Leningrad,
1962 Izdat.Akad.Nauk SSSR, 776 p.

Cherfas, B.I., Rybodovstvo v estestvennykh vodoemakh. (Ru) Moskva, Pishchepromizdat
1950

__________, Rybodovstvo v estestvennykh vodoemakh. (Fish culture in natural waters) (Ru)
1956 Moskva, Pishchepromizdat, 468 p.

Dabrowski, B., M. Leopold and W. Nowak, The species composition of catches with summer seine with
1964 bag. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 83(4):631-43

Dementeva, T.F., Metodika sostavleniia prognozov ulovov leshcha severnogo Kaspia. (Method of
1952 bream catch forecasting) (Ru) Trudy vses.nauchno-issled.Inst.morsk.ryb.Khoz.Okeanogr., 21:163-82

______, Biologicheskii tsikl severokaspiiskogo leshcha. (Biological cycle of northern
1952a Caspian bream) (Ru) Trudy vses.nauchno-issled.Inst.morsk.ryb.Khoz.Okeanogr.,21:185-94

______, Izmeneniia v raspredelenii i tempe rosta leshcha v Azovskom more pered
1955 zaregulirovaniem stoka reki Don. (Changes of distribution and rate of growth of bream in Azov Sea before water discharge regulation in Don river) (Ru) Trudy vses. nauchno-issled.Inst.morsk.ryb.Khoz.Okeanogr., 31:164-73

Dementeva, T.F., et al., O zakonomernostiakh dinamiki populatsii ryb. (On regularities in the
1961 dynamics of fish population) (Ru) Trudy Soveshch.ikhtiol.Kom., 13:7-20

Demin, D.Z., Poluprakhodnye ryby delty Tereka. (Semimigratory fishes of the estuary of Terek
1962 river) (Ru) Vop.Ikhtiol., 2(1):90-1

Disalov, N., Ribolov na Dunavu u 1963 godini. Ribarst.Jugosl., 19(5-6):149-51
1964

Disler, N.N., Osobennosti razvitiia kozhnykh organov chustv lateralnoi sistemy leshcha, karasia
1948 i plotvy. (Development features of sense organs on the skin of bream, crucian carp and roach) (Ru) (Sbornik: cf. Vasnetsov ed., pp. 219-33)

Dmitreva, E.N., Etapy razvitia tuvodnogo leshcha. (Stages of development of endemic bream) (Ru)
1960 Trudy Inst.Morf.Zhivot., 28:41-78

Domanevskii, L.N., O razmnozhenii ryb v verkhnem plese Tsimlianskogo vodokhranilishcha.
1958 (Fish spawning in the upper part of Tsimlianskoe reservoir) (Ru) Izv.vses.nauchno-issled.Inst.rechn.ozern.ryb.Khoz., 45:142-59

______, Promyslovo-biologicheskaia kharakteristika shchuki Tsimlianskogo vodokhranilishcha.
1958a (Fishery-biological characteristic of pike from Tsimlianskoe reservoir) (Ru) Izv.vses nauchno-issled.Inst.rechn.ozern.ryb.Khoz., 45:201-12

______, Nekotorye osobennosti mezhvidowykh otnoshenii shchuki i osnovnykh vidov ryb v
1964 Tsimlianskom vodokhranilishche. Zool.Zh., 43(1):71-3

Drenski, P., Ribite v Bulgaria. (Fishes in Bulgaria), Sofia, Izdania na Bulgarskata Akademiia
1951 na Naukite, 270 p.

Driagin, P.A., Polovye tsikli i nerest ryb. (Sexual cycles and spawning in fish) (Ru) Izv.vses.
1949 nauchno-issled.Inst.rechn.ozern.ryb.Khoz., 28:3-114

______, O polevykh issledovaniakh razmnozhenia ryb. (On the field research of reproduction
1952 in fish) (Ru) Izv.vses.nauchno-issled.Inst.rechn.ozern.ryb.Khoz., 30:3-70

Dubinina, M.N., Sovremennoe sostoiane izucheniia remnetsov fauny SSSR. (Ru) Parazit.Lb., 17:
1957 251-76

Dudin, A.F., O netselesoobraznosti vnedreniia plovuchikh nerestilishch. (On the ineffective-
1954 ness of floating spawning grounds) (Ru) Ryb.Khoz., 1954(7)41-5

Dyk, V., Nemoci ryb. (3d Edition), (Czech) Praha, Českoslov.Akad.Zeměd.Věd, 404 p.
1961

Dziekońska, J., The feeding characteristics of a mature pike (Esox lucius L.), perch (Perca
1954 fluviatilis L.) and pike-perch (Lucioperca lucioperca L.) in lakes. (Polish, En summary) Polskie Archwm Hydrobiol., 2(1):165-83

______, Studies on the embryonic development of fish. 1. Spawning and the embryonic
1956 development of bream (Abramis brama L.) in the Vistula Lagoon. (Polish, En and Ru summary) Polskie Archwm Hydrobiol., 3:291-305

_________, Studies on early development stages of fish. 2. The influence of some environmental conditions on the embryonic development of bream (Abramus brama L.) in the
1958 Vistula delta. (Polish, En and Ru summary) Polskie Archvm Hydrobiol., 4:193-206

Economic Commission for Europe, Water pollution control in Europe. A compendium of documenta-
1962 tion. Water Poll./Gen.1:77 p.

Egereva, I.V., Dannye o pitanii ryb - bentofagov v Kuibyshevskom vodokhranilishche. (Data on
1962 benthophagous fish feeding in Kuibyshev reservoir) (Ru) Nauchno-tekh.Biull.gosud. nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 16:5-9

Elizarova, N.S., Nekotorye osobennosti formirovaniia stada leshcha v pervye gody obrazovania
1962 Volgogradskogo vodokhranilishcha. (Some peculiarities of bream stock formation in the first years of existence of Volgogradskoe reservoir) (Ru) Trudy saratov.Otd. gosud.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 7:184-92

Engelbrecht, H., Untersuchungen über den Parasitenbefall der Nutzfische im Greifswalder Bodden
1958 und Kleinen Haff. Z.Fisch., 7(N.F.):(7/8):481-511

Eremeeva, E.F., Sravnenie etapov razvitiia leshcha Abramis brama (Linné) Kubanskikh limanov,
1960 Volgi i Dona. (Comparison of development stages in bream of Kuban lagoons, Volga-and Don rivers) (Ru) Trudy Inst.Morf.Zhivot., 25:25-37

_________, Etapy razvitiia leshcha Rybinskogo vodokhranilishcha. (Development stages of
1960a bream from Rybinsk reservoir) (Ru) Trudy Inst.Morf. Zhivot., 28:79-107

Fabricius, E., The topography of the spawning bottom as a factor influencing the size of the
1951 territory in some species of fish. Rep.Inst.Freshwat.Res.Drottningholm, (32):43-50

Filuk, J., Results of investigation performed on a stock of bream from the Firth of Vistula in
1957 1951-1952. (Polish, En and Ru summary) Pr.morsk.Inst.ryb.Gdyni, 9:221-45

_________, Biological characteristics of bream (Abramis brama) catches of Vistula Firth.
1962 Pr.morsk.Inst.ryb.Gdyni, 12/A:89-116

_________, Studies on the biology and catches of the Vistula Firth perch-pike. (Polish, En
1962a and Ru summary). Pr.morsk.Inst.ryb.Gdyni, 11/A:225-74

Flemming, H., Ueber das Blutbild bauchwassersuchtkranker Bleie (Abramis brama L.). Z.Fisch.,
1954 3(N.F.):(6-7-8):553-64

Gasowska, M., Bream of Vistula river. Polish Academy of Sciences, Zoological Institute, 1964
MS

Geyer, F., Ueber parasitische Lernaeopodiden von Balaton-Fischen (Ungarn). Zool.Anz., 127
1939 (5/6):145-59

_________, Alter und Wachstum der wichtigsten Cypriniden ostholsteinischer Seen. Arch.
1939a Hydrobiol., 34:543-644

Geyer, Fr. and H. Mann, Limnologische und fischereibiologische Untersuchungen am ungarischen
1939 Teil des Fertö (Neusiedler) Sees. Arb.ung.biol.Forsch.Inst., 11 (quoted in Laskar 1948)

Ginzburg, Ia.I, O biologii i urozhainosti molodi ryb v Tsimlianskom vodokhranilishche
1958 (po nabliudeniam 1953-1955). (On the biology and abundance of young fish in Tsimlianskoe reservoir) (Ru) Izv.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 45:111-41

Gnadeberg, W., Beiträge zur Biologie und Entwicklung des Ergasilus sieboldi v. Nordmann
1948 (Copepoda parasitica). Z.Parasitenk., 14:103-80

Gomazkov, O.A., About the question of the role of detritus in the nutrition of Abramis brama in
1959 Rybinsk Reservoir. Biull.Inst.Biol.Vodokhran., 5:23-5

Goriunova, A.I., and N.P. Serov, Akklimatizatsiia ryb v Kazakhstane. (Acclimatization of
1954 fishes in Kazakhstan) (Ru) Trudy Soveshch.ikhtiol.Kom., 3:109-13

Gosteeva, M.N., Razvitie Aral'skogo leshcha v morskoi vode. (Development of Aral bream in sea
1954 water) (Ru) Ryb.Khoz., 1954 (6):57-60

__________, Ekologo-morfologicheskaia kharakteristika razvitia Aral'skogo lescha. (Ecological-
1957 morphological characteristics of the development of Aral bream) (Ru) Trudy Inst.Morf. Zhivot., 20:121-47

Grabda, E., Sciegorza (Ligula intestinalis L.) i jej znaczenie dla gospódarki rybnej. (Polish)
1951 Medycyna wet., 7(6):377-8

Grabda, E. and J. Grabda, Tracheliastosis in the common bream (Abramis brama L.) in lake Jamno.
1957 Zoologica Pol., 8(4):325-34

__________, Parasites and fish diseases in Wdzydze Lake. (Polish, En and Ru summary).
1961 Rocz.Nauk roln.(D)., 93:239-66

Grabda, J., Parasitic Copepoda of the Vistula Firth fishes. (Polish, En summary). Pr.morsk.
1962 Inst.ryb.Gdyni, 11A:275-86

Griazeva, E.D., Izmenenie gonad leshcha Abramis brama v sviazi s sozrevaniem polovykh produktov
1936 i vozrastom. (Changes in gonads of bream in connection with sexual maturation and age) (Ru) Izv.biol.nauchno-issled.Inst.biol.Sta.perm.gosud.Univ., 10(8):285-304

Hartley, P.H.T., The natural history of some British fresh water fishes. Proc.zool.Soc.London.,
1947 117:129-206

Horoszewicz, L., Food of predatory fishes in Vistula river. (Polish, En summary). Rocz.Nauk.
1964 roln.(B), 84(2):313-23

Huet, M., Aperçu des relations entre la pente et les populations piscicoles des eaux courantes.
1949 Schweiz.Z.Hydrol., 11 (3-4):332-351

Iliina, L.K., Growth and age of Abramis brama, Blicca björkna, Rutilus rutilus and Abramis sapa
1960 in Gorky reservoir. (Ru, En summary) Trudy Inst.Biol.Vodokhran., Borok., 3(6):202-17

Irinarkhov, G.S. and N.M. Tokarev, Regulirovanie zakhoda proizvoditelei na estestvennye
1949 nerestilishcha. (Control of migration to natural spawning grounds) (Ru) Ryb.Khoz., 1949:27-8

Iurovitskii, Iu.G. and P.N. Reznichenko, Razvitie leshcha v usloviakh razlichnogo kislorodnogo
1961 rezhima. (Bream development in different oxygen conditions) (Ru) Trudy Inst.Morf. Zhivot., 33:94-110

Ivanov, S.N. and N.V. Pechenikova, Rezultaty vselenia Aralskogo leshcha v ozero Balkhash.
1960 (Results of introduction of Aral bream into Balkhash lake) (Ru) Nauchno-tekh.Biull. gosud.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 10:19-21

Ivanova, M.N., Nekotorye dannye o pitanii okunia v rozlichnykh zonakh delty Volgi. (Some data
1956 on perch food in different zones of Volga estuary) (Ru) Vop.Ikhtiol., 7:96-106

__________, On the nutrition of fishes in Koma Reservoir. (Ru, En summary). Biull.Inst.
1960 Biol.Vodokhran., 7:21-5

Ivlev, V.S., Eksperimentalnaia ekologia pitania ryb. (Experimental ecology of fish feeding)
1955 (Ru) Moskva, Pishchepromizdat, 251 p.

Janiszewska, J., Caryophyllaeidae europejskie ze szczególnym uwzględnieniem Polski. (Polish)
1954 Pr.wrocl.Tow.nauk.(B), 66:28-9

Järnefelt, H., Untersuchungen über die Fische und ihre Nahrung im Tuusula See. Acta Soc.Fauna
1921 Flora fenn., 52 N1:1-160

Karpevich, A.F., Ekologicheskoe obosnovanie prognoza izmenenii arealov ryb i sostava ikhtiofauny
1955 pri osolenii Azovskogo moria. (Ecological background for forecasting of changes in distribution and species composition of fishes resulting from salt increase in Azov Sea) (Ru) Trudy vses.nauchno-issled.Inst.morsk.ryb.Khoz.Okeanogr., 31:3-84

Karpevich, A.F. and E.N. Bokova, Peresadka ryb i vodnykh bezpozvonochnykh v 1957-1959 gg.
1961 (Acclimatization of fish and invertebrates carried out in USSR in 1957-1959) (Ru) Vop.Ikhtiol., 1(3):552-63

———, Peresadka ryb i vodnykh bezpozvonochnykh provedennaia v SSSR za 1960 i 1961 gg.
1963 (Acclimatization of fish and invertebrates carried out in the USSR, 1960-1961) (Ru) Vop.Ikhtiol., 3(2):366-95

Karpevich, A.F. and D.E. Lokshina, Peresadka ryb i vodnykh bezpozconochnyk v 1962 g.
1965 (Acclimatization of fish and invertebrates in 1962) (Ru) Vop.Ikhtiol., 5(1):178-97

Karpińska-Waluś, B., The rate of growth of bream (Abramis brama L.) in lakes of Węgorzewo
1961 district. (Polish, En summary). Rocz.Nauk.roln.(B). 77(2):455-90

Karzinkin, G.S., Osnovy biologicheskoi produktivnosti vodoemov. Moskva, Pishchepromizdat,
1952 402 p., also: Polish edition 1955, Podstawy biologicznej wydajności zbiorników wodnych. Warszawa, PWRL, 386 p. (Fundamentals of biological productivity of water bodies)

Kerr, T., The pituitary in normal and parasitized roach (Leuciscus rutilus) Flem. Quart.J.
1948 microsc.Sci., 5(89):129-37

Koblitskaia, A.F., Vliianie izmenenii rozlichnykh factorov sredy na kharakter i effectivnost'
1961 neresta poluprokhodnykh ryb v nizoviakh delty Volgi. (Influence of changes in various environmental factors on character and efficiency of spawning in semi-migratory fishes of Volga estuary) (Ru) Trudy Soveshch.ikhtiol.Kom., 13:265-76

Kogan, A.V., Materialy po pitaniu sintsa, sazana i leshcha v Tsimlianskom vodokhranilishche.
1958 (On the feeding of Abramis ballerus and Abramis brama in the Tsimliansk reservoir) (Ru) Izv.vses,nauchno-issled.Inst.ozern,rechn.ryb.Khoz., 45:178-89

———, On diurnal diet and rhythm of feeding in Abramis brama (L.) of the Tsimlianskoe
1963 Reservoir. (Ru, En summary). Vop.Ikhtiol., 3(2):319-25

Kogteva, E.P., Die Fischparasiten des Peipus Sees. (Ru, German summary). Izv.vses.nauchno-
1957 issled.Inst.ozern.rechn.ryb.Khoz., 42:243-69

Kosheva, A.F., Forming of parasitical fauna of fishes in the impoundment Kutuluk. (Ru, En
1957 summary). Izv.vses.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 42:124-31

Kozhin, N.I. and M.A. Letichevskii, Nerestovo-vyrastnye khoziaistva. (Spawning - breeding
1953 farms) (Ru) Moskva, Gizlegpishcheprom, 47 p.

Kozicka, J., Parasites and health conditions of bream from the Vistula river near Warsaw.
1951 (Polish, En summary). Rocz.Nauk.rol., 58:341-72

———, Fish parasites in lake Tajty. (Polish, En summary). Rocz.Nauk.roln.(D)., 67:171-
1953 86

———, Diseases of fishes of Druzhno Lake. (En, Polish summary). Acta parasit.pol.,
1958 6(20):393-432

———, Parasites of fishes of Druzhno Lake. (En, Polish summary). Acta parasit.pol.,
1959 7(1):1-72

Kozikowska, Z., Crustacés parasites (Crustacea parasitica) de la Pologne, Part 1. (Polish,
1957 French summary). Zoologica Pol., 8(2-3):217-70

Krizhanovskii, S.G., Ekolog-morfologicheskie zakonomernosti razvitiia karpovykh viunovykh i
1949 somovykh ryb (Cyprinoidei i Siluroidei). (Ecological and morphological principles of development of Cyprinoidei and Siluroidei) (Ru) Trudy Inst.Morf.Zhivot., 1:5-332

Kruglova, V.M., 1961 Znachenie Veselovskogo vodokhranilishcha v vosproizvodstve poluprokhodnykh ryb Azovo-Donskogo basseina.(Significance of Veselovskoe reservoir in management of semi-migratory fishes of Azov-Don watershed) (Ru) Trudy Soveshch.ikhtiol.Kom., 13:430-2

Kuznetsova, I.I., 1950 Regulirovanie kolichestva proizvoditelei na nerestilishchakh. (Abundance control of spawners on spawning grounds) (Ru) Ryb.Khoz., 1950(4):30-4

________, 1958 Elementy gazoobmena u leshcha, sazana i sudaka na rannykh etapakh razvitiia. (Elements of gas metabolism of bream, carp and pike-perch in early stages of development) (Ru) Trudy Soveshch.ikhtiol.Kom., 8:346-58

Ladiges, W., 1960 Süsswasserfische der Türkei. Mitt.hamb.zool.Mus.Inst., 58:105-50

Lapitskaia, L.N., 1958 Pitanie i pishchevye vzaimootnoshenia molodi ryb Tsimlianskogo vodokhranilishcha w 1954 g. (Feeding and food relationship of young fish in Tsimlianskoe reservoir) (Ru) Izv.vses.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 45:160-77

Laskar, K., 1941 Die Ernährung des Brassens. Fischereiztg, Neudamm., 44(51/52):339-44

________, 1948 Die Ernährung des Brassens (Abramis brama L.) in eutrophen Seen. Arch.Hydrobiol., 42:1-165

Lebedev, N.V., 1946 Elementary populations of fishes. (Ru, En summary). Zool.Zh., 25(2):121-36

________, 1961 Vozdeistve promysla na biologicheskie pokazateli ryb. (Effect of fishery on biological indices of fish) (Ru) Trudy Soveshch.ikhtiol.Kom., 13:173-9

Leeming, J.B., 1963 The chub, bream and other fishes of the Welland. In proceedings, 1st British Coarse Fish Conference, the University Liverpool., Dpt Zool., pp.48-52

Lenkiewicz, Z., 1964 Temperature preferendum of some freshwater fishes. (Polish summary). Folia Biol., Kraków, 12(1):95-140

Leopold, M. and W. Nowak, 1964 Species composition of catches with fyke net with rings. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 83(4):655-65

________, 1964a Species composition of catches with winter seine with bag. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 83(4):645-54

________, 1964b Species composition of gill net catches. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 83(4):675-80

________, 1964c Species composition of trap catches. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 83(4):667-73

Leszczyński, L., 1963 Food items of juvenile stages of some fish species from several lakes of Węgorzewo district. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 82(2):235-50

Letichevskii, M.A., 1965 Ulutshenie eksploatatsii nerestovo-vyrostnykh khoziaistv delty Volgi i likvidatsiia sezonnosti ikh roboty. (Improvement in spawning-breeding farms of Volga estuary and elimination of periodicity in their work) (Ru) Ryb.Khoz., 41(1):15-7

Liaiman, E.N., 1949 Kurs boleznei ryb. (Ru) Moskva, Pishchepromizdat, 270 p.

Lieder, U., 1954 Chromosomenstudien an Knochenfischen 2. Ueber die Chromosomenzahl und -morphologie der Plötze (Leuciscus rutilus L.) und einiger Bastarde mit anderen Cypriniden. Z.Fisch., 3NF(4/5):375-81

________, 1961 Untersuchungsergebnisse über die Grätenzahlen bei 17 Süsswasserfischarten. Z.Fisch., 10NF(4/5):329-50

Logvinovich, D.V., Vliianie solennosti i plotnosti kormovykh obiektov na pitanie i rost
1955 lichinok i malkov donskovo leshcha Abramis brama (L.) i sudaka Lucioperca lucioperca (L.). Trudy vses.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 31(2):85-96

Lucky, Z. and V. Dyk, Die Schmarotzer der Fische in Flüssen und Teichen des Flussgebietes von
1964 Odra und Dyje. (Czech, German summary). Sb.vys.Šk.zeměd.Brně, 12(1):49-73

Lukashov, V.N., Dinamika chislennosti ekspluatiruemykh stad vobly, leshcha i sudaka Severnogo
1961 Kaspiia. (Dynamics of abundance in stocks of Caspian roach, bream and pike-perch) Trudy Soveshch.ikhtiol.Kom., 13:445-53

Lühmann, M. and H. Mann, Ueber Hungerformen beim Brassen. Fischwirt., 8
1957

Maiskii, V.N., Raspredelenie i chislennost' ryb Azovskogo moria pered zaregulirovaniem stoka
1955 reki Don. (Distribution and abundance of fish in Azov sea before controlling of water discharge in Don river) (Ru) Trudy vses.nauchno-issled.Inst.morsk.ryb.Khoz. Okeanogr., 31:138-63

Makkoveeva, I.I., Pitanie molodi shchuki Rybinskogo vodokhranilishcha. (Feeding of pike in
1956 Rybinskoe reservoir) (Ru) Vop.Ikhtiol., 7:60-95

Maliarevskaia, A.J. and T.I. Birger, Biokhemicheskii sostav proizvoditelei, ikry i lichinok
1965 tarani i leshcha. In Vliianie kachestva proizvoditelei na potomstvo u ryb, Kiev, Naukova Duma, 534 p.

Margaritov, N., Paraziti po niakoi nashi sladkovodni ribi. Varna, Izdanie N.-Izsled.
1959 Institut po Ribarstvi i Ribna Promyshlennost'

Marketova, N.V., Vozrastnoi sostav i temp rosta leshcha v pervye gody suschestvovania
1958 Tsimlianskogo vodokhranilishcha. Izv.vses.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 45:190-5

Markevich, A.P., Parazitofauna presnovodnykh ryb USSR. Kiev, Izdat.Akad.Nauk.Ukr.SSR, 376 p.
1951

__________, Paraziticheski veslonogie ryb SSSR. Kiev, Izdat.Akad.Nauk.Ukr.SSR, 260 p.
1956

Markun, M.I., Materialy po rostu i sistematike aralskogo leshcha. Izv.Otd.prikl.Ikhtiol.,
1929 Leningr., 2(1):22-41

Mayre, E., G. Linsley and L. Usinger, Methods and principles of systematic zoology. New York,
1953 McGraw Hill, 328 p.

Mikheev, P.V., Isskustvennye plovuchie nerestilishcha. (Artificial floating spawning grounds)
1951 (Ru) Moskva, Pishchepromizdat, 44 p.

Mikheev, P.V. and E.V. Meisner, Sbor i transportirovka ikry sudaka i leshcha dlia zaryblenia
1954 vodokhranilishch. (Collection and transportation of pike-perch and bream eggs for stocking reservoirs) (Ru) Ryb.Khoz., (3):36-7

Mikheev, P.V. and K.P. Prokhorova, Rybnoe naselenie vodokhranilishch i ego formirovanie.
1952 (Fish stocks of reservoirs and their formation) (Ru) Moskva, Pishchepromizdat, 86 p.

Monastyrskii, G.N., Dinamika chislennosti promyslovykh ryb. (Dynamics of abundance in commer-
1952 cial fishes) (Ru) Trudy vses.nauchno-issled.Inst.morsk.ryb.Khoz.Okeanogr., 21:3-162

Moreau, E., Histoire naturel des poissons de la France. Vol. 3. Paris, C. Masson, 697 p.
1881

Morozova, P.N., Leshch Aralskogo moria. (Bream of Aral Sea) (Ru) Izv.vses.nauchno-issled.Inst.
1952 ozern.rechn.ryb.Khoz., 30:74-96

Mrugasiewicz, W., Próby hodowli leszcza w stawach. (An attempt of bream culture in ponds)
1931 (Polish) Przegl.rybacki, 4:23-4

Nebolsina, T.K., Pitanie leshcha, plotvy, gustery i sintsa v pervye gody obrazovania Volgo-
1962 gradskogo vodokhranilishcha. (Feeding of A. brama, A. ballerus, Bliccabjörkna and Rutilus rutilus in the first years of forming of Volgograd reservois) (Ru) Trudy saratov.Otd.gosud.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 7:148

Neubaur, R., Biologisches und Wirtschaftliches von Blei (Abramis brama L.) im Stettiner Haff und
1926 seinen Nebengewässern. Z.Fisch., 24:163-93

Neuhaus, E., Untersuchungen über die Lebensweise von Ergasilus sieboldi. Z.Fisch., 27:341-97
1929

__________, Studien über das Stettiner Haff und seine Nebengewässer; Untersuchungen über den
1934 Kaulbarsch. Z.Fisch., 30:1-35

Niewolak, S., Pseudomonas chloraphis as a factor that causes focal colliquative necrosis of the
1961 bream (Abramis brama L.). (Polish, En summary). Zesz.nauk.wyzsz.Szk.roln.Olsztyn, 11(109):145-50

Nikiforov, N.D., Predelnye kontsentratsii kisloroda i predielnia solenost' dlia molodi
1953 promyslovykh ryb. Izv.vses.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 33:36-41

Nikoliukin, N.I., Mezhvidovaia gibridizatsia ryb. (Interspecific hybridization of fishes) (Ru)
1952 Saratov, Saratovskoe Oblastnoe Gos.Izdatelstvo, 312 p.

Nikolskii, G.V., K poznaniu osobennostoi formirovania i rozvitiia ikhtiofauny vodokhranilishch
1948 v otdelnykh geograficheshikh zonakh. (On the peculiarities of formation and development of fish fauna in reservoirs in different geographic zones) (Ru) Zool.Zh., 27 (2):149-58

__________, O dinamike chislennosti stada ryb i o tak nazyvaemoi probleme produktivnosti
1950 vodoemov. (On the dynamics of fish population and on the so-called problem of water productivity) (Ru) Zool.Zh., 29(6):489-500

__________, O teoreticheshikh osnovakh robot po dinamike chislennosti ryb. (Ru) Trudy
1953 Soveshch.ikhtiol.Kom., 1:77-93

__________, Chastnaia ikhtiologia. (2d Ed.) (Systematic ichthyology) (Ru) Moskva, Sovetskaia
1954 Nauka, 458 p.

__________, O vliianii vylova na strukturu populiatsii promyslovoi ryby. Zool.Zh., 37(1):41-56
1958

Nikolskii, P.D., Vyrashchivanie molodi sudaka i leshcha pri uplotnennykh posadkakh proizvoditelei
1955 v usloviiakh nerestovo-vyrastnogo khoziaistva delty Volgi. (Rearing of bream and pike-perch at dense stocks of spawners in spawning-breeding farms in Volga estuary) (Ru) Ryb.Khoz., (3):42-4

Nümann, W., Die anatolischen Seen und ihre fischereiliche Bewirtschaftung. Z.Fisch., N.F.,
1962 10(8-10):773-99

Ohlmer, W. and J. Schwarzkopf, Schwimmgeschwindigkeit von Fischen aus stehenden Binnengewässern.
1959 Naturwissenschaften., 10 (quoted in Radakov, Protasov 1964)

Oliva, O., A revision of the cyprinid fishes of Czechoslovakia with regard to their secondary
1952 sexual characters. Bull.int.Acad.Prague., 53(1):1-61

Ostroumov, A.A., O vozrastnem sostave stada i roste leshcha Rybinskogo vodokhranilishcha. (Age
1956 composition and growth of bream in Rybinskoe reservoir) (Ru) Trudy biol.Sta.Borok, 2:166-83

Pacak, S., Parasites of Danube bram (Abramis brama danubii) (Czech, En summary). Pr.Lab.Ryb.
1962 Bratislava, 1:173-98

Paiusova, A.N., O metodakh nabludeniia za molodiu vobly i leshcha w elementarnykh populatsiakh.
1961 (On the methods of research of young Caspian roach and bream in elementarypopulations) (Ru) Trudy Soveshch.ikhtiol.Kom., 13:471-9

Pankratova, W.I., 1948. Materialy po pitaniu volzhskikh ryb. (Materials on feeding of Volga fishes) (Ru) Trudy zool.Inst.,Leningr., 8(3):600-20

Panov, D.A., 1960. On the larval feeding of Abramis brama in Rybinsk reservoir. (Ru, En summary). Trudy Inst.Biol.Vodokhran., Borok, 3(6):176-81

Papadopol, M., 1962. Despere prolificifatea platici Abramis brama L. pescuita in delta Dunarii si analiza dinamicii ei in ontogeneza. Anal.rom.-sov.(Biol.), 3:73-90

______, 1963. Sur le caractère de la ponte chez la brème Abramis brama danubii Pavlov pechée dans le delta de Danube. (Rumanian, Fr summary). Studii Cerc.Biol.(anim.), 15(4):465-76

Pape, A., 1952. Untersuchungen über die Erträge der Fischerei der Mittelelbe und die Auswirkungen ihres Ertragsniedergangs. Z.Fisch., N.F., 1(1/2):45-72

Pavlov, P.I., 1956. Pridunaiskii leshch v sravnenii s dneprovskim. (The Danubian bream in comparison with the Dnepr-bream) (Ru) Zool.Zh., 35(6):891-96

Pęczalska, A., 1963. The reproductive biology of bream from Szczecin Firth. Polskie Archvm Hydrobiol., (Polish, En and Ru summary). 11(1):109-39

Petkevich, A.N., 1953. Akklimatizatsia leshcha v vodoemakh Sibiri. (Bream acclimatization in Sybirian waters) (Ru) Priroda, 12:110-1

______, 1954. Akklimatizatsia sazana i leshcha v Barabinskikh ozerakh. (Acclimatization of carp and bream in Barabin lakes) (Ru) Trudy Soveshch.ikhtiol.Kom., 3:98-108

Pliszka, F., 1951. Results of investigations on the migrations of fish in the Vistula. (Polish, En summary). Rocz.Nauk roln., 57:272-83

______, 1953. Dynamics of feeding relations of the lake Harsz. Polskie Archwm Hydrobiol., 1:271-300

______, 1953a. The effect of spawning conditions in lakes on survival rates of juvenile stages. (Polish, En and Ru summary). Polskie Archwm Hydrobiol., 1:165-88

Pliszka, F. and J. Dziekońska, 1953. An analysis of the feeding conditions in Tajty as a basis for its arrangement. (Polish, En and Ru summary). Rocz.Nauk roln., 67:187-209

______, 1953a. Efforts to characterize the feed relation and feed conditions in lake Tafty for fry. (Polish, En and Ru summary). Rocz.Nauk roln., 67:209-21

Pliszka, F., et al., 1951. Investigation into the food and feeding habits of fish in the river Vistula. (Polish, En summary). Rocz.Nauk roln., 57:205-35

Podarueva, Z.S., 1960. On the nutrition of Acerina cernua in the Upper Volga Reservoir and in lake Beloe. (Ru, En summary). Trudy Inst.Biol.Vodokhran., 3(6):182-93

Poddubnyi, A.G., 1959. Some peculiarities of the distribution of Abramis brama in Rybinsk reservoir during the period of feeding. (Ru, En summary). Biull.Inst.Biol.Vodokhran., 5:32-6

______, 1960. On local populations of Abramis brama in Rybinsk reservoir. (Ru, En summary). Trudy Inst.Biol.Vodokhran., 3(6):216-27

Ponedelko, B.I., 1958. Die Verteilung des Laichs, der Larven und Jungfische im Ilmensee. (Ru, German summary). Biull.Inst.Biol.Vodokhran., 2:33-7

Popescu, L., 1958. Contributions à la biologie de la brème (Abramis brama L.) du Delta du Danube. (Roumanian, French summary). Bul.Inst.Cerc.pisc., 17(2):65-77

Potapova, O.I., 1954. Leshch kak obiekt ozernogo rybnogo khoziaistva karelo-finskoi SSR. (Bream as an object of lake fisheries in Karel-Finnish SSR) (Ru) In Materialy Soveshchania po probleme povyshenia rybnoi produktivnosti vnutrennykh vodoemov Karelo-Finskoi SSR. Petrozavodsk, Gos.Izdatelstvo Kar.-Fin.SSR., pp.86-95

Pravdin, I.F., Rukovodstvo po izucheniu ryb. Leningrad, Izdatelstvo Leningradskogo Gos.
1939 Universiteta, 245 p.

Privol'nev, T.I., Perevozka i khranenie zhivoi ryby. (Transportation and holding of live fish)
1956 (Ru) Moskva, VNIORKh - Pishchepromizdat, 80 p.

__________, Reaktsiia ryb na svet. (Reaction of fish on light) (Ru) Vop.Ikhtiol., 6:1-20
1956a

Privol'nev, T.I. and N.W. Koroleva, Kriticheskoe soderzhanie kisloroda v vode dlia ryb pri
1953 raznykh temperaturakh po sezonam. (Critical for fish oxygen content in water at different temperatures and seasons) (Ru) Dokl.Akad.Nauk SSSR, 89(1):175-6

Privol'nev, T.I. et al., Heterogeneity of ripe egg of salmon (Salmo salar L.) and bream (Abramis
1964 brama L.) (Ru, En summary). Izv.gosud.nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 58:150-158

Prost, M., Monogenoidea of gills of fishes of Vistula. (Polish, En summary). Acta parasit.
1957 polon., 5(14):299-395

__________, Investigations on the influence of salinity on the monogenoidean fauna of fishes.
1959 (Polish, En summary). Acta parasit.polon., 7(35):615-30

Radakov, D.V. and V.R. Protasov, Skorosti dvizhenia i nekotorye osobennosti zrenia ryb.
1964 Spravochnik. (Swimming velocities and some characters of fish sight, guidebook), Moskva, Izdat. Nauka, 48 p.

Regan, C.T., The hybrid between the bream and rudd (Abramis brama x Leuciscus erythrophthalmus).
1908 Ann.Mag.nat.Hist.,(ser.8), 2:162-5

Reshetnikova, A.V., O liguloze leshcha Tsimlianskogo vodokhranilishcha. (Ru) Moskva - Lenin-
1959 grad, 10 Soveshchanie po parazitologicheskim problemam i prirodnoochagovym bolezniam. vol. 2:199-200

__________, The effect of plerocercoid Digramma interrupta Rud.upon the bream growth. (Ru,
1965 En summary). Zool.Zh., 44/5:734-9

Romanova, G.P., Pitanie sudaka (Lucioperca lucioperca (L.)) Rybinskogo vodokhranilishcha.
1956 (Feeding of pike-perch in Rybinskoe reservoir) (Ru) Trudy.biol.sta.Borok, 2:307-26

Romanysheva, O.D., O prichinakh kolebanii ulovov leshcha v Aralskom morie. (On the causes of
1958 bream catch fluctuations in Aral Sea) (Ru) Vop.Ikhtiol., 11:44-8

Rümmler, H.J., Die Fangergebnisse der Sport- und Berufsfischerei auf dem Sacrower See bei
1949 Potsdam in den Jahren 1923 bis 1948 und die Auswertungsmöglichkeiten der Angler-statistik. Abh.Fisch.Hilfswiss., Lief.2:453-67

Sablina, T.B., Pozdnye etapy razvitia vobly (R.rutilus caspicus), leshcha (A.brama L.) i sazana
1960 (Cyprinus carpio) v avandeltie reki Volgi i Severnoi Kaspii. Trudy Inst.Morf.Zhivot., 25:137-61

Sakowicz, S., Zarys gospodarki rybackiej na wodach otwartych. (Outline of inland fisheries)
1952 (Polish), Warszawa, PWRiL, 259 p.

Sakowicz, S. and T. Backiel, Fish migrations through the canal connecting lakes Tajty and Mamry.
1953 (Polish, En and Ru summary). Rocz.Nauk roln.(D), 67:275-87

Sakowicz, S. and S. Zarnecki, Pool-passes- biological foundations for planning. (Polish, En
1954 summary). Rocz.Nauk roln.(D), 69:1-169

Savina, N.O. et al., Osnovnye promyslovye ryby vodoemov vitebskogo rybozavoda. (Main commercial
1964 fishes of Vitebsk water bodies) (Ru) In Biolog. osnovy rybnogo khoziaistva na vnutr. vodoemakh Pribaltiki., Minsk, Nauka i Tekhnika, pp.45-9

Schäperclaus, W., Fischkrankheiten. (3d Edition), Berlin, Akademie-Verlag, 708 p.
1954

Schumann, G.O., An electrophoretic survey of multiple haemoglobins in some freshwater fishes.
1959 Rep.Inst.Freshwat.Res.Drottningholm, 40:176-97

Sebentsov, B.M., E.V. Meisner and P.V.Mikheev, Rybovodno-biologicheski osnovania
1953 rybokhoziaistvennogo osvoenia vodokhranilishch na rekakh. (Fishery-biological principles of fishery management in reservoirs. (Ru) Trudy vses.nauchno-issled.Inst. ozern.rechn.ryb.Khoz., 6:5-120

Segestråle, C., Ueber die jährlichen Zuwachszonen der Schuppen und Beziehungen zwischen Sommer-
1932 temperatur und Zuwachs bei Abramis brama. Acta zool. fenn., 13:1-42

__________, Ueber scalimetrische Methoden zur Bestimmung des linearen Wachstums bei Fischen.
1933 Acta zool.fenn., 15:1-168

Shaposhnikova, G.Kh., Leshch i perspektivy ego sushchestvovaniia v vodokhranilishche na Volge.
1948 (Bream and pospects of its existance in a reservoir on Volga River) (Ru) Trudy zool. Inst., Leningr., 8(3):467-502

__________, Ryby Amu-Darii. (Fishes of Amu-Daria river) (Ru) Trudy zool.Inst., Leningr.,
1950 9:16-54

Shentiakov, V.A., Presnovodnyi elektrotralovyi lov ryby s primenenem poremennogo toka. (Fresh-
1964 water electric trawling of fish applying alternating current) (Ru), Moskva, Pishchevaia Promyshlennost, 82 p.

Shilov, V.I., Vozrastnye i sezonnye izmenenia iaichnikov leshcha v usloviakh formirovaniia
1962 Volgogradskogo vodokhranilishcha. (Seasonal and in age groups changes of bream ovaries in conditions of Volgogradskoe reservoir formation) Trudy saratov.Otd.gosud. nauchno-issled.Inst.ozern.rechn.ryb.Khoz., 7:118-29

Shkorbatov, G.L., On the acclimatisation theory of water animals. (Ru, En summary). Zool.Zh.,
1964 53(7):953-64

Shorygin, A.A., Pitanie i pishchevye vzaimootnosheniia ryb Kaspiikogo moria. (Feeding and food
1952 relationships in fishes of Caspian Sea) (Ru) Moskva, VNIRO, Pishchepromizdat, 268 p.

Shpet, G.I., O metodakh sravnenia produktivnosti vodnykh zhivotnykh. (On the methods of
1964 comparing productivity of water organisma) (Ru) In Biologicheski osnovy rybnogo khoziaistva na vnutr. vodoemakh Pribaltiki, Minsk, Nauka i Tekhnika, pp. 297-304

Siebold, C., Süsswasserfische von Mitteleuropa. Leipzig, W. Engelmann, 430 p.
1863

Stammer, J., Beiträge zur Morphologie, Biologie und Bekämpfung der Karpfenläuse. Z.ParasitKde.,
1959 19(2):135-208

Stangenberg, M., Participation in catch and growth of the economically most important fish in
1950 the Charzykowo Lake. (Polish, En summary). In Jezioro Charzykowo - Prace, Instytut Badawczy Leśnictwa, Warszaw, PWRiL, pp. 217-44

Starmach, K., Fisheries and biological characteristics of rivers. (Polish, En and Ru summary).
1956 Polskie Archwm Hydrobiol., 3:304-32

Steinmann, P., Schweizerische Fischkunde. Aarau, H.R. Sauerländer Co., 222 p.
1948

Stephanidis, A., Poissons d'eau douce, nouveaux pour l'ichthyofaune de la Grèce. Acta Inst.zool.
1937 Univ.Athen., 1(9-10)

Strakhov, V.A. and L.N. Nusenbaum, Elektricheskii zagraditel dlia ryb tipa ERZU-1. (Electric fish
1959 screen - type ERZU-1) (Ru) Moskva, Izdatelstvo Zhurnala "Rybnoe Khoziaistvo", 39 p.

Sukhoivan, P.G., Opyt primenenia isskustvennykh nerestilishch v nizhnem befe Kakhovskogo gidrouzla.
1959 (An experiment with artificial spawning grounds below the Kakhovsk hydroelectric station) (Ru) Ryb.Khoz., 3:28-31

Sukhoverkhov, F.M., Rybovodstvo v poimennykh ozerakh. (Fish culture in ox-bow lakes) (Ru)
1948 Moskva, Pishchepromizdat, 146 p.

Suvorov, E.K., Osnovy ikhtiologii. (Foundations of Ichthyology) (Ru) Moskva, Sovetskaia Nauka,
1948 579 p.

Svärdson, G., Note on spawning habits of Leuciscus erytrhophthalmus (L.), Abramis brama (L.) and
1949 Esox lucius L., Rep.Inst.Freshwat.Res.Drottningholm, 29:102-8

Sych, R., Observations on the propagation of fish in the Konfederatka "shoal" of the Vistula
1955 river. (Polish, En and Ru summary). Rocz.Nauk roln.(B), 69(4):527-46

Syrkov, P.G., Opyt raboty nerestovo-vyrostnykh khoziaistv v delte Volgi po vyrashchivaniu molodi
1953 krupnochastikhovykh ryb. (Experience of spawning-breeding farms in Volga estuary in rearing young fish) (Ru) Trudy Soveshch.ikhtiol.Kom., 1:346-53

Syrovatskaia, N.I., O tipe ikrometania doskogo leshcha. (On the spawning type of Don-river
1949 bream) (Ru) Dokl.Akad.Nauk SSSR., 66(5):1001-4

Tanasiichuk, V.S., K voprosu o prichinakh kolebaniia chislennosti leshcha i vobly v severnom
1952 Kaspii. (On the question of reason for abundance fluctuations of bream and Caspian roach in the northern Caspian Sea) (Ru) Trudy vses.nauchno-issled.Inst.morsk.ryb.Khoz. Okeanogr., 21:195-212

__________, Leshch severnogo Kaspia. (The bream of northern Caspian Sea) (Ru) Trudy kasp.
1959 nauchno-issled.Inst.morsk.ryb.Khoz.Okeanogr., 15:3-38

Tesch, F.W., Das Wachstum des Barsches (Perca fluviatilis (L.)) in verschiedenen Gewässern.
1955 Z.Fisch., N.F., 4(5/6):321-420

Tikhii, M.I., Rezultaty akklimatizatsii ryb vo vnutrennykh vodoemakh SSSR. (Results of fish
1954 acclimatisation in inland waters of USSR) (Ru) Trudy Soveshch.ikhtiol.Kom., 3:75-83

Timofeev, I.N., Materialy po rostu azovskogo leshcha. Trudy kasp.nauchno-issled.Inst.morsk.ryb.
1964 Khoz.Okeanogr., 50:163-77

Titova, S.D., Die Parasitenfauna der Bleie im Ubinsee. (Ru, German summary). Izv.vses.nauchno-
1957 issled.Inst.ozern.rechn.ryb.Khoz., 42:166-74

Tiurin, P.V., Factor estestvennoi smertnosti u ryb i ego znachenie pri regulirovanii rybolovstva.
1962 (Natural mortality in fish and its significance in fishery regulation) (Ru) Vop. Ikhtiol., 2(3):403-27

Tsepkin, E.A., Drevniaia promyslova fauna ryb reki Amu-Darii. (Ancient commercial fishes of Amu-
1964 river) (Ru) Vop.Ikhtiol., 4(2):280-8

Van Cleve, H.J. and J.E. Lynch, The circumpolar distribution of Neoechinorhynchus rutili, an
1950 acantocephan parasite of freshwater fishes. Trans.Am.microsc.Soc., 69(2):156-71

Vashchenko, D.M., The carp as the object of pike feeding in Kakhovka water reservoir in the first
1958 year of its formation. (Ru, En summary). Zool.Zh., 37(11):1745-8

Vasilev, L.I., Nekotorye osobennosti formirovaniia promyslovoi ikhtiofauny Rybinskogo vodokhrani-
1956 lishcha za period 1941-1952. (Commercial ichthyofauna formation in Rybinsk reservoir) Trudy biol.Sta.Borok, 2:143-65

Vasnetsov, V.V., Versuch einer vergleichenden Erforschung des Wachstums der Cypriniden. (Ru,
1934 German summary). Zool.Zh., 13(3):540;83

__________, (Ed.), Morfologicheskie osobennosti opredeliaiushche pitanie leshcha, vobly i
1948 sazana na vsekh etapakh razvitia. (Morphological characters determining the feeding of bream, Caspian roach and carp at all development stages) (Ru) Moskva - Leningrad, Izdat.Akademii Nauk SSSR, 262 p.

Vasnetsov, V.V., *et al.*, Etapy razvitia promyslovykh poluprokhodnykh ryb Volgi i Dona - leshcha,
1957 sazana, vobly, taranii i sudaka. (Development stages of commercial semimigratory fishes of Volga and Don rivers) (Ru) Trudy Inst.Morf.Zhivot., 16:7-74

Velikokhatko, F.D., Materialy k poznaniu leshcha iz Dnepra. (Materials on bream of Dnepr
1947 river) (Ru) Zool.Zh., 20(1):101-17

Vernidub, M.F., Novyi sposob obeskleivania ikry leshcha. (A new method of making bream eggs
1953 not sticky) (Ru) Ryb.Khoz., 1953(9):32-3

Vinberg, G.G., Intensivnost obmena i pishchevye potrebnosti ryb. Minsk, Izdat. Belgosuniversi-
1956 teta, 251 p.

Vladimirov, V.I., Lichinochnye kriticheski periody razvitia i smertnost u ryb. (Critical
1964 periods of larval development and mortality in fish) (Ru) Vop.Ikhtiol., 4(1):104-17

Vojtek, J., Beitrag zur Kenntnis der Helmintenfauna der Fische. (Czech, German summary).
1959 Publ.Fac.Sci., Univ.Brne, (407):437-465

Vojtkova, L., Beitrag zur Kenntnis der Fischparasiten in den Flüssen Svitava und Svratka.
1959 Spisy přir.Fak.Univ.Brne, (401):97-123

Volgin, L.V. and N.V. Vertinin, Pitanie Ubinskogo leshcha *Abramis brama* (L.). (Feeding of
1964 Ubinsk bream) (Ru) Vop.Ikhtiol., 4(4):708-15

Volodin, V.M., Influence of temperature and dissolved CO_2 on embryonic development of *Abramis*
1960 *brama*. (Ru, En summary). Biull.Inst.Biol.Vodokhran., 7:31

Waluga, D., Enzootion of focal colliquative necrosis in *Abramis brama* (L.). Acta Hydrobiol.,
1962 Kraków, 4(1):29-39

__________, Phenol effects on the anatomo-histopathological changes in bream (*Abramis brama*
1966 (L.)). Acta Hydrobiol., Kraków, 8(1):55-78

__________, Phenol induced changes in the peripheral blood of bream (Abramis brama (L.)).
1966a Acta Hydrobiol., Kraków, 8(2):87-95

Wegener, G., Die Ektoparasiten der Fische Ostpreussens. Schr.phys.-ökon.Ges.Königsb.,
1909 (50):195-286

Wierzbicka, J., The occurrence of *Assymphylodora imitans* (Mühling 1898) in Vistula. (Polish,
1964 En summary). Wiad.parazyt., 10(4-5):525-6

Willer, A., Beiträge zur Kenntnis der Bandwurmseuche (Ligulosis) der Brachsen oder Bleie
1912 (*Abramis brama* L.). Z.Fisch., 16(1):98-149

Wunder, W., Physiologie der Süsswasserfische Mitteleuropas. Handb.Binnenfisch.Mitteleurop.,
1936 2b:340 p.

Wundsch, H.H., Das Wachstum des Bleies (*Abramis brama* (L.)) in den Seen der Oberspree und Dahme.
1939 Z.Fisch., 37(4):555-612

__________, Grundlagen der Fischwirtschaft der Gross-Staubecken. Abh.Fisch.Hilfswiss.,
1949 Lief.1:17-186

Zakharova, L.K., Materialy po biologii razmnozhenia ryb Rybinskogo vodokhranilishcha.
1955 (Materials on the biology of fish reproduction in Rybinsk reservoir) (Ru) Trudy biol. Sta.Borok, 2:200-66

Zawisza, J., The growth rate of bream, barbel, *Vimba vimba* and white-bream in the middle reaches
1951 of the Vistula near Warsaw. (Polish, En and Ru summary). Rocz.Nauk roln., 57:237-71

__________, The growth of fish in lake Tajty. (Polish, En and Ru summary). Rocz.Nauk roln.(D),
1953 67:221-55

___________, The growth of fish in lakes of Węgorzewo district. (Polish, En and Ru summary).
1961 Rocz.Nauk roln.(B), 77(2):681-748

___________, Wytyczne zagospodarowania jezior w których stwierdzono silne zarazenie leszcza tasiemcem Ligula. Olsztyn (Inland Fish. Institute), (MS)

Zemskaia, K.A., Rost i polovoe sozrevanie severokaspiiskogo leshcha v sviazi s izmeneniem ego
1958 chislennosti. (Growth and maturation in northern Caspian bream in connection with changes in its abundance) (Ru) Trudy vses.nauchno-issled.Inst.morsk.ryb.Khoz.Okeanogr., 34:63-86

___________, O vliianii nagula i chislennosti proizvoditelei na velichinu potomstva kaspiiskogo
1961 leshcha. (On the effect of feeding and abundance of spawners upon the year class strength of Caspian bream) (Ru) Trudy Soveshch.ikhtiol.Kom., 13:307-13

Zheltenkova, M.V., Metodika izuchenia obespechennosti ryb pishchei v sviazi s problemoi ikh
1964 chislennosti. (Ru) Trudy vses.nauchno-issled.Inst.morsk.ryb.Khoz.Okeanogr., 50:89-108

Zhiteneva, T.S., Ueber die Ernährung des Brachsen in der Uglitsch in Ivankovo Stauseen. (Ru,
1958 German summary). Biull.Inst.Biol.Vodokhran., 2:31-2

___________, Nutrition of Abramis brama in Gorky reservoir. (Ru, En summary). Trudy Inst.
1960 Biol.Vodokhran., 3(6):170-5

Zhukov, P.I., Ryby basseina Nemana. Minsk,Izdat.Ak.Nauk Beloruskoi SSR, 191 p.
1958

Ziemiankovski, W.B. and E. Cristea, Beobachtungen zur Ernährungsdynamik der Fische während des
1961 Winters. Z.Fisch.,N.F., 10:(4/5):275-98

Zitnan, R., Vorkommen, Wirte, Lokalisierung und Invasionsextensität der Metazerkarien Metagonismus
1960 yokogawai (Katsurada 1912) bei Fischen in den Gewässern slovakischer Flüsse. Helminthologia, 2(3-4):295-306

Zukowski, Cz., Investigations on bream from Szczecin Firth and Pommeranian Bay in 1953-1955.
1962 (Polish, En and Ru summary). Pr.morsk.Inst.ryb.Gdyni, 11A:443-62

SYNOPSES OF FISHERIES BIOLOGICAL DATA

This is one of a series of documents issued by FAO, CSIRO and USFWS concerning species and stocks of aquatic organisms of present or potential economic interest. The primary purpose of the series is to make existing information readily available to fishery scientists according to a standard pattern, and by so doing also to draw attention to gaps in knowledge. It is hoped that synopses in the series will be useful to other scientists initiating investigations of the species concerned or of related ones, as a means of exchange of knowledge among those already working on the species, and as the basis for comparative study of fisheries resources. They will be brought up to date from time to time as further information becomes available either as revisions of the entire document or their specific chapters.

The relevant series of documents are:

FAO	**Fisheries Synopsis No.**	FR/S
	(replacing, as from 1.1.63 FAO Fisheries Biology Synopsis) and	FB/S
CSIRO	**Fisheries Synopsis No.**	DFO/S

Synopses in these series are compiled according to a standard outline described in FIb/S1 Rev. 1 (1965).

FAO, CSIRO and USFWS are working to secure the co-operation of other organizations and of individual scientists in drafting synopses on species about which they have knowledge, and welcome offers of help in this task. Additions and corrections to synopses already issued will also be most welcome. Comments including suggestions for the expansion of the outline and requests for information should be addressed to the co-ordinator of this work and editor of the FAO series:

A. Ben-Tuvia
Fishery Resources and Exploitation Division
Marine Biology and Environment Branch
Food and Agriculture Organization
of the United Nations
Via delle Terme di Caracalla
00100 Rome, Italy

Consolidated lists of species or groups covered by synopses issued to date or in preparation will be issued from time to time. Requests for copies of synopses should be addressed to the issuing organization.

The following synopses in this series have been issued since January 1966:

SSR/F526 (FR/S86)	Synopsis on the biology of the jack mackerel *(Trachurus trachurus)*. (Published as U.S. Fish and Wildlife Service Special Scientific Report - Fisheries No. 526)	April 1966
FRi/S30	Synopsis of biological data on the pike *Esox lucius* (Linnaeus) 1758. Provisional version	April 1966
FR/S31.1	Synopsis of biological data on common carp *Cyprinus carpio* (Linnaeus) 1758 (Asia and the Far East). Provisional version	May 1966
FR/S31.2	Synopsis of biological data on common carp *Cyprinus carpio* (Linnaeus) 1758 (Near East and Europe). Provisional version	May 1966
FR/S32	Synopsis of biological data on catla *Catla catla* (Hamilton) 1822. Provisional version	May 1966
FRm/S34	Synopsis of biological data on the blue whiting *Micromesistius poutassou* (Risso) 1810. Provisional version	September 1966
FRm/S35	Synopsis of biological data on the West African croakers *Pseudotolithus typus, P. senegalensis* and *P. elongatus*	October 1966
FRm/S33 Rev. 1	Synopsis of biological data on the Norway pout *Trisopterus esmarkii* (Nilsson) 1855	January 1968
FRi/S36	Synopsis of biological data on the bream *Abramis brama* (L.)	February 1968

MI/69608/4.68/E/1/750