Review of environmental impact assessment and monitoring in aquaculture in Europe and North America

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ABSTRACT

Environmental impact assessment (EIA) methods and practice, monitoring procedures and legislation were reviewed for aquaculture in Europe and North America. Compilation of this review has allowed comments on both the effectiveness and suggestions for improvements to be given. All freshwater and marine species, other than marine salmon culture, are considered within this review, including where possible invertebrates and fish species grown in the Europe and North America. Countries with considerable quantities of aquaculture production have been highlighted; Canada, Czech Republic, France, Greece, Hungary, Italy, the Netherlands, Poland, Spain, Turkey, the United Kingdom (UK) and the United States of America (USA). In some of these countries the implementation of the EIA process is more refined and important in terms of aquaculture development than others.

Despite the commonality of EU Directives, the review highlights that within the EU the mechanisms for EIA and monitoring of environmental impact as a statutory regulatory requirement are extremely inconsistent, ranging from a very precise or prescriptive EIA and monitoring requirement to no requirement at all. EIA implementation often depends on complicated and bureaucratic processes within individual countries, rather than implementation of a system which regulates the development of aquaculture effectively or allowing development of a common policy through effective implementation of EU Directives.

In North America, the requirements and practice for the EIA and environmental monitoring process are different and often multi-layered, with conflicts arising between local, regional, state and federal legislation. Which legislation takes precedence varies with location and type of aquaculture development. Adherence to codes of conduct and best practice developed between the industry and authorities are often considered as important as statutory regulation.

Though the level of activity varies between locality, country and region, implementation of the EIA and environmental monitoring process in aquaculture is seen as expensive and, to some extent, unnecessary in its present complicated form. The process, in general, would benefit by targeting the information required to manage impacts and estimate

capacities rather than to follow a defined procedure on a "one size fits all" basis. This targeted information may vary with cultured species, location and type of development. In addition, the contribution of information from environmental monitoring should also be optimized to be more appropriate.

In general, the EIA process for aquaculture developments is poorly implemented, with little transparency or focus. In particular, there is still much work to do to improve its use and implementation in farm-level, sectoral and environmental management. Clearly, better cooperation between regulatory bodies and aquaculture management has lead to more efficient, workable and less bureaucratic forms of environmental regulation and codes of practice being developed in some countries. In turn, this has lead to more successful and sustainable aquaculture developments.

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Acronyms and abbreviations

General

ASMO	Environmental Assessment and Monitoring Committee
ASP	Amnesic shellfish poisoning
BAP	Best aquaculture practices
BOD	Biological oxygen demand
BMP	Best management practice
CIHEAM	International Centre for Advanced Mediterranean Agronomic Studies
CCRF	Code of Conduct for Responsible Fisheries
CoP	Codes of Practice
CoC	Codes of Conduct
CPP	Consultation and Public Participation
DSP	Diarrhetic shellfish poisoning
DSS	Decision Support Systems
EEC	European economic community
EEZ	Exclusive economic zone
EFF	European Fisheries Fund
EIA	Environmental impact assessment
EIS	Environmental impact statement
EMPA	European Mollusc Producers Association
EQS	Environmental Quality Standards
ES	Environmental statement
FAO	Food and Agriculture Organization of the United Nations
FCR	Feed Conversion Ratio
FEAP	Federation of European Aquaculture Producers
FIFG	Financial Instrument for Fisheries Guidance
GIS	Geographic Information System
HDPE	High-density polyethylene
HELCOM	Helsinki Commission (marine conservation of the Baltic Sea)
IAIA	International Association for Impact Assessment
ICES	International Council for the Exploration of the Sea
ICZM	Integrated coastal zone management
MPA	Marine protected area
MRL	Maximum Residue Level
NALO	National Aquaculture Legislation Overview
NASO	National Aquaculture Sector Overview
NGO	Non-governmental Organization
NSP	Neurotoxic shellfish poisoning
OECD	Organisation for Economic Co-operation and Development
OSPAR	Oslo and Paris Conventions (marine conservation)
PARCOM	Paris Commission (reduction of toxic chemicals)
PCB	Polychlorinated biphenyls
PEC	Predicted environmental concentration
PNEC	Predictable no effect concentration
POM	Particulate organic matter

PROFET	EU sixth Framework Fisheries and aquaculture research dissemination initiative
PSP	Paralytic shellfish poisoning
RID	Riverine inputs and direct discharges
SEA	Strategic Environmental Assessment
SIA	Social Impact Assessment
SME	Small and medium enterprise
SPM	Suspended particulate matter
TP	Total phosphorus
TSS	Total suspended solids
TECAM	Technology of Aquaculture in the Mediterranean Network
UNEP	United Nations Environment Programme
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United States of America
VIA	Visual impact assessment
WWF	World Wild Fund for Native

France

AMM	Market Licence (Autorisation de mise sur le marché)
DSV	Department of Veterinary Services
INRA	Institut national de la recherche agronomique
REMI	Microbiological Network
REPHY	Phytoplankton Network
RNO	National Observation Network

Greece

AD	Administrative Directives
FGM	Federation of Greek Maricultures

Italy

API	Italian Fish Farming Association

Netherlands

RIVO	Netherlands Institute for Fishery Research

Poland

MARD	Ministry of Agriculture and Rural Development

Spain

APROMAR	Association of Marine Aquaculture Producers

Turkey

DSI	General Directorate of State Hydraulic Works
GDAPD	Directorate of Agricultural Production and Development
GDAR	General Directorate of Agricultural Research
GDOS	General Directorate of Organization and Support
GDPC	General Directorate of Protection and Control
MARA	Ministry of Agriculture and Rural Affairs
SPA	Special Protection Areas

United Kingdom

AZE	Allowable Zone of Effect
BTA	British Trout Association
CAR	Controlled Activities Regulation
CE	Crown Estate
CEFAS	Centre for Environment Fisheries and Aquaculture Science (England, Wales and Northern Ireland)
COPA	Control of Pollution Act
DARD	Department of Agriculture and Rural Development for Northern Ireland
DEFRA	Department for Environment, Food and Rural Affairs
DEPC	Department for Environment, Planning and Countryside (Wales)
DSFB	District Salmon Fishery Boards
EA	Environment Agency
EHS	Northern Ireland the Environment and Heritage Service
EN	English Nature
FRS	Fishery Research Services (Scotland)
LPA	Local Planning Authority
PPC	Prevention of Pollution and Control
SAMS	Scottish Association for Marine Science
SARF	Scottish Aquaculture Research Forum
SEAFISH	Seafish Industry Authority
SEERAD	Scottish Executive Environment and Rural Affairs Department
SEPA	Scottish Environment Protection Agency
SNH	Scottish Natural Heritage
VMD	Veterinary Medicines Directorate
VPC	Veterinary Products Committee
WFD	Water Framework Directive

Canada

AAA	Aboriginal Aquaculture Association
ACES	Aboriginal Certification of Environmental Sustainability
BC	British Colombia
CDC	Conservation Data Centres
CEAA	Canadian Environmental Assessment Act
CEPA	Canadian Environmental Protection Act
CFIA	Canadian Food Inspection Agency
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSSP	Canadian Shellfish Sanitation Program
CWS	Canadian Wildlife Service
DFA	Nova Scotia Department of Fisheries and Aquaculture
DFO	Federal Department of Fisheries and Oceans Canada
EMP	Environmental Monitoring Program
EQD	Environmental Quality Definition
FEAI	Federal Environmental Assessment Index
NWPA	Navigable Waters Protection Act
RA	Responsible Authority
VEC	Valued Ecosystem Components

United States of America

CAAP	Concentrated Aquatic Animal Production Programme
ELG	Effluent Limitations Guidelines
EPA	United States Environmental Protection Agency

FDA	Food and Drug Administration
FWS	United States Fish and Wildlife Service
INADS	Investigational New Animal Drug Exemptions
FSA	Federal Joint Subcommittee on Aquaculture
HACCP	Hazard Analysis and Critical Control Points
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PEIR	Project Environmental Impact Report
USEPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture

Summary

This review concentrates on the environmental impact assessment and environmental monitoring as well as environmental regulation methods in aquaculture in Europe and North American countries. It gives special consideration to four areas related to Environmental Impact Assessment (EIA) and monitoring in aquaculture: (1) the requirements, (2) the practice, (3) the effectiveness and (4) suggestions for improvements.

The requirements and practice for EIA and environmental monitoring are reviewed specifically for Canada, Czech Republic, France, Greece, Hungary, Italy, the Netherlands, Poland, Spain, Turkey, the United Kingdom (UK) and the United States of America (USA). The EIA and regulatory practice referred to will cover the species: Atlantic cod, turbot, Atlantic halibut, carps, seabass, seabream, tilapia, barramundi, blue mussels, scallops, oysters, abalone, freshwater salmonids, channel catfish, eel, sturgeon and seaweeds. Some of these may be considered as a group as environmental assessment practice is often consistent between species.

The review shows that despite common legislation in the European Union (EU) for implementation of the EIA process for impacts on aquatic systems, execution of this legislation within different EU countries is inconsistent and often is dependent on existing and sometimes highly bureaucratic frameworks. In some countries there is no specific requirement for an EIA process for aquaculture development. For North America, particularly within the United States of America, environmental regulatory legislation is different and often conflicting depending on whether it is considered under federal, state, or county regulation requirements; which of these takes precedent is often dependant on the locality of the aquaculture facility.

It is clear from the review of the legislative frameworks for environmental assessment that the collection of monitoring data is expensive and hence it needs to be targeted at the information necessary to manage the impacts that are deemed significant as part of the EIA. Such aspects should be identified as early as practicable within the EIA process, to optimize the contribution of monitoring data to the EIA implementation and follow up. Monitoring involves designing an appropriate survey, collecting, analyzing and reporting the data and establishing a link to improve impact management.

In general it has been found that the closer the links between the regulatory system and actual practice at fish farms, the fewer objections, difficulties and misunderstandings occur. In many locations throughout Europe for example there appears to be an unnecessary and high level of bureaucratic involvement in the development of aquaculture activity. There is poor transparency in the implementation of EIA legislation as it relates to aquaculture, and differential treatment of aquaculture sectors, which may be an impediment to aquaculture development. For example in Greece, the Netherlands and Italy, the introduction of a central "aquaculture policy" could greatly assist the development of the industry in relation to other uses of the coastal zone.

Various suggestions are made to increase the quality and effectiveness of EIA reports and therefore enhance the number and extent of environmentally beneficial modifications to aquaculture projects, including: investigating alternatives, improvement of the screening process, adopt formal scoping requirements to encourage early recognition of the need for modifications, carry out formal checks on the quality of EIA reports, strengthen wider consultation and public participation, research into various aspects of the EIA process to meet particular national and local circumstances.

Environmental monitoring methods throughout the two regions studied mostly collect data for comparisons to Environmental Quality Standards (EQSs) which have been set at a threshold where significant environmental impact occurs. New methods of combining key, but easy to measure, environmental parameters to give an overall simplified index have been developed. This is a good approach and should be investigated further. It has the advantage of simplicity, reduced requirements for sampling, reduced potential for error, ease of sampling, reduction of costs of sampling and greater potential for effective comparison between studies and monitoring programmes. However, caution should be used in implementing such indices as they give little information that can be used for comparative research to further existing knowledge of the impacts of aquaculture on the ecosystem. Therefore, distinction should clearly be made between collection of data for environmental regulation (comparison with EQSs) and collection for scientific research into the impacts of aquaculture on the ecosystem, from which the indices can be developed.

Introduction

Over the last 40 years aquaculture production and the diversity of species used under culture conditions has expanded rapidly throughout the world. Inland aquaculture is dominated by either pond culture or tank-based culture of fish species. Marine aquaculture is more varied in nature, encompassing fish, shellfish and algal species. Within the context of this review the development of intensive aquaculture within inland freshwater and marine systems of Europe and North America is showing considerable growth (FAO, 2006; Olin, 2006; Rana, 2007; Subasinghe *et al.*, 2000).

Congruent with this increase in development has been an associated increase in the environmental regulatory framework and assessment procedures used to control the activity. Pre-development assessment of potential aquaculture impacts (through Environmental Impact Assessment) and post-development assessment of actual impacts (through monitoring) have increased in prominence. These controls vary across nations and even within nations. In many countries, relatively well-defined control encompasses procedural as well as defined environmental quality standards and in others the regulatory framework is less well defined. This is reflected in this review by the variable content within the country-specific evaluations.

The principles of EIA and monitoring developed out of an increasing understanding that all development activity required some assessment of the likely impact of that development. Such regulations and procedures were initially developed, in the early 1960s, out of a need to enforce large-scale projects (e.g. power stations, construction) to take account of environmental considerations (Institute of Developing Economies, 1994). Only subsequently have EIA and monitoring filtered through to smaller scale projects, including aquaculture. In the context of aquaculture, some of the countries in this review have specifically related laws and regulations to EIA and monitoring for aquaculture, but others have no specifically dedicated outcomes to aquaculture production, with more general regulation concerning EIA and monitoring prevailing. This too is reflected in the country-specific evaluations.

This review concentrates on the Environmental Impact Assessment (EIA) and environmental regulation methods defined for freshwater salmonid production and for other non-salmonid species as grown in Europe and North American countries. The review will address the complexity and effectiveness of the EIA and monitoring processes in environmental regulation of aquaculture. The review will take form of an assessment of:

1. the regulatory requirements as they are defined and used to assess the environmental impact of aquaculture;
2. the practical application of EIA and monitoring requirements;
3. the effectiveness of the application of the EIA and monitoring requirements;
4. the provision of suggestions for improvements in the application of EIA and monitoring requirements.

The requirements for environmental impact assessment and environmental monitoring are generally built within regional and national legislation, rather than having a standard format across all areas. Even within the EIA process, which has common principles, the implementation of the principles on aquaculture development tends to be specific through its implementation within regional and local legislation. As a result it is necessary to conduct the majority of the review on a country-by-country basis.

This review focused on a selected number of countries in Europe and North America, including the Czech Republic, France, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Spain, Turkey and the United Kingdom in Europe; and Canada and the United States of America in North America.

The review will encompass non-salmonid species including Atlantic cod, turbot, Atlantic halibut, carps, eels, seabass, seabream, tilapia, barramundi, blue mussels, scallops, oysters, abalone and seaweeds. Salmonids (trout, arctic charr and salmon) grown in freshwater are also included. Marine-based salmon culture has been identified as a special case because of the scale of production, particularly in northern Europe and North and South America, and the review of EIA and monitoring in salmon aquaculture has been covered by Wilson *et al.* (this volume).

Most of the marine and freshwater species in this review are not necessarily separated under legislation and are therefore grouped in their country-specific review. As a general rule environmental impact assessment and standard monitoring methodologies are often consistent between species and this is reflected in the layout presented here.

In establishing that both environmental impact assessment and monitoring, as it relates to aquaculture, will be the primary focus of this review, it is worth at this early stage defining what these mean in some detail.

ENVIRONMENTAL IMPACT ASSESSMENT

Environmental Impact Assessment (EIA) can be defined as “a process for identifying the likely consequences for the biophysical environment and for man’s health and welfare of implementing particular activities, and conveying this information, at a stage when it can materially affect their decision, to those responsible for sanctioning the proposals” (Munn, 1979).

This remains a broad definition and does not encapsulate more recent discrete and related disciplines, such as visual impact assessment (VIA) and social impact assessment (SIA). This is important as the EU Directive on EIA (EU Directive 85/337; amended as EU Directive 97/11; European Commission, 1985; 1997) specifically includes an assessment of the impacts on these aspects. The IAIA (1999) define Environmental Impact Assessment as “The process of identifying, predicting, evaluating and mitigating the biophysical, social and other relevant effects of development proposals prior to major decisions being taken and commitments made” and perhaps more readily covers the impact process. Importantly it is not an abstract “procedure” to be followed, more a process that establishes the potential environmental (and visual and social) implications of a particular development, in this case aquaculture. What the EIA process cannot define is the specific procedures that should take place to achieve the assessment and this may lead to variations in how the process is interpreted.

This process often results in a documented submission that takes account of both statutory and non-statutory requirements. Although not exhaustive the statutory requirements include those covered under legislative and regulatory processes and procedures (at a governmental level); whilst non-statutory requirements are those mandated through voluntary instruments such as codes of practice, best practice guidelines and certification schemes, where these exist (at stakeholder level). The documented submission, referred to as an environmental impact statement (EIS), therefore encapsulates the relevant effects of development activity. Consideration of best management practices (BMPs), such as consideration of multiple alternative sites (Steinmann, 2001), outlining monitoring and management plans (if not a requirement of local legislation) and the use of reliable predictive models (Glasson *et al*., 1999) as quality indicators, are also included within the EIS. All environmental *risks* are considered and normally a *risk matrix* would be constructed to summarize the risks of all related processes and practices, mitigation measures and even monitoring plans associated with that risk.

This EIS is passed onto appropriate decision-makers who, in consultation with both statutory and non-statutory participants, will judge the impacts, effects and mitigations measures and either approve, approve with conditions or not approve the development.

As a concept the process of environmental impact assessment (EIA) came about in the United States of America in 1970, implemented under the United States National Environmental Policy Act (NEPA, 1969). Prior to this it existed only in rudimentary form. Multilateral organizations have also adopted many of the principles of EIA, including, for example, the Organization of Economic Cooperation and Development (OECD), which adopted recommendations concerning EIA within its constituent states in 1974. Since then many other countries have implemented their own EIA procedures, including Canada (1973), Australia (1974), the Netherlands (1981), Japan (1984) and the European Community (1985). This list is far from exhaustive but the combination of these implementations means the system of environmental assessment has now been adopted by more than 100 countries throughout the world. For further reference, UNEP has produced a training resource manual on EIA (Sadler and McCabe, 2002).

In this review both generally applicable and aquaculture specific environmental impact assessment processes will be reviewed.

MONITORING

The process of environmental impact assessment defines the relevant likely effects of development activity but an important strand, post-development, is the requirement for post-authorization monitoring. Monitoring, however, refers to the conduct of procedures to assess the state of the system. Generally this often means it is limited as an assessment of the environment.

It is used to evaluate changes to the system and in this context monitoring can be used to evaluate the changes against a measured pre-development state. This might manifest itself as an assessment of the sediment characteristic before an aquaculture facility is located and again after it has been in operation for some pre-determined time. More often, however, monitoring of aquaculture is used to assess state against some pre-determined quality standards that are regarded as needing to be maintained.

Environmental monitoring is key to the implementation and follow-up of an EIA, as other components of the EIA process are dependent on the scope and type of monitoring information that is provided. The primary aim of monitoring is to provide information that will aid impact management; to help achieve a better understanding of cause-effect relationships and to improve EIA impact prediction and mitigation methods. Environmental monitoring is used to (after Telfer and Beveridge, 2001);

- establish baseline conditions (a critical reference point);
- measure the impacts that occur during project construction and operation;
- check compliance with agreed conditions and standards;
- verify the accuracy of impact predictions and determine the effectiveness of mitigation measures.

The practice, methods and procedures for monitoring in the various countries under consideration is, in itself, an onerous task and the detailed elements of this are not dwelt on during this review. Regulations and monitoring requirements used in marine aquaculture throughout Europe were reviewed and compared in 1999 by the MARAQUA project (Fernandes *et al*., 2000). Across the countries under consideration there will be material differences in the type and number of samples required to assess benthic impacts in sea cages, for example, while such data may not be relevant at all for production in ponds and raceways. Similarly chemical parameters may be of less importance in marine systems because of its large buffering capacity, but are highly important in pond and raceway culture, where water exchange is limited. Consideration of methods and procedures are further complicated by amongst others:

- the monitoring infrastructure available and by the skills and training of environmental and other specialists;
- the variation between farms, which depends on the particular provisions applied to the consent to operate any particular farm, which in themselves stem from the evaluation of the site-specific environmental impact assessment;
- the variation in monitoring requirements depending on the size of the farm operation;
- the variation in monitoring requirements depending on whether one is considering freshwater or marine systems;
- the variation in culture practice between species, which causes variations in specific requirements. For example, the type of chemicals permitted for treatment of disease;
- the relative differences in composition of and therefore the assessment of impacts between differing feed types used to culture the various species.

It was not therefore feasible to evaluate specific monitoring practices to this level of detail, although during the review, where specific information sources are available, these are referred to. It is nonetheless important to consider that the monitoring of aquaculture is a necessity to ensure environmentally sustainable practices. It encompasses the formal measurement of the effects of operations on the environment and of vital importance, is the need to subsequently alter practices to reduce impacts where these are observed.

STRATEGIC ENVIRONMENTAL ASSESSMENT

Strategic environmental assessment (SEA) is a relatively new concept and aims to fill the gap between single project developments and cumulative affects resulting from large, complicated or multiple development activity (European Commission, 2001). In Europe SEA was enacted through Directive 2001/42/EC (European Commission, 2001) and legislated into community country law during 2001. At present it relates specifically to planning related issues, such a regional and local plans and development plans and in this context confers specific requirements of national and local governments to consider the environmental implication, alternatives and measurable targets related to large and complicated infrastructure developments. SEA is not yet a requirement for aquaculture development.

Although not exclusively so, the EIA process generally considers the implications of specific development activity. For aquaculture, SEA may be used at a strategic level to evaluate, for example, the cumulative or multiplicative effects of development of a few aquaculture sites in a single waterbody or in a single area. In this context there is potentially a multiplication of effects that may not be evaluated fully by individual EIAs. As far as is known such a strategy does not apply to aquaculture at present, though in future SEA is likely to become an increasingly used process to evaluate environmental effects.

Requirements and practices

The assessment of the pre- and post- development impact at an aquaculture production site will:

- incorporate the need to comply with legislative requirements;
- incorporate the need to comply with regulatory controls, where these exist;
- encompass standard monitoring methods but that are adapted for the particular development and its likely impact;
- have to take account of non-statutory requirements mandated through voluntary instruments such as codes of practice, best practice guidelines and certification schemes, where these exist.

The degree to which these are incorporated will depend on country-specific implementation strategy. In this section the country evaluation is limited to the legislative requirements for the EIA process and the implementation of monitoring processes but also encapsulates the non-statutory requirements as mandated through voluntary instruments such as codes of practice, best practice guidelines and certification schemes, where these exist. It is therefore an assessment of both requirements and practice.

INTRODUCTION – EUROPE

In most European countries there are two requirements that are enshrined in environmental legislation, applicable equally to EU member states and accession countries. They are (a) the EIA process as part of the initial planning/development application for an aquaculture system, and (b) statutory monitoring of the environment to assess impacts that may occur. Environmental impact assessment requirements for developments encompass the implementation of processes and procedures enshrined within regional, national and local legislation. Although these will specify whether or not aquaculture development is included within the legislation, these higher level guiding rules are not specifically defined for aquaculture development. An example of this is the EU Directive on Environmental Impact Assessment (EU Directive 85/337; amended as EU Directive 97/11), introduced in 1985 (European Commission, 1997; 1985). It identifies aquaculture as a Schedule 2 controlled activity, which means aquaculture development comes under the legislation and an aquaculture development will need to be evaluated to determine whether an EIA will be required or not. But the legislation itself is not aquaculture specific. The EIA Directive also defines a format for an EIA and the minimum information it should contain. This is given in Annex 1.

There is a variable implementation of the EIA Directive requirements into country legislation. The EIA Directive was fully implemented in all countries in 2002, despite being enacted under European legislation as early as 1985. Often this was done through variable pieces of legislation, in some countries specifically referring to aquaculture and in others not. The European legislation was enacted in the UK, not through one corresponding piece of legislation but through a series of laws covering a range of activities. One of these included a specific form of aquaculture production, through the Environmental Impact Assessment (Fish Farming in Marine Waters) Regulations 1999, which covers fish production (HMSO, 1999). This sets down the criteria at which an EIA would be necessary for finfish production in marine waters. The legislation does not cover inland waters, or other forms of aquaculture production, which rely instead on the more general EIA requirements. There is also other non-EIA legislation which continues to play their part in managing these other aquaculture elements. Thus whilst not all aquaculture is covered by the EIA legislation there is still a degree of control.

Whilst trigger points for the EIA process to be enacted for aquaculture development are identified in the 1999 UK act, such as maximum farm size where the requirement does not apply, it does not lay down the criteria on how impacts are to be measured and evaluated. Although criteria may not be explicitly identified within particular countries EIA legislation, it is not unreasonable to assume that the environmental impact of a cage site for finfish growth, for example, would require an evaluation of likely impacts on local water and sediment quality as part of the EIA process. Thus, even where precise requirements are not laid down, the need to investigate can trigger the implementation of standard collection and processing requirements, useful to the EIA and monitoring requirements.

The broad regulatory framework (e.g. EU EIA Directive 97/11/EEC) is translated into countries legislation in a more or less general format, as identified above. In addition, countries may manage aquaculture development through a series of policy-driven documents that aquaculture companies are expected to comply with. In general, policy-driven assessment requirements are developed through the various ministries and government departments who are responsible for aquaculture and thus have sufficient weight without the need to enshrine it in law. Whilst in most cases the onus is on the applicant to provide appropriate data (e.g. France, Spain and UK), often the onus would appear to be on the government institutions to carry out the monitoring requirements directly (as would appear to be the case in Poland and the Czech Republic, for example). Thus these policy documents and procedures form another entwined layer in the process of impact assessment of aquaculture and cannot often be materially separated from higher-level enactments.

The next level of administrative infrastructure will often be the more detailed methods. These identify the procedures that need to be followed in order to comply with both the legislation and need for information on which to base a decision. These are not policies or legislative requirements, but procedural documents that provide the methodological approaches, data processing and analysis requirements necessary. One example of this is Scotland. Government agencies have provided very detailed handbooks on all aspects of marine finfish aquaculture, its management, consent and control, and to a lesser extent, also on related aspects of freshwater aquaculture. Much of this information is not law, but nonetheless provides the basis for the day-to-day management of the industry. This is often very detailed, down to what and how many sediment samples should be collected, processed and numerically analysed. At the other extreme, aquaculture specific EIA regulation in some other countries is not readily available. Coincident with this, it was also difficult to establish the practical methods and procedures used for both the EIA evaluation and subsequent monitoring requirements. Many of the countries in this review fit between these two extremes.

The disjointedness identified above is reflected in the following country-specific reviews. It has proved difficult to uncouple the legislative requirements at the higher level (e.g. EIA legislation) with those related to aquaculture specifically and those of the practices that are required to achieve those EIA and monitoring requirements. For this reason this section of the review couples two of the elements required of this review, that of establishing the *requirements* and the *practices*.

Beyond government department legislative and policy requirements there are also so-called "soft-law" elements governing aquaculture development. These include non-statutory requirements as mandated through voluntary instruments such as codes of practice, best practice guidelines and certification schemes.

Specific non-statutory components will be reviewed on a country-by-country basis. There is, however, a need to review non-statutory organizations and review code definitions. At a world level the FAO present a Code of Conduct for Responsible Fisheries

(CCRF) (FAO, 1995). Article 1 of this document outlines the scope, identifying that "The Code provides principles and standards applicable to the conservation management and development of all fisheries". In particular, aquaculture development is referred to under Article 9.

In Europe the two key aquaculture organizations representing the production sector are the Federation of European Aquaculture Producers (FEAP) and the European Mollusc Producers Association (EMPA)[1]. These organizations are themselves formed from country trade organizations, examples of which include the Czech Fish Farmers Association – Rybarske Sdruzeni Ceske Budejovice in the Czech Republic, the FGM – Federation of Greek Maricultures in Greece and the British Trout Association (BTA) in the UK. Both European organizations have either Codes of Practice (CoP) or Codes of Conduct (CoC), which outline in broad terms the promotion of aquaculture production in a sustainable and considerate manner (e.g. FEAP, 2000). Some, though not all affiliated organizations endorse these general principles through their own CoPs. Such CoPs tend to be more specific and detailed, often outlining how specific farm related tasks (e.g. treatment of waste, fish welfare and environmental issues) will be managed to minimize environmental, ethical and social impact. Membership by specific companies to country-based trade organizations is determined through their willingness and agreement to comply with these principles and who themselves often maintain their own operating procedures that encompass the wider trade organization requirements. Thus there is, in many countries, a continuous linkage between farm-based operations and the wider community.

Globally, other non-statutory bodies include the World Wildlife Fund (WWF) for example, who are promoting work on aquaculture certification (WWF/CCI, 2008), and who generally also certify whether specific farm procedures comply with a certification scheme (Panda mark), which buyers and consumers can then base their purchase decisions on. The Marine Stewardship Council currently does not cover aquaculture, but this remains under review for possible future certification. There are many such schemes throughout Europe and other regions, including single-issue certification schemes, process-related certification, general environmental certification schemes and eco-labelling, which are reviewed comprehensively by FAO (2005). In collaboration with a wide range of stakeholders, FAO has been promoting the development of technical guidelines on aquaculture certification (FAO, 2008). Specific country-based schemes will be identified in the following country reviews, where this can be determined.

Overall, certification schemes and eco-labelling act to provide guidelines for responsible aquaculture practice and development, either more generally or more targeted towards specific aspects of aquaculture production. Within this context they do impact the nature and content of Environmental Impact Assessment and monitoring studies, but they do not necessarily specifically impact the conduct, development and execution of Environmental Impact Assessment and monitoring *per se*.

INTRODUCTION – NORTH AMERICA

Many of the characteristics of the organization of Environmental Impact Assessment and monitoring requirements identified above hold true for North America. However, North American legislation on aquaculture and implementation of the EIA process is based specifically around individual country (United States of America and Canada in this review) and regional or state legislation. As a result they do not have the commonality of EU collective legislation or guidelines against which to act. There is thus a relative inconsistency in format and implementation. What has become apparent through this review is that the application for consent which encompasses the EIA

[1] See http://ec.europa.eu/fisheries/cfp/governance/acfa/members_en.htm

process and for example responding in the application to how a farmer will operate under a Best Management Practices scheme, tends to be synonymous. It remains unclear whether EIA is specifically required in the North American context for aquaculture developments.

Certification of aquaculture products in North America predominates through the Aquaculture Certification Council who offers certification of "processes" through application of the Global Aquaculture Alliance Best Aquaculture Practices (BAP) standards (GAA/ACC, 2008). Although process-driven there is no specific reference to EIA or to monitoring, but the latter is implicit to some extent as a result of the need to identify whether the farm operator has complied with certain environment standards. One example is for channel catfish, which lays down some broader principles concerning use of feeds and affect on environment, but also specifies some more specific parameters such as minimum water quality standards

In Canada, governmental legislative requirements concerning aquaculture and other non-statutory mandates are also supplemented to take account of the values of First Nation communities. The Aboriginal Aquaculture Association (AAA) requested a feasibility study for an Aboriginal Certification of Environmental Sustainability (ACES) programme (Cross and Brackett, 2006), which at the time of writing remains in development.

EUROPEAN EIA AND ENVIRONMENTAL MONITORING REQUIREMENTS AND PRACTICES

Czech Republic

Context

Aquaculture production in the Czech Republic is relatively small compared to other European countries, and is entirely based on freshwater systems, particularly ponds. Pond culture has a 1000-year history and many of the ponds used today have been in existence for hundreds of years (Rybarske Sdruzeni Ceske Budejovice, 2008). There are 14 species of aquatic animals cultured, including trout in raceways and ponds, native species such as tench and pike and non-native species such as catfish and sturgeon. Only carp species are produced in significant numbers accounting for 88% of the total fish produced (Globefish, 2008). Carps are nearly all produced in semi-intensive pond culture, with maize added to supplement normal feeding on plankton and invertebrates (Rybarske Sdruzeni Ceske Budejovice, 2008). Common carp has been grown increasingly since the mid 1980s and some 20 000 tonnes were produced in 2005 (FAO, 2006-2008. NASO Czech Republic). All aspects of aquaculture production (collectively called a fishery because of ponds supporting role to fisheries in general) are managed through municipal authorities of municipalities with expanded competence, regional authorities and the Ministry of Agriculture, within the framework of legal requirements.

EIA implementation

The combination of the relative longevity of pond culture production in the Czech Republic and its general lack of development in recent years means that there has been little or no implementation of the principles of Environmental Impact Assessment in the aquaculture sector. The Czech Republic introduced EIA regulations originally through its 1992 National Council Act No. 244/1992. This act made no explicit mention of pond culture, aquaculture or fisheries. This Act was replaced by Act No. 100/2001 Coll. (further amended by Act No. 93/2004 Coll.) in accordance with EU EIA legislation (Czech Republic, 2004.) Changes to the act and the corresponding development of a comprehensive set of EIA procedures resulted from a PHARE Twinning Project (Karbowski and Honova, 2004).

Within the 100/2001 Coll. Act, all activities listed under Category I will always require an EIA to be carried out. Category II activities are those that initially require a less demanding “Fact Finding Procedure” (Figure 1) that may or may not result in a full EIA. Under this context it is the government “competent authority” that carries out the assessment (Czech Republic, 2004), being required to:

“………….find out whether and to what degree the project can seriously affect the environment and the population. In this, it shall employ the following criteria characterizing, on the one hand, the project itself and the relevant area of interest and, on the other hand, the consequent significant potential impacts on the population and the environment.

I. CHARACTERISTICS OF THE PROJECT

The parameters of the project must be considered particularly in relation to
1. *the size;*
2. *accumulation of its impacts with the impacts of other known projects (being implemented, prepared, considered);*
3. *exploitation of natural resources;*
4. *waste production;*
5. *pollution of the environment and impacts on public health;*
6. *risk of accidents, particularly in relation to the proposed use of substances and technologies.*

II. LOCATION OF THE PROJECT

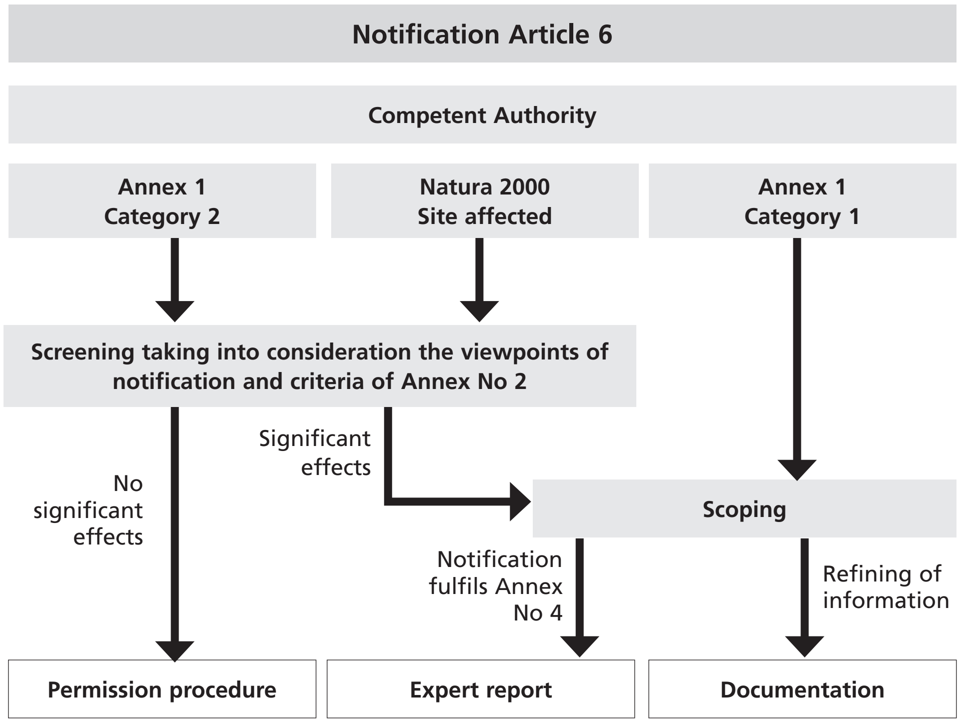
The parameters of the territory that can be affected by the project must be considered particularly in relation to
1. *the previous use of the territory and priorities of its sustainable use;*
2. *the relative number, quality and regeneration ability of natural resources;*
3. *the ability of the natural environment to bear loads; with special emphasis on*
   a) *territorial systems of ecological stability of the landscape;*
   b) *specially protected territories;*
   c) *nature parks territory;*
   d) *important landscape features;*
   e) *territories of historical, cultural or archaeological importance;*
   f) *densely populated areas;*
   g) *territories burdened above the acceptable level (including old burdens).*

III. CHARACTERISTICS OF EXPECTED IMPACTS OF THE PROJECT ON THE POPULATION AND THE ENVIRONMENT

Potential important impacts of the project must be considered in relation to the criteria set forth in points I. and II., particularly in relation to
1. *the extent of impacts (the affected area and population);*
2. *the nature of impacts in relation to trans-boundary extent;*
3. *the magnitude and complexity of impacts;*
4. *the probability of impacts;*
5. *the duration, frequency and reversibility of impacts.”*

Source: Czech Republic, 2004. (Annex 2 to Act No. 100/2001 Coll.)

FIGURE 1
Fact Finding Procedure for Category II activities under Czech Republic EIA legislation, Act No. 100/2001



Source: Czech Republic, 2004.

Fish farming is listed as a Category 2 activity and thus has to undergo a fact finding procedure, but then only under certain circumstances. Specifically, the only reference to fish culture in Act No. 100/2001 Coll. is in Annex 1, Category II, item 1.6 "Ponds intended for fish breeding with a stocking of fish over 10 t of live weight" (Czech Republic, 2004)

The aquaculture sector was under state-ownership prior to 1993, and was privatised progressively between 1993 and 1995 (Globefish, 2008). It was not possible to determine the extent of the ownership of ponds used to culture fish. Currently up to 110 owners/organizations produce the majority of the fish (Globefish, 2008). It was probable that under this transfer of ownership few, if any, EIAs were carried out. There is no evidence that government authorities had retrospectively required EIAs to be carried out on existing farms. The use of EIA may increase in the future as larger farms are developed, or perhaps more intensively cultured species are grown. Approval of a pond development under the new Act would mean that the permissions associated with it would last 30 years, and thus EIA would be an important evaluation of the environmental sustainability of any particular farm.

Post-development monitoring

A comprehensive assessment of post-development monitoring conducted in the Czech Republic between 1993 and 2001 was carried out by Braniš and Christopoulos (2005). Although this was not specifically related to aquaculture, their assessment of post-development monitoring of impacts, showed there to be little or no requirement or practical application of post-development monitoring. It appears that there are no substantive regulations concerning the monitoring of pond systems and no apparent assessment required or carried out to consistently record the post-development impact of pond culture.

The Czech Republic has issued a new version of the State Environmental Policy (Ministry of Environment of the Czech Republic, 2004), though there is no specific mention of aquaculture within the policies on protection, use and monitoring of Czech Republic waters. Here water policy is based on the Water Framework Directive (EU Directive 2000/60/EC). Protection of water quality is based on the reduction of pollutant input into receiving waters through preventative techniques and includes promoting dredging of fish farms. Permanent monitoring of organic pollutants and toxic metals in surface and ground waters and protection of the natural environment and landscape when carrying out water works is required. Water works in this context do not specifically include fish culture and this does not translate into definitive monitoring of culture sites.

France

Context

France is one of the largest aquaculture producers in Europe. Aquaculture is dominated by bivalve shellfish production with 118 120 tonnes of Oyster (*Crassotrea gigas*) and 66 250 tonnes of mussel (*Mytilus* sp.) cultured in 2005 (FAO, 2007). The farming of fish is an increasing sector, though still relatively small, and is dominated by freshwater culture of rainbow trout (32 353 tonnes in 2005). Mariculture of fish has a comparatively small production with seabass and seabream production at 3 913 tonnes and 1 778 tonnes in 2005, respectively. However, this is considered the most important area for aquaculture expansion, particularly on the Mediterranean coast.

Regulatory framework

The Ministries of Agriculture and Ecology and Sustainable Development are responsible for aquaculture in France. At the national level the implementation of the EU EIA Directive was conducted through Book 1 of the French Environmental Code via decree No. 77–1141 (LEGIFRANCE, 2008; FAO, 2006-2008 NALO France). Within this context article 2 of Law No. 76–269 concerning the protection of nature stipulated that an EIA was required the development of marine-based farms considered classified installations. In reality not all marine developments fall within this category and shellfish production is specifically exempted through decree 53–578. Therefore a part of the French aquaculture sector falls outside the requirements of the EU EIA Directive 337/1985.

Inland freshwater aquaculture – application procedure

There are two procedures for establishing an inland aquaculture facility within French legislation. An initial application for a permit or concession is required followed by an operating authorization. These are separate requirements and are under the auspice of different authorities, which themselves have different needs.

In development of an inland aquaculture site on private land, the developer must apply for a *permit*, whilst *concessions* are given for development on government-owned land. These permits/concessions are denied to farming activities that may threaten fish populations in surrounding waters. In particular, the developer must consider means of limiting the free movement of farmed fish into the water course by preventing escapees and minimising the potential for water pollution that would put fish life in jeopardy.

Applications for a permit or concession must contain the following information:

- name of applicant;
- location of development and map of the area;
- evidence of permission to undertake the aquaculture activity from the landowner or appropriate authority;
- detailed plan of the aquaculture system;

TABLE 1
Thresholds for declaration and authorization of land-based fish farms in France

Production capacity	**Freshwater salmonid farm**
> 10 tonnes/year	Authorization
500 kg to 10 tonnes/year	Declaration
Production capacity	**Other freshwater fish farm**
> 20 tonnes/year	Authorization
5 to 20 tonnes/year	Declaration

Source: after CONSENSUS, 2005b.

- description of the production method, goals and harvesting methods;
- description of measures to be used to ensure there is no danger to local fish populations through fish movement and water quality;
- drainage procedures;
- duration of operation and evidence of the financial viability of the applicant.

Applications are evaluated by a Prefect, who typically takes two months to either reject the permit application outright or to move to the authorization phase when a full EIA or Environmental Impact Notice (Notice d'impact) is required.

The authorization of land-based fish farms depends on type and production capacity (Table 1). There is no requirement for authorization if the production capacity is lower than the minimal threshold, culture of certain species must be reported to the Departmental Directorate of the Veterinary Services (CONSENSUS, 2005b). Land-based farms fall under the objectives of the EU Water Framework Directive (2000/60/EC).

Marine aquaculture – application procedure

Two different concessions are available for finfish mariculture depending on whether the land/water area is owned by the state or privately. The permit applications are addressed by the Department of Maritime Affairs, which is part of a local authority. Part of their duty is to pass the application to the statutory consultees for comment (see Figure 2). Subsequent advice given by the consultees is compiled by the Commission for Maritime Aquaculture and then given to the local prefect. It is the local prefect who is responsible for granting or declining the permit. In the case of mariculture sites the permits are granted for a maximum of 35 years and are only then subject to review. Although not yet within the EIA process there is an onus on the applicant to show that there are likely to be no or manageable risks of impact over both the short, intermediate and longer term, before a permit is granted.

The authorization phase follows the procedures given in Figure 3 and requires environmental analysis, either in the form of an EIA or an environmental notice. An EIA must be presented as part of the application process within two years of initial application for the following aquaculture projects:

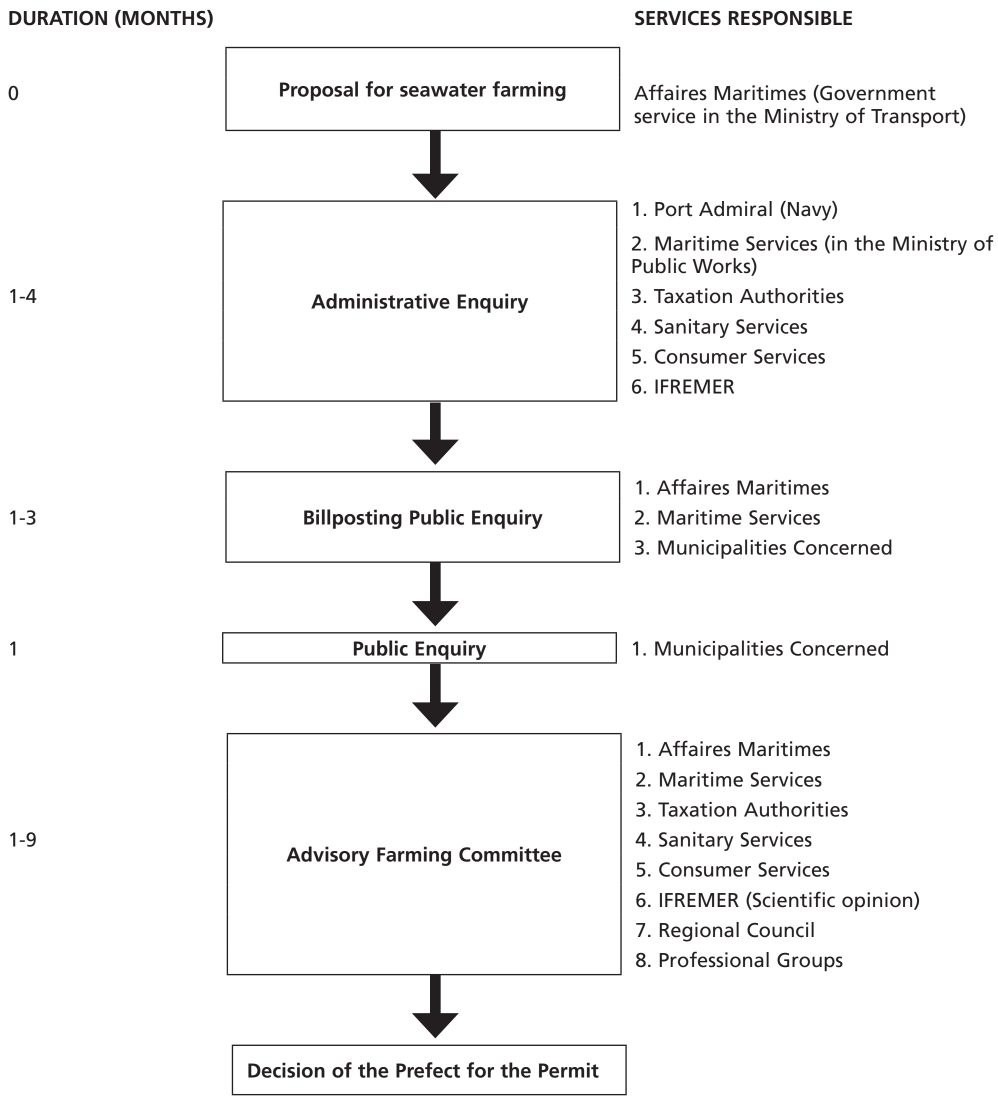
- salmon aquaculture farms;
- aquaculture farms with scientific or experimental functions;
- new fish farms with an annual production > 20 tonnes or a water surface of >3 ha, or existing farms wishing to exceed these limits.

In France the EIA requirements conform to that specified under EU Directive (97/11/EC; see Annex 1) and must include:

- a non-technical summary;
- the rationale for the aquaculture development;
- a baseline analysis of the initial state of the site and its surrounding environment;
- an assessment of likely direct and indirect impacts of the development on the environment;
- the mitigation, elimination or compensation measures proposed by the applicant;
- a critical description of a monitoring plan to assess the project's impact.

FIGURE 2

Legal procedures for obtaining a permit for development of maritime property. The first column represents the duration of steps (after Dosdat and Pomelie, 2000)



Inland freshwater aquaculture – environmental standards and monitoring

In fish farming there are no compulsory environmental standards so the amount of fish production is balanced against an acceptable level of environmental impact. This is a decision taken by discussion between stakeholders, under the auspice of the Departmental Health Council. In freshwater culture systems there are local standards of water quality (see Table 2).

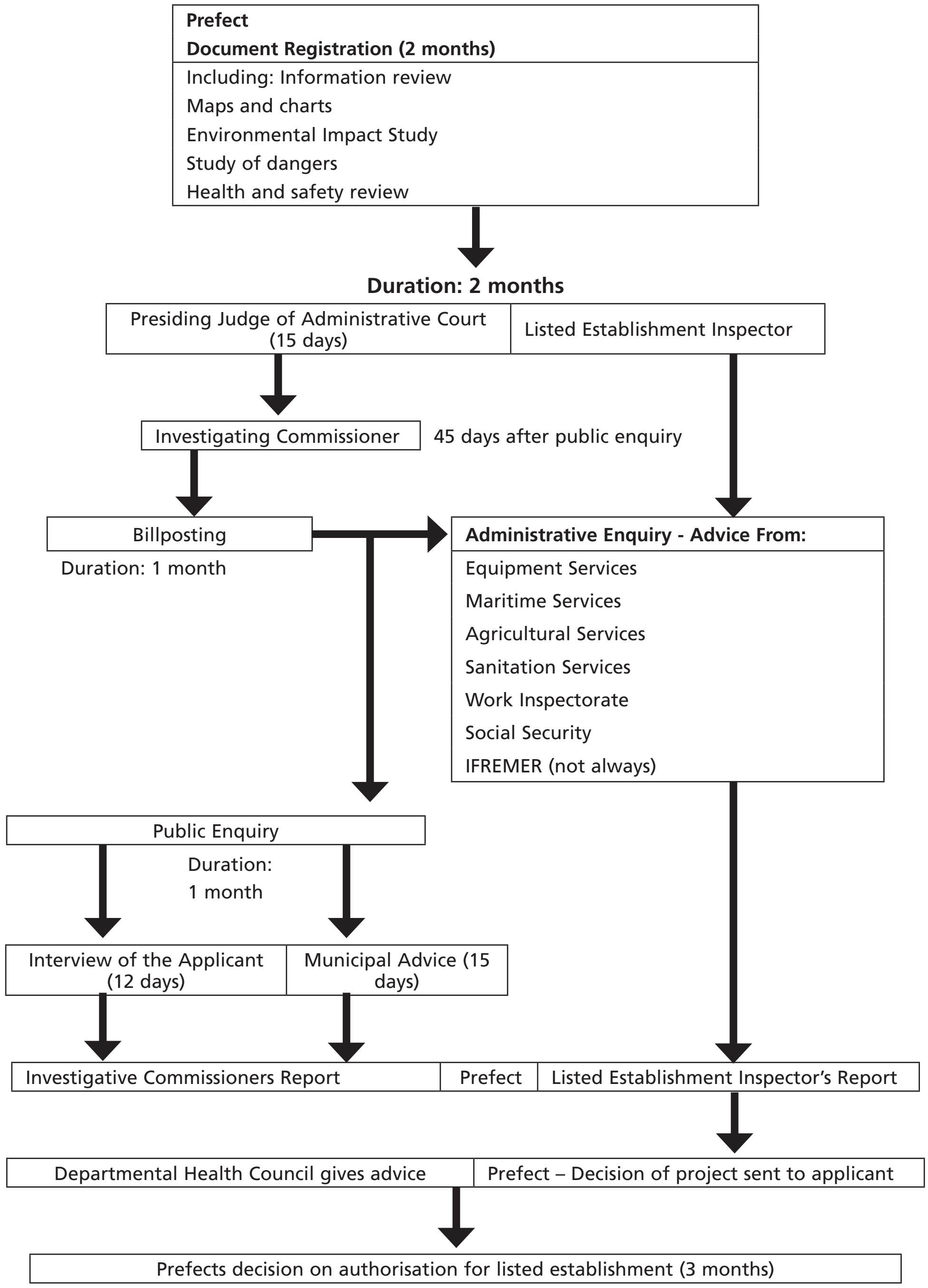
TABLE 2

Environmental quality standards applied to land-based fish farms.

Parameter	Value
Total ammonia M (mg/L)	<0.5
Nitrate N (mg/L)	<10
Phosphate P (mg/L)	<1
Oxygen saturation (%)	>70
Suspended solids (mg/L)	<25
Faecal coliforms (No/ 100 mL)	<2000
Heavy metals	No standard

Source: after Dosdat and Pomelie, 2000.

FIGURE 3
Legal procedures for authorization to operate a fish farm likely to cause environmental impact (after Dosdat and Pomelie, 2000)



The principal pollutants in the water exiting a freshwater culture system are suspended matter, nitrogen (N) and phosphorus (P). Water agencies in France use these three water quality parameters to establish the pollution tax of fish farms.

Mariculture – environmental standards and monitoring

The most common schemes for monitoring mariculture involve a survey of following parameters, carried out every six months (bi-annually):

- sediment quality

- redox potential
- benthic fauna
- organic carbon levels

Methods for analysis of these parameters tend to require specialist knowledge or equipment. Sediment quality generally relates to oxygen level, whether the sediment contains chemical tracers of environmental degradation such as methane and sulphur dioxide and whether the sediment grain size has changed as a result of farming activity. Benthic fauna identification requires extensive knowledge of taxonomic features and is a specialist skill. Measures of organic carbon require appropriate equipment to measure loss-on-ignition. Thus these requirements for environmental monitoring are carried out by specialist firms.

Also water quality in the vicinity of the cages is typically monitored by the farmers themselves, with measures of dissolved oxygen, ammonia levels and microbiological monitoring carried out at a maximum of three month intervals. Dissolved oxygen and ammonia are more readily measured, with the availability of probes allowing measures to be taken every day, if necessary.

Monitoring of other data

The fish farmer must keep production (biomass and feed used) and fish treatment records. This includes accidental events such as mortalities and escapes. These are monitored by the Department of Veterinary Services (DSV), which has the statutory power of inspection audits.

The use of veterinary products within the environment is regulated. The legislation is applicable to antibiotics, vaccines and food additives used in fin-fish culture. Since 1997 it has been compulsory under EU Directive 92/18 that there are no residues from these veterinary products retained in the fish flesh, that the products do not affect the environment and that in order to obtain a market licence, (an AMM, or Authorisation de mise sur le marché) then such effects have to be measured. The study is carried out on behalf of the manufacturer of the chemicals (at their expense) and is divided into three phases (Dosdat and Pomelie, 2000):

Phase 1:	Chemical analysis to determine the presence of a given chemical (or metabolite) in the natural environment after treatment of the fish. This gives the predictable environmental concentration (PEC).
Phase 2:	Phase 2 is always carried out in the marine environment, it is designed to define the predictable no effect concentration (PNEC). Data on the elimination kinetics of the substance in different environmental conditions are required and the acute toxicity levels for fish, shrimp larvae and algae must be determined. When the PEC/PNEC ratio is higher than one, Phase 3 must be implemented.
Phase 3:	Further investigations are necessary, for example monitoring gradual changes in the sediments, or the dispersion in the environment and the effect on free bacteria. These studies are often performed in a mesocosm.

In France, aquatic veterinary products are only available though prescription from a registered veterinary surgeon. Recently, a temporary utilization authorization has been launched in order to allow fish producers to use some veterinary products that have intermediary status before being authorized through an AMM.

There are no specific environmental monitoring or EIA requirements for shellfish in France. However, three named “networks” are monitoring (i) water quality (RNO, National Observation Network), (ii) water microbiology (REMI, Microbiological Network) and (iii) potentially toxic phytoplankton species and their cell density (REPHY, phytoplankton Network).

The RNO network verifies that the concentrations of all heavy metals (particularly mercury, cadmium and lead) in mussels and oysters remain below the threshold levels (RNO also monitor heavy metal and organic molecule concentrations in sediments). The REMI measures the concentrations of coliforms, mainly *E. coli,* every month in the water and in the shellfish, however if coliform concentrations in the water start to increase, the monitoring frequency is enhanced to one sampling per week. The frequency is also dependent on the zone indices (A, B, C or D). The REPHY measures the increase in the major dinoflagellates (*Dynophisis, Alexandrium, Prorocentrum*) and the presence of toxins in the tissues once a month, and, more often if there is a bloom (Dosdat and Pomelie, 2000). Collectively the monitoring of shellfish production conducted by the network ensures the safety of the product for human consumption.

Greece

Context

Greece cultures 26 species of aquatic organisms (FAO, 2007) in fresh, brackish and seawater. Freshwater production is dominated by rainbow trout (*Oncorynchus mykiss*), with production of 2 446 tonnes in 2005. Aquaculture, however, is dominated by the production of three marine species; European seabass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*) and Mediterranean mussel (*Mytilus galloprovincialis*). Production of these three species was 30 836 tonnes, 43 588 tonnes and 26048 tonnes in 2005, respectively.

Legislative requirements

Along with many other countries Greece has translated the EU Directive on EIA into national legislation. In 1990 the Common Ministerial Decision 69269/5387/90 implemented the EIA procedures and 75308/5512/90, the rights to public participation. The former identifies the categories of works requiring EIA, which includes aquaculture development.

In addition there are a number of specific Administrative Directives (AD) within Greek legislation that concern particular ministries and procedures for aquaculture development. These are as follows:

93/259637/AD	Administrative Directive of Ministry of Agriculture (evaluation of environmental studies concerning the establishment of aquaculture farms)
94/258374/AD	Administrative Directive of Ministry of Agriculture (procedures concerning the establishment of aquaculture farms)
89/1089177/6325/0010/AD	Administrative Directive of Ministry of Finance (concerning the procedures related to the use of coastal areas supporting marine aquaculture farms)
93/500530/AD	Administrative Directive of Hellenic Tourism Organization (concerning parts of the procedures related to aquaculture farms' establishment)
89/M3148/AD	Administrative Directive of Ministry of Mercantile Marine (concerning leasing procedures of seawater bodies for aquaculture farms' establishment)

In Greece, licensing of marine aquaculture (both fish and shellfish) is perceived as complicated, time-consuming and bureaucratic (Papoutsoglou, 2000; Dickson *et al.*, 2005). There are a large number of statutory organizations and regulations involved in licensing of new aquaculture developments in coastal regions, despite the fact that in 2005 there appeared to be no specific coordinated aquaculture policy in Greece (Dickson *et al.*, 2005). License requirements cover environmental protection, secure navigation, shipping regulation, commercial fisheries protection, public health protection, archaeological site protection and tourist activities. Socio-economic conditions are also taken into account in terms of public perception, peace and environmental sensitivities, existing land or sea area use, visual impact and politically sensitive areas. With different ministries responsible for each of these elements, there is a need for aquaculture developers to gain approval from many authorities.

Finfish sea-based net-cage farms

The leasing and licensing procedure for the aquatic area starts with the submission of an application to the authorized service (branch of Ministry of Agriculture). The application has to include a map of the major marine and land area, a site chart, a preliminary feasibility study (brief technical and economical survey with basic information on the farm design, number, type and size of cages, species to be produced, expected production and outline of production plan). A description of the underwater topography of the site is also required, with a profile of the net-cages in relation to the water depth.

At the same time, an application has to be submitted to the Ministry for Environmental, Physical Planning and Public Works to obtain a pre-approved permission for the use of the site, which also has to include a topographical map and bathymetric chart of the specific site, photographs of the site, a feasibility study and a public questionnaire. In addition, to receive final operational permission for the farm, an environmental survey, which outlines any possible 'effects' of the farm, must be sent to the land use planning authority.

Finfish land-based on-growing farms (including hatcheries)

Applications for land-based aquaculture developments are submitted to the regional branch of the Ministry of Agriculture (Department of Fisheries and Aquaculture). The application should include a map of the major area and plans for the proposed buildings, a feasibility study with detailed information on the chosen fish species, total land area and water volume required, number, size and type of tanks or raceways to be used, supply system of sea or/and fresh water, construction works, transportation needs and financial management. An environmental survey of the area and approved waste disposal methods should also be provided.

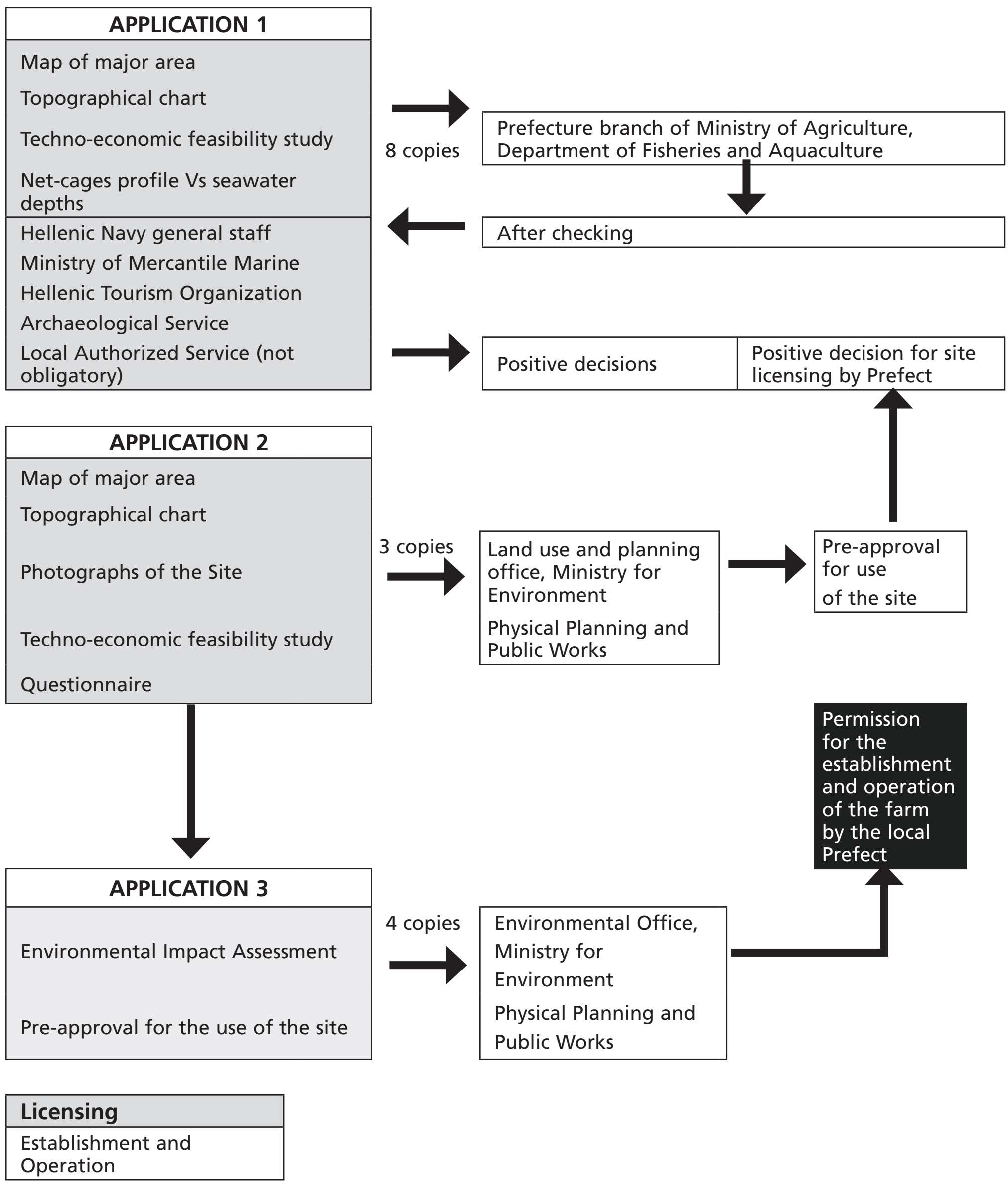
The environmental protection criteria for land-based farms come under the existing legislation. This requires an approved special waste disposal study and includes recommendations for the treatment of effluents before their discharge. However, the treatment procedure only includes mechanical filtration and sedimentation at farms with an annual production of up to 150 tonnes, and biological filtration and disinfection are only considered when annual production exceeds this limit (Papoutsoglou, 2000). Abstraction of water itself for aquaculture purposes also requires a permit, but is available for free on application from the relevant water authority (Klaoudatos, 2001).

EIA requirements

An EIA has to be submitted in order to lease the site and to be able to obtain permission for the operation of a finfish farm. The EIA is required to include production management details and a description of the specific area in terms of the physical, chemical and biological parameters of the waterbody. The procedure for submission of EIAs is given in Figure 4.

Seawater samples are analysed before and also during (monitoring) the operation of the fish farm, physical parameters include measures of temperature, salinity, turbidity

FIGURE 4
Licensing and leasing procedures for finfish net-cage farms in Greece (after Papoutsoglou, 2000)



and suspended solids and chemical parameters include measures of ionic composition, dissolved oxygen, nutrient concentration and dissolved and particulate organic matter (Klaoudatos, 2001). An EIS should also include: measurements of the physicochemical parameters of the marine environment, including suspended solids, wave height, the direction and speed of the wind, the direction and speed of the water currents, depth, substrate type of the sea bed and the structure of the macrobenthic community. Such measures of biological and chemical data are extensive but typical of fish farm development assessment in the Mediterranean (ECASA, 2007). They are readily measured using standard biological and chemical techniques.

There are specific regulations governing water quality in freshwater fish farms (in coastal lagoons and rivers). The EIS must make a statement on the impact of the culture practices on specific water quality parameter (shown below). Subsequent control of these physico-chemical parameters is necessary throughout the production process through careful monitoring (Morou, 1996; cited in Klaoudatos, 2001) and application of water quality limits below:

Dissolved oxygen	5–9 mg/l
Saturation level	50–100%
BOD5	3–6
Suspended solids	25
Ammonia	0.1 mg NH_3–N/l
Nitrites	0.1 mg NO_2–N/l
Nitrates	100 mg NO_3–N/l

Food quality standards are also imposed on the production of aquatic organisms in Greece, they comply with EU Directives and local laws and refer to:

- the formulation of artificial diets;
- storage of aquatic feeds;
- transport and storage of feedstuff and additives, sourced from both inside and outside the EU;
- quality control measures.

The complexity of the regulatory process and the number of organizations involved make aquaculture development in Greece a very cumbersome and bureaucratic process (Papoutsoglou, 2000). At present the process is far from ideal and requires a more widespread use of EIA within regulation and licensing. In the view of a stakeholder - "At a national level it is not unusual to have to apply for seven or more permits from different government departments and then to have to go to regional and local authorities to receive appropriate documentation to start [his] business" (Dickson *et al*., 2005).

In a study of non-aquaculture related EISs, Androulidakis and Karakassis (2006) suggested that in Greece much of the information included in an EIS (until recently) has been obtained from generalised published data rather than measurement of site specific environmental data. There is no evidence to confirm whether this applies to aquaculture development as described but if it is, this clearly leads to potential problems that can inhibit development of aquaculture. In particular generalised data from a local area must be treated with caution and site applications may be limited by the imposition of non-specific and unrealistic environmental controls, which might limit development. For good environmental control, it is imperative that site-specific information is gathered and presented for fish and mussel farm development.

Hungary

Context

There are 13 species of aquatic organisms cultured to varying degrees in Hungary, all grown in freshwater ponds or tanks. Farms using semi-static systems are often involved in national "Agricultural Environment Protection Programs". The farms involved in this programme represent 90% of the total fish pond area (CONSENSUS 2005a).

Production is dominated by common carp (*Cyprinus carpio*) with 9 739 tonnes harvested in 2005. However, this is a significant and constant decline in production from a peak in 1983 of 18 407 tonnes (FAO, 2007). The only species being cultured that shows increasing production is the African catfish (*Clarias gariepinus*). Catfish production remains relatively low but there has been a consistent increase in production to 1 412 tonnes in 2005 since the start of production in 2001 (FAO, 2003-2008 NASO Hungary).

Regulation

The main government agency involved in aquaculture and fisheries is the Game and Fisheries Department within the Ministry of Agriculture and Regional Development. The main task of the department is to provide overall administrative control of aquaculture and fisheries, to ensure an adequate legislative and economic framework. The department is also responsible for the maintenance of fish stocks in natural waters, the protection of their gene pools and the management of the Fisheries Fund, which is financed from state revenues (fees from fishing licenses and fines) (FAO, 2003-2008 NASO Hungary).

The New Fisheries Act has been in place since 1997, which provides the legal framework for the responsible use and protection of water resources. Fishing rights belong to the state, except for enclosed waters owned by private individuals. Fishing rights are granted by the state to various users such as fisheries cooperatives, municipalities, angling associations, state and private organizations and private persons. The main fisheries authority is the Game and Fisheries Division of the Ministry of Agriculture and Rural Development, which carries out its administrative work through 19 regional fisheries inspectors (one in each county) employed in regional agricultural offices. The licensing is a three-step procedure:

a. Submit documents that show land ownership, layout map, description of technology and facilities. Basic conditions for water supply and effluent disposal must be available to the Regional Water Authority, which gives the **preliminary** license for water use.
b. Various authorities must be approached to get a license for construction of the farm.
c. After the construction of the farm an official check-up survey is made and after consulting authorities the **final** license for water use can be received.

There has been a dynamic change in the fish production sector in Hungary following the social, economic and political changes in Eastern Europe during the early nineties which in Hungary resulted in the privatisation of aquaculture. However, during this transition, pond fish farms have deteriorated in terms of their physical structure and the facilities available, as well as in terms of environmental consideration.

The latest challenge for the sector has been during Hungary's accession to the European Union, though this has lead to the development of some specific objectives in relation to aquaculture and the environment, identified as part of a medium-term development strategy for aquaculture (FAO, 2003-2008 NASO Hungary). When Hungary became a member of the EU, the Financial Instrument for Fisheries Guidance (FIFG) became available for the modernisation of the aquaculture sector. FIFG is a community measure (Council Regulation No 1263/1999), with the main objective of setting policy priorities and establishing a framework that contributes towards a sustainable balance between fisheries resources and their exploitation. According to FIFG, measures for the modernisation of the Hungarian aquaculture sector have been outlined in the Hungarian Agricultural and Rural Development Operational Programme, which forms part of the National Development Plan. The main *environmental protection* recommendations from the FIFG for the Hungarian fish production sector are summarized (FAO, 2003-2008 NASO Hungary) as follows:

- Gain acceptance by the environmental authorities of the special nature of fish ponds, including the maintenance of aquatic habitats and biodiversity, which the state should support.
- The sector should receive reasonable compensation for the damages caused by protected birds.
- The role of the fishponds as potential biological water treatment units should be recognised and supported.
- The "Aquatic habitat sub-programme" should receive a more pronounced role in the "National Agricultural Environment Protection Programme".

However, despite these objectives being set and outlined for farmers under the Hungarian Agricultural and Rural Development Operational Programme, no specific monitoring requirements have been stipulated for aquaculture facilities.

In addition a fund has been provided by the Ministry of Agriculture and Rural Development in Hungary to develop a strategy for sustainable aquaculture development. The ministry also supports a project which aims to address best management practices for pond fish culture (CONSENSUS, 2005a).

Italy

Context

Italy has a very diverse aquaculture profile with some 46 species of aquatic organisms under cultivation (FAO, 2007) in fresh, brackish and marine waters. However, aquaculture is dominated by three main species (2005):

- Japanese carpet shell (*Ruditapes philippinarum*) – 65 387 tonnes/yr;
- Mediterranean mussel (*Mytilus galloprovincialis*) – 54 039 tonnes/yr;
- Rainbow trout (*Oncorhynchus mykiss*) – 30 558 tonnes/yr.

Italian aquaculture appears to be in a decline at present, after a peak of 245 000 tonnes in 1998 (Saroglia *et al.*, 2000). The increase in production of carpet shell has been considerable since its beginning in 1984, which however has lead to severe oxygen depletion in the clam farming lagoons in Italy (CONSENSUS, 2005c).

Regulation

The aquaculture industry in Italy is regulated (FAO, 2006-2008 NALO Italy) in terms of environmental protection under Law No. 152, which implements EEC Directive 91/271 and Directive 91/676 (European Commission 1991a; 1991b). This law aims at ensuring that all waterbodies can be designated as having "good" water quality status by the end of 2016, but being at least "sufficient" by 2008. Veterinary chemicals are regulated under Legislative Act no. 119 (1992), which implements EEC Directives 81/852, 87/20 and 90/676 (Panunzio and Iandoli, 1999; European Commission, 1990; 1987; 1981).

Aquaculture and fisheries within Italy are authorised by the Ministry of Agriculture and Forest Policies, Directorate-General for Fisheries and Aquaculture. In addition, concessions for the establishing of aquaculture facilities are the responsibility of the Ministry of Infrastructure and Transport, in particular via the Directorate-General for Maritime and Inland Navigation Infrastructures, operating within the Department of Navigation and Maritime Transport.

Regulation of agriculture (including aquaculture and fisheries) was initiated in 2001 under Law No.57 and Law No.154 of 2003. This Law on the "Modernization of the Fishery and Aquaculture Sector" established a "Blue Table" group, which is coordinated by the Minister of Agriculture and Forest Policies and includes regional councillors for fisheries and aquaculture and representatives from stakeholder groups and representative of the Ministry of Environment and Land Protection.

The current national fisheries and aquaculture policy is established as a series of three-year plans that are revised every year. These plans emphasize the importance and diversification of aquaculture in Italy, within EU guidelines under three priorities:

- site identification in terms of maximising productivity while minimising environmental impact;
- product quality and certification;
- positive environmental effects (i.e. use of vallicultura for conservation of wetlands).

The Italian Fish Farming Association (API) purports to have adopted a Code of Good Farming Practice. As a member of FEAP, it is presumed that the Italian code is consistent with the FEAP Code of Conduct for European Aquaculture (FEAP, 2000) and in turn with the FAO Code of Conduct for Responsible Fisheries (FAO, 1995).

Environmental requirements

Under the aquaculture regulations an application for an aquaculture development requires information to be submitted to the chief of the competent Maritime Compartment (Ministry), containing a technical report on the construction, a map of the required concession area, construction plans and certification of rights claimed by the applicant.

There is no systematic national legislative framework for Environmental Impact Assessment in Italy in relation to EU Directive 337/1985 (FAO, 2006-2008 NALO Italy). However, by establishing guidelines for the regulation of EIA procedures by Regional Authorities through the legislation below, the Directive has essentially been implemented for aquaculture development.

- DPCM (Prime Minister Decree) 337/88 lists projects to be subjected to the national EIA. The list reproduces the Annex I of the EIA Directive.
- DPCM on December 1988 set up technical requirements to draw up the environmental study.
- DPR (Presidential Decree) on February 1998 adds projects to the list of the DPCM 337/88.
- DPR (Presidential Decree) on September 1999 number 348 regulates technical requirements of the environmental impact assessment for some activities.
  - (i) 1089 of 1 June 1939 "Protection of artistical and historical sites";
  - (ii) 1497 of 29 June 1939 "Protection of the natural beauties";
  - (iii) 431 of 8 August 1985 "Urgent regulation for the protection of environmental interest areas";
  - (iv) 349 of July 1986 "Ministry of Environment".

Under this regulation an EIA is compulsory for aquaculture developments of over 5 ha in size if it is to be established within a protected area. Developments outside of protected areas are subject to a screening of opinion as to the need for an Environmental Impact Assessment and production of an Environmental Impact Statement (EIS).

Where an EIA is deemed to be required, the EIS should provide:

- a project description;
- potential effects on the environment;
- environmental and land-use provisions;
- mitigation and repair measures.

This applies some of the criteria within the defined EIA guidelines (see Annex 1) given in the EU EIA Directive 97/11/EC. In addition, if the application involves conservation or areas with special protection laws a "*nulla osta*" is needed (Panunzio and Iandoli, 1999) that requires an assessment from the public body entrusted with the protection of that area, which may involve, up to 30 to 40 other stakeholders. In such cases applications can take several years for both completion and the granting of a license to produce fish. Once a license for an aquaculture development has been granted a further permit is required that gives permission to discharge water from the fish farm and (if applicable) to abstract waters from freshwater systems. Depending on what is actually required there can be anything from one to several public bodies that must grant permission. The primary authority is the Ministry of Public Works. Again, if the development is complicated this procedure may take years rather than months. Overall it is demonstrated that the application procedures are often a complex and highly bureaucratic procedure (after Panunzio and Iandoli, 1999).

The environmental laws based around EU Directives 91/271 and 91/676 are to ensure sustainable waters by 2016 by applying certain standards of quality. In terms of coastal waters, water quality must be monitored seasonally for most of the year, except between June and September when they are monitored bi-weekly. Parameters measured include: temperature, pH, salinity, transparency, orthophosphate, total phosphorus, entero-bacteria, dissolved oxygen, chlorophyll a, total nitrogen, ammonia, nitrate and nitrite. Biological parameters must be measured twice per year, and "ground" parameters in culture areas are measured once per year. A trophic index is applied using data collected from these measurements:

$$Trophic\ Index = \frac{[Log_{10}(Chl\ a \times DO \times N \times P) + 1.5]}{1.2} \quad (1)$$

Waters are then classified by the value of their trophic index as in Table 3.

TABLE 3
Classification of coastal waters under the Trophic Index in Italy (Saroglia *et al.*, 2000)

Trophic Index	Condition	Characteristics
2–4	Very good	Good transparency, absence of abnormal water colouring, absence of hypo-oxygenation of sediments
4–5	Good	Occasional water turbidity, occasional hypoxia of benthic waters
5–6	Mediocre	Slight transparency of waters, abnormal water colouring, hypoxia and occasional anoxia of sediments, benthic ecosystem distress
6–8	Poor	High turbidity, persistent abnormal water colour, persistent hypoxia/ anoxia in sediments, death of benthic fauna, benthic community modification, economic damage to tourism, fishery and aquaculture

Regulations for veterinary medicines in Italy are based on EU Directives 81/851 and 90/676 (European Commission, 1990; 1981). The law forbids the use and possession of pharmacologically active substances and requires that therapeutic treatments are carried out under the direction of a professional veterinarian, under prescription. Use of therapeutants must be recorded and reported to the local health authority. The Ministry of Health can allow the use of new toxic therapeutants for which an EU Maximum Residue Level (MRL) can be determined, or non-toxic ones without the requirement for an MRL.

The general perception is that the highly bureaucratic nature of the system in Italy is a significant impediment to the development of aquaculture. It is unclear how the implementation of the more recent EU Directives will clarify the issues and system of application.

Netherlands

Context

Aquaculture in the Netherlands is limited to a few species and dominated by the mussel, *Mytilus* sp. (59 500 tonnes in 2005; FAO, 2007). There has been a general decrease in culture of mussel over the past 15 years since production peaked at 1 302 712 tonnes in 1982. The culture of European eel and African catfish began in the Netherlands in the early 1990's and both had a combined annual production of approximately 4 000 tonnes in 2005.

Shellfish culture in the Netherlands is a traditional industry but there have been no new licenses for production issued for bottom culture since the 1960's. Since 1987 several licenses have been issued for rope culture in the Oosterschelde estuary, but all prospective coastal sites are now exploited and no new shellfish culture is permitted. The potential for aquaculture expansion is therefore limited to inland freshwater systems.

There is no system in Dutch law specifically for authorisation of inland aquaculture. Each new farm requires a number of permits by various ministries mainly dealing with environmental protection and land-use planning regulations. In general terms, under the Environmental Protection Act (1993, as amended) developments involving the cultivation of animals, including fish and shellfish, require an EIA which conforms to EU Directive 85/337/EC, amended 97/11/EC (see Annex 1). However, at present there is no specific EIA requirement for aquaculture farms in Dutch law (FAO, 2006-2008 NALO Netherlands).

Regulation for shellfish culture

In the Netherlands the overall responsibility for the development and management of the aquaculture sector, rests with the Ministry of Agriculture, Nature and Food Quality. As part of the EU regulation for shellfish quality a monitoring programme is carried out by the Netherlands Institute for Fishery Research (RIVO), under contract of the Fisheries Department of the Ministry, together with the Dutch Fish Board. Monitoring of live shellfish processing is carried out by the processing companies.

Monitoring of pathogenic bacteria is done on a bi-weekly basis in several areas of the Oosterschelde, the Wadden Sea and Lake Grevelingen. If the fishery for cockles or *Spisula* spp. is extended to other areas, then the monitoring programme will also be extended. If samples are shown to exceed the standard, the area is closed for harvesting and sampling is repeated. If the subsequent samples show that limits are not exceeded, then the area will be reopened. In practice the standards are met in almost all cases, as discharge into shellfish culture areas is prevented as part of the Dutch water management (Smaal and Lucas, 2000).

The National Department for Control of Meat and Live Stock, part of the Ministry of Agriculture, Nature Conservation and Fisheries and the Dutch Fish Board are responsible for the control of water quality in shellfish culture areas, as well as handling and processing. The monitoring of biotoxins is carried out at stations along the Dutch coast where wild shellfish fisheries are located. Water samples are tested for contaminants and microorganisms and shellfish meat is tested for diarrheic shellfish poisoning (DSP), paralytic shellfish poisoning (PSP), amnesic shellfish poisoning (ASP) and neurotoxic shellfish poisoning (NSP). Contaminant concentrations in (wild) mussels are also monitored on a regular basis as part of water quality control programmes, though in practice contaminant levels rarely exceed EU quality standards for shellfish.

One of the requirements concerning shellfish production is to ensure that there is an underlying quantity of shellfish available in order to satisfy natural bird feeding needs. In order to determine whether there is a requirement to reserve food for shellfish-eating birds, annual stock assessments of mussel spat (and also of cockles and *Spisula*) are carried out by the RIVO, under contract of the Fisheries Department of the Ministry. This work is also partly funded by the producer organizations. Intertidal mussel stocks are monitored by aerial photography, along with ground observation. Subtidal mussel spat stocks are monitored prior to fishing activities in spring and autumn, for which an extensive network of monitoring stations are used. Oyster stocks are not part of a regular monitoring programme, but surveys are carried out occasionally (Smaal and Lucas, 2000).

These monitoring programmes result in the assessment of the stock prior to the fishing activity of that year and are the basis for fishery licenses. Data from the stock assessments is used to evaluate the carrying capacity of an area, in terms of the amount of food available and the stock size of other non-commercial filter feeders. In addition, the quality of the shellfish waters is designated under the EU Directive 79/923/EEC and may require protection or improvement for the production of shellfish. These waters are carefully monitored in this regard.

Wastes from broken shell, undersized mussels and mussels from the packaging, purification and processing plants in Yerseke, Netherlands, are taken by ship and dumped in regulated areas at sea (CONSENSUS, 2005c).

Poland

Context

Aquaculture in Poland is based on freshwater culture and dominated by production of the common carp and rainbow trout, with 18 600 tonnes and 15 700 tonnes produced in 2005, respectively (FAO, 2007). Over the last ten years the production of these two species has switched in emphasis. Production of carp peaked in 1992 at 25 000 tonnes and is now in decline. Trout production has increased year on year from 4 991 tonnes produced in 1995. Carp farms operate either an extensive or semi-intensive culture, which use natural resources to feed their fish, without addition or only small addition of food. Trout farms in Poland are fitted with modern, effective systems for treating water and hence are deemed to have little or no impact.

Legislative context and EIA

Strategy development for aquaculture and fisheries in Poland is within the remit of the Ministry of Agriculture and Rural Development (MARD). Within this Ministry, the Department of Fisheries is responsible for the development of marine fisheries, inland fisheries, aquaculture and marketing of fish products.

General legislation on EIA in Poland has its root in the early 1990's and significant implementation of requirements since then (see Woloszyn, 2000, for a review), after transition and accession to the EU. The principal legislation covering EIA requirements is as follows:

1. The Environmental Protection Law of 27 April 2001 (Dz. U. 2001 No 62, item 627);
2. The Regulation of the Council of Ministers of 24 September 2002 on the categories of projects that may have significant environmental impact and on the criteria of screening projects for environmental assessment (Dz. U. 2002 No 179, item 1490).

Within the above frameworks the categories defined in the Regulation of Council of Ministers (point 2 above) are particularly important as this Regulation identifies certain aquaculture development as a Group 2 activity. Group 2 activities are defined as "might require an EIA" (Jendroska *et al*., 2003). The specific requirement for consideration of an EIA process is laid out as follows:

> "*Rearing of fish in fish ponds, where the production is over 4 tonnes of fish per 1 ha of a pond surface (for carp and similar fish), and rearing of trout, where the production is 1 tonne of fish with water consumption of 1 l/s*" (Jendroska *et al*., 2003).

Many fish ponds in Poland are large, ranging between a few hectares to some 1 700 hectares (FAO, 2006-2008 NASO Poland). However, as the majority of the production is of an extensive nature the production per hectare tends to be low ranging from 2 to 300kg (Polak *et al*., 2008). There is therefore uncertainty about whether pond culture in Poland has ever specifically undergone an EIA procedure. More generally, inland pond culture is also seen to have positive benefits on biodiversity (Ciesla *et al*., 2008), whilst at the same time is perceived to have limited adverse effects on the environment.

Farmers with salmonid aquaculture or any other fish culture with a pond surface area larger than 10 ha are obliged to provide an environmental impact assessment plan, thought it was not possible to determine examples of this occurring. Whilst there is little or no available information concerning specific EIAs it is possible to infer that the EIA requirements have not specifically been invoked for aquaculture development in Poland since the EIA regulatory requirements have been in place in Polish legislation. In addition, there is no aquaculture law concerning water use (Ackefors, 2000) and pond and raceway farmers of carps and trout are free to remove water for aquaculture purposes. Within this context there are certain maximum loads that are not allowed to be exceeded (Ackefors, 2000), namely:

Parameter	Limit
Suspended solids (SS)	< 20 mg/l
Biological Oxygen Demand (BOD)	<4.0 mg O_2/l
Chemical Oxygen Demand (COD)	25.0 mg O_2/l
Phosphate (PO_4 – P)	< 0.065 mg/l
Nitrate ($N0_3$– N)	< 1.129 mg/l

It is clear from Woloszyn (2004) that the concept of EIA in Poland remains in its infancy and that little or no EIA processes have been undertaken for aquaculture development. This may have been compounded by the fact that financial support available to Polish scientific and research priorities has been modest and thus only a relatively small amount of scientific research can be applied directly to aquaculture (FAO, 2006-2008 NASO Poland). Importantly, accession to EU membership comes with access to European Fisheries Funds (EFF) and Financial Instrument for Fisheries Guidance (FIFG). Polish authorities have now developed a National Strategy for the Development of Fisheries in Poland (2007–2013), which includes the following priorities:

- to increase the profitability of the sector as a whole;
- to reduce the environmental impact of fisheries and promote environmentally friendly technologies;
- to develop aquaculture and inland fisheries;
- to improve the quality of fish products, including guaranteeing food safety for consumers;
- to develop scientific thought and new technologies.

Within this context, the elements above that concern aquaculture may include some element of environmental impact studies and assessment methods. It is believed that the success of the Polish aquaculture industry can be ensured by co-ordinating the activities of fish producers, the state administration and organizations responsible for environmental protection.

Spain

Context

Spain is the most diverse producer of cultured aquatic organisms in the EU, commercially producing 66 species since the 1980s, with 35 species still being cultured in 2005 (FAO, 2007). However, only three species are produced in significant quantities (>10 000 tonnes per annum) and of these production is overwhelmingly dominated by blue mussel culture (*Mytilus galloprovincialis*) – producing 158 059 tonnes in 2005 with a peak of 262 000 tonnes in 1999. The largest fish production is the freshwater culture of rainbow trout with 25 959 tonnes in 2005. Within the marine environment turbot, seabream and seabass are the most important fish species, totalling 23 556 tonnes of production in 2005.

Regulation

The principal authorities for aquaculture development in Spain are the ministries for agriculture, fishing, the environment and public works and transport. Regulation of aquaculture comes under federal and state laws. There are two federal laws; Law of Marine Farming (Law 23/1984) and Law of Coastal Zones (Law 22/1988). These cover the regulation of aquaculture in rivers, lakes, coastal and land-based systems, and safeguard the public use of coasts and jurisdictional waters (EEZs). EU Directive

85/337/EC, amended in 97/11/EC, has been integrated based on Royal Legislative Decrees 1302/1986 and 1131/1988 as well as Law No. 6/2001 (FAO, 2006-2008 NALO Spain). In addition, all 17 autonomous regions in Spain regulate applications for aquaculture installations by requiring (Basurco and Larrazabal, 1999; Pinchetti, 2008) the following:

- A physicochemical and biological study of the area and surroundings, including: site location studies for new installations, hydrographic survey, evaluation of depuration systems, required water resources (closed systems) and effluent depuration and dumping control to avoid modifications to the original substrate conditions. Also, appropriate controls on the amount and use of chemicals (cleaning of installations and animal treatment) and feed must be investigated.
- Biological measures should include: the appropriate control of predators, control of chemicals and other substances and monitoring of disease. Studies on the natural distribution of species and carrying capacity of natural populations must also be investigated.
- A socio-economic study, including alternative uses of old installations; any social impacts the project may have and any potential impacts on the fishing sector.
- A technical study, including an adequate choice of locations to avoid landscape modifications and excessive noise; construction plans and maps of where the installation is to take place, as well as a financial account of the total budget needed for the development.
- A photographic study of the area, giving alternative locations for the aquaculture development.
- A study of the environmental impact; variables to be measured include:
  Water: pH, temperature, suspended organic/inorganic matter, colour, salinity, dissolved oxygen, hydrocarbons, organohalogen substances, metals (Ag, Ar, Cd, Cr, Cu, Hg, Ni, Pb, Zn; mg L^{-1}), nitrogen, phosphorus, chlorine, bromide, methane and sulphur compounds and faecal coliforms.
  Sediment: grain-size, organic matter and levels of polluting agents (heavy metals, hydrocarbons and chemicals).
  Biological variables: detection of micro-organisms (sulphobacteria and coliforms by microscopic observation of selective cultures and specific biochemical tests), monitoring of plankton, nekton and benthos.

Applications are approved by a number of authorities, specifically in order of importance; 1) regional councils, 2) local councils, 3) navigation authorities, 4) National Fisheries General Directorate, 5) Ministry of the Environment. Other organizations also include the regional Tourism Office, Service of Public Health and Fishermen Associations. In addition, each autonomous area applies their complementary regulations. It normally takes between one and two years to obtain a permit through this application procedure, but this can vary with region. Licenses are granted for up to ten years and renewed from between 10 and 50 years.

Land-based farms in Spain must have an administrative concession for the use of water. Each river basin has a hydrological plan and the law on water requires that when granting a concession for water usage, fish farms are placed in fifth position after water is supplied to populations, agriculture, hydroelectric energy production and other industrial uses. An impact study is required for the installation of a land-based farm through the government decree of 28 June 1986 pursuant to European Directive 85/337/CEE. An impact study must be submitted when the farm application undergoes public consultation. The concession for water use is granted by the organization that manages the river basin and the applicant has to pay a royalty for the use of water (Petit, 1999). The proposed approach corresponds to the general mode at the national level but it should be noted that there is also legislation at a regional level and hence each region has its own legislative power (CONSENSUS, 2005b).

Environmental standards for water and sediment quality conform to EU Directives, they include quality control of waters for shellfish farming (EC 79/923/CE) and technical and sanitary control over shellfish and finfish production (EC 91/492/CE) modified by Spanish Royal Decree 571/1999. In Galicia (Sanchez-Mata and Mora, 2000), these are applied by research centres managed by the regional government:

- Red Tide Control Centre – study of algal blooms and nutrient flux;
- Marine Research Centre – providing favourable environmental conditions for exploitation of marine resources;
- Marine Farming Centre – marine shellfish reproduction for repopulation of marine farming areas;
- Marine Aquaculture Research Centre – research on bivalve reproduction, larval development and broodstock viability and production of live feeds for marine fish larval production.

Classification and control of veterinary medicines and their residues are carefully regulated in Spain. The use of chemotherapeutants not referred to in ordinance 2377/90/EEC has been forbidden. Listed chemicals include antibacterial substances, medicines (anti-helminthics) and environmental contaminants: organochlorinated compounds (including polychlorinated biphenyls – PCBs), chemicals, mycotoxins and colorants. The residue levels for chemicals used in aquaculture are centrally defined, see Cacho (1999) and are encompassed in a National Plan for Residual Research in Aquaculture, for finfish and other aquaculture products.

Turkey

Context

Aquaculture has a relatively short history in Turkey and began with the farming of rainbow trout (*Onchorhynchus mykiss*) and common carp (*Cyprinus carpio*) in the late 1960s. It developed further with gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*) culture in the mid 1980s. Production of the three major species, namely rainbow trout, seabass and seabream increased rapidly during the 1990s. Production of rainbow trout, seabass, seabream, mussel and common carp had reached 80 000 tonnes per year by 2003, stemming from 1 659 farms (FAO, 2006-2008 NASO Turkey).

Legal framework

The institutional framework for aquaculture development is well established under the Ministry of Agriculture and Rural Affairs (MARA), the Fisheries Law, Article 13, first paragraph states: "Those who wish to set up/own aquaculture production facilities have to get permission from the Ministry of Agriculture and Rural Affairs (MARA)". MARA is responsible for the administration, regulation, protection, promotion and technical assistance of fisheries and aquaculture through four general directorates: the General Directorate of Agricultural Production and Development (GDAPD), the General Directorate of Agricultural Research (GDAR), the General Directorate of Protection and Control (GDPC) and the General Directorate of Organization and Support (GDOS).

The GDAPD is the responsible authority for development and management of aquaculture. The GD includes an Aquaculture Department consisting of three divisions; marine aquaculture, inland aquaculture and aquaculture economics and marketing its main responsibilities are (Okumus, 2007):

- producing and promoting policies for development of aquaculture;
- designating sites, area and zone for aquaculture;
- administering rental procedures for the sites;
- administering licensing process and issuing fish farming licenses;

- preparing and implementing projects;
- controlling and monitoring fish farms;
- providing technical and financial support.

GDAR is responsible for research and GDPC for movements of live fish, diseases and fish as food issues. MARA has provincial directorates in 81 provinces responsible for implementing policies issued by its central office in Ankara. Most of the licensing and monitoring and control activities are carried out by these provincial directorates. A number of public institutions are also involved in the licensing process of aquaculture sites including; the Ministry of Environment and Forestry, the Ministry of Culture and Tourism, the Navigation and Oceanography Department, the Under-Secretariat of Maritime Issues and the General Directorate of State Hydraulic Works (DSI).

Aquaculture is regulated through licensing, health and environmental regulations. The primary law concerned with the regulation of aquaculture is the Fisheries Law Act No. 1380 of 1971, amended by the Fisheries Law No. 3288 of 1986. More recently the Aquaculture Regulation No. 25507 of 24 June 2004 came into force, which addresses major issues related to the sector; specific issues are regulated through ministerial decrees (FAO, 2006-2008 NASO Turkey).

The regulation covers and sets out rules for the following issues (Okumus, 2007):

- site selection for inland and marine farms;
- application and evaluation procedures for fish farming licenses;
- approving the projects and issuing licenses;
- improving production capacity, species etc, cancellation (closing down farms), site changes and sales;
- other aquaculture activities (tuna fattening, organic farming, integrated production systems);
- importing brood fish, egg and fry;
- compulsory technical staff employment;
- fish health management;
- environmental impacts and protection;
- monitoring and control of farming activities.

Before aquaculture licenses are issued all projects are evaluated taking into account national economic development plans, general health issues, transport logistics and a number of technical and scientific factors. Despite recent revisions and efforts at simplifying the licensing procedure it is still quite complex and time consuming and currently most fish farming licenses are issued by the provincial directorates of MARA. According to the Environmental Impact Assessment Regulation (EIA) No. 25318 of 16 December 2003, those farms with an annual capacity of less than 30 tonnes do not require an EIA, farms with a capacity of between 30 and 1 000 tonnes per year only require to submit a preliminary EIA, while aquaculture projects with an annual production capacity of greater than 1 000 tonnes are required to prepare an EIA report (FAO, 2006-2008 NASO Turkey).

Applicants are required to submit their applications either to Central Office (of the MARA Aquaculture Department) or Provincial Directorates of MARA. These applications are submitted with all the relevant supporting documentation, including species, capacity, production system and a map of the area (1/25000 scale). Applications for trout, carp, seabass and seabream on-growing farms and hatcheries for these species (up to two million fry/year capacity) can be submitted to the Provincial Directorates, whilst applicants for other on-growing species (namely turbot, sturgeon, eel, algae, molluscs and crustacean species) and trout, carp and seabass/seabream hatcheries with an annual capacity of more than two million have to apply directly to the Aquaculture Department in Ankara (Okumus, 2007).

A team of experts from the central or provincial office then visits the site and prepares a preliminary survey report. If the report is positive, a preliminary license is issued for 8 months and can be extended up to 12 months. Supporting documentation submitted for the preliminary licence must include an application letter, site map (1/25000 scale), the preliminary survey report and a water quality report.

The applicant can then prepare the full project documentation, which includes a farm or hatchery design and feasibility report and an EIA report. Standard applications must include: environmental management data, feed type and method, type of aquaculture, size and number of cages or tanks, sketches of onshore buildings, location, proposed stocking density, species, volume and type of discharge, volume of chemicals to be used and method of application and the maximum production tonnage. Any plans for fallowing or rotation of cage sites should also be presented (Deniz, 2001).

Approval is also needed from other related institutions dependent on the nature of the project (e.g., Ministry of Environment and Forestry, Ministry of Health, Maritime Affairs, Department of Transport, Ministry of Culture and Tourism and local government). If the project is approved the license (Fish Farming Certificate) is issued. This usually takes one year or more. The rental contract period for marine cages sites is for a maximum 15 years although the contract can be terminated earlier by the government (Okumus, 2007).

Important decision criteria for applications include (Deniz, 2001):

i the degree of enclosure of the waterbody;
ii the presence of protected species/habitats;
iii the number of other aquaculture ventures in the area;
iv the carrying capacity of the environment;
v the type of proposal.

Site selection

Initially a cage-farm site is chosen by assessing the legal requirements, site access, shelter and presence of other cage farms. However where available, allocated areas for aquaculture are preferred. According to aquaculture regulations the following requirements should be met (Okumus, 2007):

- The area should be large enough for rotation and should be no less than twice the actual area occupied by the cages.
- The distance between cage farms is determined by the central Aquaculture Department according to the following criteria; projected annual production capacity, water depth and current speed. Distance between tuna cage farms, and tuna and other fish farms cannot be less than 2 km and no less than 1 km between other fish farms.
- The minimum annual production capacities of farms are set up by the Aquaculture Department; currently the minimum capacity for a cage farm is 250 tonnes per year.
- Offshore, on the open coast and outside enclosed bays and gulfs, cage sites should have minimum 40m water depth. However, the Aquaculture Department may allocate sites for cage farming in less than 40m when taking into account the capacity of the farm, water depth, current speed and the intended production system.

Shellfish aquaculture should be at least 1 km from tourist hotels and secondary housing development to reduce the risk of disease and faecal contamination. Cage aquaculture, hatchery and tank farms should be at least 1 km from tourist centres. In scenic areas, distances of 0.5 km, 0.75 km and 1 km respectively, should be adopted. These distances are dependent on topography, concealment and screening. Hatcheries, ponds and tank farms should be screened from view with trees and shrubs. Cage and raft culture is restricted in heavily used recreational waters, but is permitted in waters with irregular traffic, this requires liaison between GDAIPD and the Navigation and Oceanic Directorate. Fish farms are encouraged to mark their boundaries clearly, all installations should have marker lights and tourists are not permitted in these areas (Deniz, 2001).

In 2006, the Ministry of Environment and Forestry amended the Environmental Law to exclude marine cages from environmentally sensitive areas, enclosed bays and near shore areas. Unfortunately the amendment to the law was prepared without any consultation with stakeholders and the definitions in the bill are considered somewhat vague. In addition the duration given to farmers to move to new sites out-with these areas was very short and unrealistic, thus the producers have taken the case to the Supreme Court. The Supreme Court has suspended the enforcement of the amended law, but operates according to the following environmental decree (Okumus, 2007):

- Parameters for sensitive areas where cage fish farms are prohibited:

Parameters	Criteria
Water depth	≤ 30m
Distance from coastline	≤0.6 mile
Current speed	≤ 0.1 m/s

- Fish farms can not be established in special protected areas or archaeological areas; large areas of the western Mediterranean and Aegean are enclosed within national parks or have special protected area status.
- Those fish farms outside the sensitive areas must be assessed according to the TRIX Index (TI) and reported to the Ministry of Environment:

TRIX Index (TI)	Explanation
TI < 4	No eutrophication risk
4 ≤ TI ≤ 6	High eutrophication risk
TI > 6	Already eutrophic

Licences granted by MARA are reviewed every two years. MARA scientists monitor conditions at representative aquaculture sites, before, during and after implementing the project. At least every two years near large farms. The data are then used to review and if necessary, alter the licensed production capacity. Licences are not automatically renewed without environmental data and can be withdrawn if the environmental quality standards are exceeded. A system of punitive measures for transgression of license conditions in order of severity may be implemented as follows: (i) monetary fine; (ii) withdrawal of licence; and (iii) withdrawal of licence and fine (Deniz, 2001).

Integrated coastal zone management

The lack of coastal zone management plans and subsequent site allocation leading to conflicts of interest and competition between the tourism and aquaculture sectors is one of the major constraints in the development of marine aquaculture. The Government of Turkey has gone to great effort since 2000 to resolve these conflicts. Site and area allocation plans have been prepared along the Mediterranean and Aegean coasts involving various stakeholders with some areas identified as immediately or potentially available for aquaculture development. Most of the marine farms have already left the well protected, near shore shallow waters and moved to relatively exposed offshore areas. In addition many farms now use the larger modern high density polyethylene (HDPE) circular cages (10–24 m in diameter) rather than the smaller locally made wooden cages.

Consumer expectations on fish quality, environmental and animal welfare issues and all year round product availability are increasing and intensification is causing serious outbreaks of disease and parasites leading to the use of antibiotics and other chemicals. MARA is attempting to effectively monitor all fish farms for diseases and to test for antibiotic/chemical residues in market size fish. Thus, stricter environmental monitoring will commence in the near future (FAO, 2006-2008 NASO Turkey).

Recently the Aquaculture Producer's Association (also a member of the FEAP) has been founded and has begun to provide valuable assistance towards aquaculture development. The current rate of development of the Turkish aquaculture sector is expected to continue, however poor product diversity, resource use conflicts, water availability and increasing environmental and animal welfare issues will be limiting factors (FAO, 2006-2008 NASO Turkey).

United Kingdom

Context

Aquaculture production in the United Kingdom is dominated by the culture of Atlantic salmon (*Salmo salar*) in Scotland. EIA regulation and monitoring for Atlantic salmon specifically is covered by Wilson *et al.* (this volume). Feeding this industry, however, is a relatively large cultivation of salmon smolts in freshwaters, through a combination of cage culture (relatively unique to Scotland) and through production in raceways. Smolt production is not typically measured in production (tonnes) but in smolts produced for on growing in sea cages. In 2006 production of smolts was 41.1 million. Other species produced in marine systems include cod, halibut and sea trout, which between them accounted for 543, 233 and 267 tonnes respectively in 2006 (CEFAS, 2008). In addition, production of rainbow trout in England and Wales totalled 4 866 tonnes in 2006 and 6 628 tonnes in Scotland. Arctic Char was also produced in small quantities (3.5 tonnes). Significant amounts of mussels (*Mytilus* sp.) and oysters (*Crassostrea gigas*) are also cultured, typically on long-lines and in intertidal bag culture respectively. In 2006 production of mussels was 4 219 tonnes and of oysters was 251 tonnes in Scotland; 3 181 tonnes and 680 tonnes respectively in England; 10 157 tonnes and 12.5 tonnes respectively in Wales and 10 000 tonnes and 346 tonnes respectively in Northern Ireland (CEFAS, 2007)

Management of aquaculture

Within the UK, the sovereign powers devolved to the regional governments in Scotland and Northern Ireland result in specific powers concerning the regulation and control of aquaculture development. England and Wales are considered together under common legislation, despite devolvement of specific powers to the Welsh Assembly. Although the legislative controls may operate differently between countries, in general terms the requirements for EIA as part of the application process (EU Directives, as applied into UK laws) and the provision of monitoring requirements, for example through permitted consent to discharge and more recently the EU Water Framework Directive, are generally similar between countries.

Throughout the UK the organizations responsible for aquaculture are the Department for Environment, Food and Rural Affairs (DEFRA), the Department of Agriculture and Rural Development for Northern Ireland (DARD) and the Department for Environment, Planning and Countryside (DEPC, Wales). In addition, there are two executive agencies responsible for scientific research and giving advice on aquaculture development; including the Fishery Research Services (FRS) in Scotland and the Centre for Environment Fisheries and Aquaculture Science (CEFAS) in England, Wales and Northern Ireland. In addition, the Seafish Industry Authority (SEAFISH) has no direct regulatory role but is a key public authority in management and promotion of aquaculture development, working across all sectors of the seafood production sector for the promotion of high quality, sustainable seafood.

Legislative framework for EIA and aquaculture

As a member of the EU the UK is required to implement EU Directives within their own legislation. The responsibility for this task lies with DEFRA (England and Wales), DARD (Northern Ireland) and SEERAD (Scotland). In the UK Environmental Impact Assessment (EIA) is an integral part of the process of determining most applications for marine fish farms, though not necessarily all others forms of aquaculture development. The EU Directive on Environmental Assessment (85/337/EC) as amended by Directive 97/11/EC seek to ensure that where a marine aquaculture development is likely to have significant effects on the environment the potential effects are systematically addressed in a formal Environmental Impact Statement (EIS).

The Environmental Impact Assessment (Fish Farming in Marine Waters) Regulations 1999 brought the amended EU Directive into force and superseded the Environmental Assessment (Salmon Farming in Marine Waters) Regulations 1988 with effect from March 1999. As the title suggests EIA now applies to all marine fish farm developments (including halibut, cod), provided they are above the trigger points for its enactment; i.e. being greater than 100 tonnes biomass or covering an area of 0.1 ha or more. It is not inevitable that an EIA will be required when the development is above these values, but the process of scoping (determination by the competent and statutory authorities) is enacted at these trigger points. Below these critical values EIA may still be required, depending for example, on the perceived environmental impact, which may vary with local water conditions.

There is currently no requirement for shellfish farm applications to undergo an EIA. Instead applications for shellfish farms are assessed only through public and statutory consultation, on submission of an application. Water quality for shellfish culture is governed under EU Directive 79/923/EEC, which requires areas to be of a suitable quality or to be improved for culture of shellfish. In Scotland, the directive has been implemented as the Surface Waters (Shellfish) Classification (Scotland) Regulations (1997). This Act establishes a classification of waterbodies where SEPA, the regulatory authority, has an obligation to implement suitable monitoring criteria to classify and ensure that waters are of suitable quality for culture. The onus is not on the aquaculture developer, who is not required to monitor their site.

Under the Registration of Fish Farming and Shellfish Farming Businesses Order (1985) and amended as Registration of Fish Farming and Shellfish Farming Businesses Amendment (Scotland) Order (2002), all aquaculture companies must register within two weeks of site operation.. The register is kept by FRS in Scotland, DEFRA in England and Wales and DARD in Northern Ireland. It records all movement of cultured organisms, to prevent spread of disease and introduction of unwanted species.

More generally the application of the EIA process in the UK is coordinated through Local Planning Authorities and to aid this process the EIA requirements are translated into a Planning Advice Note (PAN) No 58, which therefore plays a role in aquaculture development specifically.

Legislative framework for consent in aquaculture

The legislation concerning aquaculture development in Scotland is a two-fold process, with an application for siting (as outlined above) and following this, an application for consent to discharge (waste) for both marine and freshwater culture. Initially under the Control of Pollution Act (COPA) 1974, aquaculture development in Scotland now comes under the auspices of the EU Water Framework Directive as The Water Environment (Controlled Activities) (Scotland) Regulations 2005. Applicants are required to gain a Controlled Activities Regulation (CAR) license from SEPA, which permits feed, faecal and dissolved wastes generated by fish to be discharged to the environment. Each license issued is farm specific and lays down the maximal biomass (marine) or production (freshwater) allowed, the infrastructural requirements (included number and size of cages/ponds etc) based on the application. The CAR license also identifies the site-specific monitoring requirements, if applicable.

The legislation concerning aquaculture development in England and Wales is slightly different. Permission for consent to discharge wastes from pond and raceway farms is explicitly not included under the WFD legislation (The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003). Instead discharges are managed under the Prevention of Pollution and Control (PPC) regulations 2000 (UK, 2000). Under these requirements a fee is charged to the farm operator by the Environment Agency (EA) and the EA undertake all water quality assessments. In Northern Ireland consent to discharge is required under the Water Order (Northern Ireland) 1999. In a similar fashion to England and Wales a fee is charged and the regulatory authority carried out all monitoring requirements.

Aquaculture planning applications – freshwater sites

Applications for development of freshwater sites, such as for salmon smolts or trout production, are made to the Local (County) Planning Authority (LPA). Such an application is more often through a pre-application consultation with planning representatives initially, to discuss the application in general terms. Information required for such a meeting might include equipment details, requested production maxima, a general evaluation of infrastructure capacity, such as road access and a basic assessment of environmental impact. A typical example of the information required for a freshwater site application is as follows (UK, 1999):

- an ordinance survey map indicating the exact location and size of the site;
- confirmation of ownership or lease of the site, or letters of intent of sale or lease from owner;
- where appropriate, planning permission;
- a copy of the consent to discharge effluent granted by the Regulator (= Environment and Heritage Service, Water Management Unit, or written confirmation that the developer has applied for such consent under the Water Order (Northern Ireland) 1999);
- a business plan in support of the proposed operation.

Often companies planning to operate fish production facilities will have already conducted a feasibility study for a particular waterbody. Companies need to evaluate cost-effectiveness depending on the possible tonnage levels and environment effectiveness through assessment of local fish populations (in lakes specifically) or water abstraction for ponds and raceways, for example. There is a significant body of literature concerning, for example the Water Framework Directive (UK, 2008), from which the status of a waterbody and likely effects from aquaculture development can be determined. This in turn enables developers to determine how these might affect their aquaculture development plans, in terms of the infrastructure, size and design of their facility. Under current legislation freshwater sites are not required to enact the requirements of an EIA process.

Aquaculture planning applications and EIA – marine sites (mainly Scotland)

Until recently (2007) aquaculture development came under the direct coordinative control of the Crown Estate (CE), particularly for salmon in marine systems, but equally applicable to other species including Atlantic cod and halibut (Crown Estate, 1999). Authority was transferred to Local Planning Authority control in April 2007 through the Town and Country Planning (Marine Fish Farming) (Scotland) Order 2007. As a result the Scottish Government coordinated a consideration of the implications of EIA through a consultation and workshop series. This resulted in a revised methodology for the treatment of EIA for marine fish culture in Scotland (RPS Group PLC, 2007), which proposed a defined timescale for consideration of a marine fish farm application.

This process has not currently been evaluated, due to insufficient applications having been made, but it attempts to re-invigorate the EIA requirements in the EU Directive and also to simplify the requirement through "consideration of the risks of only those impacts that are liable to have a significant effect on the environment" (RPS Group PLC, 2007) and to reduce the shear volume of some EIAs, that would often contain an evaluation of all impacts no matter how small. In this context the Planning Advance Note PAN58 serves as the template for the process, which is outlined as follows:

- project initiation – 'Design with the Environment';
- screening;
- scoping and pre-application discussions;
- environmental studies;
- preparation of Environmental Statement (ES);
- submission of planning application with ES;
- review of the ES by Planning Authority and consultees (possible request for further information);
- evaluation of environmental information and other material considerations by the Planning Authority;
- decision: refuse or grant (with or without planning conditions); and
- implementation and monitoring.

With this in mind, following the formal application to the Planning Authority, it is they who coordinate initial responses (the screening assessment) from statutory consultees, which may result in either more information being provided outside the process of EIA, or a full EIA being required. The Planning Authority coordinates the statutory consultees' opinions and returns these in a single document (the screening opinion and scope for investigation) to the applicant as information that must be considered within the EIA.

Statutory consultees involved in the development of aquaculture in Scotland are (1) the Local Planning Authority (LPA), who issue planning consent, (2) the Scottish Environment Protection Agency (SEPA) who administer the regulatory control concerning the environment and who are the government's environmental regulators and responsible for issuing discharge consents for waste materials and (3) Scottish Natural Heritage (SNH), an NGO with responsibility for environmental and biological conservation in Scotland. In England and Wales 2 and 3 change to the Environment Agency (EA) and English Nature (EN) respectively and in Northern Ireland the Environment and Heritage Service (EHS). Such responses result in a screening opinion, highlighting the particular areas of concern. If sufficiently warranted, i.e. the impacts are deemed likely to be significant, then an EIA would be requested.

The requested EIA is reported in a single bound submission called an Environmental Impact Statement (EIS). The EIS requirements for marine fish farms are governed under EU Council Directive 97/11/EC, which amended Directive 85/337/EEC (see Annex 1). In Scotland a fuller explanation of the EIA requirements are also included in the SEPA fish farm manual (SEPA, 2005).. This EIS will contain the information relevant to nutrient and organic waste and medicines and will take the form of:

- a description of the physical characteristics and transport requirements of the project;
- a description of the existing environment. This includes baseline surveys to assess hydrography, sediment quality and characteristics in the proximity of the proposed cage sites;
- a description of the production processes;
- an estimate of type and quantity of expected residues and emissions from the cages;
- a description of those aspects of the environment likely to be significantly affected by wastes from the cage production, plus details of the potential effects on the waterbody as a whole;

- a description of the measures taken to avoid, reduce or remedy the impacts from nutrient and medicinal wastes;
- conclusions and
- non-scientific executive summary.

The onus in the EIA system in the UK is that the applicant must provide the necessary information to allow a determination of approval, or not, to be made at the applicant's expense. After delivery of the EIS, the applicant must make available copies of the EIS should the public require access to the information as part of wider consultation in the approval decision. The Planning Authority has the right to require a public hearing to determine whether the application can go ahead. Equally the public is free to object and make representation at a public hearing. Ultimately it is the Planning Officer who decides whether approval should be given or not.

Site monitoring requirements – marine and freshwater

In Scotland site monitoring is required at all marine sites and is the responsibility of the farm operator to pay for this to be carried out. The methods used are to a prescribed formula, which is notified to fish farmers through a regularly updated web-based manual (SEPA, 2005). The nature of the survey is dependent on the individual consent given by SEPA, but generally consists of either a "standard", "extended" or "site-specific" survey. The difference meaning simply the number of sampling stations required. All surveys are based on sediment quality criteria and sediment samples are analysed for macrobenthos (where a number of biological indices are calculated, primarily the Infaunal Trophic Index), organic carbon content, particle size, redox potential and where required, copper and zinc levels. In addition, samples are taken for analysis of concentration of the anti-parasite SLICE (active ingredient emamectin benzoate). All these parameters are compared with published Environmental Quality Standards (EQS) within an Allowable Zone of Effect (AZE) to see if the farm has passed or failed consent. As peak biomass generally occurs once during a production cycle the surveys are most often done at approximately two-year intervals. For the analysis of the anti-parasite compound used, samples must be collected within 110 days of a treatment. The locations of the sampling stations and the diameter of the AZE are often site specific depending on the local hydrography and modelled by the regulatory waste dispersion model DEPOMOD (Cromey *et al.,* 2002).

In Scotland there is to date no equivalent manual for freshwater ponds, tanks systems or cage-culture; though this is under development. For trout or pre-smolt salmon grown in cages in freshwater lochs (lakes), water samples are collected typically on a bi-monthly basis (six times per year) by SEPA. This is analysed for total phosphorus and Chlorophyll-a concentration. These are then compared to quality standards designed to characterize the trophic status of the waterbody. The implementation of the WFD is causing changes to this policy, where in more sensitive sites (typically where there is risk of failing to meet the requirements of the WFD) producers are required under their CAR license, to have some form of survey (yet to be defined and likely to be site specific) each year conducted at the farm operators' expense. This may be more detailed water quality measurements or a survey of sediments near to the farm.

Land-based cultures (mainly raceways for trout or, in Scotland, for pre-smolt salmon) rarely have similar conditions applied and farms are not specifically required to carry out water quality assessments. Most do, however, as part of their management practice and procedures. In England and Wales and Northern Ireland, where production is primarily based on pond and raceway culture no company is obligated to provide environmental monitoring (even though most do for internal management purposes).

In Scotland, freshwater farms have consents where quality of inflow and outflow water is compared. The samples are taken by the regulator. Conditions are site specific, for example:

- pH must be in the range 5–9;
- BOD of discharge must not exceed intake by more than 2 mg/l;
- the suspended solids level of the discharge must not exceed that of the intake water by more than 5 mg/l;
- the ammoniacal nitrogen content of the discharge must not exceed that of the inlet water by more than 0.5mg/l.

In all cases (marine and freshwater) a fee is charged for the consent by SEPA, the EA or EHS (depending on the country) in order to at least partially fund the monitoring the regulators undertake. In all instances failure to maintain the status defined by the environmental quality standards (in both marine and freshwaters) can result in sanctions being applied by the regulatory body. These can result in a reduction or removal of the consent to discharge wastes, in which the farm ceases operation. For serious infringement, the regulator has the power to take the operator to court, which might result in fines being imposed. However, there are no specific policies on "sanctions" and implementation of sanctions is not readily evaluated.

Use of veterinary medicines – Scotland

The authorization of veterinary medicines used for aquaculture requires a marketing authorization for its initial use and an individual, site specific discharge consent. Marketing authorization is granted by the Veterinary Products Committee (VPC), under the auspice of the Veterinary Medicines Directorate (VMD). Before this is granted there is a three phase procedure leading to an environmental risk assessment, under EU Directive 92/18. The discharge consents for individual fish farms are granted by SEPA based on the hydrographically modelled dispersion of the product on entering the environment. This consent is given in the form of a total amount of product per production cycle and has lead to the situation where fish production is limited by veterinary medicine use rather than nutrient waste entering the environment.

NORTH AMERICAN ENVIRONMENTAL MONITORING AND EIA REQUIREMENTS

Canada

Context

Canadian aquaculture is dominated by Atlantic salmon on both the Atlantic and Pacific coasts. The EIA and monitoring requirements of marine salmon cage culture is reviewed by Wilson *et al.*, (this volume). Other significant cultured species are primarily bivalve shellfish, in particular the blue mussel (*Mytilus* sp.) on the Atlantic coast (22 764 tonnes production in 2005; FAO, 2007). The focus of this review is shellfish culture, with occasional mention of finfish culture where this is relevant.

General regulation requirements

The aquaculture industry in Canada is overseen by a combination of federal, provincial and local authorities (FAO, 2007-2008 NALO Canada). There are a number of legislative, regulatory and licensing measures in place to minimize the effects of aquaculture on the marine and freshwater environment. Aquaculture operators are also bound by industry codes of practice, both at the national and provincial level. The main instruments include:

- The Fisheries Act;
- The Canadian Environmental Assessment Act;
- National Code on Introductions and Transfers of Aquatic Organisms;
- Finfish growers Codes of Conduct (salmon).

In Canada, the regulation of access to land and water for aquaculture development is under shared jurisdiction of federal, provincial and local governments. All proposals must go through an interagency referral process, which is coordinated at provincial level. The federal Department of Fisheries and Oceans Canada (DFO) coordinates, in conjunction with the provincial bodies, the review of aquaculture applications and is responsible for ensuring compliance with the Fisheries Act (1985).

Freshwater finfish aquaculture operations are on privately owned land, whereas coastal aquaculture normally occupies provincially (state/crown) owned foreshore. The latter requires an aquaculture license under the provincial Fisheries Act (1996) and a crown land tenure (lease) under the provincial Land Act (1996). Both requirements can be processed and approved at a single location, the Ministry of Agriculture and Lands. This body takes environmental issues into account as well as siting criteria, coastal resource plans and First Nations rights into account, when making a decision. If successful, a five year license is normally issued within which time the aquaculture developer is required to prove the suitability of the site for development. If within this time the developer has not done so then potentially a license can be issued for further development; or the EIA and full application has proved successful a longer 20 year license is given. This legislation is relevant to both fish and shellfish culture sites.

EIA requirements – shellfish

Under the Canadian Environmental Assessment Act (1992) (CEAA), Transport Canada must conduct an environmental assessment for marine aquaculture development. Screening factors are defined under the Act related to environmental impacts, public consultation and mitigation measures to reduce impacts (Figure 5). Essentially, for shellfish farming the DFO (in consultation with stakeholders and other legislative bodies) make the decision as to whether an EIA is required or not, whilst taking into account the size and type of development (see Annex 2). It thus determines what the scope of the EIA will be under the CEAA (DFO, 2002a):

- the project;
- contact information;
- physical location and site detail;
- design & operational plans;
- existing environment;
- aquatic environment;
- biological environment;
- socio-economic environment;
- public consultation;
- changes to the project caused by the environment;
- cumulative environmental effects.

In the context of the EIA process there is also a primary place for the public to become involved in the assessment. The competent authority is required to place much information on government registries, which are then open for access. The public is thus able to:

- review information registered on the CEA Agency's Federal Environmental Assessment Index (FEAI) at: www.ceaa.gc.ca/0008/index_e.htm;
- review a public registry that is maintained for every EIA to facilitate convenient public access to the records relating to the EIA;
- where the regional authority is of the opinion that public participation in the screening of a project is appropriate, they may provide the public an opportunity to review and comment upon the screening report and any record in the public registry.

Importantly any comments from the public received by the regional authority have to be considered in the environment impact assessment process.

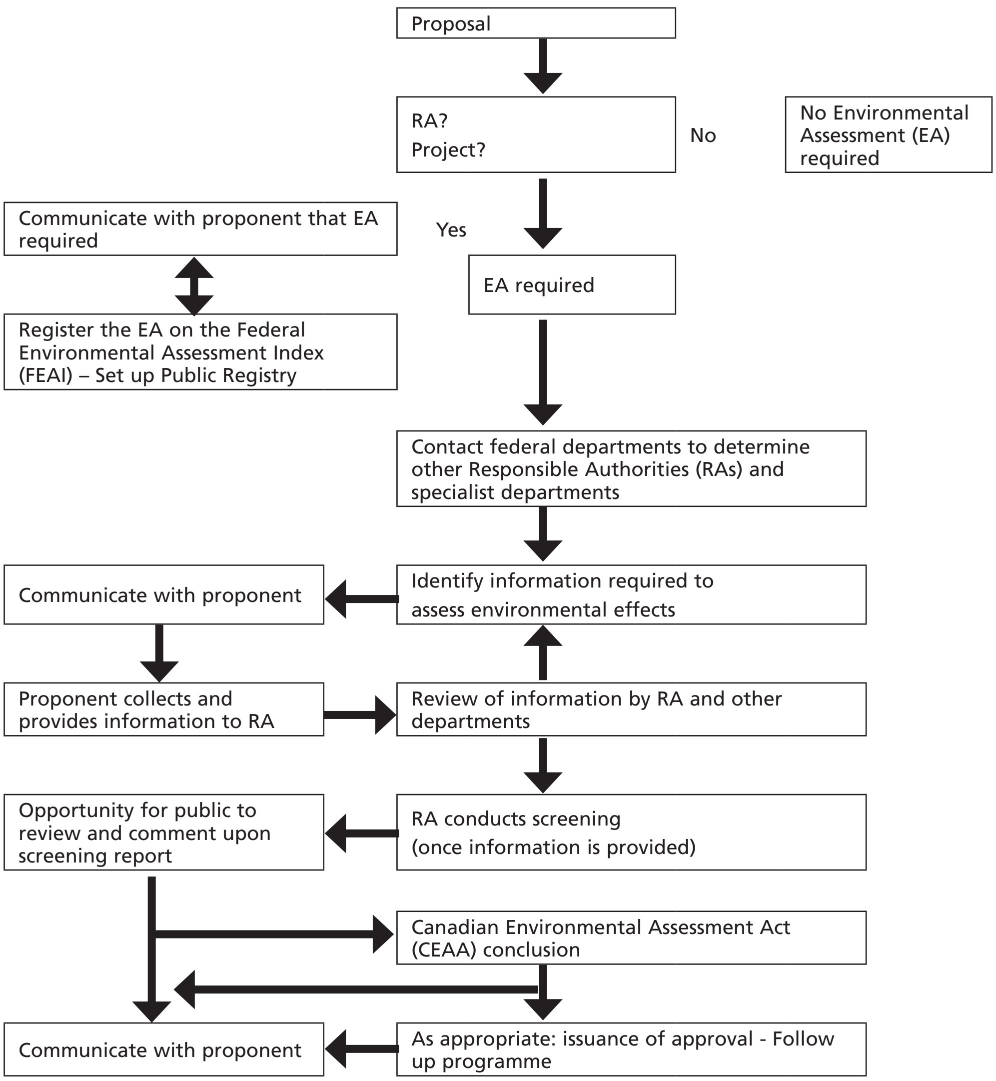
The potential for adverse effects are determined by comparison with the predicted environmental quality after development with the present conditions. This approach uses baseline data accumulated either from published information or new data collected as part of the EIA process. The significance of any adverse effects is then assessed using the following criteria defined by the Canadian Environmental Assessment Agency:

- the magnitude and severity of the adverse effect;
- the degree to which this effect is reversible or not;
- the ecological context of the adverse effect in terms of the ecosystem.

Under these criteria the significance is determined using environmental standards or using a quantitative risk assessment approach, which assumes an "acceptable" level of risk. If these assessments are not possible the DFO has the ability to apply a "best professional judgement" decision of significance of effect. Finally, the likelihood of this significant effect happening in the particular locality is determined using a "probability of occurrence" approach (DFO, 2002b).

Much of the above process can be presented in an easily understandable format using a risk matrix. An example for shellfish farming is given in Annex 3. The significance

FIGURE 5
The screening process for EIA as designated by the CEAA monitoring requirements (DFO, 2002b)



of an effect on a specific aspect of the environment (also known as Valued Ecosystem Components – VECs) and mitigation measures for all project activities are defined, as well as the determination of the significance of the effect, the requirements for follow up monitoring for each effect are also recorded.

DFO and other federal, provincial and territorial government departments monitor aquaculture operations. This may be done by reviewing monitoring data gathered by aquaculture operators as part of the requirements of their licence, lease or other approval, or by conducting periodic on-site audits of operations.

Ongoing monitoring is usually a requirement of provincial licences or approvals. Provinces often require that aquaculture operators report on the performance of their sites by measuring certain indicators in the environment that tell regulators what kinds of environmental effects might be occurring at the site. Provincial and federal officials may also visit farm sites to evaluate firsthand how well the farm is operating. Provinces also share monitoring information with federal agencies.

DFO and provincial agencies are responsible for the development of mutually agreed upon monitoring requirements, standards and methods for assessing the effects of aquaculture operations. However, Environment Canada (who is responsible for preservation and enhancement of the quality of the natural environment and the protection of Canada's water resources) coordinates environmental policies and programmes for the federal government, and remains responsible for regulating the deposits of deleterious substances into fish bearing waters. DFO supports Environment Canada in identifying options for regulating the deposit of deleterious substances by aquaculture operations and in the development of industry best management practices designed to avoid deposits due to aquaculture activities.

The DFO's guide to the environmental assessment of marine finfish aquaculture projects (see: DFO, 2008) identifies the information required to assess the environmental effects of marine aquaculture operations of most finfish species under the Canadian Environmental Assessment Act (CEAA). The documents are intended to encourage consistency in the application of DFO's review processes across regions. However, in some circumstances, regions may determine that it is appropriate to require less information than is outlined in the guides.

Factors which may affect the level of information and monitoring required include:

- the size, scope and type of the proposed operation, (e.g. Atlantic cod grow-out, may require less than an Atlantic salmon farm);
- the extent of other activities in the area;
- site characteristics;
- the temporal utilization cycle (e.g. continuous occupation, fallow periods, seasonal operation).

There are a number of oceanographic and water quality requirements:

- range of depths through site (metres) maximum depth at yearly highest tide (metres);
- minimum depth at yearly lowest tide (metres);
- minimum depth between bottom of aquaculture facilities / structures (i.e., cages) and seafloor at lowest tide (metres);
- direction of maximum fetch;
- estimated maximum wave height (metres). monthly average temperature profile, plus annual minimum and maximum water temperatures at the site;
- salinity profile, plus annual minimum and maximum salinity values for the site;
- oxygen profile taken at the deepest location during late summer or early autumn, plus Secchi disc depth;
- list any other known organic matter inputs and/or sources of contaminants that may exist within the bay or in close proximity to the site, e.g. raw sewage, agriculture, forestry, fish processing.

The Canadian Shellfish Sanitation Program (CSSP), jointly administered by DFO, Environment Canada and the Canadian Food Inspection Agency (CFIA), provides for the continuing evaluation and classification of the level of contamination in the water overlying shellfish growing areas (DFO, 2002a). If the proposed site is located within a shellfish classification area, the current classification and the date of the most recent survey must be specified. If not, the location of and distance to the nearest classified area and the date of its most recent survey must be specified.

The current regime must be described (e.g., circular, vortex, seaward, landward, inflow/outflow) and the following information on currents at the site must be provided:

- the tidal slack period (minutes);
- average current speed (cm/s);
- minimum current speed (cm/s);
- maximum current speed (cm/s);
- predominant current direction(s).

Further information on the sea bed sediments are required for monitoring on environmental impacts:

- underwater visual survey of the seafloor beneath the potential site where turbidity and depth permit, including an assessment of substrate type, abundance of flora and fauna, plus other habitat features;
- particle-size analysis;
- percent organic matter content in the sediment;
- redox (Eh) and sulphide data for the benthic environment.

The DFO uses information from the Eh and sulphide measurements and the underwater video survey, to determine existing sediment conditions.

Environment Canada also recommend that if there are other aquaculture operations, agricultural and/or other industrial activities contributing discharge or runoff to the receiving water, the assimilative capacity of the waterbody should be considered. Assimilative capacity can be determined by a number of physical, chemical and biological factors. Chemical factors may include nutrient levels (e.g. nitrogen, phosphorus), biological factors include plant composition and abundance; fish types and abundance; and the composition of invertebrate populations.

Nova Scotia – an example of aquaculture environmental monitoring at the provincial level in Canada

Due to the expansion of all forms of species culture within the aquaculture industry, increased public concern and a commitment to ensure environmental sustainability, the Nova Scotia Department of Fisheries and Aquaculture (DFA) implemented an adaptive province-wide Environmental Monitoring Program (EMP) in autumn 2003 (DFA, 2006).

Monitoring is conducted on both aquaculture leases and at reference stations and consists of collecting qualitative (video) and quantitative (sediment and water analysis) data from coastal areas throughout Nova Scotia. The EMP focuses on the potential effect of aquaculture on bottom sediment rather than the water column and follows a risk-based approach that recognizes increased risk requires increased monitoring.

All sites currently in production are tested and those with larger production are given higher priority. Sites of potential concern are subject to repeat sampling and, if required, remediation action is implemented. Through scientific research, Environmental Quality Definitions (EQDs) have been established as a means of classifying the level of environmental change in marine sediments (see Table 4). The EQDs contain both qualitative and quantitative variables. For regulatory purposes, the focus is on sediment geochemistry and analysis of marine sediment is based on the measurement of total dissolved sulphide, redox, organic content and porosity. The

Nova Scotia DFA state that sulphide is a sensitive indicator of habitat degradation due to organic loading and is the main parameter currently used to determine direct impact of an aquaculture operation. Porosity is the percentage of pore volume or void space, or that volume within any material (e.g. bottom sediment) that can contain water. Porosity is also known as sediment water content and can be used to interpret recent deposition at the sediment surface (DFA, 2006).

The EMP now has a record of the specific effects to the marine environment around aquaculture sites in Nova Scotia. It has been found that once sites have been measured multiple times in different seasons, it is possible to measure the risk of environmental impact. With this large baseline data set DFA can now assess risk between sets of alternate aquaculture strategies, such as comparing finfish vs. shellfish, bay vs. site, active site vs. non-active site. Such a system aids the decision-making process.

The EMP employs similar methods to sample a diverse aquaculture sector that includes both big and small finfish and shellfish operations located in a variety of marine ecosystems. It is the first time that such a programme has been carried out in Nova Scotia and is the first time that empirical evidence exists on an industry-wide scale. It is hoped that the growing body of data collected will go a long way to ensure that aquaculture in Nova Scotia remains environmentally sustainable (DFA, 2006).

United States of America

Context

Freshwater aquaculture production in the United States of America is dominated by the culture of channel catfish, which accounted for 275 754 tonnes out of a total of 337 021 tonnes produced in 2005 (FAO, 2007). Rainbow trout (27 504 tonnes) and crawfish (16 355 tonnes) also account for a large percentage of the total production. These three species accounted for 95 percent of the freshwater production in 2005. Within the marine sector, excluding salmon, 125 536 tonnes were produced in total in 2005 (FAO, 2007), which was dominated by the production of three shellfish species: the American cupper oyster (55 188 tonnes) on the Atlantic west central coast, and the quahog (38 635 tonnes) and the Pacific cupper oyster (21 323 tonnes) on the Pacific northwest coast.

Regulation

Aquaculture in the United States of America is regulated at both state and federal levels (FAO, 2006-2008 NALO USA). At the federal level regulation of aquaculture is done by the Food and Drug Administration (FDA), the US Department of Agriculture (USDA) and the US Environmental Protection Agency (USEPA). Other federal agencies that have an advisory role within aquaculture regulation are the National Oceanic and Atmospheric Administration (NOAA), the Department of Commerce, the Joint Subcommittee on Aquaculture (JSA) and the US Fish and Wildlife Service (FWS). The role of these federal agencies relates to the trade of goods and services from various sectors between states or with other countries, hence they are not specific to aquaculture.

At a federal level EIA regulations do not specifically require that aquaculture undergoes an EIA. Therefore in most US states an Environmental Impact Assessment is not required to register an aquaculture facility. However, before the permit for aquaculture is issued an application must be submitted that contains much of the production and practice information contained within an EIA. Some states are beginning to require EIA for aquaculture development, which stems from respective state plans for the development of the industry. For example California had become the first in 2006 to maintain "comprehensive controls on future fish farming…" (Kay, 2006) with an EIA being required for any form of aquaculture development (California Fish and Game Commission, 2007). This is transposed into a Project Environmental Impact Report or "PEIR". Available for public assessment the PEIR is used to evaluate

TABLE 4
Environmental quality definitions for Nova Scotia marine aquaculture monitoring

	Measurement	Norm-oxic	Sub-oxic	Anoxic
Qualitative measures (from video & sediment observations)	Sediment colour	Tan to depth of > 0.5 cm	Tan to < 0.5 cm and/or patchy black sediments at surface	Surface sediments black
	Microbial and algal (plant presence)	No sulphur bacteria present (also benthic micro-algae or macro-algae at shallow sites)	Patchy or occasional sulphur bacteria and cyanobacterial biofilms	Sulphur bacteria may be widespread
	Macrofaunal (animal) assemblages	Wide array of infauna and epifauna; may include large burrowers	Mixed assemblages of small infauna which may include larger animals	Small infauna or tube-dwellers at shallow sediment depths
Quantitative measures (from sediment analysis)	Redox (mV)	0 to 300	-100 to 0	< -100
	Sulphide (µM)	<1300	1300 to 6000	> 6000
	Organic content (%)	≤ reference*	1.5 to 2 x reference	> 2 x reference
	Porosity (%)	≤ reference*	1 to 10 x reference	> 10 x reference
Site classification		**Type A**	**Type B**	**Type C**

(*) Values compared to reference assume that reference and lease stations would have had similar levels in pre-culture conditions.

Source: Smith et al., 2002.

the impacts of the aquaculture development and is a key to gaining the appropriate licence to operate. Such a requirement is not specific to all US states.

More detailed environmental regulation of aquaculture exists at state level. Each state is responsible for regulation of aquaculture and each framework varies slightly in its implementation. However, in general principles adopted can be described as follows. All marine aquaculture activities within three miles of the coast are subject to state regulation and these activities must under law be registered with the relevant department, stating the owner, species grown and location of the activity.

Wastewater discharge and water quality are controlled at both federal and state levels, therefore approval must be sought from both the state (regulatory authorities vary with state) and the EPA to discharge pollutants into inter-state waters, under the Federal Water Pollution Control Act. This involves issuing a permit under the National Pollutant Discharge Elimination System (NPDES) programme. The permitting authority is usually at state level overseen by the EPA. A list of the Departments for Environmental Protection for each state is given in USEPA (2006). The required permit:

- identifies outfall points from which facility discharges wastewater to surface waters;
- sets requirements to protect the quality of surface water (such as pollution concentration limits, management practices and record keeping) that the discharger must meet;
- allows an operation to discharge pollutants as long as the operation meets the requirements in the permit.

Under the Concentrated Aquatic Animal Production (CAAP) programme and Effluent Limitations Guidelines (ELGs), new performance standards for aquatic animal production were established by the EPA in 2004 (USEPA, 2006). This establishes effluent limits for aquaculture systems producing more than 100 000 lbs (approximately 45 tonnes) of fish per year in flow-through, re-circulating or net-pen systems, which reduce suspended solids, nutrients and drugs and chemicals used to manage fish health. Tables 5 to 8 summarize the CAAP requirements for land-based and net pen fish culture (USEPA, 2006).

The following types of aquaculture are not covered by the CAAP programme and therefore are not subject to ELGs:

- molluscan shellfish (including nurseries);
- shrimp ponds;

- crawfish production;
- alligator production;
- aquaria;
- net pens rearing native species released after a growing period of no longer than four months to supplement commercial and sport fisheries.

There are several elements to a NPDES permit for CAAP systems. There are:

- **Cover page** – serves as the legal notice of the applicability of the permit, provides the authority under which it is issued and contains appropriate dates and signature(s).
- **Effluent limitations and standards** – serves as the primary mechanism for controlling discharges of pollutants to receiving waters (e.g., the specific narrative or numeric limitations applied to the facility and the point of application of these limits).
- **Monitoring and reporting requirements** – identifies all of the specific conditions related to the types of monitoring to be performed, the frequencies for collecting samples or data and how to record, maintain and transmit the data and information to the permitting authority.
- **Record-keeping requirements** – specifies the types of records to be kept on-site at the permitted facility (e.g., inspection and monitoring records).
- **Special conditions** – in NPDES permits for CAAPs, special conditions may be included, as determined necessary by the permitting authority.
- **Standard conditions** – conditions that apply to all NPDES permits, such as the requirement to properly operate and maintain all facilities and systems of treatment and control, as specified.

As part of the permit application a Best Management Practice (BMP) plan should be submitted and certified. These differ slightly for flow through systems and net-pen culture. The BMP plan for flow-through systems should describe how the producer will achieve:

- solids control;
- material storage;
- structural maintenance;
- record-keeping;
- training.

In addition to those above, for net-pen culture the BMP plan must show how the following are achieved:

- feed management;
- waste collection and disposal;
- transport or harvest discharge;
- carcass removal.

The plan must be kept on site and made available on request. More detail on each of these requirements is given in USEPA (2006), where an example of a BMP for a flow through system is given along with examples of required record keeping forms. More detail on best management practices for aquaculture in the United States of America is given in Tucker *et al*., (2003), where advice on topics such as initial site selection, feed management, solids management and disposal and management of escapes are given for flow-through, net-pen, re-circulating and pond aquaculture systems. General aspects of BMPs in the United States of America are highlighted in Box 1.

The EPA is also responsible for the Coastal Water Quality Monitoring Programme (USEPA, 2006). This programme monitors the state of coastal ecosystems and coordinates monitoring activities of other agencies to enable the issue of a permit where waste discharge will not unreasonably degrade or endanger human health, welfare, amenities, the marine environment, ecological systems, or economic potentialities. The EPA offers many types of compliance assistance and incentives to help aquaculture

BOX 1

BMPs and aquaculture

Best Management Practices (BMPs) are used widely across the United States of America. The benefits of BMPs are greatest for activities where pollution is the sum of effects of several activities separated in time and conducted over a relatively large area. This situation is characteristic of non-point source pollution from aquaculture. State environmental management agencies are responsible for designing such BMPs, which allows for some flexibility as a specific set of BMPs can be prescribed for all producers, or tailored for each facility (see Tucker *et al*., 2003).

Title 40 of the Code of Federal Regulations Part 122.2 defines BMPs as schedules of activities, prohibitions of practices, maintenance procedures and other management practices that prevent or reduce pollution. Although BMPs have traditionally focused on good housekeeping measures, BMPs may be used in a wide variety of pollution prevention activities. When used as part of a regulatory activity, BMPs are most often used:

1. to reduce pollution from activities ancillary to industrial processes (such as runoff from a plant site, spillage or leaks and so on);
2. in situations where numerical limits are not feasible;
3. in situations where they are necessary or best suited to achieve numerical limits.

When used as part of the regulatory process, BMPs are developed into formalized plans that become an enforceable part of the National Pollutant Discharge Elimination System (NPDES) permit for the facility.

In addition, voluntary adoption of BMPs, installation of BMPs to comply with product certification standards and application of BMPs to meet requirements of effluent permits are straightforward processes over which producers have complete control. They can adopt BMPs according to individual discretion and site characteristics, or they may choose to operate without BMPs. Potential problems can arise if BMPs are mandatory and especially if a specific suite of BMPs is prescribed for an entire industry.

operations comply with environmental requirements. EPA is also responsible for conducting a federal regulatory enforcement programme with respect to environmental requirements. The National Pollutant Discharge Elimination System (NPDES) controls direct discharges into navigable waters. NPDES permits, issued by either EPA or an authorized state, contain aquaculture-specific, water-quality-based limits and establish pollutant monitoring and reporting requirements.

Any aquaculture facility that intends to discharge into the Nation's waters must obtain a permit before initiating a discharge. A permit applicant must provide quantitative analytical data identifying the types of pollutants present in the facility's effluent. The permit will then set forth the conditions and effluent limitations under which a facility may make a discharge (USEPA, 2008).

More generally the information gives the monitoring and reporting requirements for dischargers authorized to discharge under the NPDES General Permit for Discharges from Aquaculture and Aquariums (General Permit), unless such monitoring and reporting requirements are modified or waived by the executive officer responsible within the relevant state body. Both inflow and outflow waters are monitored: 1) Influent monitoring – Representative influent water samples should be collected concurrently with effluent samples and analysed for total suspended solids (TSS), pH, turbidity and temperature. 2) Effluent monitoring – Sampling station should be established to obtain representative samples of the discharge before it fully mixes with the receiving water(s) or any other water flows. The representative samples of the discharge are collected and analysed according to Table 8.

TABLE 5
Summary of general reporting requirements for flow-through, recirculating and net pen facilities (after USEPA, 2006)

General reporting requirements	
Drugs	
1) Reporting of intention to use Investigational New Animal Drug Exemptions (INADS) where such use may lead to a discharge of the drug to waters of the United States of America.	• Provide the permitting authority with a written report, within seven days of agreeing or signing up to participate in and INAD study. • Identify the INAD to be used, method of use, dosage and the disease or condition the INAD is intended to treat.
2) Oral reporting of INAD and extra-label drug use	• Provide an oral report to the permitting authority as soon as possible, preferably in advance of application, but no later than seven days after initiating use of the drug. • Identify drugs used, method of application and the reason for adding that drug.
3) Written reporting of INAD and extra-label drug use	• Provide a written report to the permitting authority within 30 days after initiating use of the drug. • Identify drugs used and include the reason for treatment, date(s) and time(s) of the addition (including duration), method of application and the amount added.
Failure or damage to the structure of aquatic animal containment system	
1) Specification of reportable damage and/or material discharge	• The permitting authority may specify in the permit what constitutes reportable damage and/or material discharge of pollutants, based on consideration of production system type, sensitivity of the receiving waters and other relevant factors.
2) Oral reporting of structural failure or damage	• Provide an oral report within 24 hours of the discovery of any reportable failure or damage that results in a material discharge of pollutants. • Describe the cause of the failure or damage in the containment system. • Identify materials that have been released to the environment as a result of the failure.
3) Written reporting of structural failure or damage	• Provide a written report within seven days of the discovery of the failure or damage. • Document the cause of the failure or damage. • Estimate the time elapsed until the failure or damage was repaired. • Estimate materials released to the environment as a result of the failure or damage. • Describe steps being taken to prevent a recurrence.
Spills	
1) Oral reporting of spills of drugs, pesticides and feed	• Provide an oral report to the permitting authority within 24 hours of any spill of drugs, pesticides and feed that results in a discharge to waters of the USA. • Identify the material spilled and quantity.
2) Written reporting of spills of drugs, pesticides and feed	• Provide a written report to the permitting authority within seven days of any spill of drugs, pesticides and feed that results in a discharge to waters of the USA. • Identify the material spilled and quantity.

To facilitate this for all aquaculture effluents a log is maintained of the condition and quarterly visual observations made, of the receiving water(s) at the point of discharge and at environmental monitoring stations RW-1 and RW-2, where:

Discharges to inland surface waters –
RW-1 = 100ft (30.48m) upstream from the discharge point.
RW-2 = 100ft downstream from the discharge point.
Discharges to ocean waters –
RW-1 = 100ft up coast of the point of discharge, or beyond if receiving water appears affected.
RW-2 = 100ft down coast of the point of discharge, or beyond if receiving water appears affected.

The observations stated include the presence or absence of the following conditions:

- floating or suspended matter in the water;
- discoloration of the water;

- bottom deposits;
- visible films, sheens or coatings;
- fungi, slimes, or objectionable growths;
- potential nuisance conditions.

If deemed necessary, the executive officer can also require the discharger to submit analytical data of receiving water quality and/or photographic documentation of receiving water conditions *in lieu* of visual observations.

In addition, the following information on treatments, disinfectant and other chemicals in the discharge are submitted with each monitoring report:

- the name(s), active ingredient(s), label instructions and restrictions, Material Safety Data Sheets and amount(s) of all drug(s), disinfectant(s), or other chemical(s) used. As well as the dates and frequency of application;
- the treatment concentration(s) of the active ingredient(s), duration of treatment, whether the treatment was static or flush, amount in gallons or pounds of the drug, disinfectant, or chemical and the flow in cubic feet per second [2] (cfs) of the influent to the treatment tank;
- the quantitative measure of the active ingredient, or the estimated concentration of the active ingredient in the effluent at the point of discharge to the receiving waters;
- the flow (in cfs) during chemical usage at the point of discharge to the receiving waters.

TABLE 6

Summary of narrative requirements for flow-through and recirculating facilities, continued (after USEPA, 2006)

Narrative requirements	
Best Management Practices plan (BMP)	
1) Development and maintenance of a BMP plan on site that describes how the permittee will achieve the following five requirements:	
a) Solids control	• Employ efficient feed management and feeding strategies that limit feed input to the minimum amount reasonably necessary to achieve production goals and sustain targeted rates of aquatic animal growth in order to minimize potential discharges of uneaten feed and waste products to waters of the USA. • Identify and implement procedures for routine clearing of rearing units and offline settling basins. • Identify procedures for inventorying, grading and harvesting aquatic animals that minimize discharge of accumulated solids. • Remove and dispose of aquatic animal mortalities properly on a regular basis to prevent discharge to waters of the USA, except where authorized by the permitting authority in order to benefit the aquatic environment.
b) Material storage	• Ensure proper storage of drugs, pesticides and feed in a manner designed to prevent spills that may result in the discharge of drugs, pesticides, or feed to the waters of the USA. • Implement procedures for properly containing, cleaning and disposing of any spilled materials.
c) Structural maintenance	• Routinely inspect production systems and wastewater treatment systems to identify and promptly repair damage. •Regularly conduct maintenance of production systems and wastewater treatment systems to ensure their proper function.
d) Record-keeping	• Maintain records for aquatic animal rearing units documenting feed amounts and estimates of the numbers and weights of aquatic animals in order to calculate representative feed conversion ratios. • Keep records documenting frequency of cleaning, inspections, maintenance and repairs.
e) Training	• Train all relevant personnel in spill prevention and how to respond in the event of a spill to ensure proper clean up and disposal of spilled materials. • Train personnel on proper operation and cleaning of production and wastewater treatment systems, including feeding procedures and proper use of equipment.
2) Make the plan available to the permitting authority upon request	
3) Certify that a BMP plan has been developed	

[2] 1 cubic foot per second is equivalent to 0.028 cubic meters per second.

TABLE 7

Summary of narrative requirements for net pen facilities (after USEPA, 2006)

Narrative requirements	
Best Management Practices plan (BMP)	
1) Development and maintenance of a BMP plan on site that describes how the permittee will achieve the following eight requirements:	
a) Feed management	• Employ efficient feed management and feeding strategies that limit feed input to the minimum amount reasonably necessary to achieve production goals and sustain targeted rates of aquatic animal growth. • Minimize accumulation of uneaten food beneath the pens through active feed monitoring and management strategies approved by the permitting authority.
b) Waste collection and disposal	• Collect, return to shore and properly dispose of all feedbags, packaging materials, waste rope and netting.
c) Transport or harvest discharge	• Minimize any discharge associated with the transport or harvesting of aquatic animals (including blood, viscera, aquatic animal carcasses or transport water containing blood)
d) Carcass removal	• Remove and dispose of aquatic animal mortalities properly on a regular basis to prevent their discharge into the waters of the USA.
e) Materials storage	• Ensure proper storage of drugs, pesticides and feed in a manner designed to prevent spills that may result in the discharge of drugs, pesticides, or feed to the waters of the USA. • Implement procedures for properly containing, cleaning and disposing of any spilled materials.
f) Maintenance	• Routinely inspect production systems in order to identify and promptly repair damage. • Regularly conduct maintenance on the production system to ensure its proper function.
g) Record-keeping	• Maintain records for aquatic animal net pens documenting feed amounts and estimates of the numbers and weights of aquatic animals in order to calculate representative feed conversion ratios. •Keep records of net changes, inspections and repairs.
h) Training	• Train all relevant personnel in spill prevention and how to respond in the event of a spill to ensure proper clean up and disposal of spilled materials. • Train personnel on proper operation and cleaning of production system, including feeding procedures and equipment.
2) Make the plan available to the permitting authority upon request	
3) Certify that a BMP plan has been developed	

TABLE 8

Parameters to be analysed from samples of the aquaculture facility discharge (from: NPDES general permit for discharges from aquaculture and aquariums)

Constituent	**Units**	**Type of sample**	**Minimum sampling and analysing frequency**
Flow	MGD	Metered	Weekly
Settleable Solids	mL/L	Grab	Quarterly
Total Suspended Solids	mg/L	24-hour composite	Quarterly
Net Total Suspended Solids	mg/L	Calculated	Quarterly
Turbidity	NTU	24-hour composite	Quarterly
Net Turbidity	NTU	Calculated	Quarterly
pH	units	Grab	Quarterly
Temperature	°F	Grab	Quarterly
Dissolved Oxygen	mg/L	Grab	Quarterly
BOD	mg/L	24-hour composite	Semi-Annually (June and Dec)
Grease and Oil	mg/L	24-hour composite	Semi-Annually (June and Dec)
Ammonia (as N)	mg/L	24-hour composite	Semi-Annually (June and Dec)
Nitrite (as N)	mg/L	24-hour composite	Semi-Annually (June and Dec)
Nitrate (as N)	mg/L	24-hour composite	Semi-Annually (June and Dec)
Total Coliform	MPN/100mL	Grab	Semi-Annually (June and Dec)
Faecal Coliform	MPN/100mL	Grab	Semi-Annually (June and Dec)
Enterococcus	MPN/100mL	Grab	Semi-Annually (June and Dec)

Source: USEPA, 2002

The use of medicines in aquaculture is becoming an ever more important issue in the United States of America as the aquaculture industry expands. The use of these products is regulated both at federal and state levels, depending on implementation of law. All new drugs are registered and bi-annual records of drugs sold are provided to the FDA under the Animal Drug Availability Act (1996; see FDA, 2007, for Green Book). A guide to their use in aquaculture has recently been updated by the Federal Joint Subcommittee on Aquaculture Working Group on Quality Assurance in Aquaculture Production (JSA, 2007). In summary this makes the following recommendations for use of federally regulated products:

- Obtain a diagnosis of the problem(s) before applying any treatment.
- Seek professional advice if ever in doubt as to when or how to use regulated products.
- Use regulated products only for those species and indications listed on the label, unless extra-label use is specifically prescribed by a licensed veterinarian.
- Read and follow directions for use on the product label carefully.
- Use the proper dosage, amount, or concentration for the species, area and/or specific condition.
- Use the correct method and route of application or administration, whether by spraying aquatic vegetation, water treatment (ponds, tanks, or immersion), injection or oral administration (used with medicated feed and some biologics).
- Calculate withdrawal times accurately.
- Identify treated populations or stocks with clear markings of production and holding units.
- Do not use antibiotic drugs or medicated feed for disease prevention unless they are specifically approved for that use.
- Do not substitute unlabeled or generic products or trade-name products that are labelled and approved for aquaculture or aquatic site uses.
- Keep accurate records.
- Consider the environmental impact of discharging treated water, including possible effects on non-target organisms.
- Adopt a producer quality assurance programme or a HACCP programme that provides guidelines for preventing tissue residue violations and for producing high-quality, wholesome products for consumer use.
- Be aware of requirements concerning personal safety measures and proper procedures for farm workers and pesticide applicators that handle or apply regulated products.
- Consider the economic consequences, both short- and long-term, of treatment before using a regulated product.

There is no specific guidance on how to implement some of these recommendations, such as monitoring the environmental impacts of discharging treated water.

CONCLUSIONS

Europe

Within the context of European Union legislation the consideration of the need for an Environmental Impact Assessment for aquaculture development is implicit in the EIA Directive (EU Directive 337/1985/EEC; as amended by Directive 97/11/EC). Carrying out an EIA for the aquaculture production of animals is listed as a Group 2 requirement, where the need for an EIA is dependant upon the view expressed by local officials. In general this requirement is embedded at nation state level; within either aquaculture-specific EIA legislation, as in the UK for marine culture of salmonids, or more generally as in the majority of the accessions countries (e.g. Hungary, Poland) and in some cases not at all (e.g. Italy, Netherlands). Unfortunately, across most European countries (although not all) there is a differential requirement for the treatment of aquaculture development in marine systems, which manifests itself as a requirement to carry out an EIA for finfish culture but not for shellfish culture. The requirement to carry out an impact assessment for the development of freshwater facilities is also variable within countries and no country reviewed had specific freshwater aquaculture EIA legislation, and most (based on the available literature) had never implemented the need for an EIA in freshwater culture.

Across Europe the implementation of EIA for any form of aquaculture development is very variable. Mostly it has not been possible to access information on specific cases and therefore the specific practices employed could not be determined. However, the impacts of aquaculture on the environment in general are well understood through research. The specific methods employed to assess impacts on the sea bed, for example, are similar across the world, even though the number of samples required and the location from which they are taken are variable; both within countries, within regions and invariably between sites.

There appears, also, to be a general inconsistency with the level of data and supporting information that is required and what specific information is needed to compile an Environmental Impact Statement. Most countries reviewed appeared to require an assessment of the likely impact on the site, for example through an assessment of wastes and dispersal. Hardly any country required the development of a risk matrix which would itemise the activities, likely impacts, mitigation measures and monitoring requirements. Much of the literature concerning this is either unavailable or so embedded within more general EIA requirements that it is not obvious.

In most of the countries reviewed there was no apparent centralised system of advice. In most cases municipal, regional and local government officials were required to interpret and implement more general EIA legislation. This appears to result in a significant amount of time and effort needed to gain the appropriate permissions. Certainly permissions must be granted and this is reflected in all European countries requiring some form of application procedure and license. What appears differential is the extent of involvement of various government bodies within each country. Reviews of the procedures in Italy and Greece, for example, showed that the level of bureaucracy may result in applications taking years to either be permitted or not. This requires significant stamina on the part of both the applicant and the various bodies involved in such procedures and surely must be an impediment to the long-term future development of the aquaculture industry in Europe. Certain countries, such as Scotland within the UK, are attempting to make clear the application and EIA requirements through a series of stakeholder conferences and the implementation of specific templates to aid the process.

Not least such development requires an overall strategy concerning aquaculture development so that the aquaculture industry and their specific applications can be viewed in the context of a grand plan. Perhaps this is the reason why development and implementation of EIA and monitoring plans for aquaculture have not been developed so well in the accession countries, which clearly have different priorities to build and develop their respective industries after years of neglect. However, such development should probably work within the confines of given EIA legal frameworks in order to remain sustainable.

Although certain countries appear not to implement the explicit requirement of the EU EIA Directive, nearly all use other methods of controlling development in the aquaculture industry. This results in variable amounts of information being required in support of an aquaculture application. In Greece there seems to be a well defined requirement to consider specific impacts which can result in the developer being uncertain about exactly what to include in the EIA. For site specifications alone the Greeks required measures of non-specific such as physicochemical parameters in the marine environment, suspended solids, wave height, the direction and speed of the wind, the direction and speed of the water currents, depth, substrate type of the sea bed and the structure of the macrobenthic community. In comparison Spain appears to have a very long list of parameters (such as 12 metal forms) that may require evaluation as part of an EIA.

North America

In North America the implementation of the EIA process is inconsistent between the two countries evaluated and none more so that in the United States of America. Here there appears to be a general disregard for the EIA process in aquaculture development. Marine production of fish species in the United States of America is relatively low and therefore most species produced were not specifically part of this review, which evaluated the most commonly produced species. In its approach to shellfish culture the United States of America was consistent with the remainder of Europe, in not appearing to require any form of environmental impact assessment for this culture practice.

Within freshwater culture, which is predominated by channel catfish, and despite the lack of EIA, the permit procedure appears on the surface to be robust. This is in part because the United States of America has, at federal level, explicit water quality requirements that need to be adhered to by the aquaculture industry, through the NPDES permit process. There is a high level of data and guidance available through the USEPA Web site, and importantly, examples of the permits issued were available for evaluation. This showed that explicit site specific monitoring requirements were identified in the license, along with advice on how and when this should be carried out.

What is not clear from this review of the implementation of EIA within aquaculture development is the effect the Best Management Practice has had on the need for EIA in the United States of America. BMP means there are some fairly well defined practices that can be employed, in a similar way to Codes of Practice (CoPs) issued by European, pan-European and national trade organizations. However, the BMP procedures would appear to have a slightly higher status than CoP in Europe, because they seem to be equally embedded within the governmental (be that national, state or local) requirements. Thus, with the requirement to conduct specific practices, which have been determined to reduce environmental impact, endorsed by government departments, the need for EIA in the United States of America may be overcome.

This may be true in part. However, what has been shown is that BMP procedures in themselves do not provide for an evaluation of the impact of an aquaculture development on the environment. Clearly certain states, such as California, which in 2006 appeared to be the first state to implement the need for a full evaluation through a process of EIA, believe there is a need for a fuller investigation of the impacts of aquaculture. This means that future development of aquaculture within the United States of America might involve formal evaluation through an EIA process.

Within Canada, in contrast, there is a need to evaluate the impacts of aquaculture development, through the EIA process. This applies equally to finfish culture (which is dominated by salmon) and shellfish culture, unlike both the United States of America and Europe. Canada has a set of comprehensive EIA requirements and has produced material specific to this subject, which lays out the requirements in significant detail. The experience of Nova Scotia has also shown that it is important that a consistently collected body of data is available, over a wide area and consisting of a range of aquaculture systems. It provides the possibility that future decisions on potential environmental impacts can be better made with less data in the EIA.

General comments

Overall the review has shown that the level of EIA and monitoring within Europe and North America is both varied and inconsistent, where it is carried out. This is not only in the time taken for the process to reach completion, but also in the variable volume and type of data that needs to be evaluated both during the EIA phase and the post-development monitoring phase.

The collection of data is expensive and hence it needs to be targeted at providing the information necessary to inform the assessment, to identify an impact, to develop a mitigation strategy as part of the EIA and to manage and monitor the impacts that are deemed significant after development has been approved. Such aspects should be identified as early as practicable within the EIA process in order to identify specifically those elements and impacts requiring investigation. Such a strategy will also inform and enable optimisation of the subsequent monitoring plan.

Thus for any aquaculture development, the following general points need to be considered and agreed as part of any EIA procedure and environmental monitoring plan:

- the major impacts to be evaluated and monitored;
- the objectives of monitoring and data requirements;
- the use of the information collected;
- the response in both the EIA and monitoring procedures to unanticipated or greater than predicted impacts;
- the measures for public reporting and involvement;
- the need for a regular review of the monitoring plan, to ensure that the relevant information is being collected;
- the need for monitoring requirements to focus on the significant impacts predicted in the EIA report, taking account of:
    - the environmental values to be safeguarded;
    - the magnitude of each potential impact;
    - the risk or probability of each impact occurring.

Papoutsoglou (2000) noted that generally within an EIA process for the development of aquaculture sites, the closer the links between the regulatory system and actual practices at aquaculture (fish) farms, the less objections, difficulties and misunderstandings occur in the interpretation of the EIS and management plan. This aids rather than hinders the overall development of the aquaculture industry. Papoutsoglou (2000) noted too that the continuous appearance of new "legislation" orders, which added to bureaucratic complexities too (in Greece, but also in many other countries), means that it had become difficult to fully meet the demands of any regulatory system. Such changes are compounded by the diversity of each aquaculture development in terms of the sites, species, feeding systems, production system and management systems in use.

In Greece and elsewhere, the main problems with environmental legislation (Papoutsoglou, 2000) are associated with:

- insufficient "contact" between the marine aquaculture industry and society;
- insufficient understanding of the philosophy of aquatic environment protection, since the same conflicts between most farmers (mainly those of marine cage farms) and the local communities arise time and again and are rarely entirely resolved;
- insufficient coastal zone planning, together with the absence of designated marine aquaculture areas, leading to an almost continuous argument between neighbouring land users (including tourism and local authorities);
- insufficient control of the operational standards of farms;
- unstable local (or other) market conditions.

There remains considerable scope for improvement in the legislative framework affecting aquaculture. In Greece, the Netherlands and Italy, for example, the introduction of a central "Aquaculture Policy" could greatly assist the development of the industry in relation to other uses of the coastal zone. Provided there is sufficient central regulation with appropriate definitions and body of supportive and accessible (published) advice (such as in Canada), then it would appear reasonable that the responsibility for the review of EIAs, the leasing of sites and the licensing of operations be delegated to local government control. The important aspects remain the consistency with which the "rules" are applied, the involvement of all appropriate stakeholders and the confidence that transparency is ensured in any and all decisions made.

Effectiveness

INTRODUCTION

Due to research efforts and existing EIA and monitoring requirements and practices in Europe, Canada and the United States of America for marine fish farms, the gross effects of fish farming on sediments are relatively well understood. The impact on the sea bed is the most obvious pollution effect from marine fish farms and measures of this effect are the main method of regulating and controlling fish farms such that the local environment is not overwhelmed. Most fish farms are regulated in this respect in terms of their size or the maximum biomass of fish permissible. Other criteria such as mitigation technologies are not taken into account, though the maximum biomass allowed is often calculated on the basis of environmental factors, i.e. hydrodynamic conditions. In freshwaters, water quality parameters are used as a measure of impact, i.e. levels of phosphorus or productivity, normally denoted as amount of chlorophyll, in lakes and BOD for flowing waters in rivers. These are well monitored and can be readily measured for comparison with quality standards set by the regulator.

However, the EIA process reviews more environmental information than simply parameters used to assess biological and chemical impacts. For example, Environmental Impact Statements (EIS), which are the documents/reports produced as a result of the EIA process, include other risks and impacts such as socio-economic impacts (and benefits) and visual impact on landscape character. Both are becoming more important in the EIA process for aquaculture development, e.g. approximately 32 percent of applications for new marine fish farms in Scotland between 1999 and 2004 were rejected on the basis of visual impacts alone (Hambrey and Southall, 2005). These impacts, biological, chemical and visual, may be estimated prior to the beginning of the development using predictive models. Again, this would normally be part of the EIA process.

TECHNICAL APPROPRIATENESS IN EUROPEAN COUNTRIES

EIA is regarded as the environmental assessment tool traditionally used in Europe for the prediction of likely impacts from new aquaculture developments, rather than as a mechanism of assessing its environmental or socio-economic sustainability. This is unfortunate as the EIA could be used as an excellent tool for doing just this if the regulatory process was not being done on a project-by-project or site-by-site basis as it is at present. Consideration of the wider ecosystem including all inputs and socio-economic implications would be both beneficial and allow a wider assessment than now. As described by Becker and Jahn (1999) *"...sustainability is less a matter of particular undertakings, than of industry and society-wide decisions, trends and patterns. EIA tends to focus on the former."*

Previous research suggests that a number of factors influence the quality of EIA reports. These include the date of the EIA report, the nature of legal requirements for EIA, the experience of the proponent, the consultant and the competent authority, the existence of scoping, the length and cost of the EIA report and the nature and size of the project (see Barker and Wood, 1999). In Scotland, this was shown to be particularly true for aquaculture in terms to the variation in implementation of regulation and the quality of the EIA reporting (RSP Group PLC, 2007).

Although the study by Barker and Wood (1999) was carried out on general EIA reports and not those specific to aquaculture, it highlighted the point that the quality of EIAs and EISs varies greatly between EU member states, despite being bound to the same EU EIA Directive (97/11/EC). They also found that the EIA procedure exhibits considerable diversity both in terms of methodology and legislative framework between different countries.

As reviewed in Section 2, the monitoring undertaken for aquaculture throughout the EU is varied, both in terms of requirements and effectiveness in their use. The requirements are based on a number of EU Directives (see Section 2), which are incorporated into individual country legislation. However, this has been done to varying degrees, but has also had historical legislation to "contend" with. Often meaning that far from simplifying requirements for environmental monitoring for aquaculture developments there has sometimes been a complication of these regulations. Examples of this would be Italy and Greece. Possibly when this EU regulation is fully implemented the legislation may simplify.

Where specified, the monitoring requirements are of a similar nature, samples of water and sediments are taken from the proximity of the fish farm or discharge point and these are then compared with Environmental Quality Standards, which are specific to the type of aquaculture and/or the country using them, but are still largely based on the same scientific data used for their formulation and therefore similar in nature. In consequence, the effectiveness of environmental regulation in European countries is not dependent on the quality standards used or the monitoring methods employed. It is dependent on the variability of their implementation within legislation.

There is little information on specific effectiveness of implementation of the monitoring, as aquaculture is only one of a number of effluent discharges contributing to environmental impacts and using up the assimilative capacity of the aquatic environment, see Section 3.4. Exceptions to this are almost entirely in relation to salmon aquaculture where reviews are undertaken on data acquired through fish farm monitoring (SEPA, 2005) and specific monitoring studies to look further at wider environmental impacts, e.g. plankton blooms (Tett and Edwards, 2002), or medicants (SAMS, 2005). Both studies showed there are no significant environmental impacts that could be attributed to salmon farming in Scotland and thus the present level of monitoring and regulation is sufficient and effective.

Czech Republic

There are several factors in the Czech Republic which make the EIA procedures and practices outlined above ineffective. There is enormous difficulty determining the extent of ownership of ponds used for fish culture. This makes the implementation and policing of regulation very difficult and therefore the EIA procedure is unlikely to be implemented fully by the fish farmers. This difficulty is largely due to the state-ownership of aquaculture prior to 1993 and its progressive and poorly documented privatisation between 1993 and 1995 (Globefish, 2008). There is no evidence of the need to have done an EIA before privatisation. Currently "Rybarske Sdruzeni Ceske Budejovice" (Czech Fish Farmer Association) maintains contact with up to 110 owners/organizations that produce the majority of the fish produced (Globefish, 2008).

The use of EIA may increase in the future as larger farms are developed, better documentation is kept and as species are cultured more intensively, although the national strategic plan aims at maintaining, rather than increasing, present levels of aquaculture and fisheries sector until 2013. This future development may also be limited due to the required investment within the fish farming industry. It is generally accepted that many ponds are degraded and in bad repair, through extended under-investment. Investment and structural changes to repair ponds, or rehabilitate facilities, funded largely through the EFF and FIFG may actually limit increase in fish production and thus the need for future EIAs.

At present there is no apparent assessment or environmental monitoring required to record the post-development impacts, including that of pond culture, after privatization in 1993 (Braniš and Christopoulos, 2005), though there may be changes to this in the near future with the implementation of the Water Framework Directive (EU Directive 2000/60/EC) through the State Environmental Policy (Ministry of the Environment of the Czech Republic, 2004). This policy does not specifically mention aquaculture and therefore does not develop definitive monitoring strategies for the fish farming industry. However, as this has not taken effect there is no opportunity as yet to comment on its effectiveness.

France

A review of the EIA requirements and practice for aquaculture in France reveals an incredibly complex and in some ways archaic system of regulation in freshwaters (Madec, 2003). In marine systems there is variable regulation required with the most commonly cultured species, bivalve molluscs, not being subject to rigorous legislation at all due to legal differences existing between fish and shellfish. Shellfish only have legislation based on designated areas for culture using the EC Shellfish Directive (79/923/EEC) classification system (European Commission, 1979). Therefore the only monitoring requirements from this industry are for biotoxins and pathogenic bacteria.

The complexities of the system for freshwater fish farms and the time taken for completion of the process (up to two years) decreases the effectiveness of the implementation of the EIA particularly for smaller operators who cannot necessarily plan for two years ahead and gives little incentive. However, the stringent water quality parameters are likely to mean that, if implemented, the environment is unlikely to undergo significant impacts during farm production.

Once permission is given for development, an overall review is only mandatory after 30 years in freshwater systems and 35 years in marine systems, though monitoring results and comparison with the quality standards may result in short-term review of farming practice in consultation with the stakeholders. This may mean that there may not be rigorous safeguarding of environmental quality by this process, but there is no information available on the legislative power of the regulators in terms of sanctions and actions that can be taken by them.

This system in France requires a number of efficiency measures to make it more effective, which may include :

(i) an urgent simplification of the legislation and application process;
(ii) better documentation and recording of production sites. The diversity of groups concerned in the application means that there is no central records system. This may happen if the system is simplified; and
(iii) more defined legislative power in terms of failure to comply with legislative standards. This should be initially agreed with all stakeholders.

Greece

According to Barker and Wood (1999), EIA legislation (since 1990) appears to have had a beneficial influence on the quality of EIA reports in Greece. Again the experience of the consultants and decision-making authority involved in the EIA process caused large variations in the quality of Environmental Statements in Greece.

The legislative framework for the aquaculture sector in Greece refers to fishery exploitation and the management of aquatic resources. It does not cover the complete administration of the coastal zone, land or freshwater areas, which are under the purview of other ministries. The existence of a number of regulations per ministry for the use of these various areas, together with the lack of harmonized land planning and the lack of priorities given to the use of common resources, has caused delays and rejections of applications for aquaculture units (Klaoudatos, 2001).

For the establishment of aquaculture units, expert opinions are required from the jointly competent bodies (ministries) and licenses to operate are issued by them. Thus the use of common resources should be regulated from the beginning and disputes or problems could be avoided. In many instances, problems are discussed at the prefectural level, with the participation of local communities, who are given the opportunity to express their opinion about the aquaculture development. If granted, the competent body then issues the license that ensures the unit is operated properly. The major problems arising in Greece are due to the non-application, on the part of the governing body, of the operational rules and procedures. These are provided by the relevant authority and concern all activities which use common resources. In this particular circumstance, when examining issues or problems of the aquaculture sector, informal (*ad hoc*) committees are set up by the Ministry of Agriculture, in which aquaculture experts from the state (ministries, institutes, universities) and private sectors meet to help solve problems that arise (Klaoudatos, 2001).

Generally the strategies used by the Greek government authorities to promote awareness about the sustainable use of the marine environment are (from Klaoudatos, 2001):

(i) to create mechanisms in order to control environmental impact assessment (EIA) of aquaculture;
(ii) to encourage co-operation between aquaculture producers and national research centres;
(iii) to improve responsibility among all the users of the marine environment;
(iv) to install systems that permanently record abiotic water parameters.

Responsible services of the Ministries of Agriculture and Environment, Land Planning and Public Works, the services of the prefectural authorities and the national research centres keep a continuous monitoring record of the environmental impacts of aquaculture. Systems, which the State has installed for certain cultures (shellfish, cyprinids, salmonids), permanently record the abiotic water parameters, so that farmers are continuously informed and remain compliant with the limits set in the legislation for the protection of the environment. At the same time, the Ministry of Environment monitors the waters of all coastal areas of the country (based on the Directives of the European Union) in their specialist laboratories. However, the monitoring mechanisms used by the government authorities are not deemed to fully meet the environmental requirements and an upgrade of the control system is in progress (Klaoudatos, 2001).

The compliance of aquaculture farmers with environmental legislation requires (apart from the threat of sanctions being imposed) a conscientious acceptance of the necessity for the protection of the environment. The future plans and strategies for the perpetual use of natural resources requires thorough knowledge and long lasting co-operation between all users of the marine and coastal environment. However it is unlikely that this ideal picture will be achieved in the near future. In Greece for example, the determination of zones for agriculture, aquaculture, industry and tourism has not been concluded. This creates problems, as the procedure of determining zones of use will help solve a lot of existing problems in the governance of an expanding aquaculture industry (Klaoudatos 2001). The intention is to identify the possible adverse impacts of an aquaculture farm, prior to its construction and granting of an operational license.

In Greece, producers must provide statistical data for the production process of their fish farms and for the physicochemical parameters of the marine environment. At a national level, there is an obligation for the producers to provide statistical data, but problems arise in many instances, especially in connection with the collection and comparability of the data. The data should be collected and provided through a network so as to be available to all users. The dissemination of research results is not considered satisfactory in Greece due to the lack of a relevant information network. The sector needs more seminars, meetings and aquaculture exhibitions, as well as special publications and booklets referring to the methods for administering aquaculture units. Farmers should have continuous information to update them about new technology and the damage which thoughtless use of the marine environment could cause (Klaoudatos, 2001).

In addition, the methodology for an EIA study must be clarified in order to have comparable results. It is extremely difficult to monitor the effects of the aquaculture industry on the marine environment as the ecosystem and management differs from one farm to another. It is therefore extremely important to assign indicators to the various ecosystems and to continuously monitor them in order to intervene in the case of environmental degradation (Klaoudatos 2001).

A study focusing specifically on the performance of the EIA system in Greece (Androulidakis and Karakassis, 2006) concluded that the standard of EIAs was generally poor and they did not address the issues outlined within the scoping exercise. The inference from this is that poor implementation of the EIA process would lead to inappropriate siting of developments and if this was instigated in the same way for aquaculture it could undermine effective environmental management.

Hungary

The political transition of Hungary in the 1990s caused a number of issues related to the privatisation of commercial activities. These issues included lack of record-keeping and consistent environmental regulation, resulting in a general deterioration of water quality on fishponds and adjacent rivers and watercourses. This has lead to the development of the Hungarian Agricultural and Rural Development Operation Programme. Accession to the EU has added to these issues in the requirement for implementation of environmental directives and regulation. In addition, considerable funding is being provided towards the development of a strategy for sustainable aquaculture (CONSENSUS, 2005a).

However, there is no specific water monitoring or EIA programme specified within the Agricultural and Rural Development Operation Programme and therefore the state of the environment is largely left under the control of the user. Present EIA and regulatory monitoring in Hungary is ineffective. Implementation of the EU Directives and the additional funding invested should lead to considerable infrastructural and environmental improvements over the next five to ten years.

Italy

The fact that there is no national legislative framework for environmental impact assessment in Italy (in relation to EU Directive 85/337 EEC), has contributed to the poor involvement of the public in the EIA process and the effectiveness of environmental assessment as a whole. Although this is a generalised observation by Del Furia and Wallace-Jones (2000), it is related to the Italian aquaculture industry, as farms over 5 ha are subject to EIA under guidelines set by regional authorities. Potential obstacles to the development and approval of an EIA framework law are the inefficiency of the legal system, the lack of horizontal communication channels and coordination (between regions) and an unwillingness to accept a coherent law by the autonomous provinces and regions.

Other important steps to be taken in encouraging EIA culture in Italy are to develop best-practice guidelines and procedures for developers (for all types of project, including aquaculture), administrators and citizens. Strengthening of the Italian EIA network could take place by dedicating further resources to the EIA centre in Milan, or the establishment of another independent institute that focuses on collating EIA skills and supports all of the factors involved in establishing standards and implementing EIA. This is essential in Italy, as there is a strong possibility that approval of a framework law could take a long time (Del Furia and Wallace-Jones, 2000).

Netherlands

Aquaculture in the Netherlands is dominated by culture of mussels, which, though subject to biweekly monitoring for the presence of pathogenic bacteria and biotoxins, are not specifically subject to EIA and environmental quality regulations. In addition, there is a moratorium on new shellfish production sites. Authorization of inland aquaculture is only subject to permits required for normal planning in terms of environmental protection and land-use, which are not specific to aquaculture.

There are no specific EIA requirements and legislation specific to aquaculture in Dutch Law and therefore it is difficult to judge the effectiveness of the limited regulations specifically for aquaculture. Review of the available information suggests that aquaculture development is significantly limited in coastal systems and is minimal for inland systems in the Netherlands. Therefore present aquaculture developments are likely to have only limited environmental impacts.

Poland

Poland faces environmental challenges at present within the aquaculture industry, as there is a net increase in production of inland fish through higher levels of trout production and stabilisation of carp production. In Poland aquaculture is defined as a Group 2 activity under the EU EIA Directive and therefore may require an EIA to be performed as part of the developmental process. The production criteria specified as the threshold requirement for an EIA to be performed under these circumstances are in excess of the mostly small-scale levels of fish produced per farm and therefore EIAs are largely not actually required or undertaken. There is little evidence then that historically the EIA process in Poland has had any effectiveness in reducing the environmental effects and contributing to the environmental management of aquaculture.

With the accession to the EU, however, Poland has developed a National Strategy for the Development of Fisheries to be implemented between 2007 and 2013. In addition, there is professionalism and a well developed education system, including training at vocational, secondary and university levels, for fisheries and aquaculture in Poland. This may mean that the benefits of the EIA process in the management of fish farming are likely to be implemented within this sector in the future.

The most dynamic aquaculture sector within Poland is the production of trout for stocking and restocking of rivers and lakes. This has its own environmental implications, especially on the genetic impacts of wild stocks of fish and potential destruction of habitats for native fish. The restocking of rivers for trout is due to the "poor environmental regulation" and "construction of dams" (Wenne *et al.*, 2000, cited in Was and Wenne, 2004). The restocking of these rivers with single populations of hatchery-derived fish has lead to a lack of genetic variability between river systems (Was and Wenne, 2004), which probably would have been highlighted under an EIA process if carried out.

Spain

The range of experience of the consultants compiling the EIA, and the experience of the authority making decisions on the basis of the EIA, caused the most variation in the quality of environmental statements produced in Spain. Additionally, shorter EIA reports were often of lower quality.

Trout

During the development of the trout farming sector in Spain, serious pollution problems related to external sources (namely pesticides and fertilisers) occurred. This resulted in the closure of many fish farms that were not located in the upper reaches of rivers. Trout require clean well-oxygenated water and hence they have been a permanent indicator of river water quality. Historically, major pollution problems in rivers and changes in river characteristics have been due to heavy industry and recent efforts by the environment authorities to improve river conditions, have not been effective (Torrent Bravo and Sanchez Montañés, 2001).

Due to the above situation and the lack of legal instruments, the existing Environmental Authorities developed different laws and regulations, sometimes very quickly and also very restrictively, which lead to the owners of trout farms having to pay very large sums of money. In addition, there was also a distinct lack of effort by the Environmental Authorities to maintain or improve the river water quality used by trout farms (Torrent Bravo and Sanchez Montañés, 2001).

Use of the different laws and regulations combined with the knowledge that many of the rivers had poor water quality has lead to the closure of many freshwater facilities (Torrent Bravo and Sanchez Montañés, 2001). The farmers pay for the amount of water they use i.e. the difference between the inlet and the outlet. However, there are some limits for the dry season where the farmers can use only a predetermined water flow from the river which is called "the ecological water flow". Nowadays, after several decades of conflict between fish farms and the authorities responsible for water management, the situation is becoming reasonable. However, new environmental regulations arise and are a permanent threat to fish farms, as they often focus on specific small effluents with a high pollutant load and not on the high volume effluent with little organic solids released from a fish farm (Torrent Bravo and Sanchez Montañés, 2001).

Turbot

The environmental regulation for turbot farming has been developed over the past decades and has faced similar problems to those already encountered by trout farms. Also due to the lack of previous planning by the relevant authorities, problems concerning environmental regulation and monitoring often have to be solved as they arise. The criteria used to determine the quality of wastewater from turbot farms have been taken from those used for domestic and industrial effluents, thus regulations have not focused specifically on aquaculture activity and this particular type of effluent (Torrent Bravo and Sanchez Montañés, 2001).

Cage farming

In relation to existing environmental regulations, the situation has also been similar to trout farms. At the beginning of the 1990s, cage farming was not carried out on a large enough scale to have specific regulations. Thus the sector has been affected by a large number of different regulations designed for other types of activities (Torrent Bravo and Sanchez Montañés, 2001). In terms of aquaculture, the regulations do not clearly define the impacts generated, any parameters that demonstrate a farm is in operation, are often given a high relevance.

According to Torrent Bravo and Sanchez Montañés (2001) it has been more convenient for the regulatory authorities to relate the impact of aquaculture farms with the impacts of other activities, i.e. fishing, the release of untreated effluents or the construction of harbours. Fish farmers are concerned that more pressure is placed on their sector than on others. Spanish farmers also believe that only the negative aspects of fish farming are used as indicators when environmental monitoring programmes are designed by the regulatory authorities. The management practices of a farm are not monitored and farmers believe this should play a vital part when assessing environmental impacts.

Finally, as there are no clearly defined criteria or objectives to evaluate and track the impacts of aquaculture, confusion has been created leading to the situation that each office for different Spanish regions uses different criteria. This has caused serious problems, as the published environmental reports are being used politically and in some cases are creating confusion, especially to the public. It is public opinion that can seriously deter the development of aquaculture both on and off Spanish coasts (Torrent Bravo and Sanchez Montañés, 2001). However, the production sector, together with the administration, has taken several actions to progress environmental regulation within aquaculture. The first has been the production of the "White Book of Spanish Aquaculture", which provides a comprehensive review of the sector with a whole chapter dedicated to aquaculture and the environment. In addition, the production sector through its Association of Marine Aquaculture Producers (APROMAR), has agreed to follow a Code of Conduct developed by the Federation of European Aquaculture Producers (FEAP).

Torrent Bravo and Sanchez Montañés (2001) conclude that whilst Spain is developing its environmental laws, the development of aquaculture is suffering, due to new environmental laws, where the activity is not considered specifically. Aquaculture permits are issued with many imprecise environmental requirements that are creating uncertainty among new investors. The environmental impact reports are not precisely designed for aquaculture purposes, which creates uncertainties and give rise to doubts that the regional authorities are generally not experts in aquaculture.

A TECAM seminar during which regulators, researchers and producers discussed environmental impact assessment in Mediterranean aquaculture, gave an insight into the effectiveness of the EIA process for aquaculture in Spain (Uriarte *et al.*, 2001). Regulators and scientists commented that though complex the EIA requirements were reasonable, but that there was a lack of information on aspects such as the quality and quantity of pollutants generated, the ratios of feed and biomass, water quality and disease . It was argued that provision of this information should be fundamental and straightforward. However, a producer disagreed commenting that the guidelines on data provision and regulations for aquaculture in Spain were very strict and "*if they were followed there would be no aquaculture farms*". While these points of view reflect the different interests of the people involved, it highlights a basic problem in communication and education of the need for the EIA process and monitoring. At the same time it highlights the need to obtain stakeholder input into demystifying or "de-complicating" the regulatory process.

Turkey

Until the early 2000s, the marine aquaculture sector in Turkey has enjoyed full public support, cheap labour and a lack of strict environmental and marketing regulations and thus has developed rapidly. However, rapid development on the Aegean coast has created opposition from the tourism sector, local people, holiday homeowners, environmental NGOs and small-scale fishermen, and has also led to new environmental requirements (Okumus, 2007).

It is essential that the location, the aquaculture system (cage, hatchery, tank or pond) size and its licence status is reviewed regularly by the General Directorate of Agricultural Production and Development (GDAPD), preferably each year. Aerial surveillance may be useful for rapidly compiling information on the number, size and location of installations. This information should be held on a database and made available for use by the appropriate authorities, consultative committees and inter-ministerial working parties (Deniz, 2001). It is also important to encourage awareness of environmental protection and the potential impacts and benefits of different types of aquaculture upon the coastal environment, within the aquaculture industry and other interested parties. Aquaculture registration must be streamlined and tailored to operate within each relevant ministry and between ministries. Environmental issues demanding legislation and enforcement include the control of disease, transfer of species to new or different sites, control of chemicals, farm location and waste disposal. The development of a site selection strategy should take into account at least: depth, location, farm size and type, proximity to other developments and the species to be farmed (Deniz, 2001).

Co-operation between MARA and the Ministries of Environment and Culture must also take place. The development of a plan could allow aquaculture to progress without significant impact, by including (Deniz, 2001):

1. the identification of sensitive ecosystems, habitats, endangered species and poor sites (too shallow, slow currents) i.e. where aquaculture or any other development must not take place under any circumstances; such as turtle nesting sites/protected bird-nesting sites;
2. the identification of less sensitive sites outside these areas, which forms a 1km buffer zone where no aquaculture can take place;
3. aquaculture projects (which can take place outside the 1km buffer) can then be identified. Assessment of licence applications and EIAs for larger schemes should be more rigorous in these outer zones than in normal coastal areas. Such applications and EIAs should pay particular attention to the designated features of the protected area.

Deniz (2001) also suggests it is necessary to simplify but continue to enforce leasing procedures for aquaculture sites, to prevent developers from reclaiming large stretches of shoreline for construction. This requires direct liaison between GADP and the Ministry of Forestry and the Ministry of Tourism.

The development of a rapid and regular consultation process within Turkey is needed to assess applications for aquaculture licences with input from statutory consultees including MARA, Ministries of Environment, Reconstruction, Culture and Tourism, navigation and military interests. This should be achieved through regular meetings (every three months) and adherence to a coastal planning policy that has been agreed by all parties in advance. A system must also be in place for public consultation on developments prior to building, though guidelines should be flexible and based on evolving environmental and technical knowledge. The MARA should also liaise with the Ministry of Tourism to determine the number of existing aquaculture operations sited illegally in tourism areas, as well as their impact on the environment and landscape. If they are acceptable, they should apply for and rapidly receive a license to operate, if they are unacceptable then they should be forced to cease operation and remove all equipment. Deniz (2001) also suggests that the development of an aquaculture fraternity through producer organizations is needed to identify the needs and priorities of the aquaculture industry in Turkey. Legislation should also be strengthened in order to protect sensitive species, habitats and special sites related to the coastal environment. It is recommended that special protection areas and national parks be used as the central mechanism in this context.

Integrated coastal zone management

At present, coastal management is fragmented in Turkey, with overlapping responsibilities. Communication and coordination are lacking and there is a need for integration and harmonisation of related policies and regulations. Recent environmental national regulation (*Law No 5491* dated 26 April 2006 amending the Environmental Law) is intended to exclude marine cages from enclosed bays, but the definitions in the bill are considered somewhat vague (Okumus, 2007). In Turkey there is an urgent need to take a holistic approach when managing the coastal zone. This requires reliable, long term and transparent data, cooperation (of all stakeholders), an administrative structure (including ministries or departments of environment, fisheries, maritime affairs, culture, tourism, agriculture, forestry, transport, *etc.*) and infrastructure. Good coastal zone planning requires the drafting of strategic integrated management plans rather than taking isolated actions and amending them on an *ad hoc* basis. A forward thinking ICZM plan might also try to bring opposing sectors together rather than segregating them.

United Kingdom

The experience of the participants in the EIA process (the proponent, the consultants compiling the EIA and the competent authority making decisions of the basis of the information contained within the EIA) was found to be the single most important variable in explaining variations in the quality of Environmental Statements in the United Kingdom. In addition, scoping, and particularly the involvement of the public, also appeared to improve EIA report quality in the UK (Barker and Wood, 1999). In addition, although there is no apparent relationship between the length of EIA reports and their quality, it appears that short EIA reports are frequently of "unsatisfactory" quality. The generally positive relationship between EIA report length and quality was confirmed by the EIA reports studied from the UK (Barker and Wood, 1999)

A detailed study on Scottish environmental impact statements for cage culture in coastal waters primarily for salmon, but also for marine culture of Atlantic cod (RPS Group PLC, 2007) showed that there was a range of quality across those reviewed and the technical assessment of data within the Environmental Impact Statements (EISs) tended to be inconsistent. In general it was found that consultation and scoping were not addressed adequately and thus not focusing on the key impacts from the outset. Scoping for the Environmental Statements reviewed (and all others) was performed by statutory regulatory bodies in a non-standard format (RPS Group PLC, 2007). This causes a potential conflict in that many of the EISs reviewed where written to follow EU Directive guidelines (see Annex 1), but were trying to answer issues highlighted by a non-standard scoping approach, not carried out as a separate study for individual EIAs. This has the potential for the Environmental Statement produced to both lack information and lose effectiveness in its implementation and relevance. Introduction of a simpler and more streamlined procedure for EIA, such as that proposed by RPS Group PLC (2007; see Annex 4 to this paper) would significantly improve consistency between scoping and the final Environmental Statement and thus its effectiveness as part of the aquaculture planning process. One specific problem that is poorly addressed by both regulation and the EIA are the issues associated with cultured fish escaping into the marine environment. This is a problem that can only be addressed through either relocation of sites or by the use of improved technology. Generally in this regard the consideration of the impacts and mitigation issues of escapes were poorly dealt with during the EIA process.

The procedures for the monitoring of coastal aquaculture in the UK are largely based on salmon, but the well defined monitoring approach implemented by SEPA has generally lead to an improvement, or no degradation in environmental quality (SEPA, 2005) even though cage farming has increased.

Inland aquaculture using waters from rivers or lakes again appears to be effective in terms of minimizing environmental impacts. Strict measures are implemented to prevent changes in the trophic status of waterbodies and thus to significantly increase environmental quality within rivers. There are few incidences of significant impact on rivers and lakes due solely to aquaculture and thus we can conclude that the regulatory system is effective. Stakeholders, however, argue that the quality standards used for regulation are too restrictive and that the true carrying capacity, in terms of assimilation of nutrients within lake and rivers, is not used effectively.

TECHNICAL APPROPRIATENESS IN NORTH AMERICA

Canada

There is little to no documented information available on the technical appropriateness of the EIA process as it is applied to aquaculture developments for non-marine salmonid production in Canada, nor more generally on the effectiveness of the EIA and monitoring processes and procedures. It is perhaps explicit that at least part of the

Canadian EIA process for aquaculture is effective as controls and changes are made as a result of statutory monitoring of aquaculture developments, as defined by the federal Department of Fisheries and Oceans Canada (DFO) (see Smith *et al*., 2002). The DFO (2004) indicate as much citing that "In combination with ongoing federal and provincial environmental monitoring programmes, aquaculture projects being subjected to environmental assessments ensure that no unforeseen, significant negative consequences on the environment arise from aquaculture operations". However, there appears to be a suggestion (DFO, 2004), that the increased level of providing information and maintaining the level of detail required in the regulatory process (which would include environmental impact assessment) is costing significant time and effort and is seen as one of the reasons the aquaculture industry has not developed to its full potential.

Over time the use of EIA for aquaculture in Canada has developed, changed and by assumption become more appropriate to the situations being evaluated. Curtis (2004) refers well to the outcomes from the MARAQUA project (Read *et al.,* 2001; Fernandes *et al.,* 2000) and identifies the need for best practice within an EIA strategy to provide a well structured and informative planning evaluation tool for aquaculture. Whilst identifying the overarching guiding principles from organizations such as the United Nations Environment Program (UNEP; Sadler and McCabe, 2002) and the International Association for Impact Assessment (IAIA, 1999), the development of best practice for aquaculture is an iterative process, which the Canadians entered and are continuing to develop.

In more general terms the Canadian government has undertaken to align federal and provincial requirements of EIA through a series of government/province environmental assessment agreements (CEAA, 2008). It is hoped that this will improve the balance of government and provincial legislative requirements for EIA, including for aquaculture, although again it has not been possible to determine how appropriate this has been in practice. In principle the integration of requirements will make the process more efficient. Also, recognising the high cost and effort required, part of the instigation of tighter and more appropriate controls is the use of so-called Class Screening Reports. Class Screening Reports aims to streamline the EIA process of certain categories of project. Such reports are applied only to projects that have similar knowledge bases accumulated through past environmental assessments (Canada Transport Canada, 2007) and where baseline data and impacts are sufficiently well known. One such case is suspended oyster culture in New Brunswick, where the majority of proponents use similar methodologies and infrastructure and management. It is not, however, applied to other forms of oyster culture. Canada Transport Canada (2007) outlines the thinking and requirements of this but as yet its appropriateness and effectiveness has not been critically evaluated. There is an inherent assumption that using this concept will streamline the assessment process but as yet without the supporting information to show that it has.

It is generally accepted that in order for the EIA process to be credible and to fulfil the requirement of enabling good and sustainable control of aquaculture development, the EIA process must be fair, objective and comprehensive (Sadar, 2004). The Canadian government now ensures good public participation, the use of competent professional advice and use the best available scientific information and data through the Canadian Environmental Assessment Act 2003. However, as Sadar (2004) points out, there are key limitations, which include insufficient baseline data about the biophysical and social environments and time and resource constraints for completing the EIA process, which currently act to make the EIA process less robust than it could be. Clearly, as outlined above, the iterative development of a streamlined and appropriate EIA procedure and practice remains a high priority for Canadian aquaculture development.

In western Canada, the Legislative Assembly of British Columbia commissioned a Special Committee on Sustainable Aquaculture to review the impacts and management of aquaculture in British Columbia. The report has recently been published (British Columbia, Legislative Assembly, 2007). They made a number of recommendations in relation to finfish (salmon and cod) culture and shellfish culture on the basis of their environmental impact and related assessment. Central to these recommendations is moving to ocean-based closed containment systems within the next three years. Much of this development is to be funded by the local government. In addition, incentives will be given to the aquaculture industry to facilitate this transition. There should be no new finfish species introduced for ocean-based aquaculture other than salmon. Shellfish aquaculture should be encouraged and expanded within inshore waters in areas that are designated to minimize competition with other coastal resource users. A code of practice should also be adopted to respect the interests of other coastal stakeholders, including First Nations, residential communities, small shellfish operators, tourism and other businesses and recreational users. In addition, it is envisaged that the Ministry of the Environment should increase environmental regulation to minimize release or debris and waste from shellfish operations. Thus, on the basis of results from existing environmental regulation, there is the perception in western Canada that inshore waters should be primarily used for shellfish production. Graham, the DFO's then Assistant Deputy Minister, at the Aquaculture Canada 2003 meeting (Graham, 2003) recognised that there was a need for all governmental agencies to synchronize their information requirements for the review of marine finfish and shellfish aquaculture applications, and this is now being done (CEAA, 2008), although its impact is yet to be fully realized. More recently, Heaslip (2008) commented that there is still some way to go in the practice of monitoring fish farm wastes in British Columbia. He suggested that the monitoring of these wastes should include far field monitoring (at a considerable distance form the fish farm) to include impacts on clam-harvesting and traditional fishing, and to "broaden and integrate" the experience and practices of First Nation peoples. The integration process between science and local knowledge though is acknowledged as very difficult, especially in presenting this in a manner which is readily understandable to decision-makers (Berkes *et al*., 2007).

By continuing to tackle and develop its strategy, the Canadian government authorities can advance the aquaculture industry's own capacity to produce dependable environmental assessment plans. This along with the management outlined above should increase the government decision-making efficiency and thus reduce the expenditure associated with the preparation of aquaculture applications. That said, full, creditable and critical analysis of the appropriate use of EIA for aquaculture development in Canada remains scarce.

United States of America

There is no documented information found specifically on the effectiveness or technical appropriateness of EIA and environmental monitoring in aquaculture in the United States of America. However, there seems to be an environment of implementation of new regulations for regulating environmental impacts (e.g. report of the Marine Aquaculture Task Force; 2007). But this again does not give specific measures for environmental assessment but instead suggests a mechanism of federal governance.

USE OF GENERATED DATA – THE EXAMPLE OF OSPAR/RID

The recent data report of the OSPAR study on Riverine Inputs and Direct Discharges (RID) includes information on the discharges of nitrogen and phosphorus from aquaculture plants at national levels (OSPAR, 2006). Estimates of the nutrient discharges are based on data from the relevant effluent control programme of each OSPAR member state.. The collected data on nutrient (nitrogen, phosphorus) discharges from aquaculture operations indicate that aquaculture activities in Norway and Scotland do contribute to some extent to the total nitrogen and phosphorous loading produced by the country as a whole (OSPAR, 2006). There have been previous efforts of compiling data on nitrogen and phosphorous loads from aquaculture, however based primarily on estimates rather than monitoring data (see EEA, 2003, for further references). European experts however indicated that these figures would have to be viewed with significant caution (CONSENSUS, 2005d). In any case, there is no clear evidence that this loading has resulted in significant undesirable changes in the wider coastal environment (EEA, 2003). The discharges, although only indicative, also contributed to the overall load from inland and coastal areas together with discharges from agriculture, forestry, industry and domestic waste (EEA, 2003).

CONTROL AND IMPROVEMENT OF ENVIRONMENTAL QUALITY

An evaluation of general EIA system performance in eight EU countries (Barker and Wood, 1999) found that due to an EIA being carried out, modifications to projects took place in most case studies undertaken as a result of the EIA process. The EIA process had having a notable effect on the number of project modifications taking place. Most modifications were undertaken by developers prior to submission of their applications for authorization. In some cases modifications took place at the decision-making stage, although opinions expressed during the earlier consultation and review stages were influential in the adoption of modifications during decision-making. On the basis of interviews, literature searches and general EIA data analysis it appeared that the consultees were more influential than the public in proposing modification measures. Consultation and public participation can influence modifications at both the pre-submission and the post-submission phases of the EIA process in most of the countries studied. The involvement of consultees and the public prior to submission of EIA reports was an important factor in proposing modifications to projects.

There is limited information available specifically on aquaculture EIAs. However, studies by Androulidakis and Karakassis (2006) and RPS Group PLC (2007) indicated that the Environmental Statements completed by contractors or private bodies outlined the main impacts on the environment well, but were poor at specifying monitoring requirements or fully analysing alternative sites or environmental mitigation through technology use. However, in many regions monitoring of environmental quality is statutorily part of the legislation and therefore often considered beyond the remit of the EIA within these regions. Specifying further monitoring may be confusing or simply ignored as “not legally required”. One conclusion from these studies was that generally EIAs are not an effective way of gathering the required information to control and improve environmental quality and that maybe a more structured procedure would be more appropriate.

THE USE OF EIA GENERATED INFORMATION FOR IMPROVED MANAGEMENT

Information obtained through the EIA process is designed to provide information to allow decision-makers to judge whether a development can take place or not. Use of data and information generated through the EIA process is inconsistent depending on the location or region. In many eastern European regions implementation of EIA legislation is infrequent and little policing is done, meaning that the EIA often has no role in the decision-making process. In other countries where the role of EIA in aquaculture is more refined within the licensing framework, use of this information is often inconsistent as well. Often the information is given different weighting depending on whether is was specifically asked for by the statutory regulatory bodies within the scoping process, or potentially other political or public agendas. For example, in Scotland much weight is given to the visual impact assessment as part of an environmental assessment. This is not necessarily poor use of the information as other aspects, such as direct impacts on water and/or sediments may be addressed elsewhere in the licensing process which is taking place in parallel with the EIA and for which different reporting is often done (for example issuing of individual discharge consents). However, this is often an indication of wasted effort and thus lack of efficiency within the EIA process.

Many producers view the environmental assessment and environmental monitoring as part of the application and licensing process and only make use of this information if required to do so by regulations. For example, much information is derived for maintenance of environmental quality, but the measures put in place by regulators such as setting production or size levels to conform to Environmental Quality Standards (EQSs) is seen as achieving environmental sustainability. Some larger producers use the EIA as part of the process of implementation of Codes of Practice or accreditation schemes (i.e. ISO 14001, or organic status). The conclusions and recommendations contained in the EIA may form part of the "environmental policy" of the company. Public perception of aquaculture in Europe and North America has been generally negative in terms of environmental impacts and management. The production and publishing of EIAs and can contribute to alleviating fears of most of the public.

In the United States of America a number of states are using BMPs as voluntary or required components in their effluent regulations and for guidance and education for producers and regulators. Some BMPs have been developed for specific species and associated production systems. Additionally, numerous research studies are underway or planned at regional and state levels to identify technologies and practices that have measurable benefits for environmental protection and are affordable and practical for implementation at facilities. This research and development work is expected to continue and result in improved BMPs that support both environmental protection and producer adoption (Tucker *et al.,* 2003). For example, the "Best Management Practices for Channel Catfish Farming in Alabama" (Boyd, 2003) have been adopted by the USDA Natural Resources Conservation Service (NRCS) to supplement the Service's technical standards and guidelines. The guide sheets address a variety of topics, including reducing storm runoff into ponds, managing ponds to reduce effluent volume, controlling erosion, using settling basins and wetlands and implementing feed management practices (Tucker *et al.,* 2003).

REVISION AND REVIEW OF EIA AND MONITORING PROCEDURES

As the EU Directive on EIA is implemented at both an international and national level, there is some allowance for EU Member States to carry out regular revision and review of the prevailing EIA system and monitoring procedures for aquaculture. Various evaluations of performance of the EIA process have been undertaken (e.g., Barker and Wood, 1999; Wood *et al.*, 1996).

In 2003, the European Commission published its report "On the Application and Effectiveness of the EIA Directive (Directive 85/337/EEC as amended by Directive 97/11/EC): How successful are the Member States in implementing the EIA Directive?" (European Commission, 2003). The report examined key areas covered by the EIA Directive. These included *inter alia*: "screening" (determining whether an EIA is required for a specific project), "scoping" (identification of content of environmental impact study- EIS) and decision-making (authorising the project). The report also examined how Member States dealt with EIA issues such as alternative options, public participation and quality control. Nine shortcomings were identified in the following areas:

- The unsystematic "screening" of Annex II projects. Annex II of the Directive lists the categories of projects that have to undergo an EIA if they are likely to have a significant impact on the environment;
- Wide variation between Member States in the criteria for "screening". This means that a certain project would be subject to an EIA in one Member State but not in another;

- Poor "scoping". "Scoping" is the process of identifying the content of environmental impact studies;
- Insufficient consideration of the cumulative effects of projects;
- Processing of transboundary EIAs require more formal and informal consultation;
- Poor quality control systems for the EIA process. Setting quality control systems is not an obligation deriving from the Directive itself but it is left to the Member States;
- Variable levels of EIA activity between Member States, i.e. different numbers of EIAs carried out in the Member States;
- The inadequate incorporation of EIA results in development decisions;
- Incomplete transposition of Directive 97/11.

The general conclusion of this review report was that even after fifteen years of application the EIA Directive had not been properly implemented within all Member States, with most infringements of those EIAs reviewed (65%) being concerned with the bad application of the Directive in relation to individual project.

A review of the performance of the EIA system in Greece (Androulidakis and Karakassis 2006) showed that EIA studies frequently failed to address critical issues of the EIA despite the fact that all of them had followed the same legal framework on the structure of the EIS and subsequently the competent authorities have approved them. EIA studies for new developments carried out in Greece are often simplified, without the contractors or reviewers taking into account crucial elements and procedures, which should be included and thoroughly elaborated upon. The inadequate competence and multidisciplinary nature of the study groups and authorities themselves is considered one of the fundamental problems in the procedures of EIA. Some of these groups tended to lack appropriate scientific background to tackle all issues regarding the environment and the technical characteristics of each project. Problems also arise due to the large number of EIAs submitted and the small number of reviewers examining them. The time allocated to examine each study is significantly short and consequently it is uncertain that a detailed and thorough examination is carried out. The majority of EISs in Greece performed rather poorly in respect of most indicators used and there was little evidence of improvement with time. It is concluded that the authorities in charge still have little experience in coping with the increasing bulk of project submissions and are primarily interested in conformity with formal requirements rather than in reliable predictions and in overall quality of the EIA procedure.

Hence, Androulidakis and Karakassis (2006) point out that in Greece and possibly in several other EU countries, there is a need to address whether the review of the environmental assessments submitted are carried out by state or private bodies, which could lead to a vicious circle with no end-point. They conclude that the optimal reviewing measure could be applied by the well-informed public, who can act and judge the situation in an unbiased manner. This would be particularly useful for aquaculture, however in certain countries where aquaculture has received damaging media coverage, it would be very difficult to find an objective public.

There is limited documentation on the review of EIA procedures within North America. Much of the implementation of the outcomes of the EIA are implemented through best management practices at farm level. In Canada there are regional differences in the implementation of EIA and monitoring procedures with New Brunswick (east coast) having practices which are based on the same legislation but implemented in a different context to that in British Columbia (west coast). There have been reviews on the application of impact information, for example in British Columbia, where a review of aquaculture practice has just been published (British Columbia Legislative Assembly, 2007). This has the overall objective of defining aquaculture policy within a difficult political framework involving considerable environmental lobby pressure and traditional rights of indigenous populations. However, there is no documentation found on the review and assessment of the EIA procedures employed and how effective they are.

In the United States of America, where legislation is complex (see Section 2), there is little review and assessment of the process. There is considerable interest at the present in looking at aquaculture and its sustainability, as can be seen, for example, in the US Commission on Ocean Policy and the US Ocean Action Plan (USA, 2004). The former is concerned specifically with increase of targeted aquaculture research at NOAA and the latter includes the establishment of a regulatory structure for the further sustainable exploitation of offshore aquaculture. There is nothing specific however in either of these policies on the review, assessment or improvement of the existing or future EIA process for aquaculture. There is no documented information on the effectiveness of inland aquaculture EIAs in the United States of America. Again, best management practices through implementation of codes of conduct tend to be the method of acting on environmental policy. These management practices are under review by accrediting bodies through which they are implemented, e.g. the WWF through their series of dialogues on a number of commonly cultured organisms, including salmon and tilapia (see review by Boyd *et al*., 2005). However, there is no specific information on EIA or environmental monitoring of aquaculture.

STAKEHOLDER PERCEPTION OF EFFECTIVENESS OF EIA AND MONITORING IN AQUACULTURE

There is no available published or documented information available, despite extensive searching, that can be reviewed to study, analyse or research stakeholder perceptions in European and North American countries. Projects such as CONSENSUS (2008) and PROFET (2008) give information on the opinions of the stakeholders in terms of environmental indicators for sustainability and environmental policy but no detailed analysis which can be used here in terms of effectiveness of implementation of environmental impact assessment regulations.

It is important for all stakeholders to have a realistic understanding of the role that EIA is intended to play in development approvals. Also, in order to ensure continued support for the EIA process, its benefits need to be explicitly recognized and acknowledged and if necessary, action taken to add value.

An interesting study published by the IUCN (2004) commented on the methods of improving environmental sustainability of aquaculture in the Mediterranean Sea. Several conclusions were made for a variety of sustainability factors, one being the improvement of environmental impact assessment and monitoring. These factors were addressed from the side of the producers, national/international bodies and researcher's side. The improvements from the producers' point of view were based on the development of appropriate tools for "valorisation" of best practices, improved feed management and monitoring and improvement of techniques for monitoring of environmental impacts.

To some extent many of these issues have been addressed through a number of research and development projects,funded through the EU including CONSENSUS (2008), MERAMED (2007) and ECASA (2007). There is still some way to go on implementing these into actual farm practice through systems such as, for example, the sustainability protocols developed through CONSENSUS, and some of these are being incorporated into FEAP codes of practice.

In terms of mitigation or alternative management options which could be considered in EIA processes there is the potential for use of integrated aquaculture systems where more than one species, usually a combination of net contributors and net users of nutrient wastes, are grown close to each other. This should be incorporated into the EIA in terms of the consideration of alternative sites or technologies for the Mediterranean

Sea (IUCN, 2004) and in Canada (Cross, 2006). This could also include the application of artificial habitats for rehabilitation of aquaculture-degraded habitats. The IUCN study also highlights that different EIA legislation is applicable to different systems and sizes of aquaculture. There is a need to simplify the criteria and its implementation. In addition, it is suggested that there should be a system of public minimum guarantee (where the impact study is produced by the public sector authorities) and the private sector would only provide complementary information. This would integrate local public and private investment to everyone's benefit (IUCN, 2004).

There is little documented information on stakeholder perception of EIA effectiveness. Practical experience shows that many producers consider EIAs as a complicated, expensive and non-essential activity during the development stage of their farm. Little of the information is used directly by them in day-to-day farm management, though it is accepted that environmental regulators may use this information to impose management practices upon the farmer. Producers generally consider the regular statutory environmental monitoring, where measured parameters are compared with EQSs, more useful in terms of recognising sustainability of their farm's environment. Only large aquaculture companies which implement Environmental Accreditation Schemes (e.g. ISO 14001) would directly use the EIA information as part of the scheme's requirements.

Possible improvements

Although improvements in EIA efficiency and EIA report quality have occurred across Europe and measures are being taken to strengthen procedures relating to nearly every stage of the EIA process, it is still felt by all of the various stakeholders that there is room for improvement.

The shortcomings in the implementation of the EU EIA Directive which were identified in 2003 (European Commission, 2003) reflect earlier criticisms and deficiencies outlined by Wood *et al.* (1996). Various methods were suggested to increase the quality and effectiveness of EIA reports and therefore enhance the number and extent of environmentally beneficial modifications to projects. These suggestions include:

- strengthening the treatment of alternatives (to ensure early consideration of modifications);
- strengthening screening (to ensure that all significant projects are assessed);
- ensuring that scoping takes place by adopting formal scoping requirements (to encourage early recognition of the need for modifications);
- introduction of strategic environmental assessment (to ensure that environmental impacts are considered very early in the planning process);
- institute formal checks on the quality of EIA reports to ensure that mitigation is fully considered and that modifications ensue;
- strengthening provisions for consultation and public participation (to increase the number of proposed modifications);
- institute EIA monitoring and auditing to ensure that modifications are implemented;
- undertake research into various aspects of the EIA process, in order to replicate and expand on the results reported here and to refine these recommendations to meet particular national circumstances.

More recently a question as to the necessity for a full adoption of EIA process for marine fish farming has been (and is being) addressed in Scotland, based on salmon, but of relevance to all finfish culture including cod and halibut. Here it was discovered that even though the full EIA process and initial monitoring/baseline studies were undertaken, sites were nonetheless rejected using a set of basic rules. Rejection or acceptance of the development was still based on the points within the original scoping requirements, often ignoring other additional information provided. In addressing this inconsistency, a “toolkit” for the initial process of environmental impact assessment of marine fish farming was produced for the Scottish Aquaculture Research Forum (SARF) (RPS Group PLC, 2007). The aim of this “toolkit” was to give practical guidance to developers on potential issues that may arise that would either negate the reason for the EIA or reject the aquaculture system on environmental grounds at an early stage. A series of templates was developed for completion from which planners and regulators could make early recommendations on the appropriateness for continuation of the EIA process within a planning application. These templates can be considered a substitute for pre-application and full planning application for marine aquaculture and even for the environmental statement produced as a result of the EIA. Though these are mostly relevant to salmon aquaculture, they are also applicable to Atlantic cod and halibut and could potentially be used for all type of aquaculture applications. The existing templates are available (SARF, 2007) as blank forms, which may be completed *in lieu* of an EIA. The templates were developed after consultations, workshops and review of existing

EIAs. Though these were based on coastal salmon aquaculture, the scoring system used to grade the EIAs reviewed was based on methods of Lee *et al.* (1999), to assess overall quality and compliance with minimum statutory requirements (see Annex 4). This process is clearly an improvement and if implemented in this form elsewhere in the EU (albeit with templates specific to each individual country's legislation), it may smooth the process and decrease the present level of bureaucracy.

Improvements in the process of assessing environmental impacts in the wider sense may be gained through the introduction of Strategic Environmental Assessment (SEA). SEA is a process to ensure that significant environmental effects arising from policies, plans and programmes are identified, assessed, mitigated, communicated to decision-makers, monitored and that opportunities for public involvement are provided. The importance of this is becoming more widely recognised, but is targeted at more strategic development:

- to support sustainable development;
- to improve the evidence base for strategic decisions;
- to facilitate and respond to consultation with stakeholders;
- to streamline other processes such as Environmental Impact Assessments of individual development projects.

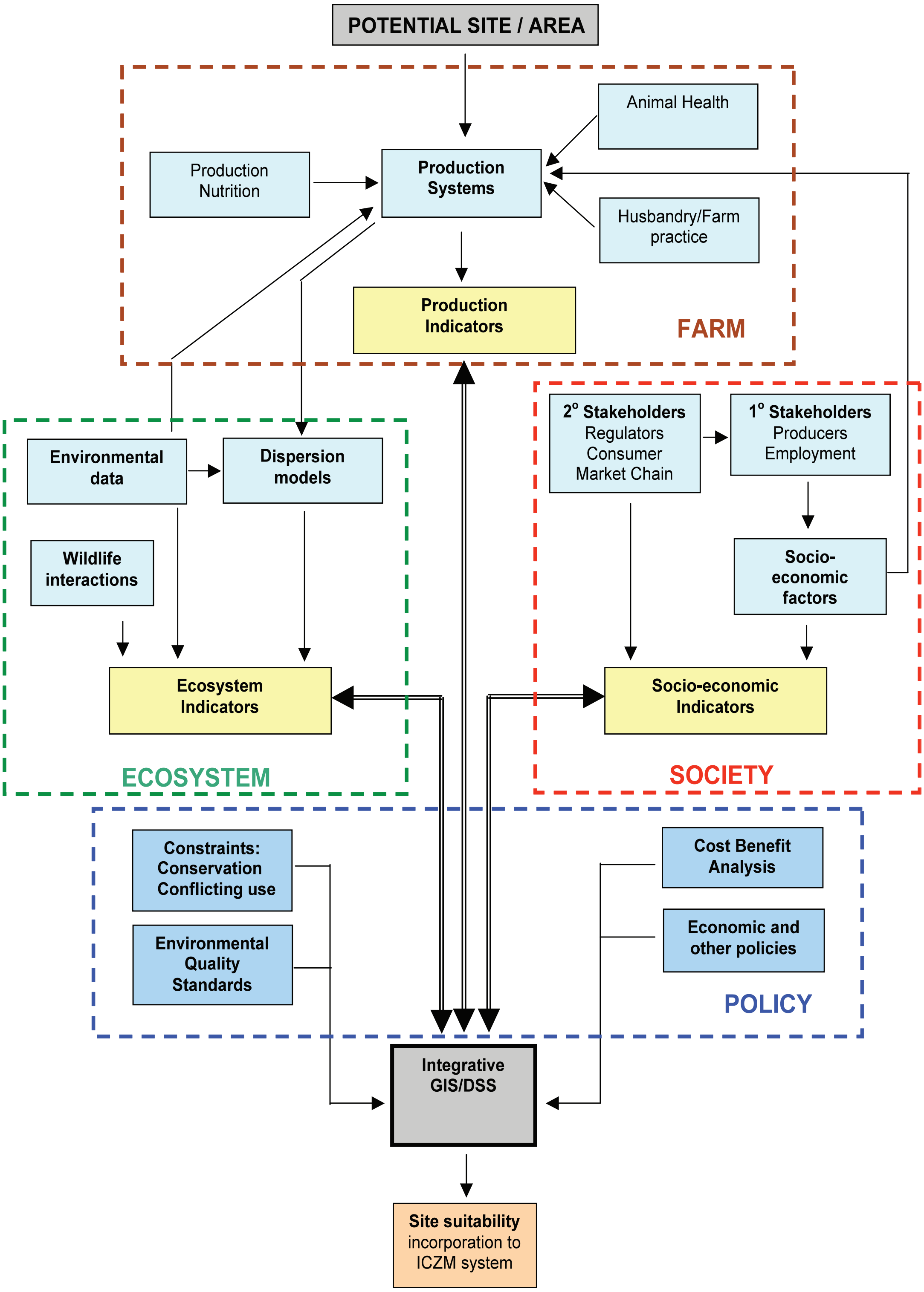
A particular form of SEA was being introduced by the European Union Directive 2001/42/EC (European Commission, 2001). This requires national, regional and local authorities in Member States to carry out strategic environmental assessment on certain plans and programmes that they promote.

SEA is clearly designed for a more strategic approach and therefore would be inappropriate for individual aquaculture developments. However, it would be of considerable use in considering aquaculture impacts in terms of area, regional or national strategy. For example, an SEA could be performed for an area containing a number and variety of aquaculture systems or developments. This would complement the approach under investigation by SARF, where individual development EIAs may be "performed" using the template approach (as described above) and this could feed into a more strategic plan for a larger area. This would be complemented by different wider-reaching modelling systems which can investigate multiple and combined impacts and incorporate the concept of carrying capacity for aquaculture. This can be used not only for incorporating impacts of new or previously developed aquaculture sites, but for more effective selection of sites for potential new developments and included within integrated coastal zone management plans and policy.

An approach for incorporating much of the information provided through the EIA and SEA processes through a single modelling and data collation process involves the use of geographic information systems (GIS). Models such as that presented in Hunter *et al.* (2006) and Hunter *et al.* (2007) could be widely used to integrate this process. These models are still under development but GIS as a tool for management of aquaculture is becoming more popular and widespread by development organizations including the FAO (e.g. Kapetsky and Aguilar-Manjarrez, 2007). The GIS approach to the selection of sites of offshore fish farms is recommended in the "Code of conduct for responsible aquaculture development in the US exclusive economic zone" (NOAA, 2003).

The main thrust of these models is to link complex databases of environmental (including requirements of EIA and environmental monitoring), socio-economic, farm level production information and governmental policy information in a single spatial framework to create an integrated GIS-based Decision Support System (DSS) for aquaculture development and regulation. Figure 6 shows a conceptual model of this approach. The ecosystem-based models for this approach have already been developed (Hunter *et al.*, 2006). This system would allow developers to isolate sites for the development of aquaculture on the basis of all of these criteria and again pre-model

FIGURE 6
Conceptual model of an integrative GIS-based decision support tool for effective implementation of aquaculture development



GIS: Geographic information system
DSS: Decision support system
ICZM: Integrated coastal zone management

Source: Hunter et al., 2006.

much of the criteria for development. In some cases, this may be a complex and time consuming process to implement fully, however even at its simplest level, GIS mapping and spatial analysis will enhance future implementation of the EIA and environmental regulatory process, through data storage, manipulation and acquisition.

Environmental monitoring procedures are often complex and inconsistent between countries. Most methods investigate water quality and/or sediment-based parameters and compare these measured parameters to environmental quality standards (EQSs) set by the environmental regulators and based on best scientific knowledge. Where possible the level of the EQS has been set at a threshold perceived where significant environmental impact occurs or where sustainability is impaired. In some countries, there has been a trend of combining the EQS method of assessment with modelling of waste distribution and combining different environmental parameters into a single index of effect (Gillibrand *et al.,* 2002). The purpose here is to simplify the requirements of environmental monitoring by concentrating on a few key, but easy to measure, parameters (e.g. sediment redox potential), which are indicative of environmental change as a whole. This is a good approach and should be investigated further. It has the advantage of simplicity, reduced requirements for sampling, reduced potential for error, ease of sampling, reduction of costs of sampling and greater potential for effective comparison between studies and monitoring programmes. This would give a more consistent and, to the environmental regulator, more meaningful implementation of monitoring procedure. However, a note of caution should be introduced. These indices or parameters are very good for comparison with EQSs and thus effective regulation, but they must be very carefully defined using extensive environmental data. They should be specific and defined differently for different environments (e.g.. between NE Atlantic and Mediterranean systems). In addition, they would give little information which can be used for comparative research to further existing knowledge of the impacts of aquaculture on the ecosystem sustainability as, by their nature, they simplify data collection and thus less information is available to make detailed overall conclusions. Therefore in this circumstance the distinction should clearly be made between collection of data for environmental regulation (comparison with EQSs) and for scientific research into the impacts of aquaculture on the ecosystem.

Conclusions and recommendations

Although there is now a greater understanding of the environmental impacts of aquaculture, improvements in existing EIA and monitoring requirements in Europe and North America still require more in-depth investigation. This will be an initial step to identifying the greatest risks posed by aquaculture installations and help pinpoint the most important parameters that should be monitored or investigated, therefore streamlining the EIA and environmental regulatory process.

Much research remains to be done regarding the dynamics of waste input, responses from the sediments in terms of the interactions between microbial and macrobiological processes, how these influence the chemistry of the sediments, and the physical processes of oxygen supply, sediment resuspension and mixing by water currents. In addition, inter-annual variability in biological factors, such as the supply of invertebrate larvae, probably has effects that are not as yet well understood.

Further studies of phytoplankton abundance and species composition are required to bring together long-term programmes of monitoring of nutrients, phytoplankton and algal toxins and understanding better the water movements within lakes, rivers, coastal bays and fjords and their interaction between the different waterbodies.

In terms of shellfish cultivation, especially in the EU, a fuller understanding of the interaction of suspended-culture mussel populations with other components of the ecosystem, in terms of their scope for growth (phytoplankton availability), their impact on other suspension feeders in the food web and the potential for nutrient release from accumulated biodeposits is required. Such studies should be linked to the development of models to assist in calculation of appropriate stocking densities for each bivalve cultivation area and the identification of sites where mussel cultivation could be practised to advantage.

A greater understanding of the potential benefits of integrating aquaculture species through more and larger scale research may also be an interesting prospect, using a combination of nutrient extracting species on-site with nutrient enriching species, with a view to increased productivity in the former and a net reduction in nutrient release from the latter. This may lead to a different system requirement for the EIA process and specific environmental regulation.

Finally more information is required on the long-term environmental fate of medicants and anti-foulants and their potential toxicity to pelagic and benthic organisms commonly found in the proximity of fish farms within the EU and North America. Antifoulant usage by the aquaculture industry should be better quantified. Copper and zinc concentrations, speciation and toxicity in fish farm sediments should be further investigated. It may be that a better understanding of finfish metal dietary requirements is needed to reduce metal concentrations in feed and consequent metal input into the marine environment.

The development and improvement of legal and institutional frameworks within the aquaculture industry will continue, but the issues of enforcement and monitoring of compliance with environmental regulations, especially requirements for EIA and regular environmental monitoring are still to be addressed in many countries. In addition, even where there is a mechanism for implementation of the EIA procedure, this is over complicated and often too bureaucratic in many countries. Implementation of standard legislation at regional, state or country levels in a consistent manner would facilitate better and more streamlined implementation of EIA and environmental regulation. The implementation of the more meaningful ecosystem approach to environmental analysis, which allows for all ecosystem impacts to be included in this process rather than individual developments, would be a more meaningful assessment of the actual sustainability of our aquatic environments in relation to aquaculture and its future development.

A more strategic approach to environmental assessment (SEA) may well be pursued through a combination between simplified and more targeted EIA procedures and legislative monitoring and an all encompassing SEA process including assessment of the wider carrying capacity issues and strategic socio-economics implications and the more focused use of wider sustainability indicators and codes of practice/conduct (see CONSENSUS, 2005). This could be built into national and possibly regional legislation. SEA enables many layers to be taken into consideration. This would conform well to a European legislation and to the mixtures on local, state and federal legislation in Canada and the United States of America.

It is of critical importance that future development of the industry and research are effectively linked in those areas where environmental management and performance can be improved, for example research on better site locations, better diets and less expensive protein sources; technological innovations on feed manufacturing and efficient use of energy. More research is needed for the implementation of integrated aquaculture at larger production scales followed by training and extension so that the farmers are able to implement these approaches effectively. Capacity building and knowledge transfer is important particularly to develop and implement better management practices. Also more effective communication is needed at all levels both to share experiences in better management of the sector to all concerned and create dialogue and partnerships to improve understanding and find solutions to the pressing environmental issues affecting the development of this important food producing sector (FAO, 2006).

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ANNEX 1

EU Environmental Impact Statement requirements for marine fish farms under Council Directive (85/337/EEC amended by Directive 97/11/EC; European Commission, 1997).

Under the European Union Council Directive 97/11/EC amending Directive 85/337/EEC, the overall format and content of an Environmental Impact Statement (EIS) is specified in the Second Schedule of the Regulations (see Article 25; appended further below). In addition, applicants are requested to ensure that the data requirements listed below are incorporated into the EIS.

Note: EIS should be presented as a single bound submission comprising narrative and appended technical studies.

1 The description of the physical characteristics of the project should include the location, number and type of cages, as well as details of moorings and any other floating structures proposed. Associated land based facilities (including facilities for disposal of dead fish) should be described. Transport requirements (land and sea) to and from the site should be detailed and related to existing infrastructural facilities such as roads and piers. Requirements, if any, for additional infrastructural facilities should be specified.

2 The description of the production processes should include quantity of fish to be harvested annually. Quantity and type of food to be used should also be specified.

3 The estimate of type and quantity of expected residues and emissions should include details of fish farm effluent characteristics. All chemical and antibiotics intended for use in stock treatments should also be listed.

4 The description of those aspects of the environment likely to be significantly affected by the project should include the following:

- sediment study – including type, depth and redox potential;
- a baseline survey of water characteristics:

– Physical	Temperature profiles
	Salinity profiles
	Water transparency
– Chemical	Oxygen tension
	pH
	Ammonia (total)
	Nitrate
	Total N
	Total P
	Silicate
– Biological	Phytoplankton
	Chlorophyll
	Zooplankton
	Benthic fauna

Note: Selection of control sites/monitoring stations is extremely important in order to follow natural fluctuations, seasonal cycles etc.

- details of shellfish beds and fisheries in the area;
- commercial activity in the area (sea and environs);
- recreational activities (including water sports, boating, angling and bathing);
- implications for wild fish stocks in the area.

5 The likely significant effects of the project on all other beneficial users of the sea and environs (including scenic aspects) should be detailed.

6 The description of the likely effects of the project on the environment resulting from the emission of pollutants and elimination of waste should give details of the potential effects of the fish farm effluents and chemicals on the waterbody as a whole; the sea bed; and other fish/shellfish life in the area. This section should therefore include the conclusions derived from a depth survey and a hydrodynamic investigation, both of which should be included as appendices.

The hydrodynamic investigation should specifically address the following:

- the movement and eventual degradation of solid waste from the farm;
- the effect of the fish farm effluent on the chemistry of the waterbody as a whole (this will involve an estimate of the turnover time of water in the bay);
- the time and concentration of chemicals used on the fish farms in the vicinity of shellfish beds.

Sufficient field measurements must be undertaken to enable these assessments to be made.

In open sites with no sensitive areas (e.g. shell fish beds) near-by, the first point above needs to be considered. This will involve, at the very least, current measurements of speed and direction at three depths over a complete tidal cycle.

In other areas additional field measurements will be necessary to enable the required hydrodynamic investigation to be carried out. The Department should be advised in advance of the proposed parameters to be measured.

7 The description of the measures envisaged to avoid, reduce or remedy adverse effects of the fish farm should include the following:

- consideration of the ability of the cages to withstand wave conditions likely to occur at the site. A wave climate analysis will be required to determine this and should be included as an annex;
- details of measures envisaged to prevent escapes;
- details of anti-predator measures;
- details of navigational lighting and marking or cages;
- details of proposed arrangements for bleeding of harvested fish.

Second Schedule – Article 25
Information to be contained in an Environmental Impact Statement

1 An environmental impact statement shall contain the information specified in paragraph 2 (referred to in this Schedule as “the specified information”).

2 The specified information is –

(a) a description of the development proposed, comprising information about the site and the design and size or scale of the development;

(b) the data necessary to identify and assess the main effects which that development is likely to have on the environment;

(c) a description of the likely significant effects, direct and indirect, on the environment of the development, explained by reference to its possible impact on –

- human beings
- flora
- fauna

- soil
- water
- air
- climate
- the landscape
- the interaction between any of the foregoing
- material assets
- the cultural heritage

(d) Where significant adverse effects are identified with respect to any of the foregoing, a description of the measures envisaged in order to avoid, reduce or remedy those effects;

(e) a summary in non-technical language of the information specified above.

3 An environmental impact statement may include, by way of explanation or amplification of any specified information, further information on any of the following matters –

(a) the physical characteristics of the proposed development, and the land-use requirements during the construction and operational phases;

(b) the main characteristics of the production processes proposed, including the nature and quantity of the materials to be used;

(c) the estimated type and quantity of expected residues and emissions (including pollutants of surface water and ground water, air, soil and substrata, noise, vibration, light, heat and radiation) resulting from the proposed development when in operation;

(d) (in outline) the main alternative (if any) studied by the applicant, appellant or authority and an indication of the main reasons for choosing the development proposed, taking into account the environmental effects;

(e) the likely significant direct and indirect effects on the environment of the development proposed which may results from –

- the use of natural resources
- the emission of pollutants, the creation of nuisances and the elimination of waste;

(f) the forecasting methods used to assess any effects on the environment about which information is given under subparagraph (e);

(g) any difficulties, such as technical deficiencies or lack of knowledge, encountered in compiling any specified information.

In paragraph (e), "effects" includes secondary, cumulative, short, medium and long term, permanent, temporary, positive and negative effects.

4 Where further information is included in an environmental impact statement pursuant to paragraph 3, a non-technical summary of that information shall also be provided.

ANNEX 2

Environmental Impact Assessment requirements for shellfish farming in Canada (DFO, 2002a)

The information identified in this section is to be collected by the proponent and compiled in the form of a report to be provided to the DFO assessor responsible for the environmental assessment of the aquaculture project.

Project Description

Contact Information

Provide the following contact information for the project:

- name and address of proponent (including company name);
- name of principal contact person;
- telephone and fax numbers; and
- email address.

If the EA information submission was prepared by a consultant(s) or another group on behalf of the proponent, provide contact information for the agency or individual(s).

Indicate which other permits, licences and approvals for which you have applied.

Physical Location and Site Detail

Provide a copy of a topographic map, navigational/bathymetric/nautical chart or orthophoto map showing the exact location of the proposed tenure, aquaculture facility and the onshore facilities used to access the site.

Provide a detailed sketch or plan (to scale) of the site and specify:

- latitudinal and longitudinal corner and centre co-ordinates of the site;
- datum (NAD 27 or NAD 83); and
- dimensions of the site.

Provide the surface area of the proposed site and area of production (m^2 or hectares).If the application is for an expansion, provide the area of the existing site (m^2 or hectares) and the proposed expanded area (m^2 or hectares).

Briefly describe the location of the point of access for the proposed site (i.e., wharf, slipway) and locate it on the topographic map or nautical chart (from #1 above). Use nearby area features such as landmarks, islands, highways, wharves, etc. in this description.

On the map, draw a 2 km circle and 5 km circle around the proposed site with the site situated in the centre. Within the 5 km circle, indicate the location of all other users of the area (e.g. other aquaculture operations, shellfish beds, processing plants, campgrounds, cottage communities, municipal or industrial sources of effluent, tourism operators, navigational channels, First Nations territories/reserves, commercial, recreational and aboriginal fisheries, any known future projects and activities, etc.). This may be available from the province or another source. An equivalent mapping plan with the same information, if available, can be substituted for this either all or in part – all available information relative to other users is expected to be included in the proponent's submission.

Within the 5-kilometre circle on the map, identify the location of any environmentally sensitive areas surrounding the proposed site (e.g., rearing or spawning habitat, migration corridors, protected areas or proposed protected areas, location of streams and connected waterbodies such as lakes, wetlands, sensitive migratory bird habitat, areas used extensively by marine mammals, etc.).

Briefly describe the current use of the foreshore/shoreline of the land adjacent to the proposed site. Provide the name the shorefront property owner, if applicable. Indicate the water depth at all four corners of the site at lowest and highest tides. 8. Describe the site selection process, including the opportunities and constraints that were evaluated in the process.

Indicate whether the proposed site adheres to regional or provincial siting guidelines. If yes, indicate how and why. If not, indicate why not.

Design & Operational Plans

Construction and Installation
Provide labelled scale drawings of the proposed aquaculture facility in two dimensions (plan view and cross sectional view). Include all equipment such as mooring system, anchors, long lines, floats, tables, trays, socks, rafts, predator nets, etc. Include details of any land-based components, as applicable.

Note: If it is anticipated that the operation will be expanded in the foreseeable future, provide a second set of drawings illustrating the expanded layout. Provide a detailed description of any plans for future expansion including approximate dates of completion. Include the addition of works, diversification of species cultured, any future infrastructure, or any other plan that might affect the site. If it is anticipated that the infrastructure will be moved within the tenure boundaries, provide drawings of likely alternate siting configurations.

Is the site sub-tidal or intertidal?

Describe the anchoring / mooring system (e.g., screwed in, non-attached, etc.) and explain the placement and installation procedures to be employed.

Provide details on how the structures will be installed and the type of machinery or equipment required for installation, operation and harvesting.

For Bottom Culture
Provide a description of the type of structure(s) to be used and associated works such as predator nets/car cover (e.g., type of material, dimension and mesh size); fences and supporting structures (e.g., type of material, dimension and mesh size); tables (e.g., numbers and dimensions).

Indicate the area of the bottom covered by these structures.

Will beach modifications be required? If yes, provide details about what will be modified, how and when the modifications will occur.

Note: If beach modifications are proposed (e.g., addition or removal of substrate, creation of rock berms/windrows), it may be necessary to obtain an authorization under subsection 35(2) of the Fisheries Act from Fisheries and Oceans Canada (DFO.

In addition, there may be provincial requirements which must be met. Consult DFO and provincial authorities on these requirements.

For Near-Bottom Culture

Describe the culture technology to be used. Provide the appropriate dimensions of bags, socks, trays, cages or tables as well as the number of units. For example:

- tray type;
- height of table, frame or trestle from sea bottom;
- tray dimensions; and
- number of trays per stack.

Give the total number of tables and units to be used on a yearly basis, as well as the expected number at full site utilization.

For Suspension (Long-Line) Culture (Off Bottom)

Give the number and dimensions of longlines and/or rafts. If the site is being developed incrementally, provide details on the developmental phases, including schedule.

Provide information regarding the culture units to be used for growing. Include a description and the dimensions of gear. For example, include:

- type and number of culture units (i.e., socks, trays, lanterns, etc.);
- if lanterns, give the number of levels per unit and the diameter of each level;
- if trays or bag units, specify dimensions;
- if socks, specify the length to be used;
- number of lines on site, length of lines, space between lines;
- specify spacing between units on longlines;
- specify total number of units per longline; and
- number and dimension(s) of flupsy(ies) (floating upwelling systems), including anticipated flow at peak production.

Describe grow-out husbandry techniques and practices (i.e., raising and lowering of longlines, cleaning of in-water equipment, etc.) to be implemented.

Infrastructure

Describe other facilities, either existing or proposed, associated with the proposed aquaculture operation including during the construction and installation phases. These may include wharves, access roads, staff facilities, portable washrooms, oceanfront property, land facilities, etc. Indicate the location of these facilities on the topographic or orthophoto map or nautical chart provided. Include details and a schedule of what activities will take place and where.

Note: *A specific permit under provincial or federal legislation may be required for such works/activities. Contact the provincial agency(ies) responsible and DFO Habitat Management or Navigable Waters Protection Programme for additional information.*

List standard operating procedures and planned mitigation measures to mitigate any potential harmful effects of the installation, construction and operation phases of the facility. Measures may include ensuring that the construction site remains clean, siting the operation away from sensitive fish habitat, installing silt fences at specific locations to minimize deposition of silt into the marine environment, ensuring that shoreline areas are not harmed by construction activities, and environmental monitoring. Details regarding these measures will be required to provide assurance to DFO officials that potential environmental effects can be mitigated.

Note: *Mitigation measures (measures to mitigate) are actions taken to avoid, reduce or minimize effects on the environment. These may include such actions as timing activities to avoid migration times of aquatic species or conducting in water activities during low tide or isolating in-water activities to reduce habitat disruption.*

Describe facility inspection and maintenance procedures, including their frequency and the actions to be taken. Discuss daily, weekly, monthly and yearly maintenance requirements, as well as post-event (storms, predator incursions, etc.) inspection and maintenance procedures.

Production
Specify the species and source of shellfish to be raised, including the spat collection technique and location.

Confirm your plan to obtain a licence through the Introductions and Transfers Committee(s) for the transfer of your stock from one location to another.

Note: The transfer of fish (including shellfish) from one location to another requires a review by DFO (and perhaps the provincial) Introduction and Transfers Committee, and a licence pursuant to section 56 of the Fisheries (General) Regulations.

Seed and brood stock imported inter-provincially or internationally must be certified disease free. Further details will be required for the Introduction and Transfers Committee.

Provide the total stocking biomass and estimated production (harvest) level at the site.

Describe seeding, maintenance and harvesting procedures including scheduling and transportation of product from the production site to the processing plant. Describe any measures to be implemented to mitigate potentially harmful effects resulting from harvesting and transportation activities.

Indicate location and methods of disposal of shell, rope, socking, net debris, etc. The *Canadian Environmental Protection Act* (CEPA) prohibits the deliberate disposal of any substance at sea unless the substance is specified on Schedule 5 of CEPA. Deliberate disposal at sea of specified substances requires a Disposal At Sea permit from Environment Canada under section 127 of CEPA (Environment Canada, 2001). Before being granted such a permit, the proponent will have to show that all other disposal or recycling and reuse options have been evaluated and an extensive review by Environment Canada will be required.

Ancillary Management

Predator Control
Describe measures to be taken to minimize predator (birds, mammals, other fish, crabs, etc.) attraction and interaction (e.g. minimal perching areas; barrier systems; visual and/or acoustic deterrent devices, etc.). Provide details on how these measures may affect the predator.

Note: *Destruction of "fish" by means other than fishing may require an authorization under section 32 of the Fisheries Act from DFO.*

Note: *Environment Canada's Canadian Wildlife Service (CWS) has a "Policy for the Issuance of Scare Permits for the Aquaculture Industry". To minimize impacts on migratory birds while protecting aquaculture operations against depredation of their crop, this policy places strong emphasis on siting considerations and early avoidance of problems. Contact CWS for information on this policy or go to: http//www.cws-scf.ec.gc.ca/1_pdf/Aqua.pdf.*

Note: *Proponents should also contact DFO and provincial wildlife agencies with regard to their predator control policies and regulatory requirements.*

Anti-fouling

Provide details for any anti-fouling materials that may be used and describe how each may be applied, including location, method and frequency of application. Also describe any mechanical removal processes used. Explain where the fouling organisms and other water/material will be disposed. 2. Provide details of the rope and gear cleaning procedures and location(s) where cleaning will take place.

Hazardous & Human Waste Materials

Provide a list of any hazardous materials that may be used on site (e.g., cleaning agents, fuels, etc.). Provide details regarding the transportation, use, storage and disposal of these materials and their containers (e.g., paint cans, oil containers).

Describe the procedure used for collection and disposal of routine garbage and human wastes generated on site.

Decommissioning

Should decommissioning be required, describe the process, including measures to restore the area to its pre-development state.

Accidents & Malfunctions

Identify potential risks from malfunctions or accidents that may occur during the installation, operation and decommissioning phases of the project (e.g., fuel spills, storm destruction, extraordinary loss of shellfish, etc.). Discuss operational plans (such as boat and equipment safety protocols, staff presence on the site) to prevent such accidents and malfunctions and contingency plans (including emergency spill response plans, containment and cleaning of spills) to deal with each of these potential situations, including details of appropriate equipment and materials to be kept on site. What is the expected response time to deal with an onsite emergency?

Existing Environment

Note: *It is recommended that proponents meet with DFO officials early in the project planning process. Such a meeting will serve to help identify site-specific information requirements, environmental factors to be considered and the anticipated level of effort and detail that may be required in collecting and compiling information for the EA. It is an opportunity to direct the information gathering process and to focus the efforts of both the proponents and the reviewers.*

Aquatic Environment

Oceanographic

1. Provide the following information pertaining to the proposed site:
   - range of depths (metres) throughout the site (a profile diagram is useful to convey this information).

  - these can be obtained from a hydrographic chart of the area. Indicate the chart number.
  - if you provide soundings that you have taken yourself, also provide the date the soundings were taken and the start and finish times. State if the soundings you provided have been reduced for tide.
- what is the higher high water large tide (HHWLT) in metres and the lower low water large tide (LLWLT) in metres?
  - these can be obtained from tide tables or hydrographic charts for the area.
- what is the minimum depth (in metres) between the bottom of the aquaculture facility or structures and seafloor at LLWLT?
- what is the direction of maximum fetch at the site?
- estimate the maximum wave height (in metres).

Note: Some government agencies provide oceanographic data on their Web sites. For example, Oceans Science Web site for Maritimes Region (www.mar.dfompo.gc.ca/science/ocean/home.html) and Pacific Region (www.pac.dfompo. gc.ca/sci/osap/) includes such information as ocean currents, water temperatures, salinity. As well, information is available on the St. Lawrence Observatory site (www.osl.g.ca). It may be beneficial to check such sites.

Water Quality

Some measures to characterise the food supply are useful for calculating the potential carrying capacity of the site. These include suspended particulate matter (SPM), particulate organic matter (POM) or chlorophyll. This information is most necessary in areas of shallow depth and/or restricted water exchange where effects of particle removal by filter feeding cultured species is expected to be greatest. DFO will confirm, based upon site characteristics, the extent to which this information is required, on a site-by-site basis.

Provide the Secchi disk depth (the depth at which a 30-cm diameter black and white disc disappears from site under calm conditions during the day) can be used to calculate SPM if direct measurements are not available.

List any other known organic matter inputs and/or sources of contaminants that may exist within the bay or which may be in close proximity to the site. These may include sources of contaminants resulting from raw sewage, agriculture activities, log boom storage, forestry, effluent from fish processing plants, disposal at sea, land-based industries, etc. Indicate how these activities or inputs/contaminants could affect the site and aquaculture operation.

The Canadian Shellfish Sanitation Program (CSSP), jointly administered by DFO, Environment Canada and the Canadian Food Inspection Agency (CFIA), provides for the continuing evaluation of the level of contamination in the water overlying shellfish growing areas and their classification as to sanitary quality. Specify whether the proposed site is located within a shellfish classification area. If so, specify the current classification and the date of the most recent survey. If not, specify the location of and distance to the nearest classified area and the date of its most recent survey.

Note: As a starting point, check the Shellfish Growing Area Classification Index at www.ns.ec.gc.ca/epb/sfish/maps/class.html for the East Coast and www.pyr.ec.gc.ca/ep/shellfish/shell_e.htm for the West Coast. Contact DFO or Environment Canada for more information. Note that this information is not available in Quebec.

Note: Sampling guidelines/protocols for Currents and Benthos may be obtained from DFO – Habitat Management.

Currents

In general terms, describe the current - is it relatively weak, medium or strong? Current description should be based upon the following:

Weak	< 2 cm/s
Medium	2–10 cm/s
Strong	> 10 cm/s

Benthos

Note for the following section in particular, various factors may affect the level of information and monitoring required as outlined in the Preface. Consult with DFO to confirm whether this information is required for your project.

Characterize the benthic habitat. Where depth and turbidity permit, an underwater video record *should* usually be obtained using a diver-operated (handheld) camera. In deeper water, a towed camera system can be used. [Guidelines for obtaining video recordings of bottom conditions can be obtained from Habitat Management.] The visual survey provides critical information on both marine life in the area (e.g., invertebrates, fish and plants), as well as seafloor characteristics (substrate size, relative proportions) at the proposed lease site. Where other types of surveys have been conducted (bottom raking survey, bottom type surveys) include the information they have produced.

In intertidal areas, characterization of the benthic habitat *may* require a standardized, transect-based habitat survey including a description of the assessment area (habitat observations, maps and photos). DFO officials will indicate for which projects this will be required.

Information *may* be required on the percent organic matter (weight loss on ignition at 550 C for four hours) in surface sediment and sediment type through samples collected using benthic grabs and/or cores. This provides an indication of sediment characteristics prior to organic enrichment and, therefore, indicates the potential for assimilation of organic by-products.

Depending upon depth and currents at the site that create the potential for organic enrichment or depending upon the distance to sensitive fish habitat, there *may* be a requirement for additional measurements of specific water column (SPM, POM and chlorophyll a) and sediment (Eh, total sulphides and organic content) variables. General information on water depth, variability in current speed over a tidal cycle and sediment texture should be sufficient to indicate if additional environmental data is required.

Biological Environment

Note: *For this section, a number of resources should be consulted to collect information. These may include an underwater video survey, commercial and recreational fishers, aboriginal groups, Fishery Officers, local fishery organizations, other local residents, etc. A great deal of information concerning fishery resources is available to the public through local regional development authorities. Ensure that all information transfer is documented and attached. It is the responsibility of the proponent to demonstrate* *a reasonable effort to collect information. Provide details about the sources of the information (contact name, agency, phone number, etc.).*

From the video survey (when conducted) and collected site knowledge, describe fish habitat at the site. A map indicating substrate type (silt, sand, gravel, cobble boulder) plants (eelgrass, kelp) significant patches of animals (urchins, lobsters, crabs, sea cucumbers, etc.) and any other habitat features (e.g., rocky outcrop) should be provided. Include approximate abundance of each component, i.e., percent cover or number of individuals observed in a given area.

Standard Sediment Grain Size Fractions:

Boulder > 256 mm	Sand 2 – 0.062 mm
Cobble 64 – 256 mm	Silt 0.062 – 0.004 mm
Gravel 2 – 64 mm	Clay <0.004 mm

List other fish species that may use this area as spawning, rearing, or over-wintering habitat. Include the source (name, agency, publication, etc.).

Note: *Under section 34 of the Fisheries Act, fish habitat is defined as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes".*

Note: *Under section 2 of the Fisheries Act, the definition of fish includes "…shellfish, crustaceans, marine animals and… the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals".*

Does this site lie within the migratory route of any fish species? If so, identify the species and the predicted time(s) of migration.

What is the distance from the site to the nearest stream(s)? If the site is less than one kilometre away from the stream, provide information on physical habitat of the stream, including photographs, steepness at the mouth of the stream and presence/location of any fish species, life stage, etc., which may inhabit the stream either seasonally or year-round.

Identify the type(s) of potential predators (e.g., birds, seastars, crabs, snails, mammals, etc.) that may interfere with the operation. Give the time of year they are most prevalent, noting particularly the presence of breeding areas, colonies, spring and fall staging areas, wintering areas, food sources and feeding areas.

Are any species at risk associated with the site? If so, provide details as to the species that may be present permanently or temporarily, as well as food sources, feeding areas and any proposed recovery plans.

Note: *Contact the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) at www.cosewic.gc.ca or Conservation Data Centres (CDC) at* www.abi-canada.ca*.*

Are there any areas in close proximity to the proposed site where birds are likely to congregate, such as ecological reserves, National Wildlife Areas, government parks, Migratory Bird Sanctuaries, Ramsar Sites, Important Bird Areas, or Western Hemisphere Shorebird Reserve Network Sites? If yes, provide details, including species likely to be present, breeding areas, colonies, staging areas, wintering areas, food sources and feeding areas.

Note: *Information is available at www.cws-scf.ec.gc.ca/cwshom_e.html or contact the regional offices of the Canadian Wildlife Service (Environment Canada). In addition, also consult Environment Canada's Environmental Assessment of Shellfish Aquaculture Projects: Guidelines for Consideration of Environment Canada Expertise at* www.atl.ec.gc.ca/assessment/facts.html.

Socio-Economic Environment

Note: Under CEAA, the Responsible Authority (RA) is required to consider any effect of any change that a project may cause in the environment, including any effect of any such change on socio-economic conditions.

Describe any fishing activities (e.g., commercial, Aboriginal or recreational fisheries), tourism operations, recreational activities (e.g., boating, diving, skiing, swimming, etc.) in the vicinity of the site that could potentially be affected by changes in the environment resulting from the establishment and operation of the proposed aquaculture site. Provide information on their time(s) of operation and proximity to the site.

Provide contact names and comments received from any other users, such as fishers or their association(s), tourism operators, etc., that have been contacted to discuss the proposed development.

Note: *Under CEAA, the RA is required to consider any effect of any change that a project may cause in the environment on the current use of lands and resources for traditional purposes by aboriginal persons.*

Could the project have an effect on aboriginal people and use of their lands for traditional purposes? Indicate why or why not. If there are aboriginal persons that could be affected by your project, summarize any discussions and correspondence you have had with them.

Note: For information on Aboriginal groups, contact either the First Nations Tribal Councils or Band Council identified at www.johnco.com/firstnat OR the appropriate regional office of Indian and Northern Affairs Canada at www.inac.gc.ca.

Does the proposed site contain anything of historical, archaeological, paleontological, or architectural significance? If so, explain its significance.

Note: Parks Canada, Canadian Heritage and/or a local natural history museum, or other cultural agencies in the area may be able to assist.

Is the proposed site near potential or existing Marine Protected Areas (MPAs) or other federally or provincially classified parks? If yes, specify which one(s) and their locations.

Note: Contact DFO, Parks Canada and provincial authorities for information.

Public Consultation

Provide information on and copies of, any advertisements and public notices regarding the proposed development, including the date(s) and sources (e.g. newspapers, radio; newsletters, etc.).

Describe the public notification and consultation process. Provide names of contacts and dates of meetings or interactions. Provide information on comments and recommendations received in support of or in opposition to the proposed venture. Indicate how the issues raised by these parties may be addressed.

Changes to the Project Caused by the Environment

Note: *Environmental effect also includes: any change to the project that may be caused by the environment.*

Identify any changes to the project that may be caused by the environment. Aspects of the environment, such as weather and climate, tides, toxic and non-toxic algal blooms, wind and wave effects and ice, should be considered. Identify measures to be put into place to mitigate these changes. If available, provide a copy of any studies or supporting material, such as engineering reports.

Cumulative Environmental Effects

Note: *Under CEAA, DFO is required to consider any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out.*

The concept of cumulative effects is the recognition of the complex ways in which the environmental effects of individual projects and activities interact and combine with each other over time and distance. Thus, to address cumulative environmental effects in environmental assessments requires *thinking cumulatively*. This means giving consideration to: (1) the temporal and geographic boundaries of the assessment; and (2) the interactions among the environmental effects of the project, other existing and future aquaculture and non-aquaculture projects and activities. The mapping exercise specified above, Question 5, as well as the other information provided by the proponent,, will serve to identify potential environmental effects that exist within the 5 km circle around and beyond the proposed development site. The actual area for potential cumulative environmental effects around a proposed site may vary depending upon the physical characteristics of the location. Based on information provided and other available information, DFO will assess the scope, likelihood and significance of adverse cumulative environmental effects associated with the proposed shellfish aquaculture project. The proponent may be requested to provide additional input to assist with the assessment of cumulative environmental effects. As with environmental assessment in general, there is no one approach or methodology for all assessments of cumulative environmental effects. Different circumstances, such as location of project and type of potential environmental effects will dictate appropriate methodologies. Where information may be lacking, qualitative approaches and best professional judgement are used.

Follow-up Programme

As part of this exercise, the RA may conclude that a follow-up programme (monitoring) is required to verify the accuracy of the environmental assessment and to determine the effectiveness of mitigation measures implemented. The proponent will be required to comply with the monitoring programme, including carrying out any sampling required and ensuring that monitoring results are provided to DFO.

ANNEX 3

An example of an environmental risk matrix for shellfish farming in Canada (DFO, 2002a).
(Available: http://govdocs.aquake.org/cgi/ content/abstract/2004/410/4100270)

A. Marine Habitat (including water quality)				
Project Activity	**Potential Environmental Effects**	**Possible Mitigation**	**Significance of Adverse Environmental Effects**	**Follow-up Monitoring**
Construction and Operation	Reduced water quality and effects to water column flora and/or fauna. Organic loading, smothering or alteration of habitat. Impacts on the health of local marine organisms. Reduction of phytoplankton in the ecosystem.	Avoid low water exchange areas for large projects (intense culture). Minimize in-water activities to reduce release of sediments and sediment-laden water into any waterbody. Time in-water activities to avoid migration and spawning windows. No foreshore modifications without consulting the DFO. Locate sites where current and flow provide adequate movement of nutrients. Catch nets or double socking to catch fall-off.	Determination of significance of adverse environmental effects to be made by DFO.	Established monitoring programme.
Refuse Disposal	Waste accumulation in the water column and on benthic habitat. Degradation of water quality.	Solid waste to be removed from site and disposed of in an appropriate manner (no disposal of materials to the water column). Periodic removal of all garbage (e.g. ropes, socks) from site and disposal in approved landfill. Catch nets or double socking to catch fall-off.	Determination of significance of adverse environmental effects to be made by DFO.	
Accidental events/spills (e.g. fuel, hydraulic fluid and lubricants)	Degradation of water quality. Release of hazardous materials. Effects to shellfish health and production.	Use of less toxic alternatives to hazardous products. Development of Emergency-Spill Response Plan. Designation of areas for storage and refuelling with proper containment. Training of workers in the effective use of fuel and lubricants.		
Debris accumulation on the sea bed	Alteration of the substrate by smothering.	Catch nets or double socking to catch fall-off. Waste products to be removed from site and disposed of at a suitable location.		
Biofouling control measures (physical removal and treatment of equipment	Degradation of water quality (increased particulates, toxicity to some species).	Use of appropriate defouling methods and proper disposal of waste. As appropriate, allow fouling organisms to be released back into suitable habitat, rather than allow to 'dry-out'. Land or boat-based defouling.		
Placement and removal of anchoring system	Physical disturbance to benthic habitat.	Minimize extent of in-water activities. Provide minimum buffer zone around sensitive habitats like eelgrass, saltmarsh and kelp beds.		

B. Fisheries Resources

Project Activity	Potential Environmental Effects	Possible Mitigation	Significance of Adverse Environmental Effects	Follow-up Monitoring
Construction and Operation	Alteration of fish migration patterns.	Locate sites away from important migration routes. Meet all siting guidelines.	Determination of significance of adverse environmental effects to be made by DFO.	

C. Wildlife (including birds, crabs, mammals and species at risk etc)

Project Activity	Potential Environmental Effects	Possible Mitigation	Significance of Adverse Environmental Effects	Follow-up Monitoring
Construction and Presence of Infrastructure (e.g. physical presence, noise, disturbance, attraction) and bird deterrent programmes	Predator attraction to sites as a food source. Alteration to staging and distribution patterns. Disturbance to shorebirds and displacement or reduced access to traditional areas of use. Entanglement/drowning of birds in predator nets.	Site selection to reduce predator interest and areas with large numbers of migratory birds. Proper on-site maintenance and cleanliness. Predator management plans. Mesh sizes of predator nets should be in accordance with recommendations of the Canadian Wildlife Service, Environment Canada.	Determination of significance of adverse environmental effects to be made by DFO.	
Accidental spills (e.g. fuel and lubricants)	Potential mortality from oiling. Long-term effects e.g. impairment to reproduction.	Use of less toxic alternatives to hazardous products. Proper storage of materials. Develop Emergency-Spill Response Plan. Spill kits to be maintained on-site in case of accidents. Designation of areas for storage and refuelling with proper containment. Train workers in the safe and effective use of fuel and lubricants. All machinery to be in good working condition, free of leaks.		Further monitoring after Emergency-Spill Response.

D. Traditional Use of Lands and Resources by Aboriginal Persons

Project Activity	Potential Environmental Effects	Possible Mitigation	Significance of Adverse Environmental Effects	Follow-up Monitoring
Access to site and harvesting activities.	Interference with use of infrastructure (wharf, roads etc).	Consult with local aboriginal groups. Avoid areas of lands and resources currently used for traditional purposes. Meet all siting guidelines.	Determination of significance of adverse environmental effects to be made by DFO.	
Construction and Operation	Interference with traditional uses.	Consult with local aboriginal groups. Avoid areas of lands and resources currently used for traditional purposes. Meet all siting guidelines.		

E. Fisheries Activities (e.g. commercial, recreational and aboriginal)

Project Activity	Potential Environmental Effects	Possible Mitigation	Significance of Adverse Environmental Effects	Follow-up Monitoring
Operation of aquaculture site/ vessel traffic	Interruption of access to fishing areas.	Abide by Navigable Waters Protection Act (NWPA) approvals and conditions, including site-marking requirements. Consult with local fishermen and other marine user groups. Avoid sites with significant fisheries. Maintain access to site by fishermen, as operational and safety conditions permit. Meet all siting guidelines.	Determination of significance of adverse environmental effects to be made by DFO.	

F. Historical, Archaeological, Paleontological and Architectural

Project Activity	Potential Environmental Effects	Possible Mitigation	Significance of Adverse Environmental Effects	Follow-up Monitoring
Site operations and activities.	Information gap identified.	Consult with interested and knowledgeable parties. Avoid areas of significant physical and cultural heritage. Background check into history of area.	Determination of significance of adverse environmental effects to be made by DFO.	

ANNEX 4

Quality assessment method as applied to aquaculture EIAs in Scotland (RSP Planning, 2007 – Scottish Aquaculture Research Forum Report 024)

The reviewer is instructed to read all of the advice for reviewers and read the review topics (areas, categories, subcategories) for familiarity. A key part of the evaluation should be whether the EIS was found to be:

- focused on the key questions;

scientifically and technically sound; and

clear and coherently organised so that it can be understood.

The reviewer is made aware of areas of weakness, omission or concealment in the EIS. These may occur when:

- certain tasks are omitted, unsuitable or *ad hoc* approaches are taken;
- bias or inaccurate supporting data (references) is provided; and
- the rationale or justification for conclusions is not given.

The review is then completed in line with the Lee & Colley methodology (Lee *et al.*, 1999). This method considers the quality of the EISs in four separate review areas as follows:

- description of the project and the environment;
- the identification and evaluation of key impacts;
- the treatment of alternatives and mitigation; and
- the communication of the information.

These are further broken down into categories and subcategories. In total, each ES was assessed against 55 criteria (for definitions of these see RSP Planning Ltd, 2007[1]). The grades for each criterion are combined to give a grade for each category and subsequently each review area and final overall grade for the EIS. The grades for each criterion are described below:

Grading system for Assessing the Quality of EISs

A	Relevant Tasks well performed no important tasks left incomplete
B	Generally satisfactory and complete, only minor omissions and inadequacies
C	Can be considered just satisfactory despite omissions and inadequacies
D	Parts are well attempted but must, as a whole be considered just unsatisfactory because of omissions and/or inadequacies
E	Not satisfactory, significant omissions or inadequacies
F	Very unsatisfactory, important task(s) poorly done or not attempted
NA	Not applicable. The Review Topic is not applicable or is irrelevant in the context of this Statement

[1] RSP Planning Ltd (2007) Literature, legislation and planning review environmental impact assessment marine fish farms prepared for Scottish Aquaculture Research Forum, Highland Council, and the Scottish Executive. Available at: www.sarf.org.uk/SARF024.htm.