Mariculture Committee **ICES CM 2001/F:04**

REPORT OF THE

WORKING GROUP ON MARINE FISH CULTURE

By Correspondence

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

TABLE OF CONTENTS

1 PARTICIPANTS

The current membership of the Working Group on Marine Fish Culture (WGMAFC) is as follows:

Belgium:	P. Coutteau, P. Lavens, P. Sorgeloos
Canada:	J. Castell (Chair), C. Clarke, D. Martin-Robichaud, E. Trippel
Denmark:	I. Fjallstein. P. Laussen, J. Støttrup
France:	B. Chatain, J. Person-Le-Ruyet
Germany:	H. Rosenthal, B. Ueberschaer, U. Waller
Iceland:	B. Björnsson
Ireland:	R. Fitzgerald
Latvia:	A. Mitans
Norway:	T. Harboe, J. C. Holm, A. Mangor-Jensen, I. Opstad, T. van der Meeren
Portugal:	P. Pousao-Ferreira, A. Ramos
Spain:	J. Iglesias, J. B. Peleteiro
Sweden:	H. Ackefors, A. Alanärä, J. Andersson
UK:	I. Bricknell, M. Gillespie, B. Howell, S. Wadsworth
U.S.A.:	D. Bengtson, L. Buckley, D. Perry
Israel (Observer status):	Wm. Koven, A. Tandler, G. Kissil

2 TERMS OF REFERENCE

The following terms of reference were approved by the Council (C. Res. 2000/2F04) during the 2000 Annual Science Conference in Bruges, Belgium:

The Working Group on Marine Fish Culture [WGMAFC] (Chair: Dr J. Castell, Canada) will work by correspondence in 2001 to:

a) report on the current status of marine fish cultivation in Member Countries and on the factors that are likely to constrain further development of the industry;
b) graph and evaluate current and historical trends for major species;
c) initiate collaboration with the Working Group on Environmental Impacts of Mariculture (WGEIM) on the review of technological developments in relation to fish production and their application to various species;
d) report on alternative sources of protein and lipid, including references to electronically available bibliography;
e) prepare an inventory of the use of the ICES standard reference diets and the use of microdiets among laboratories and their use with different fish species;
f) support research programmes on fish health and report on existing and emerging diseases of cultured marine fish, including treatments used;
g) compile a comprehensive list of procedures and methods for monitoring of feeding regimes;
h) review fish welfare in relation to marine fish culture to initiate a process to establish a set of welfare guidelines or indicators as to the state of the health and well-being of the fish;
i) refer to the work of the Working Group on the Application of Genetics in Fishes and Mariculture (WGAGFM) in developing standard culture conditions under which strains, stocks, or species might be tested to evaluate their performance.

WGMAFC will report by 31 May 2001 for the attention of the Mariculture Committee.

3 ACTIVITIES OF THE WORKING GROUP

3.1 Introduction

WGMAFC did not meet in 2000/2001 but worked by correspondence to plan its next meeting in 2002. The principal activities were the collection of information on the current status of marine fish culture in ICES Member Countries during 2000 [Term of Reference a], preparation of an electronic bibliography of alternative protein source references [ToR d], preparation of a report on existing and emerging diseases of cultured marine fish [ToR f] and preparation of proposals for theme sessions for the ICES Annual Science Conference in 2002. There was also some limited progress made on other terms of reference for the year, but many will be better served at the next meeting of the WGMAFC. An informal meeting of a number of Working Group members during the Larvi 2001 meeting in Ghent, Belgium, 3–7 September 2001, is proposed. The next formal meeting of the WGMAFC is proposed for 11–14 March 2002 in Portugal. After considerable discussion it was decided that if the WGMAFC is to continue and productively serve its objectives, than it should meet formally on an annual basis. It is proposed that the 2003 meeting be held in Weymouth, England, March 2003.

3.2 Marine Fish Production in 2000 [Term of Reference a)]

Summaries of the 2000 production figures of marine fish in ICES and observer countries are presented in Appendix 1, Tables 1 and 2. These were based on submissions by WG members or found in the Federation of European Aquaculture producer's web site. Note that the Federation of European Aquaculture Producers has an excellent web site where production statistics, including numbers of juveniles produced, are posted: http://www.feap.org/index.html. Production statistics are also available from FAO at: http://www.fao.org/WAICENT/FAOINFO/FISHERY/statist/fisoft/fishplus.asp, though the FAO statistics are only provided through 1997.

3.3 Production Trends

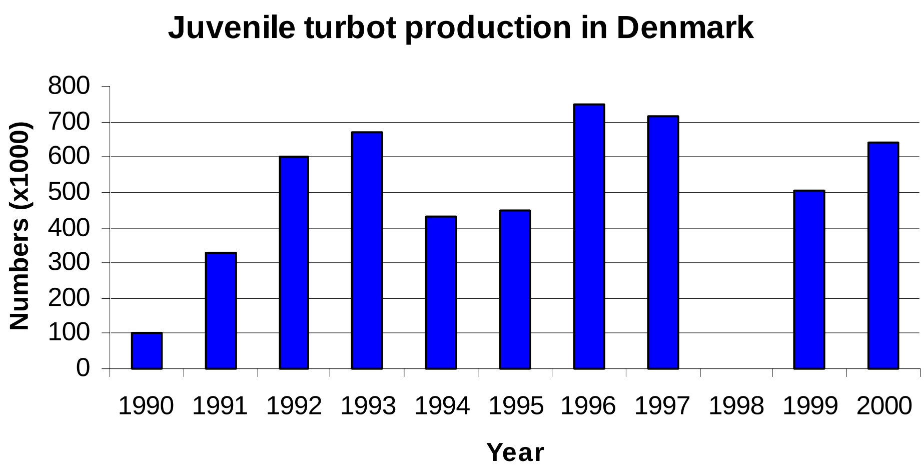
ToR (b): graph and evaluate current and historical trends for major species

While we have summarized data reported by the WGMAFC and the predecessor Working Group on Mass Culture of Juvenile Marine Fish and included data for turbot, sea bass and sea bream in Appendix III, there was little input in response to this ToR. It is anticipated that a more complete historical perspective of marine fish production in ICES member and observer countries will be developed during the next year.

Denmark:

The juvenile turbot production in Denmark reached about 660,000 in 1993, decreased for a couple years and peaked again in 1996. It has been more or less steady since then. The bulk of these juveniles are exported to Spain for on-growing to market size.

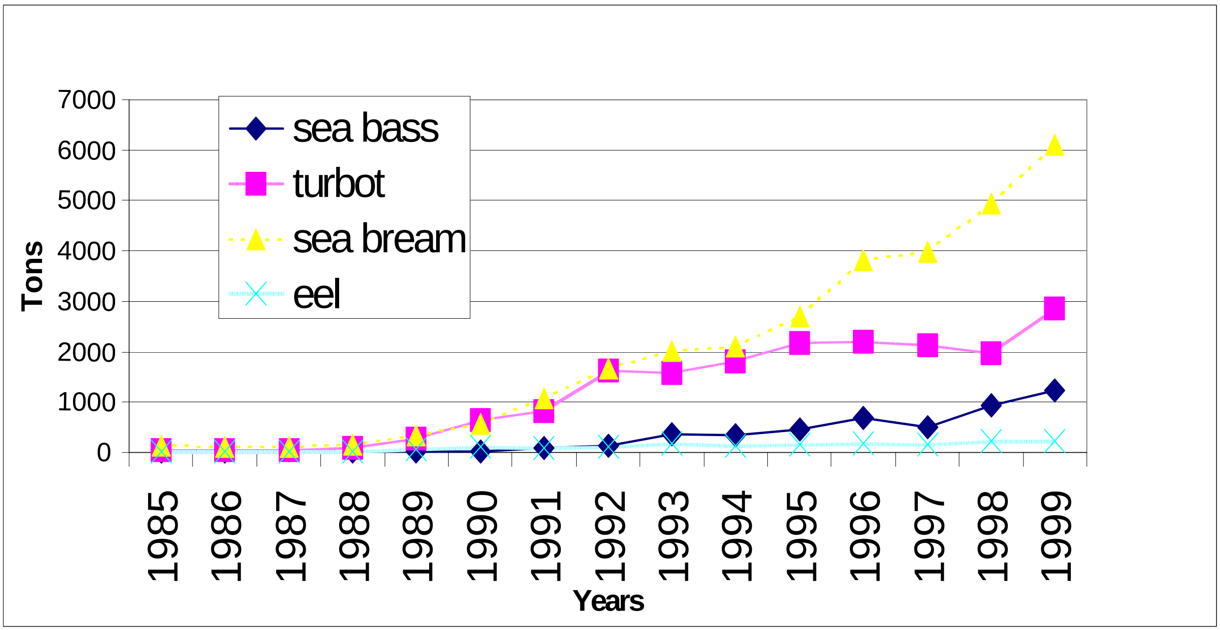
Figure 3.3.1. Juvenile turbot production in Denmark. Data supplied by Dr Josianne Støtrup.



Spain:

Sea bream culture in Spain has experienced near exponential growth, or 7,600 metric tonnes in 1999. This exceeded 10,000 tonnes in 2000. Sea bream and turbot had been running about equal until 1992, when juvenile turbot availability began to become limiting. Sea bass culture has also experienced a steady growth, but at a much lower total production level than sea bream.

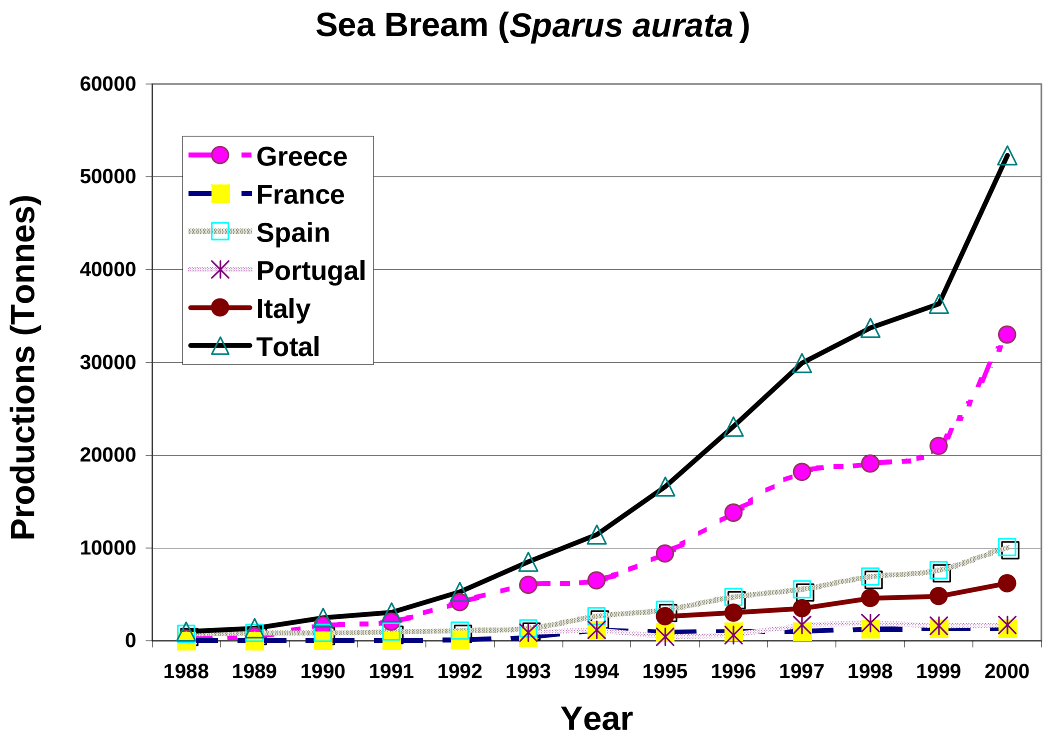
Figure 3.3.2. Production of farmed marine fishes (tonnes) in Spain.



Sea Bream (*Sparus aurata*)

Of the ICES Countries, Spain is clearly the leader in sea bream production, but Greece (an Observer status country) is, and has been since 1990, clearly the dominant country in sea bream production, exceeding 33,000 tonnes production in 2000. The juvenile production in Greece increased from 90,000 in 1999 to 108,000 in 2000, indicating a further significant increase in the 2001 production figure. Total European production exceeded 53,000 tonnes in 2000 and one would predict continued exponential growth of the culture of this fish.

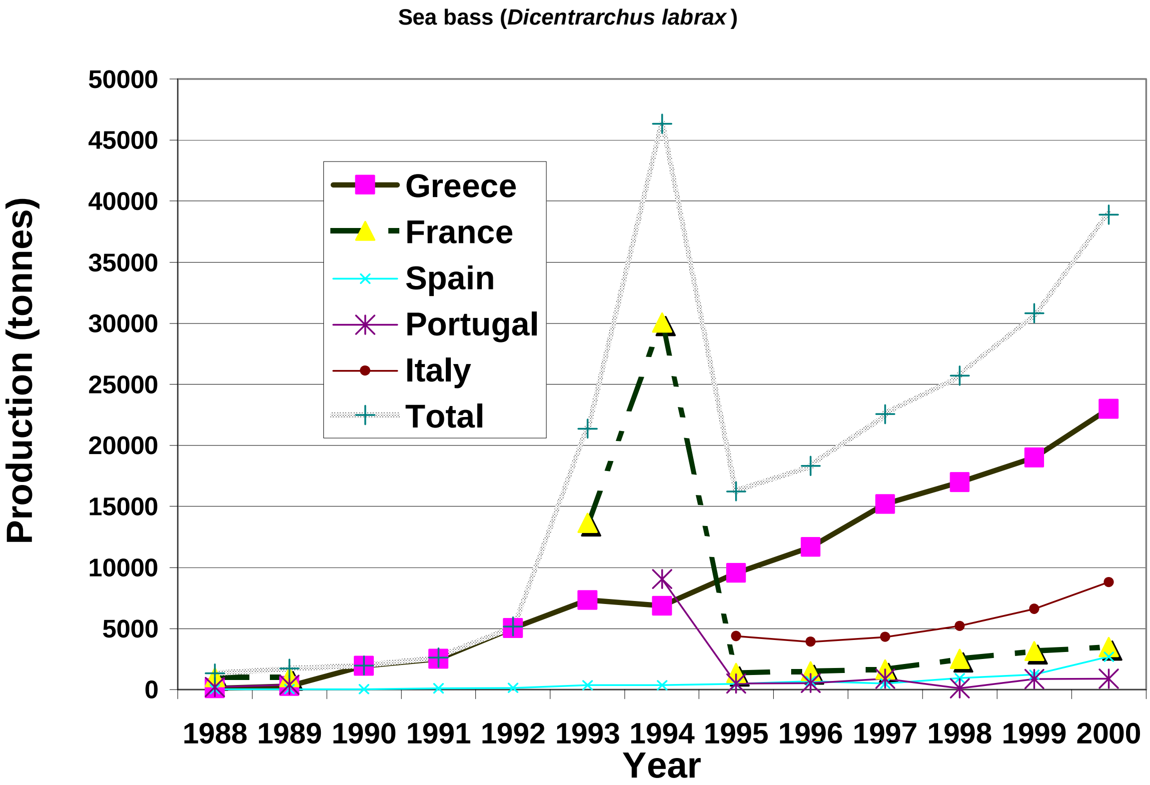
Figure 3.3.3. Sea bream production. Data from previous ICES WGMAFC reports, Federation of European Aquaculture Producers, and FAO.



Sea Bass (*Dicentrarchus labrax*)

The production data for the years 1993 and 1994 for France (these were reported in the ICES WGMAFC reports) seem to be about an order of magnitude higher than the earlier and later values reported, respectively by the ICES WGMAFC and the Federation of European Aquaculture producers. As with sea bream, the production of sea bass in Greece has dwarfed production in other European countries. With total production at nearly 40,000 tonnes in 2000, up from around 2,000 tonnes in 1990, this species also has been experiencing a dramatic increase in production. Spain, Portugal and France are all also seeing consistent growth in sea bass production. The increase in juveniles in 2000 supports the increased growth.

Figure 3.3.4. Sea bass production in European countries. The values for France for 1993 and 1994 are inconsistent with other years and may be inaccurate. Data from previous ICES WGMAFC reports, Federation of European Aquaculture Producers, and FAO.



3.4 Collaboration with the Working Group on Environmental Impacts of Mariculture (WGEIM).

ToR c): initiate collaboration with the WGEIM on the review of technological developments in relation to fish production and their application to various species:

There was no activity, as the WGEIM did not meet this year.

3.5 Alternative Protein and Lipid Sources

ToR (d): report on alternative sources of protein and lipid, including electronically available bibliography:

Discussions have been initiated with the ICES Secretariat in Copenhagen to establish an electronic bibliography of references on alternative protein and lipid sources. An initial text file that was sent contained 344 references listing, when available, the following: author(s), title, year of publication, conference title, book name, editors, journal, volume, issue, pages, abstract, species, key words, author's address and e-mail address. It is probable that this will be listed on the ICES Web Site in ACCESS. This would permit easier searching for references on various topics. The programmer at ICES has been developing another web-based ACCESS program. John Castell has agreed to serve as editor and will provide revisions and updates, as they become available. The text file is currently available to any interested parties from castellj@mar.dfo-mpo.gc.ca.

3.6 ICES Standard Reference Weaning Diet and Enrichment Emulsions

ToR (e): prepare an inventory of the use of the ICES standard reference diets and the use of microdiets among laboratories and their use with different fish species:

Table 3.6.1. Overview of the use of ICES reference emulsions and diets.

A. ICES emulsions

Species	**Research**	**Institute**	**Publication/year of purchase**
1. Unknown			
		Centro Oceanográfico de Murcia, Es	2001
		NIOO-CEMO, Nl	2000
		The Oceanic Institute, USA	1998
2. Fish			
Haddock larvae (via rotifers)	FA nutrition	DFO, Biological Station, Ca	2000
Larval fish		CEFAS, Conwy, UK	1997–1999
Scophthalmus maximus (via *Artemia*)	Egg and larval quality	Lab. of Aquaculture & ARC, BE	Dhert *et al.* 1995
Scophthalmus maximus (via *Artemia*)	Effect of DHA/EPA ratio of live food on turbot larvae	Lab. of Aquaculture & ARC, BE and ULL, Chile	Cure *et al.* 1995
Solea solea	Effect of larval diet quality	CEFAS, Conwy, UK	
Marine fish	Larval requirements	DFO, Ca	
Dentex dentex	Larval requirements	SEAMASA, Mallorca, Es	
Hippoglossus hippoglossus	Larval requirements	Dunstaffnage Marine Lab, UK	
3. Molluscs			
Nodipecten nodosus	Broodstock and larval nutrition (Inco-DC project IC18-CT97–0188)	ULL, Chile	1999–2001
Argopecten purpuratus	Broodstock conditioning	Universidad Catolico del Norte, Chile	Martinez *et al.* 2000
Tapes philippinarum, *Argopecten purpuratus*, *Crassostrea gigas*	Broodstock and juvenile nutrition	Lab. of Aquaculture & ARC, BE	Caers *et al.* 1998, 1999a & b, 2000a, b, c & d
Crassostrea gigas	Broodstock nutrition and offspring quality (Fair project CT96–1852)	IFREMER Brest, FR	Samain *et al.* 1999, Soudant *et al.* 1999a & b, 2000
Placopecten magellanicus	Dietary FA requirements	Lab. of Aquaculture & ARC, BE	Coutteau *et al.* 1996
Mercenaria mercenaria	Effect of lipid supplementation	Lab. of Aquaculture & ARC, BE	Coutteau *et al.* 1994
Crassostrea gigas	Testing of filtration and ingestion	Lab. of Aquaculture & ARC, BE and IFREMER, FR	
Tapes philippinarum	Dietary FA requirements	Lab. of Aquaculture & ARC, BE	
4. Crustaceans			
Penaeid shrimp (via *Artemia*)	Osmoregulation	Centro de Investigaciones Biologicas del Noroeste, Mx	2001
Scylla serrata	Larval nutrition, FA and vitamin requirements	Department of Ichthyology and Fisheries Sciences, Rhodes University, SA	1999–2001

Table 3.6.1. Continued.

Species	Research	Institute	Publication/year of purchase
Scylla paramamosain	Larval nutrition	Can Tho University, Vietnam	1999–2001
Macrobrachium rosenbergii	Larval quality	Lab. of Aquaculture & ARC, BE	Cavalli *et al.* 2000
Penaeus vannamei (larvae and postlarvae) via *Artemia* and *Brachionus*	Effect of n-3 HUFA	Cenaim, EC	Wouters *et al.* 1997
Penaeus monodon (postlarvae) via *Artemia*	Effect of DHA/EPA ratio	Lab. of Aquaculture & ARC, BE	Kontara *et al.* 1995
Penaeus vannamei (postlarvae)	Dietary n-3 HUFA requirements	Cenaim, Ec	Naessens *et al.* 1995
Penaeus vannamei (larvae)	Effect of n-3 HUFA and DHA/EPA ratio in live feed	Cenaim, Ec	Naessens *et al.* 1995
5. Zooplankton			
Artemia franciscana	Physical properties of emulsions	Lab. of Aquaculture & ARC, BE	Kyungmin Han *et al.* 2001 in press
Artemia franciscana	Enrichment efficiency	Lab. of Aquaculture & ARC, BE	Kyungmin Han *et al.* 2000
Artemia franciscana	Lipid classes and their n-3 HUFA	Lab. of Aquaculture & ARC, BE and Universidad de Cadiz, Es	Coutteau & Mourente 1997
Artemia franciscana, Artemia sinica	Stability of DHA	Sintef, No	Evjemo *et al.* 1997
Artemia franciscana	Enrichment strategy	Lab. of Aquaculture & ARC, BE	
Artemia	Enrichment	NERC Unit of Biochemistry, Stirling, UK	
Daphnia galeata	n-3 HUFA requirements	Center of Limnology, Niewersluis, Nl	Weers & Gulati 1997
Daphnia	n-3 HUFA requirements	Max-Planc-Institut fur Limnologie, D	
Daphnia	n-3 HUFA requirements	Univ. California Davis, USA	
Copepods	n-3 HUFA requirements	Nederlands Inst. for Sea Research, Texel, Nl	

B. Reference diet

Species	Research	Institute	Publication
Haddock	Larval nutrition	DFO, Biological station, Ca	2000
Scophthalmus maximus, Hippoglossus hippo-glossus, Sparus aurata	Antioxidant research (FAIR project CT97–3382)	Lab. of Aquaculture & ARC, BE; Universidad de Cadiz, Es; Norwegian University of Science and Technology, No, and University of Stirling	1998–2000
Dicentrarchus labrax L. (juveniles)	Role of phospholipids	Lab. of Aquaculture & ARC, BE	Geurden *et al.* 1997a
Scophthalmus maximus (juveniles)	Role of phospholipids	Lab. of Aquaculture & ARC, BE	Geurden *et al.* 1997b

Species	Research	Institute	Publication
Dicentrarchus labrax L. (juveniles)	Role of phospholipids	Lab. of Aquaculture & ARC, BE	Geurden *et al.* 1997 c
Dicentrarchus labrax L. (weaning and first ongrowing)	FA requirements: comparison of diets	Lab. of Aquaculture & ARC, BE	Coutteau *et al.* 1996
Dicentrarchus labrax L. (weaning and first ongrowing)	HUFA requirements: selection of basal diet	Lab. of Aquaculture & ARC, BE	Coutteau *et al.* 1995
Scophthalmus maximus (postlarvae)	Incorporation of FA from dietary neutral lipids	Lab. of Aquaculture & ARC, BE	
Anarchichas lupus	HUFA requirements	Fisheries and Marine Institute, Ca	

3.7 Disease

ToR (f): support research programmes on fish health and report on existing and emerging diseases of cultured marine fish, including treatments used; Submission prepared by Ian Bricknell, UK.

3.7.1 Introduction

The major economic pressure on aquaculture is to increase the diversity of the species being cultured, especially in northern latitudes where the industry has traditionally concentrated on salmonids. This diversification has been very successful, bringing Atlantic halibut, Atlantic cod, wolf fish and haddock into culture in Canada, Norway and the UK (although not all species in all countries), as well as the huge increase in bass, bream and Tunny in the Mediterranean, and numerous other marine species in the Far East, South America and Oceania. However, breaking the life cycle of "new species" for aquaculture production is only the beginning of the process and apart from the problems of rearing the new species to market size, a major problem is preventing outbreaks of disease in both the hatchery and on-growing farms.

For most marine species the production cycle has two phases: (1) the larval period usually takes place in a dedicated production hatchery, and (2) the on-growing period occurs either in sea cages in the ocean or in a pump-ashore re-circulation system. The hatchery poses the biggest set of problems. Here eggs are collected from the broodstock and reared in specialised incubators often with low water exchange rates and using specialised live foods. The diseases the larvae are likely to encounter are those already present in the environment they are being reared in, either in their incubators or from their prey. In sea cages or in pump-ashore re-circulatory systems, the on-growing animals usually will be exposed to endemic diseases present in the wild fish in the local ecosystem or interact with the diseases of farmed populations of fish.

3.7.2 Larval disease risks

3.7.2.1 Hatchery design

Possibly the first risk that can be avoided is bringing in pathogens in the incoming seawater supply. While it is impossible to avoid encountering pathogens from the environment, it is possible to reduce the risk by pre-treating the water with ozone or UV. This technology requires further development for hatchery systems.

Required research

- Development of bio-security systems for marine hatcheries.

3.7.2.2 Viral disease

Larval fish can be exposed to viral disease in the following ways:

- Vertical and horizontal transmission from broodstock;
- By bioaccumulation in prey organisms;
- By shed viruses from infected animals in the environment entering the hatchery in the water supply.

Vertical transmission from broodstock

Little is known about vertical transmission of infectious disease in fish. There is evidence for the transmission of bacterial kidney disease (*Renibacterium salmoninarum*) and infectious pancreatic necrosis virus (IPN) in salmonids, but it remains unknown if these or other pathogens can be transmitted vertically among emerging marine species.

Horizontal transmission of disease from broodstock

As the broodstock animals of most emerging species are batch-spawning animals, there is a tendency to hold these animals on or near the hatchery site for their reproductive life. If these animals are, or become, chronically infected with disease, there is the risk that they will act as a source of infection either via the water supply, especially if this a re-circulation system, or by direct contact with contaminated equipment. The risk that pathogens will be shed during certain stressful events such as during spawning already has been proposed as a possible method for the shedding of nodavirus from broodstock in halibut hatcheries.

Required research

- Development of non-destructive methods for the determination of the health status of broodstock;
- Development of polices to exclude chronically infected broodstock from breeding programmes;
- Discovery of what species of virus (or bacteria) can be vertically transmitted and/or cause a carried state to develop in broodstock and the circumstances which induce shedding;
- Development of hatchery bio-security systems to ensure that water entering the site is pathogen free.

Bioaccumulation of virus in larval diets

As most live food organisms used as larval diets (e.g., rotifers and *Artemia* spp.) are filter feeders, there is the potential that these organisms can accumulate significant levels of bacterial and viral pathogens in their digestive system or on their surface. This risk can be reduced by growing the diets under abiotic systems, the use of sterile seawater for rearing live diets, and the avoidance of wild-caught plankton as a larval feed.

Required research

- The development of abiotic live feed systems;
- The development of effective disinfection systems for live diets prior to feeding;
- The development of techniques to disinfect the seawater used in live feed culture systems.

Viruses shed by infected animals into the environment entering the hatchery in the water supply

See hatchery design issues.

3.7.3 Bacterial diseases

Many of the issues for viral disease are directly applicable to bacterial diseases, and the research recommendations remain the same, simply substituting bacterial for viral.

- Hatchery design;
- The risk of vertical and horizontal transmission from broodstock;
- The importance of “clean” live diets;
- The development of appropriate bio-security systems and policies.

However, the major problem with bacterial disease is the development of extensive bio-films in the incubator. This is particularly important in species which have a long yolk sac/green-water period where the bio-films in these incubators can build up significant numbers of bacteria and often contain pathogenic vibrios. These well-developed bio-films can act as a source of infectious organisms, allowing outbreaks of disease if environmental conditions deteriorate.

These bio-films are very difficult to control in the incubator, as the larvae are often too small to transfer to a clean incubator without significant losses. Yet, the bio-films are often felt to be important in developing good "aged" water that is beneficial to larval fish.

Controlling potential pathogens in the bio-film is difficult. Abiotic culture is a possibility, but has been implemented in producing animals that are compromised when they are moved out of abiotic conditions to the on-growing environment. The role of probiotics has also been considered but the Holy Grail of a probiotic that will remove potential pathogens from bio-films remains elusive.

Required research

- Understand the environments that encourage bio-films to develop and the conditions that encourage the growth and maintenance of pathogens;
- Develop an understanding of microbial interactions in incubator bio-films and develop potential probiotic organisms.

3.7.4 Immuno-therapeutics

Vaccination is often seen as an important goal for the control of infectious organisms in aquaculture. However, the small size of larval fish means that they are not suitable for injection vaccination, leaving only the oral and immersion routes open to exploitation. The neoenous nature of larval fish, however, often means that there is no perceived immune system for the vaccines to work with until the development of the thymus at metamorphosis. Obviously, there is an urgent requirement to understand the development of the immune system of larval fish to determine when vaccines can be delivered successfully.

There is a concern over immuno-stimulant usage in larval fish. One school of thought feels that immuno-stimulants should be included as soon as possible and the other is more cautious arguing that immuno-stimulants should be used only when the immune system is fully developed. The arguments are simple; the use of immuno-stimulant school believes that there is an advantage to the developing animals. On the other hand, the second school believes that there is the potential to damage the immune system by presenting these compounds before the immune system has fully developed and, until then, their use should be avoided. In short, there is not a clear answer to this problem and much research is required to clarify the situation.

Research requirements

- Determine the optimum timing of vaccine delivery to larval fish;
- Determine the optimum timing and role of immuno-therapeutics in larval fish.

3.7.5 On-growing situations

The requirements of on-growing are quite different from that of the hatchery when animals are usually in cages in the marine environment or in pump-ashore systems, possibly under re-circulation. Here the major risks are interaction with disease from wild or farmed stocks in the sea or by the accidental introduction of a pathogen from the environment into the pump-ashore system. The obvious solution to these problems is vaccination and bio-security.

3.7.5.1 Vaccination

There are many cases where vaccination has been very successful in controlling disease in farmed fish, especially if the animals are being cultured in the open ocean. Indeed, there are many successful vaccines on the market for the more common bacterial diseases and there are numerous viral vaccines under development, which look very promising. However, there is a role for vaccine manufacturers to evaluate the usefulness of these vaccines for emerging species and to optimise delivery systems and the role of adjuvants, etc.

There is always the risk that, when bringing a new species into cultivation, the species will develop its own disease problems. While this is always a risk, this problem can be avoided if a research programme has been established to provide assessment of the disease risk of the new species.

Research requirements

- Establish effectiveness of existing commercial vaccines in emerging marine species;
- Establish the requirement of adjuvants in the emerging species;
- Evaluate the disease risks to the species from established aquaculture diseases in that country and the likely risks of that species developing unique diseases under farmed conditions.

3.7.5.2 Immuno-stimulants

Unlike the role of immuno-stimulants in larvae, it is well established that immuno-stimulants can play an important role in on-growing fish. These compounds can provide enhanced immunity during periods of stress such as shipment or spawning. Their use needs to be optimised for application with the marine fish species of interest. This is an area of research that should be promoted within ICES Member Countries as it holds great promise for significant gains in fish health and survival in commercial marine fish culture.

3.7.5.3 Pump-ashore/re-circulation culture systems

The role of vaccination and immuno-stimulants is as applicable to these systems just as much as they are to ocean-based systems. There is the added opportunity to control the environment by the use of filtration, cleaning, etc. The biggest risk to these systems is bringing in pathogens in the water supply or obtaining chronically infected stock for on-growing.

To a large extent, the risk from the seawater source can be greatly reduced by the use of ozonation or UV treatment of incoming water. However, the risk of purchasing infected stock remains unless effective methods are developed for the detection of pathogens in carrier fish or the elimination of disease in broodstock. Advances in both areas would contribute to reducing this risk.

Research requirements

- Establish good bio-security for pump-ashore re-circulation systems;
- Develop methods for the detection of disease carrier-state in the species of interest;
- Develop non-destructive tests for broodstock animals.

3.7.6 Broodstock disease issues

The health of the broodstock in an emerging species is a vital point in the success of commercialising any new species; however, it is also the most vulnerable. As mentioned above, broodstock animals are vulnerable to infection in exactly the same way as on-growing animals and appropriate bio-security should be practiced as well as vaccination and the use of appropriate immuno-stimulants.

One of the biggest worries concerning broodstock, especially in an emerging species, is the requirement for wild-caught broodstock. Obviously, the health and genetic history of these animals is unknown and there is a risk that these animals are cryptically infected with disease. This then poses a risk of vertical and horizontal transmission to larvae and horizontal transmission between the potential broodstocks.

As the majority of marine species are batch-spawning animals, there is a requirement to maintain these animals from year-to-year, especially as the useful reproductive life of cod and Atlantic halibut has been estimated as between 3–7 years and 10–15 years, respectively. Obviously, these animals should be maintained disease free for the duration of their reproductive life for the reasons outlined above. However, if these animals are maintained in sea cages or in pump-ashore systems with poor bio-security, then there is a risk that they will be exposed to disease. Thus there is a strong argument for maintaining broodstock in bio-secure units away from other fish farms and preferably in isolation from the hatchery unit.

Research requirements

- Non-destructive disease testing of broodstock animals;
- Bio-security of broodstock sites;
- Vaccination strategies for broodstock animals;
- Rates of pathogen shedding during chronic infections;
- Stress and disease interactions, e.g., disease susceptibility and emergence of carried-state diseases during spawning.

3.8 Procedures for Monitoring Feeding Regimes

ToR (g): compile a comprehensive list of procedures and methods for monitoring of feeding regimes:

Staff at the CEFAS Laboratory in Weymouth (UK) are currently addressing the issue of optimising feeding strategies by developing a technology that can detect uneaten food and regulate the supply accordingly. Critical to this is the development of a novel image analysis sensor that will detect and count individual fish feed pellets escaping from culture systems in rearing tank effluent. Recent developments in computer vision and camera miniaturisation have provided an opportunity to introduce image analysis technology to aquaculture. The sensor will provide input to decision functions that will control feed supply, allowing the implementation of adaptive feeding strategies and facilitating the development of advanced computer-based stock management and database systems for the advancement of sole culture. The technology will, however, also be applicable for tank-culture of other species.

Relatively little progress has been achieved on this task and it should probably be continued in a ToR for the next year when members will be meeting together and can share information to develop a useful report on the various technologies that are available for monitoring feeding.

There are a number of commercially available technologies that might provide improved feed efficiency and water quality:

1) SimFlex Systems has developed a software program and automated feeding barge that allows remote location control of feeding and monitoring of fish feeding at cage sites (even open ocean cage systems). Their Aqua Feeder Barge was displayed for industry viewing for the first time at the St. Andrews Aquaculture Exposition Conference and Fair in St. Andrews, NB, Canada 21–22 June 2001. Information is available at their web site: http://www.simflexsystems.net/aqua/index.htm
2) The SEA System™ was developed by Future SEA Technologies Inc. to create a controlled rearing environment for finfish aquaculture. The flexible, round, watertight enclosure is supplied with pumped water that can be drawn from optimum locations to regulate temperature, oxygen levels and overall water quality. They claim that this system avoids toxic algae, manages water quality, reduces disease transmission, improves food conversion, increases growth and reduces production costs. They also demonstrated their system at the St. Andrews Aquaculture Exposition Conference and Fair in St. Andrews, NB, Canada, 21–22 June 2001. More information is available at their web site: http://www.futuresea.com.

3.9 Fish Welfare

ToR (h): review fish welfare in relation to marine fish culture to initiate a process to establish a set of welfare guidelines or indicators as to the state of the health and well-being of the fish;

A welfare indicator currently being developed in the UK (CEFAS, Weymouth) is a non-invasive assay for the amount of cortisol (the classic stress hormone) that fish release into the water. This novel method is initially being applied in concert with water quality, behavioural, morphological, and physiological measures to examine the relationships between welfare, stocking density, and environmental conditions. This laboratory work will then be extended to determine the effects of stocking density on commercial farms, and the potential of a suite of welfare indicators for on-farm use. Although the research is initially focused on rainbow trout, it will be extended to marine fish, in particular within recirculation systems.

One of the conditions for good animal welfare is "freedom from hunger", this requires feeding to a level where all fish in a population have an opportunity to gain access to feed. The smart-feeding system being developed by CEFAS (see 3.8 above) would allow species-specific feeding strategies to be implemented that maximise fish welfare ensuring that even subordinate members of a population are satiated. Matching food supply directly to appetite also would suppress competition within a population, reducing the occurrence of dominance hierarchies, fin nipping and subsequent secondary infection. Fish would be able to feed more naturally, resulting in less frenzied feeding and fewer resulting injuries. The reduction of uneaten food would improve tank hygiene and the general health of fish stocks. In addition, unusual patterns of feeding behaviour, for example, reduced appetite, symptomatic of stress or a pre-disease situation, would be immediately apparent. This would allow the prompt identification and correction of a stress situation or early diagnosis and more effective treatment for disease.

3.10 Standard Culture Conditions

ToR (i): refer to the work of WGAGFM in developing standard culture conditions under which strains, stocks or species might be tested to evaluate their performance;

Due to time constraints and the difficulties or relying on correspondence for conducting WG business this year, we have made no progress on this topic and it might be recommended to deal with it when members are assembled at the next WG meeting. We will attempt to arrange with the WGAGFM a number of their members who might work with us on this topic.

4 THEME SESSION FOR THE 2002 ICES ANNUAL SCIENCE CONFERENCE

Possible Theme Session for 2002:

PROPOSED THEME SESSION FOR ICES ANNUAL SCIENCE CONFERENCE

Copenhagen, 2002
Mariculture Committee
Working Group on Marine Fish Culture

1. Improvements in Quality of Cultured Juvenile Fishes

Hatchery rearing of commercially important marine fish is a *sine qua non* in ICES countries for modern commercial aquaculture of marketable product and for stock enhancement of commercial fisheries. In the last quarter century, many of the technical problems that caused the *quantity* of larvae and juveniles reared to be a “bottleneck” for food production have been overcome. Today, it is the *quality* of the juveniles produced that is of interest, but quality means different things to different end-users. Commercial aquaculture operations increasingly want juveniles from broodstock that have been selectively bred for fast growth and disease resistance, whereas stock enhancement operations want juveniles with genetic diversity as close as possible to that of wild populations. In either case, the quality of hatchery rearing depends on broodstock nutrition and holding conditions, larval nutrition, microbial ecology of the larval rearing tanks, and many other factors. Recent studies have shown that epigenetic factors operating during the early stages of development determine quality of individuals during later stages and direct effects are not always easy to determine.

This theme session will be devoted to an examination of the genetic and environmental factors involved in improvement of juvenile quality, including a) selective breeding vs. maintenance of genetic diversity, b) biotic and abiotic factors important in the larval rearing conditions, and c) methods to assess and predict juvenile quality and subsequent performance in commercial on-growing or the natural environment. Thus, the session should be of interest to commercial aquaculturists, government scientists involved in stock enhancement programmes, and academicians. We will solicit papers from people in a broad range of disciplines and from a wide geographic area.

Proposed co-conveners:

David A. Bengtson, Department of Fisheries, Animal and Veterinary Science, University of Rhode Island, Kingston, RI 02881, USA (Bengtson@uri.edu).

Karin Pittman, Department of Fisheries and Marine Biology, University of Bergen, High Technology Center, 5020 Bergen, Norway (Karin.pittman@ifm.uib.no).

Patrick Sorgeloos, Laboratory of Aquaculture and Artemia Reference Center, University of Ghent, Ghent, B-9000, Belgium (Patrick.sorgeloos@rug.ac.be).

2. "Use of Immunomodulators and Probiotics in Marine Fish Feeding" possible beneficial effects, including the synergetic ones, and risk evaluation.

In the face of multi-drug antibiotic resistance, and vaccine limitations, working towards natural disease resistance whether by genetic selection or other means has turned into a crucial issue. The use of immuno-modulators and/or probiotics in marine aquaculture has the potential to provide many benefits to the industry. Immuno-modulators can, in theory, improve fish health by up-regulating the immune system, reducing the requirement for intervention with immuno-therapeutics, and improve animal welfare. They also offer the potential to improve larval and fry survival, as judicious use of these compounds could protect larvae from endemic pathogens in the hatchery.

Probiotics may have a wide range of beneficial effects on animal health, but few have been documented in fish so far. They may act directly on the host by stimulating the immune response, and the ontogeny of digestive enzymes in larvae. They may fight against pathogens by secreting antagonistic compounds like antibiotics, surfactants, etc. They may also intervene in the host-pathogen relationship by competing for adhesion sites, nutrients, or by destroying toxins. This variety allows synergy, and probiotics could be also combined with immuno-stimulants.

It is proposed that the theme session examine these topics and investigate the potential benefits and possible detrimental effects that the use immuno-modulators and probiotics may have on marine fish culture.

Proposed co-conveners:

Ian Bricknell, Fisheries Research Service, Marine Laboratory, P.O.Box 101, Victoria Road, Aberdeen AB11 9DB, Scotland (UK); I.R.Bricknell@marlab.ac.uk.

Joel Gatesoupe, Fish Nutrition Lab, Unité Mixte INRA-IFREMER, Centre de Brest IFREMER, BP 70, 29280 Plouzané, France; Joel.Gatesoupe@ifremer.fr.

Other possible co-conveners not yet confirmed:

Simon Wadsworth (UK)
Olav Vadnstein (Norway)
Jorunn Skjerno (Norway)
Tony Ellis (UK)

5 CONCLUSIONS

(ToR b) There were inconsistencies in production data reported in previous years by this and the preceding ICES Working Group on Mass Culture of Marine Fish (Appendix III gives a summary of data previously reported). While FAO data are available for many of the ICES countries, many of the newly emerging marine fish species are not reported there. The Federation of European Aquaculture Producers also reports some of the recent 1995–2000 production statistics, but there are also deficiencies in these data. More research is required to assemble a representation of the historical trends in marine fish culture in ICES member and observer countries.

(ToR c) Will attempt to initiate collaboration with WGEIM in the next year.

(ToR d) Working with ICES Secretariat to develop the appropriate format for the alternative protein bibliography to be posted at the ICES Web Site under WGMAFC.

(ToR e) Standard reference diets for marine fish larvae continue to play a vital role in ensuring consistency and comparability among research programmes around the world and we plan to continue to encourage the Artemia Reference Center, University of Ghent, to make the ICES Standard Reference Weaning Diet and Enrichment Emulsions available at cost to researchers and to compile a list of research that has involved their use.

(ToR f) Dr Ian Bricknell compiled an excellent overview of marine fish diseases and possible means of reducing or preventing their occurrence. The continued growth of marine fish aquaculture will require regular review of the disease situation. Perhaps the marine Fish Disease Report could be edited and published in the *ICES Journal of Marine Science*.

(ToR g) Little progress was made in compiling procedures and methods for monitoring of feeding regimes. This task must be carried forward to the ToR for the next year.

(ToR h and I) The situation is the same as for ToR g.

6 RECOMMENDATIONS FOR FUTURE ACTIVITIES

The Working Group on Marine Fish Culture [WGMAFC] (Chair: Dr J. Castell, Canada) will meet in Olhao, Portugal, 11–14 March 2002 to:

a) report on the current status of marine fish cultivation in Member Countries and on the factors that are likely to constrain further development of the industry; graph and evaluate historical production trends for major marine finfish species and predict future development;

b) review technological developments in relation to fish production and their application to various species;

c) report on alternative sources of protein and lipid, including references to electronically available bibliography;

d) review the use of ICES standard reference diets and emulsions in research programmes and recommend any modifications to existing formulations and procedures;

e) review progress on the use of microdiets for feeding larval fish and assess whether a reference diet or procedure can be recommended;

f) work with the WGPDMO to review fish health research and report on existing and emerging diseases of cultured marine fish, including treatments used;

g) compile a complete list of procedures and methods for monitoring of feeding regimes;

h) review current/emerging policies on fish welfare in relation to marine fish culture (country by country, FAO, EU, etc.) and prepare a report;

i) work with Working Group on the Application of Genetics in Fisheries and Mariculture (WGAGFM) in developing standard culture conditions under which strains, stocks or species might be tested to evaluate their performance;

j) prepare a review paper on one or two interrelated major recent advances that have significantly improved marine finfish production capabilities or survival during a specific life history stage in a variety of species (e.g., technology, nutritional, physiological or disease prevention/detection).

Priority:	This is an important aspect to the future development of mariculture in the sea and in land-based operations.
Scientific justification:	a) This provides a continuing mechanism for focusing the WG activities. In addition to providing data on the most recent year's production by country for each marine fish species being cultured, it would be useful to have a multi-year graphical perspective to more clearly see trends that are developing. The 2001 report has provided some preliminary historical pictures but the accuracy of some of the data is in doubt, and the WGMAFC will review and revise these data and figures. b) The continued expansion of marine fish culture is dependent on new technological developments such as improved methods for sorting larval and early juvenile fish to prevent cannibalism, improved land-based recirculation systems and the need for better methods to estimate growth. c) The increasing demands for fish meal and fish oil by aquaculture and agricultural industries has resulted in increases in price. The high prices and the lack of opportunities to expand the capture fishery make it imperative that alternative protein and lipid sources be developed for use in feeds for aquaculture. Information on alternative sources of protein and lipid are vital to the continued expansion of the aquaculture industry. d) Enhanced standardisation of experimental procedures would facilitate comparison of growth, survival and other performance criteria of fish in nutrition experiments and thereby greatly enhance the value of work in this area. In this respect there is a need to define recommended protocols, in particular the inclusion of reference diets in the experimental design. The ICES Standard Reference Weaning Diet and enrichment emulsions are such tools that can help in this regard. As new research results identify nutritional requirements of various marine fish species it will be possible to modify the formulation of reference diets and perhaps develop species specific reference diets.

	e) It is still necessary to provide live food organisms at first feeding for most marine fish species that are utilized in aquaculture. There are, however, very encouraging recent research results in the development of microdiets that might shorten the period of time that live feeds are required and perhaps eventually permit larval marine fish to be fed prepared feeds and avoid live feeds. As a number of members of the WG are involved in such research, we propose to develop a collaborative micro-diet research programme. f) While fish diseases are well covered by the WGPDMO, many factors such as water quality, nutritional status, physiological stresses and all aspects of culture technology do affect disease resistance and fish health. As the marine fish culture industry grows, there will become an increasing need to develop disease control procedures such as new vaccines, improved monitoring and other aspects of fish health. It is very important to have knowledge about the most recent developments in marine fish health research. Each newly identified disease poses a threat to the growth of the marine fish culture industry. Knowledge of the relationships between disease and culture technologies is a vital tool in the fight to control these diseases. The WGMAFC will work with the WGPDMO to review existing and emerging diseases of cultured marine fish and assist in preparing a report on the most effective treatments to control these diseases. g) To ensure that fish culture is economical and to reduce contamination of the aquatic environment, it is vital to reduce the amount of feed that is wasted and not consumed by the fish. It is thus necessary to make available a complete list of procedures and methods for monitoring of feeding regimens and indicate which are the most effective in improving efficient feed utilization and reduce waste. h) By culturing fish, as opposed to harvesting from the wild, we make a commitment to proper care of the cultured animals. There is increasing pressure to ensure that cultured animals receive humane treatment. The WGMAFC will review the aspects of fish welfare in relation to marine fish culture. i) Though genetics is the topic for another Mariculture Committee Working Group, the WGMAFC proposes to work with the WGAGFM to develop standard culture conditions under which strains, stocks or species might be tested to properly and consistently evaluate their performance. j) Significant new technological advances in the production of marine finfish are discussed during WG meetings with leading researchers from ICES countries. However it is important to disseminate these critical developments to the global aquaculture community to quickly take advantage of and improve new procedures and techniques.
Relation to Strategic Plan:	Responds to Objectives 1 (d), 2 (a, d), 3 (b), 5 (a), and 7 (b, e).
Resource Requirements:	None required, other than those provided by the host institution.
Participants:	WGMAFC members
Secretariat facilities:	None required
Financial:	None required
Linkages to Advisory Committees:	There are no direct linkages to the advisory committees.
Linkages to other Committees or Groups:	WGPDMO, WGAGFM, WGEIM
Linkages to other Organisations:	

APPENDIX 1

Table 1. Production ('000s) of juvenile marine fish in ICES countries in 2000 (values for 1999 in parenthesis).

Country **Species**	**Canada**	**Denmark**	**France**	**Iceland**	**Norway**	**Portugal**	**Spain**	**UK**	**USA**	**TOTALS**
Sea Bass (*Dicentrarchus labrax*)				140 (200)		(4,500)	9,300 (7,300)	170		**9,610 (7,500)**
Sea Bream (*Sparus aurata*)						(11,340)	42,400 (35,000)			**42,400 (35,000)**
Turbot (*Psetta* [*Scophthalmus*] *maximus*)		643 (505)		30	150 (150)	(140)	2,100 (1,000)	* (50)		**2,773 (1,705)**
Cod (*Gadus morhua*)	20 (107.5)			2	530			5 (34)	2♣	**177 (291.5)**
Atlantic Halibut (*Hippoglossus hippoglossus*)	55.2 (46.1)			400 (300)	530 (350)			70 (160)		**525.2 (856.10)**
Pacific Halibut (*Hippoglossus stenolepis*)	0 (0.05)									**0 (0.05)**
Flounder (*Platichthys flesus*)		60.5 (73)								**60.5 (73)**
Winter Flounder (*Pleuronectes americanus*)	4 (0.5)									**4 (0.5)**
Yellowtail Flounder (*Limanda ferruginae*)	(1)									**(1)**
Summer Flounder (*Paralichthys dentatus*)									(306)	**(306.00)**
Lemon Sole (*Microstomus kitt*)								(27)		**(27.00)**
Red drum (*Sciaenops ocellata*)									(> 500)	**(> 500)**
Tautog (*Tautoga oritis*)										**(0)**
Sablefish (*Anoplopoma fimbria*)	12.1 (1.6)									**12.1 (1.60)**
Haddock (*Melanogrammus aeglefinus*)	90 (57)								2♣	**90 (57.00)**
Eel										**(0)**
TOTALS	**181.3 (213.3)**	**703.5 (578)**	**(0)**	**575 (500)**	**930 (650)**	**(15,980)**	**53,800 (43,300)**	**245 (271)**	**(> 806)**	**55,654.8 (45,668.75)**

No data were available for Belgium, Estonia, Finland, Germany, Ireland, Latvia, Netherlands, Poland, Russia or Sweden. No data were available from Portugal for year 2000.
No data were available for turbot juvenile production for the UK. Cod and bass production data were from demonstration units rather than commercial operations

♣ Produced in the US in 2000 for research purposes

Table 2. Production (tonnes) of farmed marine fish in ICES countries in 2000 (values for 1999 are in parenthesis).

Country Species	Canada	Croatia	Denmark	France	Greece (observer)	Iceland	Italy	Norway	Portugal	Spain	Sweden	Turkey	U.K.	U.S.A.	TOTALS
Sea Bass (*Dicentrarchus labrax*)		 (1,000)		3,500* (2,600)	23,000* (19,000)	15 (20)	8,800* (5,800)		899* (719)	2,702 (1,670)		8,000* (6,500)			**46,916 (37,590)**
Sea Bream (*Sparus aurata*)		 (1,000)		1,300* (1,300)	33,000* (21,000)		6,200* (5,100)		1,715* (1,352)	10,090 (7,600)		6,000* (7,300)			**57,305 (45,200)**
Turbot (*Psetta [Scophthalmus] maximus*)				1,000* (2,000)		0		200 (100)	510* (378)	3,683 (2,083)			 (~150)		**5,393 (4,333)**
Cod (*Gadus morhua*)						15 (2)		150 (30)					10		**175 (32)**
Atlantic Halibut (*Hippoglossus hippoglossus*)	 (1.5)					30 (12)		450 (400)					2 (~2)		**482 (415.5)**
Pacific Halibut (*Hippoglossus stenolepis*)	44[11] (54)[1]														**44 (54)**
Flounder (*Platichthys flesus*)															**0 (0)**
Winter Flounder (*Pleuronectes americanus*)															**0 (0)**
Yellowtail Flounder (*Limanda ferruginae*)															**0 (0)**
Summer Flounder (*Paralichthys dentatus*)														5.5	**5.5 (9)**
Lemon Sole (*Microstomus kitt*)															**0 (0)**
Red drum (*Sciaenops ocellata*)														1,000 (> 500)	**1,000 (> 500)**
Tautog (*Tautoga oritis*)															**0 (0)**
Sablefish (*Anoplopoma fimbria*)															**0 (0)**
Haddock (*Melanogrammus*)	0.08 (0)														**0.08 (0)**
Eel (*Anguilla anguilla*)			2,500*						200*	350 (300)	250* (253)				**3,300 (553)**
TOTALS	44 (55.5)	 (2,000)	2,500 (0)	5,800 (5,900)	56,000 (40,000)	60 (34)	15,000 (10,900)	800 (530)	3,324 (2,449)	16,825 (11,353)	250 (253)	14,000 (13,800)	2 (~152)	9	**114,320 (88,687)**

No data were available for Belgium, Estonia, Finland, Germany, Ireland, Latvia, Netherlands, Poland, Russia or Sweden. No data were available for Portugal for year 2000.
No data were available for turbot production for the UK. Cod production data in the UK were from a demonstration unit rather than commercial operations.

* Values reported on the Federation of European Aquaculture Producer's Web Site.
[1] Live-captured adults that were held in cages for up to nine months

APPENDIX 2

Contact for official members of the ICES Working Group on Marine Fish Culture as identified by their ICES country delegates.

Delegate	Name	Country	Address	Telephone no.	Fax no.	E-mail
Observer	Dr Bill Koven	Israel	Israel Oceanographic & Limnological Research Ltd. National Centre for Mariculture P.O. Box 1212 Eilat 88112 Israel	+972 7 6361420	+972 7 6375761	koven@agri.huji.ac.il
Observer	Dr George Wm. Kissil	Israel	Head, Nutrition Department National Center for Mariculture P.O. Box 1212 Eilat 88112 Israel	972 7 636–1444	972–7-637–5761	kissil@agri.huji.ac.il
Observer	Dr Amos Tandler	Israel	National Center for Mariculture P.O.Box 1212 Eilat, 88112 Israel	+972–7–6361420	+972 7 6375761	tandler@agri.huji.ac.il
Yes	Mr Peter Coutteau	Belgium	INVE TECHNOLOGIES N.V. Oeverstraat 7 B-9200 Baasrode Belgium http://www.inve.be	+32–52–331320	+32–52–334531	PeterCoutteau@ compuserve.com
Yes	Dr Patrick Lavens	Belgium	INVE Europe Services K. Albertlaan 2B 9080 Lochristi Belgium http://www.inve.be	+32 9 337 77 77	+32 9 337 77 70	p.lavens@inve.be
Yes	Dr Patrick Sorgeloos	Belgium	Laboratory of Aquaculture & Artemia Reference Center University of Gent. Rozier 44 B-9000 Gent, Belgium	+33 9 2643754	+32 9 2644193 +32 55 302871	patrick.sorgeloos@ rug.ac.be
Yes	Dr John D. Castell	Canada	Department of Fisheries & Oceans Biological Station 531 Brandy Cove Road St. Andrews NB E5B 2L9 Canada	(506) 529–5904	(506) 529–5862	castellj@ mar.dfo-mpo.gc.ca
Yes	Dr Craig Clarke	Canada	Department of Fisheries & Oceans Pacific Biological Station Hammond Bay Road Nanaimo BC V9R 5K6 Canada	(250) 756–7009	(250) 756–7053	ClarkeC@ pac.dfo-mpo.gc.ca

Delegate	Name	Country	Address	Telephone no.	Fax no.	E-mail
Yes	Dr Jacques A. Gagné	Canada	Department of Fisheries & Oceans Institut Maurice-Lamontagne 850, route de la Mer C. P. 1000, Mont-Joli Quebec G5H 3Z4 Canada	unknown	(418) 775–0542	CagneJ@ dfo-mpo.gc.ca
Yes	Ms Debbie J. Martin-Robichaud	Canada	Department of Fisheries & Oceans Biological Station 531 Brandy Cove Road St. Andrews NB E5B 2L9 Canada	(506) 529–5923	(506) 529–5862	Martin-RobichaudD@ mar.dfo-mpo.gc.ca
Yes	Mr Randy Penney	Canada	DFO P.O. Box 5667 St. John's Newfoundland A1C 5X1 Canada	(709) 772–4704	unknown	PenneyRa@ dfo-mpo.gc.ca
Yes	Dr Edward Trippel	Canada	Department of Fisheries & Oceans Biological Station 531 Brandy Cove Road St. Andrews NB E5B 2L9 Canada	(506) 529–5937	(506) 529–5862	TrippelE@ mar.dfo-mpo.gc.ca
Yes	Mr I. Fjallstein	Denmark	Fiskaaling P/F Vid Air 430 Hvalvik Faroe Islands Denmark	002 98 474747	002 98 474748	il@difta.dk
Yes	Mr P. Laussen	Denmark	DIFTA Nordsøcentret 9850 Hirtshals Denmark	unknown	Unknown	pl@difta.dk
Yes	Dr Josianne Støttrup	Denmark	Danish Institute for Fisheries Research Department for Marine Ecology and Aquaculture Charlottenlund Castle 2920 Charlottenlund Denmark	+45 33 93 33 94	+45 33 96 33 33	jgs@dfu.min.dk
Yes	Mme Béatrice Chatain	France	IFREMER Station de Palavas Recherche Aquacole Chemin de Maguelone 34250 Palavas-Les-Flots France	Unknown	unknown	bchatain@ifremer.fr
Yes	Mme J. Person-Le-Ruyet	France	IFREMER Centre de Brest BP 70 F-29280 Plouzané France	Unknown	unknown	No e-mail available
Yes	Dr B. Ueberschaer	Germany	Institut für Meereskunde an der Universität Kiel Düsternbrooker Weg 20 D-24105 Kiel Germany.	unknown	unknown	bueberschaer@ ifm.uni-kiel.de

Delegate	Name	Country	Address	Telephone no.	Fax no.	E-mail
Yes	Dr Uwe Waller	Germany	Institut für Meereskunde an der Universität Kiel Düsternbrooker Weg 20 D-24105 Kiel Germany.	++49 +431 597 4035	++49 +431 4035	uwaller@ ifm.uni-Kiel.de
Yes	Dr Björn Björnsson	Iceland	Marine Research Institute P.O. Box 1390 Skúlagata 4 IS-121 Reykavík Iceland	354–552–0240	354–562–3790	bjornb@hafro.is
Yes	Dr Richard Fitzgerald	Ireland	Zoology Department University College Cork Cork Ireland	00353 21 904050	00353 21 277922	nadc@ucc.ie
Yes	Dr A. Mitans	Latvia	Latvian Fisheries Research Institute Daugavgrivas Street 8 LV-1007 Tiga Latvia	unknown	Unknown	maris@mail.junik.lv or mitans@latfri.lv
Yes	Dr Victor Øiestad	Norway	Norwegian College of Fishery Science University of Tromsø N–9037 Tromsø Norway	+46 776 4600	+47 766 46020	victor@nfh.uit.no
Yes	Mr Jens Christian Holm	Norway	Institute of Marine Research Austevol Aquaculture Research Station N-5392 Storebø Norway	+47 5618 0342	+47 5618 0398	jens.christian.holm@ imr.no
Yes	Mr Torstein Harboe	Norway	Institute of Marine Research Austevol Aquaculture Research Station N-5392 Storebø Norway	+47 5618 0342	+47 5618 0398	torstein.harboe@ imr.no
Yes	Dr Anders Mangor-Jensen	Norway	Institute of Marine Research Austevol Aquaculture Research Station N-5392 Storebø Norway	+47 5618 0342	+47 5618 0398	anders.mangor.jensen @imr.no
Yes	Mr Tore H. Naess	Norway	Institite of Marine Research Austevoll Aquaculture Research Station N-5392 Storebo Norway.	+47 56180342	+47 56180398	tore.naess@imr.no
Yes	Mr Terje van der Meeren	Norway	Institute of Marine Research Austevoll Marine Aquaculture Station 5392 Storebø Norway	+47 56180342	+47 56180398	terje.van.der.meeren@ imr.no
Yes	Mr P. Pousao-Ferreira	Portugal	IPIMAR Av. 5 de Outubro 8700 Olhao Portugal	+351.289.70 27 79	+351.289.71 53 46	ppousao@ualg.pt or ppousao@mail.telepac.pt

Delegate	Name	Country	Address	Telephone no.	Fax no.	E-mail
Yes	Dr Alice Ramos	Portugal	Instituto de Investigação des Pescas do Mar Av. 5 de Outubro 8700 Olhao Portugal.	unknown	unknown	aramos@ipimar.pt
Yes	Dr Jose Iglesias	Spain	Instituto Español Oceanografia Centro Oceanográfico Apfo 1552 E-36280 Vigo Spain.	+34 86 492111	+34 86 492351	jose.iglesias@vi.ieo.es
Yes	Mr J.(Tito) B. Peleteiro	Spain	Instituto Español Oceanografia, Centro Oceanográfico Apfo 1552 E-36280 Vigo Spain.	+34 86 492111	+34 86 492351	tito.peleteiro@vi.ieo.es
Yes	Prof. Hans Ackefors	Sweden	Department of Zoology University of Stockholm S-106 91 Stockholm Sweden	unknown	unknown	Hans.Ackefors@ zoologi.su.se
Yes	Dr Anders Alanärä,	Sweden	Vattenbruksinstitutionen SLU 901 Umeå Sweden	+46 90 7867 676	+46 90 12 37 29	anders.alanara@ vabr.slu.se.
Yes	Dr Jan Andersson	Sweden	Fiskeriverket Kustlaboratoriet Simpevarp 570 93 Figeholm Sweden			jan.andersson@ fisheriverket.se
Yes	Dr Stephen Baynes	UK	Centre for Environment Fisheries and Aquaculture Science Weymouth Laboratory Barrack Road Weymouth DT4 8UB UK	+ 44 (0) 1305 20660	+ 44 (0) 1305 206601	S.M.Baynes@ cefas.co.uk
Yes	Dr Ian Bricknell	UK	Fisheries Research Service Marine Laboratory P.O.Box 101 Victoria Road Aberdeen AB11 9DB Scotland	+44 01224 866544	+44 01224 295511	bricknellir@ marlab.ac.uk
Yes	Mr Malcolm Gillespie	UK	Seafish Marine Farming Unit Artoe, Acharcle, Argyll PH 36 4LD UK	+44 1967 431 213	+44 1967 431 343	m_gillespie@ seafish.co.uk or M_Gillesoie@ fc.uhi.ac.uk
Yes	Dr Bari Howell	UK	Centre for Environment Fisheries and Aquaculture Science Weymouth Laboratory Barrack Road Weymouth, DT4 8UB UK	+ 44 (0) 1305 206600	+ 44 (0) 1305 206601	b.r.howell@cefas.co.uk
Yes	Simon Wadsworth	UK	Seafish Marine Farming Unit Artoe, Acharcle, Argyll PH 36 4LD UK	+44 1967 431 213		s_wadsworth@ seafish.co.uk

Delegate	Name	Country	Address	Telephone no.	Fax no.	E-mail
Yes	Dr David Bengtson	USA	University of Rhode Island Dept. of Fisheries, Animal and Veterinary Sciences Kingston RI 02881 USA	(401) 874–2668	(401) 874–401	bengtson@uri.edu
Yes	Dr Larry Buckley	USA	Director, URI/NOAA CMR Program Graduate School of Oceanography University of Rhode Island Narragansett RI 02882 USA	(401) 874–6671	(401) 874–6240	larry.buckley@ noaa.gov or lbuckley@gso.uri.edu

APPENDIX 3

Table A3.1. Fry production (x 1000) of three species of marine fish as reported in previous ICES Working Group Reports.

Turbot (*Scophthalmus maximus*)

Country	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Denmark	9								810	502	505.5	750	713			
France	75								1,250	1,650	1,800	2,000	2,500		505	
Germany	0												5			
Holland																
Ireland																
Norway	25								350	411	250	210	220		150	
Portugal																
Spain	60				178	304	368	386	1,012	1,028	1,500	850			100	
Sweden									1	0						
UK	250								325	250	100	100	100		50	
Total	419				178	304	368	386	3,748	3,841	4,155.5	3,910	3,538		805	

Table A3.1. Continued.

Sea bass (*Dicentrarchus labrax)*

Country	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Cyprus					500											
Denmark	5	5														
France	1,150	1,500		1,000	1,000				13,650	30,056	14,900	16,500	13,000			
Germany													15			
Greece	100	600														
Iceland											110	150	60		200	
Israel				20	60											
Italy	1,200	2,000		100	1,500											
Morocco				100	120											
Norway																
Portugal				200	400					9,063						
Spain				70	220	442	1401	1270	2370	4,035	3,920	3,854			7,300	
Tunisia				100	120											
Turkey																
UK	5	5								500						
Yugoslavia	2,000	2,000		2,000	2,8000											
Total	**4,560**	**760**		**35,90**	**31,920**	**442**	**1,401**	**1,270**	**16,020**	**43,654**	**18,930**	**20,504**	**13,075**		**7,500**	

Table A3.1. Continued.

Sea bream (*Sparus aurata*)

Country	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Cyprus					500											
Denmark									0	220						
France	700	120							5,020	5,400	5,200	10,500	17,000			
Germany																
Greece	100	1,000		1,200	1,500											
Israel		300		600	750											
Italy	800	1,000		1,100	2,000											
Norway																
Portugal					400				7,200	6,597	2,396					
Spain	30			2510	9,187	12,400	16,168	15,660	15,660	17,675	30,100	28,419			35,000	
Tunisia																
Turkey				500	1,000											
UK	5	5														
Yugoslavia				500	700											
Total	**1,635**	**2,425**		**6,410**	**16,037**	**12,400**	**16,168**	**15,660**	**27,880**	**29,892**	**37,696**	**38,919**	**17,000**		**35,000**	

Table A3.2. Harvest production (in tonnes) of three species of marine fish as reported in previous ICES Working Group Reports.

Turbot (*Scophthalmus maximus*)

Country	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Denmark		0							28	30	5	80	90	< 100		
France		34							440	600	800	850	950	1,000		
Germany		0											2			
Holland									0	10	11	0				
Ireland									4	3	0	32		< 100		
Norway		0							10	40	50	30	55	< 100		
Portugal		0									82	1,890				
Spain		80		97	271	640	825	1,622	1,622	1,809	800	850	2,225	2,250		
Sweden																
UK		100							5	20	0	5	5	< 100		
Total		**214**	**0**	**97**	**271**	**640**	**825**	**1,622**	**2,109**	**2,512**	**1,748**	**3,737**	**3,327**	**3,250**		

Table A3.2. Continued.

Sea bass (*Dicentrarchus labrax)*

Country	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Cyprus	1	1	0	3	10	15	15	29	33	20						
Denmark									250	144						
France	70	90	140	145	250	300	414	550	1,330	2,138	1,350	1,500	1,650	2,300	2,600	
Germany													2			
Greece	20	90	70	110	300	1,952	2,530	5,043	7,345	6,870					19,000	
Iceland											0	1	1		20	
Israel									75	145						
Italy	100	100													5,800	
Morocco																
Norway									50	0						
Portugal									249	342	254	310	902	1,000	1,000	
Spain	11	31	38	29	24	30	92	143	370	351	650	900	829	1,200	1,670	
Tunisia	15	30	40	316	300	283	305	161	419	571						
Turkey															7,300	
UK																
Yugoslavia																
Total	**217**	**342**	**288**	**603**	**884**	**2,580**	**3,356**	**5,926**	**10,121**	**10,581**	**2,254**	**2,711**	**3,384**	**4,500**	**37,390**	

Table A3.2. Continued.

Sea bream (*Sparus aurata*)

Country	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Cyprus			2	2	16	35	42	42	136	187						
Denmark									0	45						
France	15	10	10	170	20	30	40	100	329	1,158	900	1,000	1,016	1,250	1,300	
Germany																
Greece	20	30	65	220	490	1,598	2,069	4,126	6,012	6,500					21,000	
Israel	100	150	45	60	80	84	70	54	155	555						
Italy	50	60													5,100	
Norway																
Portugal									867	1,179	419	605	1,700	1,900	1,900	
Spain	360	450	550	750	850	850	965	1,070	1,300	2,600	3,300	4,700	5,530	6,900	7,600	
Tunisia										40						
Turkey		34	65	100	798	103	910	937	1,029	6,070					7,300	
UK																
Yugoslavia																
Total	**545**	**734**	**737**	**1,302**	**2,254**	**2,700**	**4,096**	**6,329**	**9,828**	**18,334**	**4,619**	**6,305**	**8,246**	**10,050**	**44,200**	