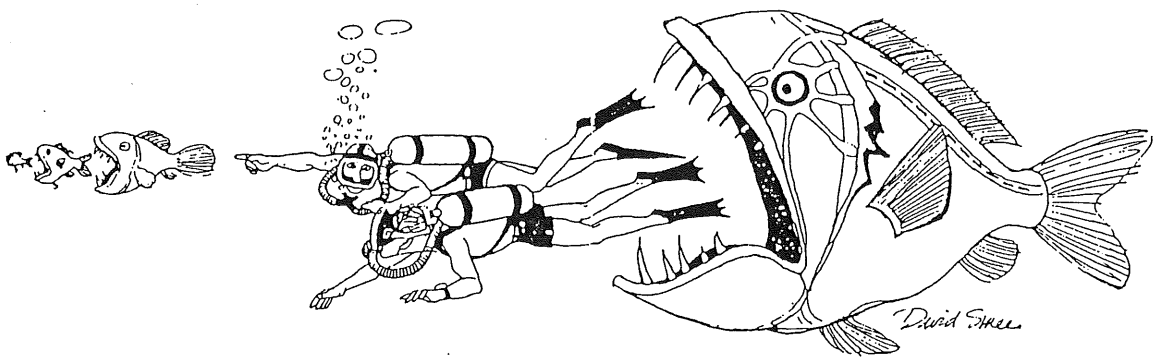
ICES International Council for the
Exploration of the Sea

CM. 1994/F: 3
Mariculture Committee
Ref.E Marine Environmental
Quality Committee

Report of the Working Group on "Environmental Interaction of Mariculture"

University College Cork, and
Aquaculture Center
Cork, Ireland,
March 28 to 31, 1994



"Do you realise we are witnessing one of the eternal truths ?"

Address:
General Secretary
ICES
Palægade 2-4
DK 1261 Copenhagen K
Denmark

Table of Contents

Summary 4

Résumé 4

1. Introduction 5
   1.1 Participation 5
   1.2 History of the Working Group activities and name change 7
   1.3. New Working Group TORs 7
   1.4. Terms of Reference for the 1994 Working Group Meeting 7
   1.5 International Activities related to Environmental Issues of Mariculture 8

2. National Reports on Mariculture and Research Projects 9
   2.1 Comments on National Reports 9
   2.2 Update of list of Research Projects Related to Environmental Impact 10

3. Biological Interactions Between Types of Mariculture and other Coastal Zone Uses 10
   3.1 Interactions between Types of Mariculture and other Coastal Zone Uses 10
      3.1.1 Competition for space 10
      3.1.2 Capture of wild shellfish spat 11
      3.1.3 Interactions with design of sewage treatment systems - shellfish quality 11
      3.1.4 Effects on anglers 11
      3.1.5 Removal of redundant structures 12
   3.2 Potential environmental implications of new culture systems in ICES member states 12
      3.2.1 New systems 12
      3.2.2 New species 12

4. Consideration of the NASCO Position paper 13

5. New approaches to environmental assessment and monitoring of mariculture development 15
   5.1 Background 15
   5.2 Responses to questions and comments by the EIM Working Group 17

6. Information on ongoing monitoring programmes in ICES member countries 18

7. The role of models in mariculture and recent relevant developments in modelling 21

8. Guidelines on the ecotoxicological information needed for the assessment of the environmental impact of therapeutants 23
   8.1 Factors influencing the fate of antimicrobial agents in the marine environment 24
   8.2 Bioavailability, bioactivity and binding influence on analysis and drug resistance .. 25
   8.3 Drug Resistance 26
   8.4 Significance for Ecotoxicology Assessments 27
   8.5 References cited 28

9. Developmen of Biological Criteria for gauging environmental impacts of aquaculture ... 28

10. Coastal zone management issues 29
   "Integration of Mariculture into Coastal Zone Plans and Management Strategies" 29
   10.1 The Case for Coastal Zone Management for Sustainable Mariculture Development 29
      10.1.1 The Importance of the World's Coastal Zones 29
      10.1.2 The role of mariculture in Integrated Coastal Zone Management 30
      10.1.3 Experience in Integrating Mariculture into Development Planning in Coastal Areas within ICES member countries 31
         10.1.3.1 The Case of Norway 31
         10.1.3.2. The Case of Canada 32
         10.1.3.3 The Case of France 33
      10.1.4 Pro-active Coastal Zone Planning and Management for Sustainable Mariculture 34
      10.1.5 Coastal Zone Management Issues that Need to be Addressed 36

10.2 Recommendations for Future Activites of the WGEIM in CZM studies 36
10.2.1 Establishment of a Coastal Zone Management Study Group 37
10.2.2 Development of Education Programmes 37
10.2.3 Preparation of Guidelines 37

11. Status of the preparation of Technical reports 39

12. Sea Trout Commentary 39
12.1 The nature of the decline of sea trout stocks 40
12.2 The evidence of a correlation between the decline in sea trout stocks and sea lice abundance 40
12.3 Understanding the mechanism underlying the interaction between host/parasite/environment 40
12.4 The relationship between the number of sea lice on juvenile sea trout returning to the rivers and the distance between those rivers and the nearest salmon farm 40
12.5 Possible approaches to evaluating the role and nature of any lice-trout interactions. 41

13. "Mariculture and Coastal Zone Management" Planning a session for the 1994 Statutory Meeting 41

14. Recommendations 42

15 Action list 44

16. Relevant Literature (provided by Participants) 45

Appendix I Studies related to environmental aspects of Mariculture 59

Appendix II WG Environmental Interactions of Mariculture: Membership, invited experts, and observers 76

Appendix III Tentative Agenda of the Working Group Meeting, Cork 1994 79

Appendix IV Country Reports 81

Appendix V Discussion Paper on "Development of biological criteria for gauging environmental impacts of aquaculture. (James E. Stewart.) 111

Appendix VI Mariculture and the Environment: The Saldanha Bay System Programme 117

Appendix VII NASCO Position paper: Interaction between salmon aquaculture and the wild salmon stocks..... 121

Appendix VIII Working Group on Interactions between Mariculture and the Environment (South Africa), A. Moldan and P. Monteiro 123

Appendix IX Comments On Chapter "Modelling" of the Draft Technical Report on .. "Management of the Environmental Impact of Marculture" 126

Appendix X Updated chapter V of the draft Technical Report on "The Management of the Environmental Impacts of Mariculture" : Monitoring 128

Appendix XI Summary, Cartographic catalogue of coastal zones sensible to eutrophication: the case of Brittany. (IFREMER) 134

Appendix XII Partly Annotated Bibliography 135

Summary

The ICES Working Group on the **Environmental Interaction of Mariculture** met for four days (28-31 March, 1994) in Cork, Ireland. National reports clearly indicated that in the two years since the last meeting, growth of the industry occurred only in a few areas while in most countries aquaculture maintained its recent production level or declined slightly.

Under the new Terms of Reference, the Working Group updated the cataloque on completed, ongoing, and new research programmes in member countries related to environmental issues of mariculture. and examined the biological interactions between types of mariculture and other users of the coastal resource system. Major conflict areas were identified and in particular, the need of improved standards for technical safety to prevent escapes and reduce risk of disease transfer were identified. These issues were also discussed in relation to interactions between farmed and wild fish. Recent developments in the use of monitoring and modelling programmes applied in environmental assessment of mariculture are outlined.

Further discussions centered around the ecotoxicological evaluation of complexed and/or particle-bound contaminants (e.g. antibiotics) from fish farms. The WG concluded that analytical procedures for residues determination in sediments have been greatly improved in recent years. However, almost all cases, these substances are complexed and biologically not active and therefore, in an eco-toxicological sense, non-existent. There is a need to develop better methods to determine bio-activity of residues in ecosystems to evaluate more realistically their ecological implications.

A large part of the WG meeting centered around various aspects of integration of mariculture development into larger Coastal Zone Management (CZM) schemes. There is an urgent need to actively promote pro-active approaches for planning and managing mariculture as an integral part of coastal zone management plans and investment strategies. Such plans and management strategies must be based upon sound scientific management principles for the protection of environmental processes which maintain the functional integrity of coastal ecosystems and sustain mariculture and other renewable resource dependent activities. The Working Group recommended that WORKSHOPS be organized on Modelling of environmental interactions of mariculture, and on mariculture development as part of CZM planning activity. It is hoped to bring together the expertise of various scientific groups and governmental officials involved in managing the coastal resources, including mariculture.

Résumé

Le Groupe de Travail du CIEM sur les Interactions de la Mariculture avec l'Environnement s'est réuni durant quatre jours (28-31 mars 1994) à Cork, en Irlande. Les rapports nationaux ont clairement montré que, dans les deux années ayant suivi la recontre précédente, la mariculture n'a montré de croissance que dans quelques cas, alors que, dans la plupart des pays, cette activité s'est maintenue à son niveau de production récent ou a légèrement décliné.

Suivant ses nouveaux termes de référence, le Groupe de Travail a réactualisé le catalogue des programmes de recherche des pays membres concernant les effects de la mariculture sur l'environnement (programme achevés, en cours ou nouveaux), et examiné les interactions biologiques entre différents types d'élevages et les autres utilisateurs des ressources côtières. Les sources de conflit les plus importantes ont été identifiées; en particulier, le besoin de normes techniques de sécurité pour prévenir les fuites de poissons et réduire les risques de transmission des maladies a été ressenti. Ces effets ont également été discutés pour ce quiconcerne les interactions entre les poissons d'élevage et les stocks sauvages. L'évolution récente des programmes de surveillance et de modélisation appliqués aux études d'impact de la mariculture sur l'environnement a été soulignée. Des discussions ont porté sur l'evaluation écotoxicologique de contaminants compléxes ou associés au matérial particulaire issus desfermes de poissons (ex. antibiotiques). Le Groupe de Travail a conclu que les procédures analytiques de détermination des résidus dans les sédiments ont été considérablement améliorées au cours des dernières années. Cependant, dans la plupart des cas, ces substances sont complexées et sans activité biologique et, dans un certain sens, n'exitent donc pas en terms d'écotoxicologie. Il est nécessaire de mieux déterminer l'activité biologique des résidusdans l'environnement pour apprécier plus précisément leurs implications écologiques.

Le Groupe de Travail a conscré une partie importante de son temps aux divers aspects de l'intégration de la mariculture dans les schémes d'aménagement de la zon côtière. Il existe un besoin urgent de promouvoir une approche volontariste pour planifier et gérer l'aquaculture comme une partie intégrante des plans d'aménagement et des stratégies d'investissement. De tels plans et strategies doivent être basés sur des principes scientifiques sériux de protection des processus environnementaux qui maintiennent l'intégrité fonctionnelle des écosystèmes côtiers et supportent la mariculture et les autres activités lées aux ressources renouvelables. Le Groupe de travail recommande d'organiser des ateliers sur l'utilisation de la modélisation des relations entre la mariculture et l'environnement dans la planification des zones côtières. Il espère réunir les expériences de divers groupes scientifiques et administratifs concernés par l'aménagement des ressources côtières, dont la mariculture.

1. Introduction

The 1994 meeting of the ICES Working Group on "Environmental Interactions of Mariculture" was held in Cork, Ireland, March 28 to 31, at the University College, Cork, Ireland and with the assistance of the Aquaculture Development Center of the University College Cork. The Working Group was welcomed by the Vice-President of the University College and Chairperson of the newly established Marine Institute, Prof. Dr.M. Mulcahy. Dr. Mulcahy explained the aims and goals of the newly established institution and mentioned the particular focus on coastal resources.

1.1 Participation

There were 22 (23) participants representing 11 member countries present. Additionally, invited experts attended parts of the meeting to provide advice on specific agenda items. Furthermore, observers attended from NASCO and from South Africa.

Rosenthal, Harald (Chairman)	Federal Republic of Germany
Alderman, David *(Chair: subgroup on "Particle-bound contaminants")*	United Kingdom
Black, Eward E. *(Chair: subgroup on "Management of Environmental Impact of Mariculture")*	Canada
Burbridge, Peter *(Chair: subgroup on "coastal zone management strategies")*	Scotland*
Doyle, Jaqueline *(Chair: subgroup on "Monitoring")*	Ireland
Silvert, William, S. *(Chair: subgroup on "Modelling")*	Canada*
Ackefors, Hans	Sweden
Aure, Jan	Norway
Davies, Ian *pariticapted by daily (sometimes hourly) fax communication*	Scotland
Dijkema, Renger	The Netherlands
Dosdat, Antoine	France
Ervik, Arne	Norway
Fitzgerald, Richard	Ireland*
Hutchinson, Peter *(Observer, NASCO, attended agenda item)*	Scotland**
Kempf, Marc	France*
Kryvi, H.	Norway
Lewis, Tony	Ireland*
Merceron, Michel	France
Monteiro, Pedro	South Africa **
Newell, Carter	United States of America

O'Connor, Brendan	Ireland
Smith, Pete	Ireland
Thomson, Mike	Ireland
Werner, Iris (Secretary)	Federal Republic of Germany

During the Meeting several subgroups were formed and met on two occasion during the Working Group meeting to address specific TORs. The membership of these subgroups was as follows.

Subgroup (1): Particle-bound contaminants
- D. Alderman (Chair)
- H. Rosenthal
- P. Smith
- (H. Ackefors, part-time participant)

Subgroup (2): Coastal zone management strategies
- P. Burbridge (Chair)
- (H. Ackefors, part-time participant)
- R. Fitzgerald
- M. Kempf
- T. Lewis
- H. Kryvi
- M. Thomson

Subgroup (3): Monitoring
- J. Doyle (Chair)
- A. Ervik
- R. Dijkema
- M. Merceron
- B. O'Connor
- E. Black

Subgroup (4): Modelling
- W. Silvert (Chair)
- J. Aure
- A. Dosdat
- C. Newell
- P. Monteiro

Written contributions were received from Scotland (Ian Davies, Aberdeen), Finland (Kari Ruohonen and Timo Mäkinen, Helsinki) and Poland. Dr. Ian Davies participated during the WG meeting extensively by providing requested information through daily faxes. Subjects covered include local and regional monitoring programmes throughout the UK, various aspects of impacts of new cultivation systems, and comments and views on interactions of complexed and/or particle bound contaminants. Most of these contributions were incorporated into the body of the report.

A list of the Working Group membership is attached to this document as Appendix II. Because of the change in name of the WG and subsequently of the TORs, the nomination of additional experts to the membership has not yet been completed. Therefore, the meeting draw largely on expertise of invited experts (marked by an asterisk* in the list of participants). Further changes and additions to the membership are anticipated during the intersessional period.

1.2 History of the Working Group activities and name change

A Study Group on Environmental Impact of Mariculture was formed by the Mariculture Committee in 1986 with its original Terms of References being adopted by the Council in 1986 and1987 (ICES C.Res 1986/2:36; C.Res. 1987/2:40).

Beginning in 1986, the Study Group and its successor Working Group have carried out a detailed examination of the impacts of mariculture. The Working Group met 5 times between 1987 and 1992 and has produced a number of documents, provided advice to the Mariculture Committee, and (through ACMP) to other intergovernmental organisations (e.g. HELCOM, NASCO). Research priorities had also been identified. Most of the tasks of the WG on Environmental Impact had been completed by 1993.

In the course of delineating the dimensions and nature of the various effects, the WG concluded that the effects have not been as great as either they or the public perceived or anticipated. If conducted properly, mariculture could contribute to "sustainable development" in coastal areas. However, it was recognized that mariculture cannot develop without due consideration of resource use conflict issues, and that many of the past failures have partly been experienced because of the lack of appropriate integrated planning within a coastal zone context. To reflect these needs the WG recommended to the Parent Committee that the scope of the group be broadened to encompass the interaction of mariculture with other human activities. The parent Committee endorsed the recommendations given by the WG and proposed the name change to the Council and new Terms of References were formulated.

1.3. New Working Group TORs

Based on the decision taken by the Council during its 1992 Statutory Meeting (C.Res. 1992/2:45) the Working Group was renamed to *"Working Group on Environmental Interactions of Mariculture"* to reflect a broadened interaction of mariculture with other human activities in coastal areas with extended terms of reference including:

a) developing criteria and a standard system of monitoring and reporting;

b) delineating the scope and nature of environmental interactions between mariculture and other uses of the coastal marine resources;

c) providing advice on approaches in such areas as improved site selection and through advances in husbandry to minimize conflicts between mariculture and other coastal zone activities;

d) reviewing and evaluating national monitoring programmes and preparing regular status reports on the impact of mariculture within ICES.

1.4. Terms of Reference for the 1994 Working Group Meeting

The TORs for the 1994 Working Group meeting were approved during the 1993 Statutory Meeting in Dublin by Council Resolution (C.Res. 1993/2:26) to:

(a) update the catalogue of ongoing research programmes on environmental interaction issues related to mariculture.

(b) examine biological interactions between types of mariculture and other coastal zone uses

(c) identify major long-term research priorities particularly in the subject area of resolving conflicts in use of the marine environment

(d) assemble and compile, intersessionally, information on ongoing monitoring programmes in each country related to the assessment of the impacts and interactions of mariculture, with a view to its publication in the Cooperative Research Report Series.

(e) evaluate the potential of environmental effects of new culture systems in ICES member states.

(f) assemble and comment on the evidence for the interactions of complexed and/or particle-bound contaminants (e.g. antibiotics, antifoulants, biocides, etc.,) from fish farms with marine flora and fauna, and the significance of these interactions within marine ecosystems.

(g) prepare guidelines on the ecotoxicological information necessary to permit assessment of the relative environmental impacts of therapeutants.

(h) develop and coordinate plans for a Committee session on "Mariculture and Coastal Zone Management" at the 1994 Statutory Meeting.

1.5 International Activities related to Environmental Issues of Mariculture

Public interest in Mariculture and coastal zone management needs have recently been recognized in many parts of the world, and this is expressed by the growing number of international conferences, workshops, regional and national meetings dealing with these issues. Besides those mentioned in the 1993 interim Working Group report, the chairman reported on the following events:

(a) European and World Aquaculture Conference, Torremolinos, April 1993
Several papers presented dealt with environmental issues of various forms of mariculture (abstract booklet available)

(b) World Aquaculture Conference in New Orleans, January 1994
A special Session on Environmental impact was held at this meeting. (Abstract book available)

(c) A two day Meeting was held Aug31/Sep 1, 1993 at the Marine Biological Laboratory, Woods Hole, entitled "Aquaculture and the Marine Environment: The shaping of public policy. The Conference was designed around two main topics: Waste Management and The Interaction of Aquatic Species with Native Stocks.

(d) GESAMP Working Party 31 met in January 1994 and dealt mainly with aspects of monitoring aquaculture activities for both farm management and regulatory purposes.

(e) Aquaculture and the Environment , Santiago de Chile, September 1993
With the growth of the salmon farming industry in Chile, environmental issues are addressed at an early date to learn from experience elsewhere. The workshop discussed the local situation during two days of presentations of experience papers from Chile and invited review papers from Europe.

(f). Workshop on Fish Farm Effluents and their Control in EC Countries
The Workshop was held in Hamburg, Germany, Novembere 23 to 25, 1992. With the Common Market approaching a new phase in 1993, the question arose whether there is a need to harmonise the regulatory efforts within EC countries and to standardize the recommended control procedures. The Workshop addressed key problem areas

related to these issues in modern fish farming. A full account of the outcome of the Workshop was presented to the Mariculture Committee at the 1993 Statutory Meeting of ICES in document C.M.1993/F:13.

(g) A Working Group on "Interactions between mariculture and the environment" has been formed at the Sea Fisheries Research Institute, Cape Town, South Africa. Information on the activities of this group can be found in Annex VIII.

The Chairman and Working Group members provided information on recently published books relevant to the subject areas of the Working Group. Citations can be found in the references listed.

2. National Reports on Mariculture and Research Projects

2.1 Comments on National Reports

National reports were provided by nine countries, reporting on production trends, regulatory issues and on ongoing research programmes with respect to environmental and coastal zone management issues. The present situation of mariculture development and concern on environmental issues in member countries was discussed by the Working Group. In a few member countries modern aquaculture continues to grow while in others production trends are stable or slightly declining. Salmon production continues to increase substantially with an anticipated production of over 160,000 tonnes in Norway in 1994.

In most ICES member states, public perception of environmental impact of mariculture is unrealistically negative. This is particularly the case for intensive fish farming and to a lesser degree for other farming activites (e.g. shellfish farming). New fish farming technologies have been tested in recent year, however, cage culture of salmon seems still to be the most cost-effective technology for grow-out. Environmental conflicts between have increased in recent years, although the industry is heavily regulated. Appropriate site selection, management plans, strict control on chemicals and other measures have contributed to make mariculture more environmentally friendly. For example, for a number of reasons (e.g. development of effective vaccines, relatively low temperatures during the past winter) the total amount of antimicrobials used in fish farming in Norway has been drastically reduced, amounting to only about 25% of the volume used in previous years, while production increases. On the other hand, the problem of interaction between wild fish and farmed fish seem to gain importance in some countries (e.g. Ireland, Norway).

There is a trend towards administrative over-regulation of mariculture. While a lead agency is existing in several countries, some countries still do not have a mariculture or aquaculture policy. Research activities on environmental issues have increased in most member countries (see also 2.2 and listing of projects in Annex I)

In several countries production trends and the performance of the industry is also influenced by political and economic changes taking place in neighbouring countries (e.g. mainly countries of central and eastern Europe), resulting in temporary distortion of markets because of extremely low prices for fishery products arriving from these countries on western European markets.

Few new aquaculture species seem to have entered the mariculture scene. Halibut culture is becoming established in some countries (e.g. Norway, Scotland) while experimental work continues in others (e.g. Canada)

2.2 Update of list of Research Projects Related to Environmental Impact

During the intersessional period it was noted that many of the members of the former Working Group on "Environmental Impact of Mariculture" had changed duties and are no longer working in this field. It was, therefore, extremely difficult to update part of the data base on on-going research programmes. The present list contains, therefore, incomplete information on projects reported in earlier documents. Because this exercise has been very useful to provide orientation for both the Working Group membership (for their own elaborations and for the formulation of research needs and priorities) and for other organisations and agencies involved in mariculture development, it was decided to continue the activity with the aim to trace as much information as possible on those projects which had been completed during the intersessional period. New projects have been appended to the list and assigned serial numbers. Presently, the catalogue lists a total of over 250 projects.

3. Biological Interactions Between Types of Mariculture and other Coastal Zone Uses

3.1 Interactions between Types of Mariculture and other Coastal Zone Uses

Co-culture and integrated farming systems have so far received little attention. The subject was briefly discussed and mention was made of the greater importants of these systems in the Mediterranean and in Southeast Asia. It was generally felt that integrated farming systems, in particular waste-water fed mariculture systems, may be re-considered in several regions within ICES.

Further information provided by Dr. Davies (Aberdeen) was briefly discussed and additional information relevant to the subject was given by other members of the WG. These included the following aspects:

3.1.1 Competition for space

- Tourism (aesthetics of appearance, disturbance in remote areas). It was generally felt that many of the issues related to tourism were difficult to quantify and seem more related to public perception and emotions rather than fact.
- Nature conservation (disturbance of wildlife): Although it is generally accepted that aquaculture development may interfer with nature conservation interests, there are also examples that nature conservation measures interfere unintentionally with aquaculture needs. One example was recently reported from Eastern Canada, where wetland and bird sanctuaries have been created and led to increased bird populations, interfering with shellfish culture because of increased faecal counts derived from bird faeces on intertidal shellfish beds. Products no longer met human health standards.

Most of these aspects are taken into account in many member countries when the applications for leases are assessed by the regulatory agencies. In the UK this is done mainly by the Crown Estate Commissioners and other authorities. In the UK, most of the sea bed belongs to the Crown, and the CEC administrate this "estate" on behalf of

the Crown, although the revenues go to Treasury. Along the German coast, regulatory steps within the 3 mile zone are mainly managed by the "Länder".

- Fishing (new mariculture related activities; traditional fishing grounds): The use of wrasse in sea louse control has created a new industry of wrasse fishing in Scotland. They are caught by stationary gear (mainly nets), and a number of areas of high populations have been identified. The best assessment currently available (based on limited catch and effort data in Scotland) suggest that the populations are not being overfished at current exploitation rates. One wrasse is worth about £1,20 to £ 2,00, depending on quality, species, time of year, etc. Limited efforts are underway to develop wrasse cultivation to provide more secure supplies.

3.1.2 Capture of wild shellfish spat

- The scallop, queen, and mussel industries are dependent upon the capture of wild spat. Oyster spat is obained from hatcheries. Many thousands of spat collectors are deployed each year in areas where spatfall is normally good. Mussels are usually collected on ropes or on seed beds, while Pectinid spat is collected on scrap netting inside netting bags in some countries. The time of deployment to collect spat before other fouling makes the surfaces unattractive is critical. Current evidence indicates that spat collection is not significantly affecting the recruitment in wild shellfish populations in Scotland and that recruitment is largely influenced by other factors. Several member countries (e.g. The Netherlands, Germany,etc) reported repeatedly poor spatfall and limited supply of seed mussels in recent years.

3.1.3 Interactions with design of sewage treatment systems - shellfish quality

- The issue of water quality in relation to shellfish growing areas under the EC Directive on Shellfish Hygiene is of growing concern. There is potential for conflict where Class A waters used for shellfish production may receive discharges from new sewage treatment facilities designed to meet urban waste water standards under the EC Urban Waste Managment Directive.

- Recent proposals for sewage effluent disposal at a site in Scotland may have detrimental effects on an established shellfish farm with the consequential downgrading of water quality and the need to install further cleansing equipment to comply with the EC Directive. In addition a salmon farmer has objected to a proposal for a sewage outflow less than one mile from his farm Whilst the local authority suggests that there is no pollution risks, his insurers have indicated that they will withdraw cover if permission for the outfall is granted. These cases illustrate the complexity of problems in relation to water quality, they raise questions of liability and compensation which are not addressed in the legislation. This example underlines the need for a broader approach to coastal zone management issues which are particularly addressed in the respective WG Report section below.

3.1.4 Effects on anglers

- In Scotland, wild salmon are prized fish. Anglers have clear views on the relative values of wild and farmed salmon as sport fish, and have expressed considerable concern over the proportion of recognisable farmed fish (escapes) that are taken by rod and line in some west coast rivers. The proportion of farmed fish in the important east coast rivers is small. This subject is further discussed in the WG elaborations of the NASCO position paper.

3.1.5 Removal of redundant structures

- In some locations, difficulty has arisen over the responsibility for the disposal of structures and materials which are either obsolete or are "left behind" if a company ceases to trade. Such problems occur occasionally in some countries despite existing regulations.
- Increased use of infrastructure is another area of concern which is specifically addressed in the Coastal Zone Management" section of this report.

3.2 Potential environmental implications of new culture systems in ICES member states

3.2.1 New systems

Culture systems and culture strategies may change in the future and this will require different risk assessment criteria than presently used. The WG discussed an optional scenario for salmon cultivation in Norway which was discussed at the Trondheim Technical Conference on Aquaculture in 1993 (see Fig. 1). Although cage farming is presently the most cost-effective grow-out system for salmon, alternative strategies which utilize a larger variety of combinations of land-based and water-based systems, including short-term ongrowing of smolts in well-protected inshore bays using bags and "floating tanks" are being increasingly considered by the industry to overcome environmental problems and cope with increasingly stringent regulatory measures.

Polyculture and co-culture was briefly discussed during the meeting. In ICES member countries, poly-culture in its strict sense is presently not practiced to any significant scale in mariculture. However, co-cultivation between fish and shellfish species has been tried and studied on an experimental scale in several countries. If co-culture develops (e.g. salmon and mussels at the same site) this may be considered environmentally beneficial. However, some risk aspects have to be considered. In theory, it is possible that farmed shellfish in the vicinity of fish farms could accumulate medicinal compounds from the water or particulate matter. In practice, in several member countries (e.g. Scotland, Ireland, Sweden, Germany, etc.) the separating distance between fish and shellfish farms effectively reduce this risk to negligible levels. Co-culture has been studied in British Columbia (see ref. Black et al. 1991). and in France (Goulletquer P., Prou J., Héral M., 1993., see literature listing)

3.2.2 New species

There is developing interest in Scotland in the potential of halibut cultivation. A number of leases for this activity have already been granted. The main environmental impact is expected to arise from the on-growing phase in sea cages. In Norway, tank culture in onshore facilities is practiced.

It seems likely that halibut on-growing will take place, at least initially in Scotland, in surface floating cages. There have been engineering difficulties with sea bed enclosures. The cages might be about four metres deep, and would have a tarpaulin sewn into the base and stretched across a frame to give the required rigidity to the bottom of the cage. The cages would need to be located in very sheltered waters, as they could easily be damaged in more exposed locations. The fish might be fed two or three times a week, and should show feed conversion ratios similar to, or better than, salmon. The faeces would escape from the cage through a netting opening in the middle of the base, taking up perhaps 2-3% of the area of the base. Initial indications are that the fish are resistant to furunculosis, but some concern exists as to their

susceptibility to IPN (Infectious Pancreatic Necrosis). There are now four small-scale hatcheries in Scotland, three of which produced juveniles last year and there are plans to increase the level of production in 1994.

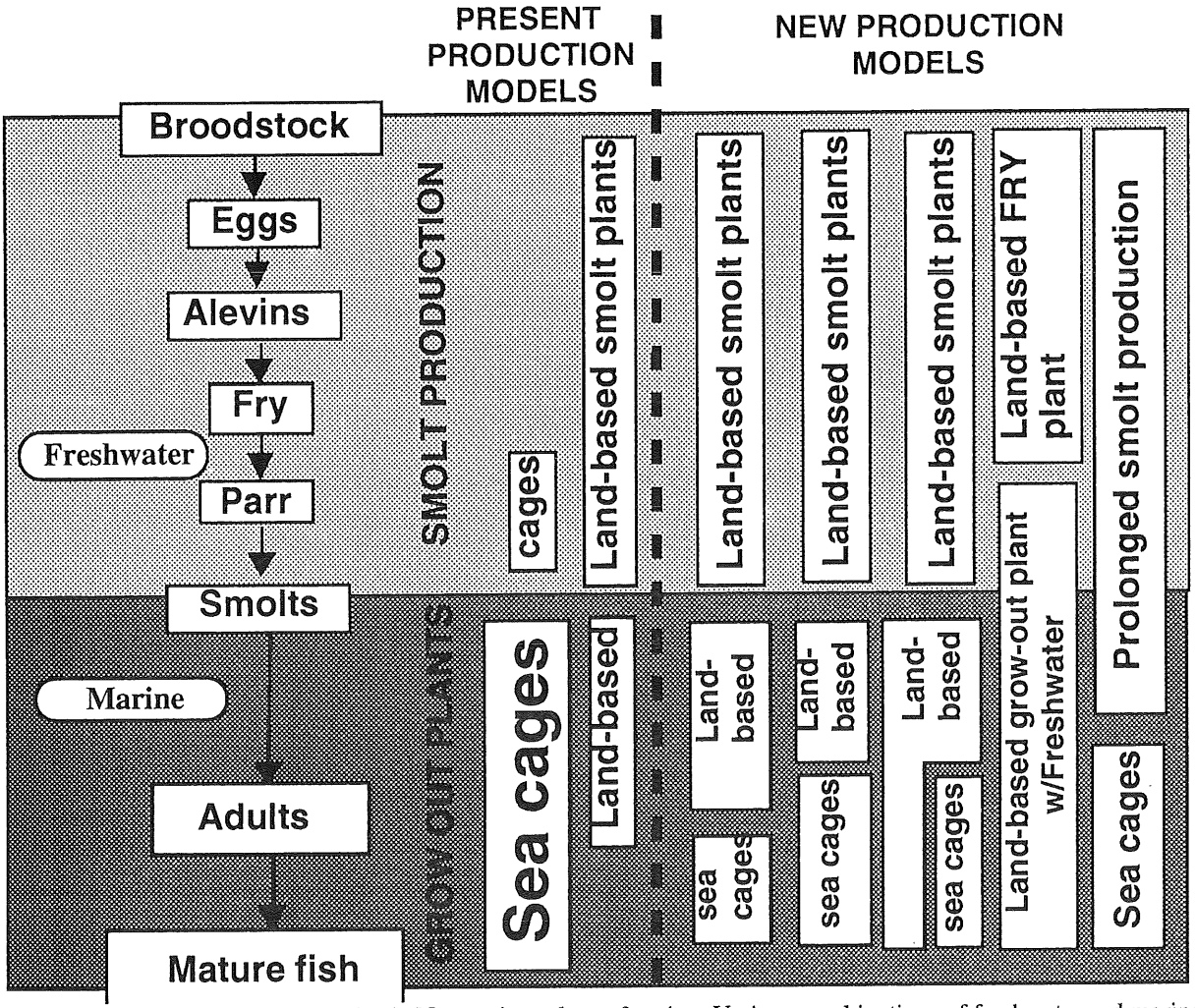


Figure 1: Changing culture strategies in Norwegian salmon farming. Various combinations of freshwater and marine production scenarios are emerging that relief partially the environmental load to coastal marine waters even if total production increases further

4. Consideration of the NASCO Position paper

The Working Group noted that several ICES Working Groups are addressing NASCO requests for advice. These include ... Genetics, WGPDMO, The WG on Environmental Interactions of Mariculture discussed the guidelines proposed by NASCO and concluded that many of the issues have already been discussed and agreed by the former ICES Working Group on "Environmental Impact of Mariculture". The Working Group was pleased to see that quite a few of earlier conclusions were taken up by NASCO. However, some of the aspects outlined in the more recent discussions deserve further consideration and agreement. Upon invitation of the Chairman, NASCO submitted a position paper on the subject. Dr.Peter Hutchinson participated in the meeting when dealing with the agenda item and introduced the document to the Working Group.The main areas of concern to NASCO are:

(a) improvements in the containment of farmed fish
(b) improvements in the prevention of diseases and parasites
(c) the use of areas for the protection of wild salmon
(d) use of sterile fish by the salmon farming industry

The following is a short summary of the Working Group elaborations:

(a) improvements in the containment of farmed fish

The WG noted that there are three main aspects to the escape of farmed fish.
- the impact of severe weather on cage structure
- the impact of predators
- the impact of the trickle effect of minor losses during grading and harvesting.

There was general agreement that the best approach to minimizing major losses was to improve the standard of cage design and most importantly the routine maintenance of structures and moorings. The Norwegian inspection programme outlined has cut such losses by nearly 75% in 1992.

Improvements in anti-predator controls are also essential. The WG suggests that ICES is the competent authority to address these problems and recommends that a Study Group be established to evaluate existing knowledge and technology, having regard to the biological requirements of the species to be farmed, to make recommendations for improving the functional reliability of the systems including anti-predator measures.This Study Group could be combined with the Study Group on "new systems" proposed in recommendation 1.

The reduction of minor escapement over protracted periods must be addressed by raising the awareness of fish farmers and educating operators. In this regard the maintenance of good stock records at farm level should identify where these problems occur and remedial action can be taken.

The question of recapture of large-scale escapees was considered impractical and expensive in open sea conditions and more likely to interfere with migratory wild salmonids if major netting is undertaken. The only practical method is to remove identifiable farm stock at spawning time from rivers where trapping facilities are available.

The question of tagging farmed fish was discussed and on a cost basis considered impractical for the time being, unless it could be combined with some beneficial procedure such as vaccination. Such approach would be still slow and ineffective to identify problem farms while technical safety and control measures are considered to be of a more immediate effectiveness.

The suggestion of land-based sea water systems as an alternative to cage culture was presently not perceived as being economically viable. However, the proposed study Group should address progress in this area.

(b) Improvements in the prevention of diseases and parasites

It is recognized that such improvements are of benefit to both the wild fishery interests and the farmer. Considerable effort is continuing to achieve this by development of new epidemiological strategies, therapies and vaccines, by improved husbandry methods such as site rotation, fallowing, single generation sites and single bay management (see also WG Rep 1993). However, despite these improvements it must be recognized that wild fish act as carriers of pathogens and can still transmit diseases to and between farms.

(c) The use of exclusive areas for the protection of wild salmon.

So far little is known about the effectiveness of such experiments. Work initiated in Norway in 1989 will be avaluated in the current year and their report should be considered by the Working Group in the intersessional period and recommendations be formulated at the next WG meeting.

(d) The use of sterile fish

The problem related to the use of sterile fish was that at the present stage of development they were economically unattractive to the industry. The industry identified slower growth, vulnerability to disease and consumer resistance as major constraints to the use of steril fish. A second problem relates to a lack of knowledge about the ecological implications of the escape of large non-spawning fish, particularly with respect to competition for available feed resources in the marine environment.

While for ranching purposes the use of local strains for broodstock purposes is generally accepted, the evidence from Scandinavia, Ireland and elsewhere would suggest that such limitation would severly inhibit the development of the salmon farming industry where genetically selected strains for fast growth and late maturation are already used for brood stocks. However, the WG notes that national initiatives using local strains may asist developments of local brood stocks which are suitable for mariculture.

The WG concludes that progress on this issue is dependant on the outcome of proposed research and will review the matter at its next meeting.

Infection by parasites has been a problem that received much attention by fishery management organisation and has also been discussed in public. Epidemiological examination of sources of *Gyrodactylus* suggests that fish moved as part of restocking programmes played a greater role than farmed fish in the spreading of this parasite.

ICES retain the responsibility in this area and may establish a Study Group at the next Statutory meeting, to elaborate and evaluate possible means of bio-technology to improve functional reliability of culture systems in particular with regard to escapes.

5. New approaches to environmental assessment and monitoring of mariculture development

Before examining and discussing recent developments in monitoring programmes and in modelling approaches in ICES member countries, the Norwegian approach to environmental assessment and monitoring (MOM) was considered after a brief presentation of this principle strategy by Arne Ervik, Bergen. The presentation and discussion can be summarized as follows:

5.1 Background

In an effort to find another way to regulate the aquaculture industry which includes the environmental impact of aquaculture, there is a need to assess the impact of a given aquaculture operation and to control the impact relative to predefined standards. The regulations should be relative to the holding capacity of the site. In Norway, we are

developing a standardized method of monitoring which is integrated with a simulation model of the activities and impacts. First, we had to simplify the impact: the relationship between the dose and response had to be known, the impact had to be significant to both the fish producers and the environment, and the impact had to be easy to quantify and suitable for regulatory purposes. Thus, we focused on benthic organic enrichment.

Environmental quality objectives include:

- the long term use of the site is safeguarded.
- organic deposition and chemical levels cannot exceed predefined levels.
- benthic macrofauna must be present.

The Model **MOM** (developed by A. Stegebrangt, Sweden) incorporates modelling, monitoring and fish production

The relationships among the model, the monitoring program, the level of exploitation l(i.e. fish production) and the level of surveillance are illustrated in the attached flow chart, Figure 1. With regards to the level of exploitation, the environmental impact is related to the holding capacity of the site. The level of surveillance is controlled to ensure that the impact does not exceed enviromental quality standards.

There is a connection between the level of exploitation and the level of surveillance, e.g.:

1st level of exploitation	>	1st level of surveillance
2nd level of exploitation	>	2nd level of surveillance
3rd level of exploitation	>	3rd level of surveillance

The monitoring includes both internal control, where the growers themselves monitor particulate output continuously (*) using settling traps and testing the color, consistency and smell of the sediment (A). Experts are used to determine sediment thickness beneath the pens, and aspects of sediment chemistry (pH, pS, Eh, organic content) and the presence of macrofauna (B). Finally, experts are used to analyze the macrofauna (C). Based on the level of exploitation, the frequency of surveillance is related to production cycles (PC) in the following scheme:

	A	B	C
1st level of exploitation	*	0.5/PC	every 8th year
2nd level of exploitation	*	1/PC	every 5th year
3rd level of exploitation	*	2/PC	every 2nd year

The interaction among the four modules which compose MOM, namely the fish model, the water quality model, the dispersion model and the sediment module are illustrated in Figure 2. One aspect of the water quality module is that the local conditions within the pen are modelled as well as the water quality of the receiving waters. The model MOM is used in two ways:

-To simulate the impact of a given fish farming operation.
-To simulate what size farm can be permitted at a given site not to exceed a given impact.

The fish module simulates the actual effluent, the dispersion module relates to the farm area, depth and current conditions, the sediment module simulates the accumulation and decay of the waste, and the water quality module simulates dissolved compounds and oxygen.

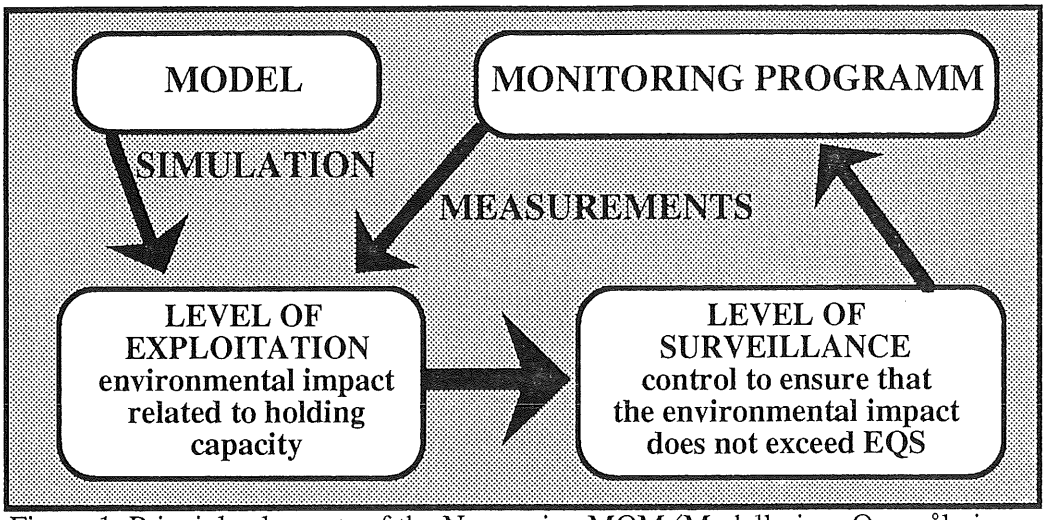


Figure 1: Principle elements of the Norwegian MOM (Modellering, Overvåkning, Matfishanlegg), programme

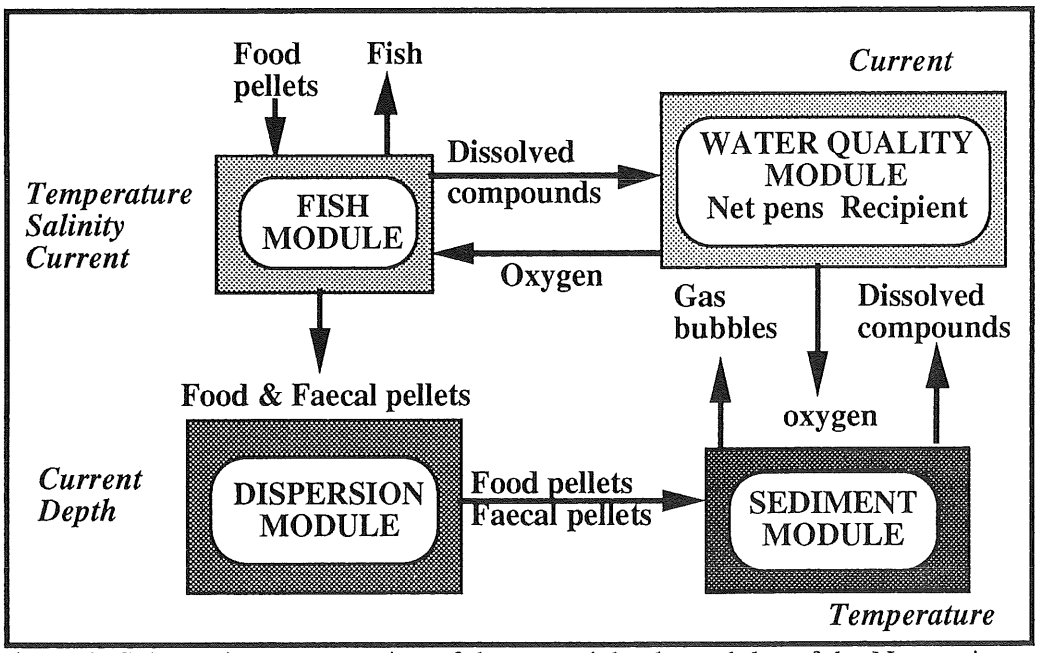


Figure 2: Schematic representation of the essential sub-modules of the Norwegian MOM- programme for Monitoring and modelling environmental impact of mariculture for regulatory purposes.

5.2 Responses to questions and comments by the EIM Working Group:

(a) The system will be tried out in Norway next year (1995).
(b) The system will be documented and published in the literature after scientific review.
(c) The levels of exploitation (1-3) and associated monitoring frequencies have not been set yet.
(d) We were encouraged that both management agencies, the Department of Fisheries and the Department of the Environment commissioned this.
(e) With regards to quality control of the data, level A done by the farmers makes them more aware of their impact. Levels B+C are performed by experts for the purposes of a regulatory data base.

(f) We have found that it is redundant to do water sampling except right around the farms.
(g) Due to patchiness, it is difficult to make sense of oyxgen measurements in the water column and this is not measured. We are trying not to make this a scientific study: this is regulatory.
(h) This approach, of getting the modelling and monitoring groups together, is important.
(i) There was a discussion of nutrients and primary production: while there is not evidence that fish farms stimulate algal blooms, primary production is a concern in land-locked fijords, where fish phosphorous is assumed to be converted into phytoplankton biomass (measures as carbon) and its decomposition and subsequent oxygen demand is considered relative to the bottom oxygen concentration in deep fjords.
(k) Norway is not concerned with nitrogen because the areas are not eutrophicated.

6. Information on ongoing monitoring programmes in ICES member countries

The subgroup on Monitoring met on 29 and 31st March to consider a number of documents which are listed in Appendix I and reviewed the existing draft of Chapter 5 on Monitoring of the Technical report on "Management of the Environmental Impact of Mariculture". It also noted the terms of reference "d" :

- to assemble and compile, intresessionally, information on ongoing monitoring programmes in each country related to assessment of the impacts and interactions of mariculture, with a view to its publication in the ICES Co-operation Research Report Series.

As many countries are currently reviewing their existing monitoring programmes in the light of new scientific information and with a view to making them more flexible and site/country specific, it was decided to address this task in the coming months when reviews are expected to be completed and forward the results to the Chairman of the Working Group.(Ms Jacqueline Doyle to act as co-ordinator and rapporteur).

The subgroup on "Monitoring" was chaired by Ms Jacqueline Doyle, Ireland and included Arne Ervik, Norway, Renger Dijkema, The Netherlands, Michel Merceron, France, Edward Black, Canada and Brendan O'Connor, Ireland. Due to the differences in the levels of impact from finfish and shellfish cultivation it was decided to appoint two rapporteurs and Regner Dijkema was appointed as the shellfish rapporteur while Brendan O'Connor was appointed as the finfish rapporteur.

The subgroup discussed proposals from Arne Ervik on protocols designed for Norwegian waters and from Brendan O' Connor for Irish shallow shelf areas, reviewed a number of monitoring regimes in Scottish waters sent to the working group by Ian Davies and discussed the GESAMP report circulated to the group by Uwe Barg (FAO).

Arne Ervik presented the group with an outline of a developing site management tool for Norwegian waters. The tool consists of two elements, a monitoring programme which is integrated with a simulation model. He outlined that the biological requirements of the cultured organisms must be fulfilled and that the environmental quality objectives given by the society must be met. He continued by saying that it was necessary to define and assess the environmental change of an aquaculture operation

and the need to be able to control the environmental impact relative to predefined standards. In practical terms, one has to concentrate on regulating the major impacts and emphasis must be placed on deciding which impacts should be controlled. One should know the relationship between load and impact, the impact must be significant for both the cultured fish and the environment and that the impact must be easy to quantify and suitable for regulation. He stated that the long-term use of the site must be safe guarded, that the accumulation of organic wastes must not exceed predefined levels and that benthic macrofauna must be present under cages. He stressed that some impact has to be accepted but that this impact has to be predefined and that monitoring must be used to ensure that this environmental quality standard is always maintained. He noted that the scale of monitoring depends on the scale of the farming operation, and this regime is incorporated into Chapter 5 of the Technical Report on the Environmental Interactions of Aquaculture. (see recommendation).

Brendan O'Connor presented a monitoring protocol for Irish waters and in an introduction he noted that current thinking on identifying areas where impacts of marine fish farming are most clearly recognisable in shallow shelf waters is highlighting the sea floor under and in the immediate vicinity of the production location. This is because the sea floor acts as an effective storage area for wastes which settle out from the fish cages. The rationale he outlined is divided into two phases. In the first approach, as full a survey as possible is recommended in order to establish background or base line data for future monitoring studies and to provide input data for modelling exercises. Such input data include information on bathymetry and current speed and direction collected over as long a time period as possible. Information from such surveys will also indicate where benthic sampling stations should be positioned and the possible number of such sites, including possible control locations.

Other data which should be collected include sediment samples for chemical, physical and biological evaluation of such parameters as Eh, organic carbon levels, granulometry and macrobenthic faunal composition. The use of still photography is advocated as it provides a permanent visual record of benthic conditions with time. Additionally, diver observations made during the course of the photographic survey provide a wealth of ancillary information on sediment colour, sediment texture, the distribution of Beggiatoa, outgassing, the presence of uneaten food pellets and the nature of the macrobenthic fauna under and in the vicinity of the production site. The incorporation of Sediment Profile Imagery (SPI), is advocated as it is a fast and cost effective method in mapping and monitoring impacts from finfish cultivation on the sea floor.

Where data already exist on the hydrography of a particular location, a combination of still photography and SPI is recommended. The carrying out of such surveys are is suggested during periods of maximum biomass.

Water quality monitoring is not advocated for the majority of Irish Shelf waters under current levels of production as it is a macrotidal environment with sufficient assimilative, dilution and dispersion capacity to absorb nutrients produced by finfish farming. Some small, silled bays and locations where phytoplankton blooms are known to occur would require some level of water column monitoring.

In discussion of these presentations it was recognised that deep water sites such as in Canada and Norway would not be suitable for such benthic studies.

Presentations received from Mr. Ian Davies included monitoring protocols from the Highland River Purification Board, The Shetland Islands Council and The Clyde River

Purification Board. These were reviewed by the subgroup members and strong emphasis placed on the need to monitor the sea floor was noted and the group agreed with the general focus of these documents. In particular the group recognised the valuable contribution that farm records such as biomass, mortalities, food conversion ratios etc could make in assisting the assessment of impact and recommended that such records should be included as part of routine monitoring and assessment.

The subgroup next considered the GESAMP report and it was felt that the report represents an important step in helping to design monitoring programmes. It was noted that the report should mention from the outset that it deals only with organic impacts which derive from fin fish farms.

The subgroup spent considerable time in re-editing Chapter of the Technical Report in the light of the discussions and current thinking.

Recommendations made by the subgroup for consideration in plenary of the WG were:

1. ICES endorses the strategy for monitoring outlined in Chapter 5 of the Draft Technical Report which is appended to this WG Report to facilitate early dissemination. The Technical Report as a whole in unlikely to be published in the immediate future because of the rapid development of mangement strategies which will require additional modification of the existing chapters. Monitoring strategies have been recently simplified in the light of scientific experiences in Member Countries which will assist in the development of the application of new monitoring programmes at national level. A timely distribution is therefore recommended.

2. That more research is required to determine subtle and far field effects of wastes from fish farms including therapeutants and chemicals in light of the findings of the subgroup of chemicals and their ecotoxicological effects, in particular with regard to their bio-activity. It is recommended that priority be given to compiling new research results in this area in the intersessional period and avaluation at the next meeting of the Working Group.

The following documents were reviewed by the Monitoring Subgroup during the ICES WG EIM meeting, Cork, March 28 - 31st., 1994.

1. Draft of Chapter 5 on Monitoring of the ICES Technical Report.
2. Monitoring and Modelling of fish farms in Norwegian waters. Arne Ervik, Norway.
3. Proposal for annual benthic surveys at fish farms to provide a baseline for internal management and to provide an annual "environmental audit" for legislators. Brendan O'Connor, Ireland.
4. Monitoring programmes stipulated by the Highland River Purification Board, Scotland.
5. Monitoring programmes stipulated by the Shetland Island Council, Scotland.
6. Monitoring programmes stipulated by the Clyde River Purification Board, Scotland.
7. Monitoring the ecological effects of coastal aquaculture. GESAMP working group (31) on Environmental Impacts of Coastal Aquaculture.

7. The role of models in mariculture and recent relevant developments in modelling

After reviewing the documentation available (e.g. chapter on modelling of the draft Technical Report on "Management of the environmental impact of Mariculture"), the subgroup dealing with modelling issues identified the main goals of modelling in the context of mariculture as the following:

1: Providing information on environmental issues to regulatory agencies. This is essential for effective planning of development in the coastal zone where defining the holding capacity and or carrying capacity are of great importance.

2: Modelling as a means to improve husbandry and optimize productivity, providing advice on site selection and management practices.

3: Design of practical and appropriate monitoring strategies which allow assessment of regulatory thresholds and acceptable risk.

4: Coastal zone management advice, including socioeconomic factors such as value of production, costs of input, employment implications and other macroeconomic issues related to the contribution of mariculture to regional scale economy and employment.

These goals raise more specific requirements for model development:

A: The modelling approach and design should include an appropriate and flexible interface to be accessible to those making regulatory, monitoring and socioeconomic decisions:

- Expert systems : The interface between potentially complex numerical models and the conceptual level of users is critical. Decision support tools offer both flexibility and the possibility of reviewing the rationale for decisions. Further, they also allow resident expertise to be retained after the expert may no longer be available. The starting point is the acceptability criterion: what is the limit perceived by the managers which the proposed activity cannot exceed ? Training managers to use the models is also an important step. It is necessary to allow managers to manipulate the programme to customize it to specific needs (ref. CZM report).

Models can couple site-specific data bases (e.g. GIS systems) to expert systems so that it is easy to develop fairly generic systems which incorporate site-specific information.

- Geographical Information Systems: These are a useful category of data base for use by both modellers and managers as they offer a user-friendly graphical interface as well as simple access to geographically indexed data. The wide and diverse range of GIS models on the market make it necessary that a standard be chosen to interface with expert systems.

The coupling of these modelling systems make it possible to address both regional and site specific requirements.

B: Model output should include ecologically significant consequences as well as more easily quantifiable loading values.

It is generally easy to build models which predict loadings of nutrients, particulates, etc., but difficult to estimate the ecological consequences of these loadings. Never-the-less, these ecological effects are the meaningful quantities for management decision-making, and are therefore essential outputs. A recent paper, (Sowles et al. 1994) shows that important indicators of the status of the benthic community are correlated with deposition. In some instances, suitable variables are not easily measured. This can be overcome by the use of correlations with more easily measured parameters, as in the work of Cranston (1994) which relates carbon burial rates to easily measured chemical gradients. This makes the identification of indicator variable important. Recent work by Hargrave (1994b) is important in that it derives a benthic enrichment index related to organic carbon sedimentation rate. The point at which the slope of the curve changes indicates degradation.

Monitoring should stress both the monitoring of environmental variables to assess the ecological impacts of mariculture and the monitoring of the loadings which cause these ecological effects, in order to test and validate models and to identify interactions which may not be correctly represented in existing models.

C: There is a need to define thresholds of environmental degradation:

Many ecological impacts can be characterized by critical values at which the quantitative nature of the impact changes. We need to identify critical thresholds for delimiting the acceptable impacts of mariculture (e.g., the presence/absence of macrofauna as used by the Norwegians in the **MOM** models). Examples of other thresholds are: azooic benthic conditions; cessation of growth; and threshold concentrations for outbreak of disease. These critical values provide clear landmarks which can be the basis for a standardized approach to estimating allowable levels of development. A recent paper by Findlay and Watling (1994) presents an important empirical relationship between the aerobic decomposition of settled carbon and current speed. Thus, loadings for a given current speed can be evaluated in the context of this model to see if anoxia is likely to develop at a particular site.

Models must deal with the various spatial and temporal scales characteristic of different processes associated with mariculture (Silvert 1992). The determination of minimum spatial and temporal resolution thresholds is central to a successful monitoring programme, and modelling even on a purely conceptual basis can contribute to the design of effective and relevant monitoring strategies.

D: Different types of models are required:

There is a variety of models available which are designed around specific problems or processes as well as different spatial and temporal scales. For examples see Appendix 5 CM1992/F: 14, and the evaluation of this document which is appended to this report. In general mariculture models address two main spatial scales; the *near field* which characterizes the farm scale and the *far field* which relates to the entire ecosystem on an inlet-wide basis. Two new developments are proposed as examples:

Hydrodynamic Models:

Until now the development of numerical models based on detailed hydrodynamics has been seen as being too costly in all except limited applications. New developments may make these a more widely applicable tool,

as illustrated by recent work on modelling hydrodynamics in Maine by Panchang et al. (1993). A step-wise approach to site-specific models was described which results in *net* sedimentation estimates, taking into account resuspension by tidal currents, wind-induced currents, and waves. In Ireland, Norway, and France, for example, flow models are now being used as planning tools for mariculture.

MOM: Norwegian Suite of models:

This suite of models described by A. Ervik (ref. Norwegian report) integrates the various environmental components (Fish, Water Quality, Dispersion and Sediments) in a format which provides user friendly format for managers.

The Working Group encourages the view that models be developed (as was the case for **MOM**) in a modular basis and that active comparisons between these components be carried out through better communication among scientists, regulators, farmers and modellers.

On the basis of these discussion, two recommendations were formulated. (1) to organize a workshop for identification and comparison of different approaches to modelling, and (2) to compile detailed descriptions of existing models

8. Guidelines on the ecotoxicological information needed for the assessment of the environmental impact of therapeutants

A number of official bodies concerned with the licensing of veterinary medicines in the aquatic environment have now published or made available drafts of guidelines which describe the type and range of data which they consider to be necessary for proper assessment of the potential environmental safety of new veterinary medicinal products for aquaculture. Amongst these bodies are the Committee for Veterinary Medicinal Products (CVMP) of the EEC, the UK Veterinary Medicines Directorate (VMD), the Norwegian Medicines Control Agency and (in broader terms) the USA Food and Drug Administration (FDA). Because these guidelines are now becoming more widely available it is perhaps not necessary to go into great and possibly repetitive detail here.

To take the draft UK ecotoxicological guidelines as an example, a 3 tiered approach is taken. Tier 1 consists of the basic physico-chemical parameters, including UV-visible absorption spectrum, melting point/boiling point/range, water solubility, dissociation constants and octanol/water partition coefficient. Studies on the fate of the product including chemical and physical routes of breakdown studies are required. Basic toxicity studies using suitable juvenile fish and appropriate invertebrates selected on the basis of the environment in which the product will be used are required. Protocols such as those published by OECD should be employed in these studies. In the event of evidence of environmental accumulation and persistence and the type of dose response to acute toxicity trials, additional studies into adsorption and desorption, biodegradation and bioaccumulation are needed, together with chronic toxicity and reproductive studies. Additional tests on other appropriate aquatic species including sediment organisms may be advisable. A third tier of dispersion studies may be needed, particularly with substances applied as topical baths where large volumes of the dilute product may be discharged to the environment. Such studies need to be carried out in natural water bodies of defined hydrographic characteristics.

It must be born in mind that the data required for assessing a product for licensing purposes is also needed for assessing and determining the ability of the final fish farm user to discharge water and particulates contaminated by such a product from the farm site. Such discharge consents are regulated in the UK by the National Rivers Authority and (in Scotland) by River Purification Boards. Access to such data will be critical in the production of an Environmental Quality Standard (EQS) for a product. Such EQS documents provide guidance for the determination of specific local discharge consents which can only be developed on a basis of the local farm environment. Since much data produced for veterinary medicine licensing may be "Commercial in Confidence", there are obvious sources of conflict between the two regulatory approaches.

In addition a number of additional problems of methodology and approach are appearing, particularly as microbiologists begin to address some of the problems which result from the developing regulatory environment. These are not simple problems and may require some considerable modification of approach. Some are discussed below.

8.1 Factors influencing the fate of antimicrobial agents in the marine environment.

In order to determine the appropriate range of concentrations to be used in ecotoxicological tests it is important to establish the concentrations, the biological activity and the location of antimicrobial agents in the environment of fish farms. It is generally agreed that the majority of antimicrobial agents that leave marine farms do so associated with particulate matter. Their fate will however critically depend on their distribution between faeces and uneaten feed pellets. Uneaten feed pellets will sediment rapidly and will accumulate directly under the cages and in wild fish and shellfish in the vicinity of the farm. In contrast, faeces leave farms as a well-dispersed cloud and may only fall slowly, if at all, to the sediment. Faecally associated antimicrobial agents are very much less likely to accumulate in wild fish and shellfish. The smaller particle size of the faeces and the longer time it spends in the water column will facilitate the resolution of faecally associated antimicrobial agents. Thus faecally associated agents are primarily important in the water column whereas feed associated agents are primarily important in sediments and the macro-fauna.

The extent to which antimicrobial agents are feed or faecally associated will be influenced primarily by the quality of the farm husbandry. Over presentation of feed is not only uneconomic and will also result in environmentally unacceptable accumulations of organically enriched material on the under cage sediment. These sediment conditions are those that will select for a high frequency of non-specific, low-level, multiple resistant strains even in the absence of antibacterial agents (See Section 8.3 below). Over presentation of medicated feed will result in high sediment concentrations of the agents as detected by HPLC and significant concentrations entering wild fish. The published data is consistent with these theoretical considerations. The majority of studies of sediment concentrations of oxytetracycline have detected concentrations in the range 1-10 µg g-1 (Bjørklund et al., 1990,1991; Jacobsen and Berglind 1988; Coyne 1994). Samuelsen et al., (1992), however, studied a farm that had piles, up to 50cm deep, of undecomposed feed accumulated on its under cage sediments. These sediment conditions suggest serious overfeeding and represent an unacceptable environmental impact even before the issue of antimicrobial agent use at this farm is considered. Under these conditions they detected concentrations of oxytetracycline of

200-300 µg g- after therapy of lightly stocked cages. It is worth noting that the 'lift up' systems that have been developed in Norway may result in a significant reduction in the amount of antimicrobial agents that enter the environment associated with feed but may have little impact on the entry of faecally asssociated material.

8.2 Bioavailability, bioactivity and binding : influence on analysis and drug resistance

The assessment of the environmental impact potential of veterinary medicines used in aquaculture is an essential part of the process of approval of the product for use. It is also an essential part in the establishing of permits to discharge potentially contaminated water and other wastes from the site on which the product is being used. Increasingly the Environmental Quality Standard (EQS) concept is employed to establish levels for such discharges and such EQSís are set quite separately from the initial veterinary medicinal licensing process.

In recent years the use of chemical methods to investigate the presence in environmental samples and animal tissues of compounds such as veterinary medicines have become totally dominant. As such methods develop, preparation methods have become increasingly aggressive as analysts seek their ìholy grailî of 100% recovery from spiked samples. Such methods are perhaps appropriate for use when determining meat residues, but increasingly some workers are becoming less convinced that such methods are appropriate for use in environmental samples for biologically active and complex molecules such as antimicrobials and other veterinary medicines. The basic point which appears either to have been ignored or, more charitably to have been increasingly lost site of is the fact that chemically determined concentrations are not the same as biological concentrations. The term bioactivity may perhaps best be used to express the ratio of biologically available activity compared to chemically determined concentrations. For example the concentrations of Mg^{++} and Ca^{++} normally present in sea water have been shown to reduce the biological activity of oxytetracycline (Lunestad & Goskyor 1990) and the 4-quinolones (Smith pers comm. for 4quinolones) in both cases by >90%, vis a vis their activity in distilled water. Much the same inhibition will occur in most natural fresh waters where the same divalent ions are also present in effectively unlimited quantities. In fresh waters (and in many inshore marine waters) the presence of a wide range of humics will have a similar effect, potentially further reducing the bioactivity of compounds that in chemical terms are clearly present in readily detectable concentrations.

Binding to physical particulate matter such as sediment, feed and faeces also has a significant inhibitory effect. In the marine environment agents may desorb from particulates and re-enter the water column. The extent of such movements between the solid and liquid phases may be an important factor in determining the biological activity of such agents in the aquatic or marine environment.

The consequence for analyses, and even more so for the interpretation of the significance of those analyses, is that chemically based methods although very specific and sensitive are capable of generating highly overestimations of the biological significance of the data. There is clearly a very great need to develop assays that properly enable a valid quantitation of the biological activity (or bioactivity) of substances. The only assays currently available in this area are microbiological plate diffusion assays. These however have major problems and limitations of their own, .e.g. lack of specificity, potential specific and non specific inhibition from the sediments etc. under assay. Some thought is being given to alternative approaches, but these are in a very early stage of gestation.

This problem of bioactivity and analyses is also of considerable significance at what may be described as the other end of the problem of antimicrobial usage on fish farms. This is the fact that such veterinary medicines are normally presented to the fish coated onto the surface of fish feed pellets i.e. supplied by the oral route. Feed itself has many of the same complexing factors and abilities as seen in water and sediment. This means that although it may appear from chemical analysis that medicated feed has adequate amounts of an antimicrobial available for absorption by the fish, in fact most of the drug is not available biologically and is largely not absorbed but instead passes straight through as faeces. To at least partly reduce this problem either the development of an alternative oral matrix or an alternative route of application will be needed.

These problems mean that present approaches to the consideration of many environmental aspects of veterinary medicines are in need of reconsideration. This does not been that the basic approaches are totally incorrect, more that there are complex considerations of scaling which must be taken into consideration, particularly when data is derived from chemical analyses, but the real area of interest and concern is bioactivity. The basic concept which must not be ignored is that chemical presence and biological presence are not the same.

8.3 Drug Resistance

Antibacterial agents have been developed on the basis of their selective toxicity for prokaryotes as opposed to the eukarote cell. Thus it is reasonable to expect that they will influence prokaryotes and the processes that they mediate at concentrations lower than those which will exert toxic effect on eukaryotic macrofauna. Data suggest that the rate of decompostion activity mediated by prokaryotes is only reduced by concentrations of agents significantly higher than those which will inhibit or kill sensitive bacterial species. Thus the increase in the frequency of resistant bacteria is potentially the most sensitive indicator of the biological activity of antimicrobial agents in the environment.

Significant methodological problems are encountered in studying the development of antimicrobial resistance in the microflora of the environment of fish farms. Studies of this phenomenon have relied on culture on solid media with and without the addition of various concentrations of the antimicrobial agents in question. The media available for these studies are very inefficient. None are capable of detecting over 1% of the viable flora present in the environments studied, and each of them will, in all probability, select qualitatively a different sub-population. Even within the limited range of microflora capable of forming colonies on these media a significant number of the ëresistantí colonies detected may be of no significance. Some may be eukaryotic cells such as yeasts and others may be members of prokaryotic groups that were never sensitive to the antimicrobial agents employed in the study. The 4-quinolones such as oxolinic acid have, for example, little or no activity against Gram-positive prokaryotic species.

A further methodological problem is encountered in the choice of selection concentration of the antimicrobial agent to be used in selective media. Sea water is frequently incorporated in media used in studies of resistance in the marine environment. As indicated above, sea water will inhibit the activity of almost any agent incorporated in the media and will therefore alter the selective properties of such media. The selective properties of the media used should be related to the type of resistance that is being studied. There are two basically different mechanisms of resistance that may be

encountered in marine microflora. The first is the genetically determined positive function resistances. These result in resistance to high levels of specific agents and are frequently coded by R plasmids. The second group are frequently the result of genotypic or phenotypic membrane changes. Strains possessing such mechanisms will manifest low levels of resistance to, and may therefore be selected by, a broad range of inhibitory compounds including many non medicinal compounds that may be found in the environment. This group are frequently transient in the environment and the resistances are rarely if ever transferable to other species. Even though they may occur at lower frequencies than the transient , low level, multiple resistances, it is clear that the high level specific transferable resistances are of more significance in assessing environmental impact.

As a rather basic simplification it should be noted that no study so far published has established a clear relationship between drug levels detected by HPLC and the frequencies of resistance in the microflora. The data rather suggest that the frequencies of resistance are elevated in fish farm effluents whether or not the farms have used antimicrobial therapy. It is possible that the metabolic breakdown products of fish feed present in the effluents may themselves have been the agents of selection for such increased resistance. Laboratory experiments have demonstrated that such selection can occur.

Thus, many of the resistant strains detected in the farm environment may possess low level, non specific, mechanisms that are non transferable. Still others may be innately resistant eukaryotes or members of prokaryote groups that were never susceptible to the agents in question. Clearly data on the frequency of resistance in the marine environment requires very careful interpretation.

There is critical requirement for wide scale standardisation and validation of methods used in detecting resistance frequencies in environmental samples. To date nearly all published studies have used methods that differ with respect to media and concentrations of selective agents and incubation conditions. These variations in methods have the result that it is not possible to compare , and draw general conclusions from, the limited data that is available in this area.

8.4 Significance for Ecotoxicology Assessments

Ecotoxicological assessments are, as indicated in the Chemicals Technical Report, required to demonstrate the safety of any chemicals used in aquaculture. The problem of binding of bioactive molecules has been considered above and has an obvious and marked influence in the area of toxicity trials and assessments.

Provided that toxicity trials are designed to take account of the real and expected environment in which products will be used, then many of the problems of available biological activity rather than of chemical presence will automatically be taken into account. However, if toxicity tests are carried out in a real environment, then their relevance to the way in which any compound will behave in that real environment must be regarded with more than a little scepticism.

Therefore in the assessment of any data presented for in regard to environmental safety of a veterinary medicine, the relevance of the conditions under which the data was produced must form one of the first considerations of its validity.

8.5 References cited

Bjørklund, H.V., Eriksson, A., Bylund, G. 1990. Residues of oxytetracycline in wild fish and sediments from fish farms. Aquaculture 86: 359-367.

Bjørklund, H.V. ,Råberg, C.M.I., Bylund, G. 1991. Residues of oxolinic acid and oxytetracycline in fish and sediments from fish farms. Aquaculture 97: 85-86.

Jacobsen, P., Berglind, L. 1988. Persistence of oxytetracycline in sediments from fish farms. Aquaculture 70: 365-370.

Coyne, R., Hiney, M., O'Connor, B., Kerry, J., Cazabon, D., Smith, P. 1994. Concentration and persistence of oxytetracycline in sediments under a marine salmon farm. Aquaculture. in press.

Samuelsen, O., Lunestad, B.T., Ervik, A. 1992. Residues of oxolinic acid in wild fauna folowing medication in fish farms. Dis. Aquat. Org. 12: 111-119.

Samuelsen, O.B., Torsvik, V., Ervik, A. 1992. Long range changes in oxytetracycline concentrations and bacterial resistance towards oxytetracycline in fish farm sediments after medication. The Scienc of the Total Environment 14: 25-36.

9. Developmen of Biological Criteria for gauging environmental impacts of aquaculture

The Position Paper submitted by Dr. J.E. Stewart (Dartmouth,NS,Canada; see Appendix V) presents evidence to support the proposal that biological criteria can be used to assess impacts of mariculture on the environment.

In a lengthy and wide ranging discussion, the WG considered all aspects of the document reaching a number of conclusions.

In general, there was broad support for the approach that past measurements and experience can be used for predictive management purposes and it was noted that individual case studies were useful in providing scientific insight, e.g. yellowtail culture in Nagashima Bay, Japan, and the Marenne-Oleron experiences. However, there were a number of serious reservations, in relation to the draft, in particular Section B, while Section A was referred to the Coastal Zone Management Sub-Group for review.

There was also a consensus that the document over-emphasized the negative aspects of the mariculture industry in relation to other users without recognising both the legitimate and intrinsic rights and responsibilities of the sector as only one user of the coastal zone.

In a general comment many members felt that it was necessary to implement an integrated approach in establishing monitoring programmes, e.g. stock health monitoring programmes must be linked to environmental monitoring programmes. Similarly, practising aquaculturists must be made aware of the benefits of risk control in their management strategies. Particular emphasis was placed on development of site selection criteria incorporating modelling techniques and on the question of feed regulation and utilization.

A more specific query from the WG related to the practicality of developing and using a common, standard, monitoring scheme given the broad spectrum of aquatic systems spread over a wider geographical area to which it would be applied.

10. Coastal zone management issues: "Integration of Mariculture into Coastal Zone Plans and Management Strategies"

The Working Group discussed issues relevant to the TOR (b) of its agenda ("...examine biological interactions between types of mariculture and other coastal zone uses") and felt that the subject is dealt with best when considering it in the larger context of coastal zone management.

10.1 The Case for Coastal Zone Management for Sustainable Mariculture Development

10.1.1 The Importance of the World's Coastal Zones

The coastal zones of the world are a major focus of human populations and economic activities. About 60% of the world's population-nearly 3 billion people- live within 60 km of the sea. Some two-thirds of cities with populations over 2.5 million are located along estuaries. These same estuaries and adjacent coastal areas will form the locus of future population growth and the diversification and expansion of economic activity. Much of this development has been stimulated and is sustained by the diverse and rich array of natural resources generated by highly productive coastal ecosystems. The future development of these and new activities will depend upon the wise use of available land and water resources and the resolution of problems which degrade or threaten to foreclose available resources development opportunities.

Worldwide there is mounting recognition of the need for major improvements in the way we plan for and manage coastal development. Concepts and principles for Coastal Zone Management have been formulated over the past 30 years which have laid the foundations for major advances in sustainable coastal resources development in both developed and developing nations. These principles include:

- The coastal zone is unique and special planning and management arrangements are required to achieve sustainable use of renewable natural resources;
- Wherever feasible, planning and management of coastal land and water uses must be based upon conservation of environmental process that maintain the health and productivity of coastal ecosystem and maintain the flows of natural resources that sustain human activities;
- Water is the major integrating element in coastal resource systems;
- Coastal zone land and water uses must be jointly planned and managed;
- Emphasis is placed on **multiple use of renewable resources** to optimise economic and social benefits;
- A lead agency should be given primary responsibility for stimulating and co-ordinating integrated approaches to coastal area and natural resources development;
- Boundaries for coastal zone management are issue based and adaptive;
- Coastal Zone Management is structured for incremental implementation;
- Emphasis on environmental assessment;

However, opportunities for promoting the sustainable growth and diversification of coastal aquaculture are not being fully realised and options for future development are being foreclosed. Unfortunately, the rapid expansion of traditional forms of small-scale brackishwater aquaculture in many developing nations and the introduction of mariculture into formerly undeveloped areas in developed nations has not been matched by the development of policies, plans and management strategies to guide mariculture and protect other users of coastal zones. Where guidance has been developed, this has followed rather than led the development process and often fails to incorporate good science and valuable experience from other regions. In more developed nations where mariculture is a relatively new form of coastal activity, farmers are subject to controls and standards which are administered by a complex array of institutions far in advance of those applied to other activities. This both hinders the legitimate development of mariculture and fails to maintain environmental conditions required to sustain mariculture.

The World Bank and other international donor agencies are developing guidelines for developing coastal zone management programmes. FAO, ICLARM and other international groups are exploring ways of integrating fisheries management with coastal zone management. Although these agencies are addressing basic institutional and technical issues concerning the establishment of coastal management in developing nations, no international organisation has yet developed pro-active approaches or practical guidelines for the integration of mariculture as a legitimate development activity into coastal planning and management activities in both developing and developed nations. Where integration is being attempted, it is based upon local or regional planning within individual nations.

10.1.2 The role of mariculture in Integrated Coastal Zone Management.

A first step in attempting to define the role of mariculture in Integrated Coastal Zone Management (ICZM) is to point out that the industry is relatively new and that its development has coincided with a large increase in environmental awareness. Unlike many other industries located in the coastal zone, mariculture relies heavily on natural aquatic resources for its very existence, and it is characterised by the demand for a very high quality environment. It should also be stated that mariculture development, because of its specific site selection requirements, tends to be forced into some of the most remote and disadvantaged regions with limited opportunities for development. However, there has been a parallel increase in a number of other competing interests for coastal space. Given these converging trends, it is not surprising that there have already been instances of conflict and it is inevitable that the number of these will increase in the future unless adequate steps are taken.

The mariculture industry operates in all environments (physical, social, economic etc.), requires many inputs to be successful and also has multiple impacts on these environments, some positive and some negative. For instance, in the physical and biological environment mariculture has been accused of visual, organic, chemical and genetic pollution in addition to disease and parasite transfer to the native fish populations and the cause of navigational hazards. On the positive side mariculture produces a prime product in demand by the consumer and in the eyes of some people provides an element of activity and interest in rural areas. A further positive physical impact is that the very presence of a fish or shellfish farm will help discourage pollution from less environmentally-friendly industries. Unfortunately, technologies developed have not always led to the enhancement of many fisheries world-wide. An important point to

stress here is that many mariculture projects that have resulted in pollution, almost exclusively due to poor management, have ultimately ended in their own demise.

The socio-economic impact of mariculture has largely dominated the debate regarding the fast development of mariculture to date. Aquaculturists readily claim to have made a significant impact on the economies of some of the most peripheral regions of the EU for instance, and generated many jobs (direct and indirect) maintaining the integrity of very fragile rural communities, characterised by high unemployment and emigration. However, on the macro-economic scale, mariculture in Europe is relatively insignificant, producing less than 1% of GNP. It has been stated that socio-economic data on mariculture developments are scanty and that further studies are needed in this area.

Carrying on from the social aspects referred to above the cultural impact of mariculture has been similarly ignored. It is not disputed that aquaculture has had a significant contribution to maintaining rural community structure which in turn contributes much to the diversity of culture and allows the maintenance of traditions which characterise many areas and people. At the same time it should be noted that the creation of communities that rely heavily on one industry may be increasingly vulnerable to external financial considerations. Future studies should address this gap in our knowledge and take full account of the importance of the impact of aquaculture on cultural aspects.

The political environment also affects and is affected by mariculture. Government policy varies from country to country and legislation and regulations in particular, are often inadequate and non-specific to mariculture. In fact, mariculture has found itself at the forefront of the battle for Integrated Coastal Zone Management since by its nature it spans both the terrestrial and aquatic environment and has highlighted much duplication, confusion and uncertainty, which in itself has resulted in conflicts with other coastal users and managers. It is up to Government to determine policy based on the resources available to them and adopt scientifically-based integrated coastal management systems. One particular argument that is likely to become more and more important for mariculture regions is the balance to be reached between tourism and mariculture development. This is a very good example of the need for the integration of mariculture and tourism into CZM.

Inter-connecting all of the above environments is effective communication. The current awareness of the general public and coastal managers regarding mariculture is very poor. This has undoubtedly led to much of the conflict to date and one of the primary aims of any future ICZM planning must fully address improved communication at all levels. This will facilitate the implementation of proactive development of the mariculture industry and avoid much of the confrontational and reactionary debate currently taking place. The future role of mariculture in ICZM is to develop the industry with a full appreciation of the ecosystem/industry interdependencies and become a legitimate sub-system of the overall ecosystem. Mariculture techniques and planning and management must be developed with natural ecosystems and other coastal users in mind so that negative impacts can be reduced.

10.1.3 Experience in Integrating Mariculture into Development Planning in Coastal Areas within ICES member countries

10.1.3.1 The Case of Norway:

The rapid expansion of the mariculture industry in Norway in the eighties caused managerial problems along the coast. The siting of the farms was undertaken on a largely uncoordinated manner where the local authorities had little or no influence in the siting process. This caused a lot of discomfort, especially at the municipal level.

Planning in coastal waters had not been done and a proper planning technique did not exist. A programme to meet the need for planning, LENKA (a method for a nation-wide analysis of the suitability of the Norwegian coast for mariculture), was launched in 1987 and ended in 1990. The programme aimed to develop an efficient and standardised tool for coastal zone planning. Consideration was given to aspects of the environment, existing utilisation and infrastructure. The model dealt with demands and regulations connected to the recipient as well as to the use of coastal areas. The recipient aspect: the environmental requirements for the farmed fish (salinity, exchange of water, bottom-topography etc.) and the pollution standards set by the authorities. A model for calculating the holding capacity was set up. The area aspect: existing use (settlement, ports, fisheries, naval use, fairways, industry etc.), infrastructure (roads, electricity, fish processing facilities, health service, guiding service, offal disposing system), end the environment (nature reserves, recreation activities, wild life protection, salmon protection zones, fishing, spawning grounds etc.).

Lessons learned:

LENKA helped to initiate the process of coastal zone planning in Norway. Most of the coastal municipalities with mariculture interests have started to produce coastal zone plans and the LENKA procedure has to a great extent been used. The recipient model has been replaced by a new and more reliable mathematical model.

Disease aspects were not dealt with in the original project which was a drawback. Epidemiological considerations now form an integral part of the Norwegian planning system for mariculture and are considered an essential factor in coastal zone planning. Through the development of a more comprehensive planning system many of the traditional conflicts between mariculture and other legitimate interests in the coastal waters have been greatly reduced or even eliminated.

10.1.3.2. The Case of Canada:

A conflict resolution/minimisation approach was initially adopted where mariculture development was guided to locations in area with minimum conflicts with other uses would occur. This worked well while suitable undeveloped sites were available and few conflicts occurred. However, when the availability of undeveloped sites decreased, mariculture interests were forced to use more marginal areas to avoid potential conflicts with existing uses. This approach essentially denied the mariculture industry rights of access to coastal areas and resources equal to those enjoyed by other forms of activity.

A new approach was then adopted where areas of the coast are designated to promote mixes of activities which were deemed most appropriate to interests of society. Three categories of areas were designate, namely:

- Special Areas (tourism, recreation etc.)
- Reserved Areas (parks etc.)
- Preferred Development areas where aquaculture and agriculture were given priority status

The designation of Special Areas is undertaken by the local authorities, while Reserved Areas and Preferred Development areas are designated by provincial

authorities. This effectively gives mariculture equal rights of access to and use of coastal resources along with other legitimate uses of the coastal zone.

10.1.3.3 The Case of France:

Planning applied to mariculture

Early attempts to plan for mariculture include:

(a) National planning: "Schéma directeur de la conchyliculture"

Marine Affairs Dept, mid - 1970's, atlas;
General planning scheme for shellfish culture (oysters, mussels), showing the existing situation in relation to other conflicting uses (population, urban and industrial waste, harbour activities, tourism...), and indicating also favorable and unfavorable sites.

The existence of a shellfish growing cadastral plan, prepared by the Marine Affairs Dept has also to be noted.

(b) Local or regional planning: Potential site inventory.

Designed and carried out on behalf of local authorities ("Départements" and "Regions") in the mid 1970's-early 1980's by IFREMER (formerly CNEXO). Traditional and new techniques were considered, as well as significant environmental parameters. The conclusions were set up to be integrated in the existing planning schemes (POS = land use plan at a municipal level ; SAUM = planning and management scheme at a local or regional level).

(c) Economic activity management : Shellfish ground management

Recent attempts to manage shellfish culture grounds according to their holding capacity, in order to avoid overstocking and to obtain the best cost-benefit equilibrium permitted by the natural conditions. The necessary modelling is now operational (IFREMER), but internal structure difficulties of this mainly family scale industry make its application uncertain.

Land use planning applied to the coastal zone

Special land use schemes for the coastal zone were designed. An experimental phase took place in the mid 1970's -early 1980's and an official scheme system was set up in the late 1980's, which is presently under progress in several regions.
These schemes are "urbanistic documents", specially designed for the coastal zone, which is only incompletely included in the existing land use planning and never considered for its specific needs. They are aimed to eliminate or prevent conflicts by a zoning of existing and future uses of the area and to contribute to decision making. They are launched in answer to a local request (conflicts,development projects, management needs,...) and worked out after studies and consultations.

SAUM experiences (approx.1975-1980)

SAUM = "Scheme for the aptitude and use of the sea"
Experimental phase , to define the methodology on several cases (bay, estuary, shellfish growing zone, ..). The final schemes only apply to administrative decisions, but have no legal standing.

Present SMVM (Gov. decree 1986)

SMVM = "Schemes for the development of the sea". Several schemes under progress since 1990.
The State defines the general framework and approves the final scheme, giving it a legal standing. Thematic commissions elaborate the scheme and the final propositions (e.g. Aquaculture and Fisheries). Technical and scientific studies are requested when necessary for decision making. This procedure needs a constant dialogue between the State administrations, local Authorities, scientific bodies, professionnal and private users.

Complementary instruments

Several practical instruments may be called for to complete these planning schemes and apply their decisions :
- city contracts,
- bay contracts ,
- river contracts.

These constitute agreements between local Authorities and Water Basin Authorities in order to improve water quality, and provide the convenient frame to raise the necessary fundings.

Discussion

There is a general difficulty in eliminating the conflicts by means of other than those allowing a simple coexistence of the less antagonistic activities. For, constraining political choices are hardly taken either by consensus or elected bodies. Also, there is a heavy pressure on the coastal zone, which is already largely used, inclusively by traditional aquaculture.

There is no recent planning for aquaculture, in spite of a certain demand of the farmers (e.g. for special fish farming zones). There is also no pro-active policy to defend aquaculture against other coastal zone users, due to several difficulties or insufficiencies :

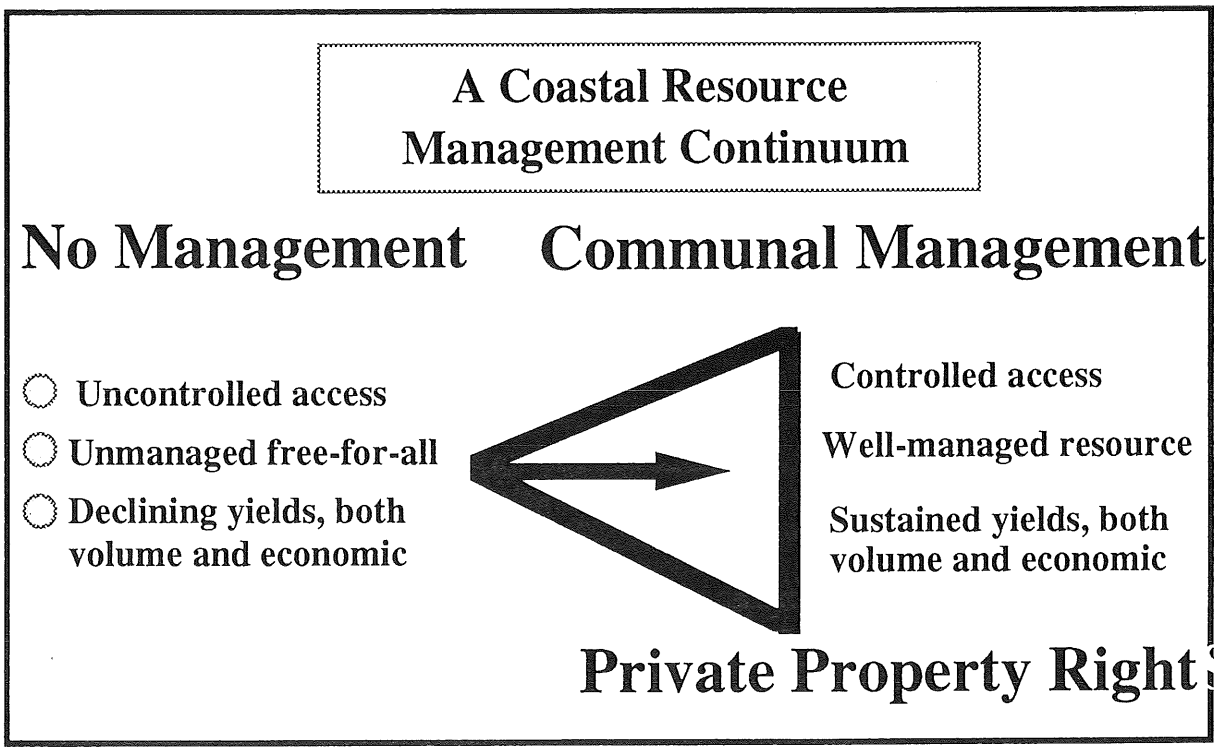
- relative socio-economic weight fairly modest, especially in case of new species and techniques;
- lack of professional or local taxes payed by aquaculture (which is the case of agriculture also), which constitute no incentive for local communities to accept and promote it;
- relative weakness of the professional organizations and public administration in charge of the sector;
- existence of space occupation conflicts inside the mariculture profession itself (shellfish growing <>intensive fish farming).

10.1.4 Pro-active Coastal Zone Planning and Management for Sustainable Mariculture

There is an urgent need to actively promote pro-active approaches for planning and managing mariculture as an integral part of coastal zone management plans and investment strategies. Such plans and management strategies must be based upon sound scientific management principles for the protection of environmental processes

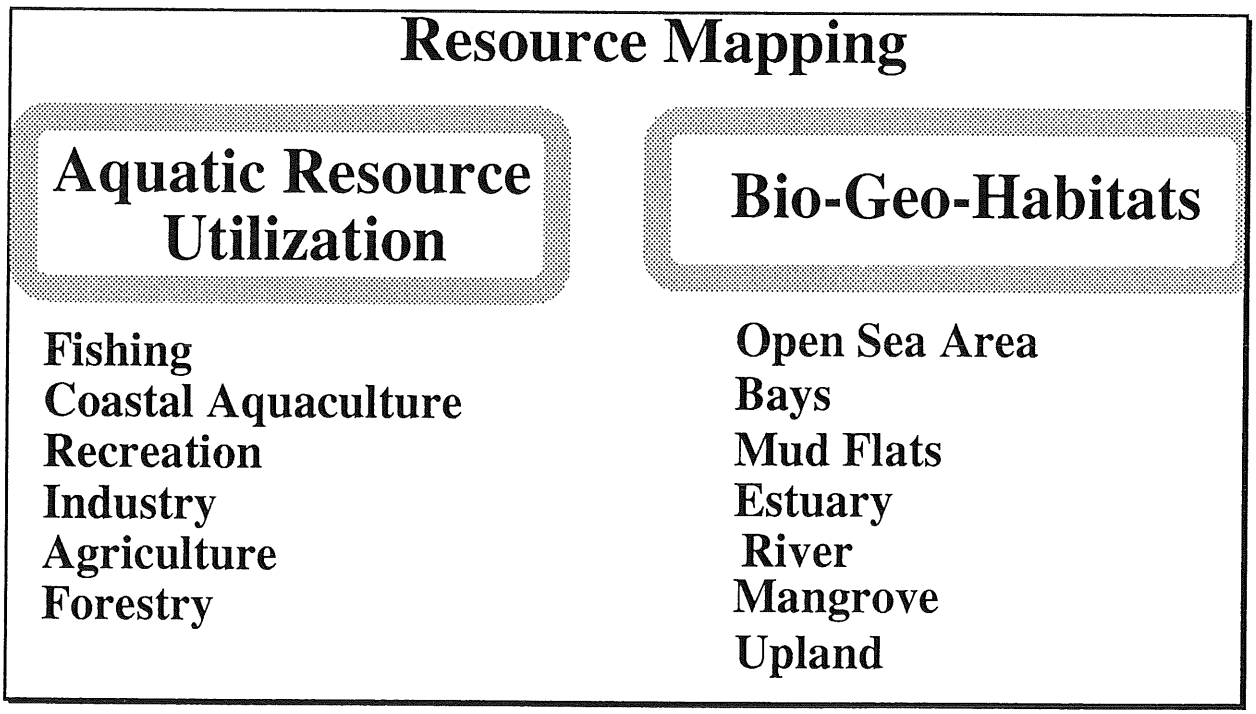
which maintain the functional integrity of coastal ecosystems and sustain mariculture and other renewable resource dependent activities. Basic objectives of this pro-active approach would be to :

- Promote the integration of mariculture into sustainable resources management strategies;
- Analyse, document, and disseminate information of the status of mariculture, existing trends and future innovations in the culture of different species and concomitant resources requirements and implications for planning and management, with due attention to trends in other coastal resources development and utilization.
- Increase awareness of the importance of CRM policies among the mariculture industry, in research institutions, and regulatory bodies while increasing interdisciplinary skills.
- Suggest solutions to coastal resources use conflicts by development of resolution techniques.
- Promote institutional arrangements that foster integrated multisectorial planning of coastal resource utilisation and facilitate the transfer of new developments between researchers, the industry and regulatory bodies.



- Improve evaluation of the capacity of living coastal resource systems to sustain mariculture within a multiple-use management framework
- Initiate inter-disciplinary research into the planning and management of mariculture, by development of criteria to help evaluate the benefits and costs of mariculture including the socio-economic impact and corresponding cultural implications

It has to be realized that the process of integrating mariculture in planning processes has already started in severel ICES member countries but full realization of coastal zone management practices can only be implemented by incremental steps as part of an overall strategic approach (see Figures) where different scenarios between communal management and private property rights obligations may co-exist depending on local and regional development priorities.



10.1.5 Coastal Zone Management Issues that Need to be Addressed

Positive assertion of the legitimate role of aquaculture as a sustainable form of natural resources development.

Appropriate Agency/ Co-ordinating Body to drive the process forward

EIA philosophy (GESAMP and UNEP)

- Identifying beneficial and adverse impacts
- Suggesting mitigation strategies to reduce or prevent adverse impacts
- Identifying residual adverse impacts which cannot be mitigated
- Developing strategies to track impacts
- Aiding selection of the "optimum" alternative resource uses

Aspects of modern EIA include the understanding of EIA as a positive, improvement-oriented approach and as an interactive process (not a single study), whereby consultation and public participation are included and socio-economic and socio-cultural issues are covered.

10.2.0 Recommendations for Future Activites of the WGEIM in CZM studies

The Working Group discussed at length the range of issues that need to be addressed in this area as the Cork Working Group meeting is the first under the widenend scope

of its overall TORs. It was generally felt that it is important to interprete these terms by considering a more holistic view of the subject in order to provide a framework for future elaborations. The WG also considered the plan for a special session on Coastal Zone Management concerning mariculture and its interrelations with the environment and the outcome of these discussions is presented under item 13. Additionally the WG recommends that ICES take the initiative to promote the integration of aquaculture into emerging coastal zone management plans through three principal actions:

10.2.1 Establishment of a Coastal Zone Management Study Group

Such a group should be charged with exploring ways of promoting the integration of aquaculture into Coastal Zone Management initiatives. The WG EIM, therefore, suggests that a joint meeting with the GESAMP Group be considered at an early date and GESAMP be invited to participate in the special session on "Mariculture and Coastal Zone Manangement" which will be held at the upcoming Statutory meeting.

Examples of post-implementation of evaluations of coastal zone planning activities should be included. The Working Group strongly suggests that such aspects be included in the elaboration of the suggested and submitted contributions.

GESAMP is about to prepare within its Working Party on Coastal Aquaculture Impact document on coastal zone planning issues with main emphasis on oceanographic and biological aspects and the Working Group suggests to co-ordinate the efforts, placing the emphasis on areas of central focus such as other resource use conflicts.

Differentiating between such things that can be considered as tools such as CRIS and LENKA and those versus the actual planning process which involves a balance of different coastal use values.

It was also suggested to try to attract additional input to the Study Group from the ."Coastal Zone Industrial Planning Conference" which takes place at about the same time as the Statutory Meeting in St. Johns. The Chairman of the Mariculture Committee (Dr. Cook) presently negotiates with potential speakers as they might be interested to widen their views while at the same time receive additional attention to their views. It is believed that such input from neighbouring disciplines would greatly open the perspectives for modern approaches to coastal zone management issues from which mariculture managers could learn.

10.2.2 Development of Education Programmes

Programmes should be designed to raise peoples' awareness of the legitimate role of mariculture in sustainable coastal development. This should include practical training initiatives designed to improve the knowledge and skills of planners and managers concerning planning for mariculture development. This should incorporate the location and natural resources needs of mariculture for it to be sustainable.

10.2.3 Preparation of Guidelines

Guidelines for use by Policy Makers, Planners and Managers responsible for formulating and implementing Coastal Zone Management Plans. These guidelines should address the following issues/subjects to be explored by the working group:

A. Inventory, mapping and development of GIS systems for land and water resources in the coastal zone.

a) Coastal land strip
b) Coastal structure
c) Bottom structure
d) Water circulation, currents, water quality etc.
e) Structure of fauna and flora

B. Different users of the coastal zone-conflicts

a) Culture conservancy
b) Nature conservancy
c) Recreational life for local people
d) Tourism and summer houses
e) Sportfishing
f) Commercial fishery
g) Mariculture
h) Shipping and navigation
i) Military requirements
j) Mining and oil exploitation
k) Industries and other establishment
l) Pollution

Define the requirements of each activity e.g.

TOURISM
a) Clean waters
b) Large free areas
c) Sites and harbours for leisure boats
d) Exploited areas versus non exploited areas
e) Sportfishing
f) Sites for camping
g) Bathing sites

Development of criteria to help improve the environmental assessment of proposed coastal developments, including the following factors:

a) Socio-economic
b) Bio-geophysical
c) Cultural and political

C. Institutional infrastructure and legal system

a) Various authorities and their competence areas
b) Law systems
c) Administrative limits for each authority
d) Research and monitoring in the coastal zone

D. Integration and co-ordination of mariculture activities with the regulatory system adopted by the authorities responsible for the coastal zone.

E. Planning of mariculture and other activities at the community level.

a. The intention of the community for future activities
b. Identification of problems and prospects.
c. Description of land and water resources
d. Preliminary plan for desired activities
e. Allocation of land and water resources for various activities
f. Identify the need for investigations and research
g. A strategy for implementation of the plan.
h. How to harmonise old establishments with new activities as mariculture

F. Public education in mariculture at the community, regional, national and international level.

a. Education on community levels through primary and secondary schools, open house meeting at mariculture sites
b. preparations, popular lectures, contacts with local newspapers, etc.
c. Education on regional level- specific high school for fishery people and aquaculturists.
d. Education on national level- university studies
e. Education on international levels Organisations as European Aquaculture Society and World Aquaculture Society Symposia
f. Newsletter etc.

G. International co-operation for solving various issues

a. Fishery
b. Pollution
c. Shipping and navigation
d. Tourism

H. International conventions and bodies

a. HELCOM (environmental issues)
b. PARKOM (environmental issues)
c. Fishery conventions, IBSFC, EC, NEAFC
d. IMO,UNEP (environment)
e. FAO (fishery, mariculture, environment etc.)
e. ICES (fishery, mariculture, environment etc.)

11. Status of the preparation of Technical reports

The Chemicals Technical Report has been updated and will be forwarded for publication to the Secretary General by May 15, 1994.

The Management Report has been partly updated (in particular the monitoring and modelling chapters) because of the substantial development in these areas during the intersessional period. Time did not permit to work equally intensively on other chapters of the report. It was decided that this will be done by correspondance with the aim to finalize the report for evaluation by the Mariculture Committee during the 1994 Statutory Meeting. To achieve this aim, an action list has been prepared (see below).

12. Sea Trout Commentary

(Rapporteurs, H. Rosenthal, H. Kryvi. E. Black)

The Working Group reviewed the 1992 and 1993 reports of the Working Group on Sea Trout tabled by Ireland. Background information was supplied by J. Doyle and R. Fitzgerald.

The WG examined what these reports had to say on four aspects of the sea trout problem in Ireland, the decline in sea trout fisheries and the associated sea lice problems on Irish fish farms.

These were:

- The nature of the decline of sea trout stocks.
- The evidence of a link between the decline in sea trout stocks and sea lice abundances.
- The understanding of the mechanism underlying the interaction between host/ parasite and the environment
- The relationship between the number of sea lice on juvenile sea trout returning to the rivers and the distance between those rivers and the

nearest salmon farm.

12.1 The nature of the decline of sea trout stocks.

Historically sea trout stocks have displayed cyclical changes in abundance in different regions. In the west coast of Ireland there is evidence of some decline since the mid 1970s. Unfortunately, catch per unit effort is not presented for a wide selection of rivers for the interpretation of historic population trends. These have to be inferred from catch data alone.

Regardless of whether the decline is interpreted as gradual or precipitous, almost all stocks appear to have reached minimal abundance in 1989 or 1990. Since 1990 most stocks have remained depressed, while a few stocks have shown some recovery.

12.2 The evidence of a correlation between the decline in sea trout stocks and sea lice abundance.

Only a small number of rivers have any time series data on lice abundance on juvenile fish and on the abundance of the fish stock, e.g. the Gowla, Invermore, Delphi, Costello. Two of these, the Invermore and the Costello have shown an increase in catch since the start of the time series data on the abundance of sea lice. Only in the Costello has there been a drop in the abundance of lice on sea trout. This occurred after the start of the recovery of the sea trout. The treatment for sea lice on the farms makes the data of sea lice on sea trout data difficult to interpret.

12.3 Understanding the mechanism underlying the interaction between host/parasite/environment

To reasonably understand the effect of Sea lice have on Sea trout populations it is necessary to consider the tripartite nature of interactions which determine the ultimate change effect on the host trout populations. These interactions include:

host - parasite
environment - host
environment - parasite

To some degree comment has been made on some aspects of all of these interactions. However, inadequate information has been developed and presented to draw any conclusions on the relative importance of these factors and their interactions.
From the information provided to this Working Group, it would be inappropriate, at this stage of investigations, to suggest that the host-parasite interaction is the sole or dominant factor impacting on sea trout populations.

12.4 The relationship between the number of sea lice on juvenile sea trout returning to the rivers and the distance between those rivers and the nearest salmon farm.

East coast sites should not be combined with west coast data in the analysis, because they are in oceanographically distinct water bodies. An attempt should now be made to partition groups of farms on the northwest, west and southwest coast.

12.5 Possible approaches to evaluating the role and nature of any lice-trout interactions.

The importance of the environment in sea lice infection and moralities of sea trout
- could be examined by a mark-release experiment utilizing cultured sea trout from a common source released into different streams.

The role of smolt size and developmental stage in susceptibility to sea lice infection
- lab exposure of different size smolts to lice
- release of size graded cultured sea trout released into a river associated with heavy lice infections

The role of environmental effects on lice:
- collecting lice from a number of heavily infected areas and exposing cultured sea trout to fixed titer of lice in each of these areas.

The WG EIM endorses to install traps on key river systems to provide information on smolt migrations and adult returns.

13. "Mariculture and Coastal Zone Management" Planning a session for the 1994 Statutory Meeting.

The WG considered the plan for a special session on **Coastal Zone Management** and found that this is a particular timely undertaking as the WGEIM is beginning to enter a new phase of its work. Recognizing the complexitiy of the issues involved in solving coastal zone management issues it is anticipated that the future work of WGEIM will greatly benefit from this event as it can draw on outside expertise which is urgently needed.

The Working Group proposes to have invited contributions to the session related to the following topics:

(1) Review of the Coastal Zone Profile research work within ASEAN countries with special emphasis on mariculture (suggested authors: T.,E. Chua and H. Rosenthal, Kiel)

(2) Planning processes in Coastal Zone Management (suggested author. P. Burbridge, Stirling)

(3) Case histories and new approaches to planning and modelling for Norwegian mariculture (A. Ervik and co-authors?)

(4) Swedish coastal zone management : a system for integration of various activities. (already submitted: Hans Ackefors and Kjell Grip)

(5) Canadian West Coast CORE activities (suggested authors: Edward Black and J. Truscott)

Examples of post-implementation of evaluations of coastal zone planning activities should be included. The Working Group strongly suggests that such aspects be included in the elaborations of the suggested and submitted contributions.

GESAMP is about to prepare within its Working Party on Coastal Aquaculture Impact a document on coastal zone planning issues with main emphasis on oceanographic and biological aspects and the Working Group suggests to coordinate the efforts, placing the emphasis on areas of central focus such as other resource use conflicts.

Differentiating between such things that can be considered as tools such as CRIS and LENKA and those versus the actual planning process which involves a balance of different coastal use values.

The Working Group therefore suggests to consider - at an early date - an intensiv contact with the respective GESAMP Group in order to obtain assistance on issues already discussed there.

It was also suggested to try to attract additional input from the ."Coastal Zone Industrial Planning.Conference" which takes place at about the same time as the Statutory Meeting in St. Johns. The Chairman of the Mariculture Committee (Dr. Cook) presently negotiates with potential speakers as they might be interested to widen their views while at the same time receive additional attention to their views. It is believed that such input from neighbouring disciplines would greatly open the perspectives for modern approaches to coastal zone management issues from which mariculture managers could learn.

14. Recommendations

The WGEIM recommends

(1) - that a study group should be formed to evaluate recent development in land-based and sea-based salmon farming technology. The group should identify various opportunities for the development of rearing strategies, including technical, economical and safety aspects. The composition of the group should include manufacturing specialists, insurance experts, and biologists.
Justification: The high level of salmon escapes from fish cages has created great concern regarding the possible negative interactions between wild and farmed fish. The move towards offshore farming was mainly based on a trial and error approach. Criteria for the development of technology standards for various systems which address in particular the minimization of technical failures (e.g. cage losses, net destruction from predators,etc.) would greatly assist in minimizing ecological risks associated with escaped fish and diseases. Strategies that incorporate land-based systems economically into the overall production scheme would also open opportunities for improved risk management and risk distribution.

(2) - that ICES Member Countries support the preparation of a list of models currently used in mariculture along with detailed descriptions, scope of applicability, and availability. The list will be prepared intersessionally by individuals selected by the parent Committee at the next Statutory Meeting.
Justification: Because the development of a number of models is presently underway, and because the Working Group meets only every other year, it would be too late to facilitate good linkage and understanding of the different regional

needs for such models and the reasons for differences in approach. The compilation will also be needed for the workshop suggested below.

(3) - that ICES Member States organize a workshop on "Modelling environmental interactions of mariculture" to be chaired by individuals selected by the parent Committee at the next Statutory Meeting and to be held during 1995.
Justification: A number of models are presently being developed independently in ICES member countries, with almost no comparative testing. There is a great need for the identification and comparison of different approaches to modelling the environmental interactions of mariculture with the dual goals of facilitating communication between researchers and evaluating performance and cost-effectiveness of models as a guide for regulatory agencies and other client groups.

(4) - that consideration be given to alternative oral matrices by which medication might be presented to fish to improve bioavailability and thus improve efficiency and reduce the amount of medication passing into the environment
Justification: The problems and implications of the poor bioactivity and bio-availability of almost all usable antimicrobial agents when supplied in the form of medicated feeds has been addressed in the WG' annual report. Analytical data on environmental residues alone may be misleading as to their wider ecological implications.

(5) - that the 1994 TOR (d) (to assemble and compile, intersessionally, information on ongoing monitoring programmes in each country related to assessment of the impacts and interactions of mariculture with the view to its publication in the ICES Cooperative Research Reports series be changed and the report and comments prepared at the 1994 meeting be attached as appendices to the existing Draft Technical Report on "Management of the Envrionemtal Impacts of Mariculture".
Justification: Because the Tech. Rep. on "Management of the Environmental Impact of Mariculture." must include a section on monitoring, the preparation of a new Technical Report on parts of the subjects covered would be a duplication of effort.

(6) - that in response to TOR 94/(h) the proposed special session on "Coastal Zone Management" be built around papers already submitted and invited speakers (see listing under 13). The session should be co-chaired by the Chairman of the Mariculture Committee (Dr. Cook, Canada), Dr Peter Burbridge (Scotland, as expert on CZM) and Dr. H. Rosenthal, (Germany). Additional expertise should be invited as proposed by the Chairman of the Mariculture Committee (see also 13).
Justification: Recognizing the complexitiy of the issues involved in solving coastal zone management issues it is anticipated that the future work of WGEIM will greatly benefit from this event as it can draw on outside expertise which is urgently needed.

(7) a Study Group on **Coastal Zone Management** be established to meet in early 1995 for 3 days under the Chairmanship of Dr. Peter Burbridge (Scotland). Such a group should be charged with exploring ways of promoting the integration of mariculture into Coastal Zone Management initiatives and should include the required expertise from neighbouring disciplines not yet available within the fisheries and oceanography- oriented scientific community of ICES.
Justification: The WG EIM has just started under its new TORs to outline the overall requirements for integration of mariculture into a pro-active, improvement

oriented CZM strategy and suggests that such a Study Group meeting could greatly enhance orientation and guidance for the formulation of key issues for its future work.

(8) - The GESAMP Working Party on Coastal Aquaculture Impact be invited to participate in the activities of the WGEIM, including the Special Session of the Mariculture Committee at the 1994 Statutory Meeting of ICES, the proposed Modelling Workshop and the Meeting of the proposed Study Group on Coastal Zone Management.
Justification: GESAMP is about to prepare within its Working Party on Coastal Aquaculture Impact a document on coastal zone planning issues with main emphases on oceanographic and biological aspects and the Working Group recommends a coordinatin of effort, placing the emphasis on other areas of central focus such as resource use conflicts.

(9) The Working Group recommends

that it meet for 4 days in Nantes (France) in March 1996 to undertake the following tasks:

(a) to update the catalogue of completed, ongoing, and new research progrmmes on environmental interactions and related issues related to mariculture in ICES member countries and identifies major research priorities

(b) review progress made in member countries in relation to analysing contaminent residues in sediments under and near fish farms (e.g. antimicrobials) while at the same time identifying their bioactivity with the view to preparing advice on adequate monitoring strategies and interpretation of monitoring data on residues with respect to their wider ecological implications.

(c) Analyse, document, and disseminate information of the status of mariculture, existing trends and future innovations in the culture of different species and concomitant resource requirements and implications for planning and management, with due attention to trends in other coastal resources development and utilization.

(d) to continue to study the interactions of mariculture with other users of the coastal resources and analyse the outcome of the proposed workshops and study groups with the view of preparing guidelines for the management of mariculture within the larger context of a CZMP.

It is anticipated that the Terms of Reference for the 1996 Working Group meeting will have to be updated and/or expanded at the 1994 and 1995 Mariculture Committee sessions (ICES Statutory Meetings) because of the rapid development of this sector and the various activities taking place during the intersessional period.

15 Action list

Members of the Subgroup on Modelling (Antoine Dosdat, Carter Newell, Wiliam Silvert):

should identify through contacts by correspondance an Institution to host the proposed Workshop (Recommendation 2). Further, a list of potential participants (including affiliation) should be prepared and submitted to the Chairman of the WGEIM and the Chairman of the Mariculture Committee for ease of further planning of the workshop.

Subgroup members should also identify the infrastracture (e.g. PCs, audiovisuals, etc) required for such a Workshop.

New research results regarding subtle and far-field effects of mariculture wastes are to be compiled by all members for their respective country and these compilations be transmitted to the WG Chairman no later than January 31, 1995 for inclusion into the next WG -Report, which will be prepared by correspondence.

In order to further update and finalize individual chapters of the Technical Report on "Managment of the environmental Imapct of Mariculture", the following tasks and timetable has been agreed upon by the identifed WG members:

- 1.0 Introduction	(Rosenthal)	August 1994
- 2.0 Range of environmental effects..	(Gowen & Rosenthal)	August 1994
- 3.0 Project & site description/selection	(Black & Gowen)	August 1994
- 4.0 Modelling	(Dosdat)	August 1994
- 50 Monitoring	(Doyle & Black)	August 1994
- 6.0 Conclusion	(Rosenthal & Gowen)	Dec. 1994

This timetable for the compilation of final versions of chapters should permit presentation of a draft to the Mariculture Committee for circulation and feedback. The document should be finalized by the end of the year 1994 for early printing in 1995.

The Technical Report in the "Use of Chemicals in Mariculture" has been updated during the WG meeting. The relevant new literature needs to be included into the final version (D. Alderman). Table 2 on types of chemicals used in member countries will be updated and provided by the end of April for inclusion as Annex 2 (H. Rosenthal). The ready-to-print version will be forwarded to the Secretary General for publication by May 15th 1994 (D.Alderman). The manuscript will be send as hard copy and on a disk.

16. Relevant Literature (provided by Participants)

Finland (compiled by Kari Ruohonen and Timo Mäkinen)

Eskelinen, U., Vielma, J. 1993. Kalaviljely ja vesiensuojelun tavoitteet. Fiskodlingen och målen för vattenskydet. Suomen Kalankasvattaja 1993(1): 29-29. [In Finnish and Swedish].

Karttunen, V., Vielmaa, J. 1993. DKalankasvatus ja ympäristö. Suomen Kalankasvattajaliitto r.y. 68s ISBM 951-96591-1-0 [In Finnish].

Mäkinen, T. 1993. Effect of temperaature, feed ration and other growth factors on the growth of rainbow trout *(Oncorhynchus mykiss* Walbaum 1792) cultured in Finland. PhD. Thesis, 121 pp.

Ruohonen, K., Vielma, J. 1993a. Baltic herring-based feeds migh help to diminish the nutrient load from mariculture to the Baltic Sea. ICES, C.M. 1993/F:17.

Ruohonen, K., Vielma, J. 1993b. Palasilakkaruokinnan täydentäminen kirjolohen kasvatuksessa vähän valkuaisainetta sisältävällä kuivarehulla. Silakan käyttö kirjolohen rehuna. Vuosiraportii. Helsinki, Riista-ja kalatalouden tutkimuslaitos, s. 23-42. [In Finnish].

Ruohonen, K., Vielma, J. 1993c. Ruokintatajuuden vaikutus kirjolohen kasvuun ja ravinnekuormitukseen palasilakalla ruokittaessa. Silakan käytto kirjolohen rehuna. Vuosiraportti, Helsinki, Riista- ja kalatalouden tutkimuslaitos, s. 3-22. [In Finnish]

Ruohonen, K., Vielma, J. 1993d. Tiedustelu silakan käytöstä kalojen rehuna. Silakan Käyttö kirjolohen rehuna. Vuosiraportti. Helsinki: Riista- ja katalouden tutkimuslaitos, s. 43-51. [In Finnish].

Tshernij, V., Lehtonen, E. Suuronen, P., Mäkinen, T. 1993. Onko pendeliautomaatien aukjoloa säädeltävä kirjolohien verkkoallasviljelyssä? Syntyykö rehuhukkaa? (Bör pendelautomaterna tidvis stängas vid odling av regnbågslax i nätkassar?). Suomen Kalankasvattaja - Fiskodlaren 2: 30-34. [In Finnish and Swedish].

France (compiled by Marc Kempf, Antoine Dosdat, M. Merceron)

Bachelet G., Desprez M., Ducrotoy J.P., Guillou J., Labourg P.J., Rybarczyk H., Sauriau P.G., Elkaim B., Glémarec M., 1992. Rôle de la compétition intraspécifique dans la régulation du recrutement chez la coque, *Cerastoderma edule* (L.). Ann. Inst. Oceanogr; Paris, vol. 68(1-2), p. 75-87.

Bacher C.,1991. Etude de l'impact du stock d'huîtres et de mollusques compétiteurs sur les performances de croissance de *Crassostrea gigas*. ICES Mar. Sci. Symp., 192 : 41-47.

Bacher C., 1993. Ecosystem modelling : sensitivity of physical characteristics to spatial box design. NATO ASI Series, Vol G33, Bivalve Filter Feeders in estuarine and coastal ecosystem processes edited by R.F. Dame. Springer-Verlag Berlin Heidelberg : 517-518.

Bacher C., 1993. Use of an ecosystem model for the assessment of the influence of cultivated oysters (*Crassostrea gigas*) on the nitrogen cycling in the Marennes-Oléron Bay. Rapport CEE-FAR Contrat AQ 2500 : 139 - 151 p.

Bacher C., Bioteau H., Chapelle A., 1993. Modeling the impact of the cultivated oyster population on the nitrogen dynamics : the case of the Thau lagoon (France). Ophelia, submitted.

Bacher C., Heral M., Deslous-Paoli J.M., Razet D., 1991. Modèle énergétique uniboîte de la croissance des huîtres (*Crassostrea gigas*) dans le bassin de Marennes-Oléron. Can. J. Fish. Aquat. Sci., 48 : 391-404.

Barillé A.L., 1993. Modélisation de la moule sur filière dans le pertuis breton (17) : capacité trophique du Pertuis Breton. Rapport Université Aix-Marseille II, Centre d'Océanologie de Marseille, Station Marine d'Endoume, 94 p.

Barillé L., Prou J., Héral M., Bougrier S., 1993. No influence of food quality, but ration-dependent retention efficiencies in the Japanese oyster *Crassostrea gigas*. J. Exp. Mar. Biol. Ecol., 171 : 91-106

Bayne B.L., Iglesias J.I.P., Hawkins A.J.S., Navarro E., Héral M., Deslous-Paoli J.M. 1993. Feeding behaviour of the mussel *Mytilus edulis L.,* response to variations in both quantity and organic content of seston. J. Biol. Ass. U.K., 73 :813-831

Bioteau H., 1993. Modélisation de l'écosystème de l'étang de Thau : rôles du sédiment et des huîtres cultivées sur le cycle de l'azote. DEA Paris VI, 47 p.

Blanc G. et Loussouarn S., 1993. Pharmacokinetics of levamisole in the european eel definitive host of the Nematode Anguillicola crassus. International workshop "*Anguillicola* & *Anguillicolosis* of eels, Ceske Budejovice, 5-7 october 1993.

Bodoy A., S. Bougrier, P. Geairon, J. Garnier, V. Boulo et S. Heurtebise,1991. Does the prevalence of *Bonamia* and *Marteilia* diseases be reduced on flat oysters (*Ostrea edulis*) of Atlantic and Mediterranean origin, when they are reared together with the Japanese oyster (*Crassostrea gigas*) in tidal ponds ? Note au CIEM, Shellfish Committee K : 28 : 9 p.

Coulibali N.D., 1992. Possibilités de développement de bactéries d'origine fécale dans les élevages aquacoles. Mém. ISPA (option Halieutique) Rennes, déc. 1992 : 50 p. (stage CNEVA-LNPAA Brest).

Dao J.C., Fleury P.G., Paquotte P., 1992. Eléments de reflexion pour l'évaluation économique de la filière d'élevage de la coquille Saint-Jacques. Rapport IFREMER DRV-RA-92.001, Brest, 60p.

Dardignac-Corbeil M.J., Prou J., 1993. Manque de naissain de moule pendant 3 années consécutives dans les bouchots du Pertuis breton. Submitted to Haliotis.

Debarnardi J. M., 1992. Influence de l'antibiothérapie en pisciculture de marais maritimes sur l'environnement conchylicole. Application à l'oxytétracycline. Thèse de doctorat vétérinaire, Nantes.

DEL/EL *et al.*, 1993. *Gymnodinium cf nagasakiense* dans l'étang de Diane (Corse) : résultats des tests biologiques et des analyses chimiques. DEL/Ecologie, DEL/Corse, DEL/Concarneau & DEL/Toulon. Rapp. IFREMER DEL Brest 92.23, nov. 1993 (in press).

Deslous-Paoli J.M., 1991. Le rôle des organismes filtreurs dans l'écosystème. In Ecothau, synthèse des résultats. Jouffre D. et Amanieu M. ed, Univ. des Sc. Tech. du Languedoc, Montpellier : 235-236.

Deslous-Paoli J.M., 1993. Physiologie alimentaire des coquillages : conséquences sanitaires. In : Coquillages, I.T.S.V.F. ed. : 205-219.

Deslous-Paoli J.M., Lannou A.M., Geairon P., Bougrier S., Raillard O., Héral M., 1992. Effect of feeding behaviour of *Crassostrea gigas* (Bivalve Mollusc) on biosedimentation of natural particulate matter. Hydrobiologia, 231 (2) : 85-92.

Deslous-Paoli J.M., Mazouni N., Souchu P., Landrein S., Pichot P., Juge C., 1993. Oyster farming impact on the environment of a mediterranean lagoon (Thau). (Preliminary results of the OXYTHAU programme). In "Bivalve filter feeders in estuarine and coastal ecosystem processes". NATO ASI Series, Vol. G. 33., R.F. Dame ed., Springer. Verlalg Berlin Heidelberg : 519-521.

Deslous-Paoli J.M., Wolowicz M., Boromthanarat S., 1992. Les réserves énergétiques de *Mytilus edulis* : compaison des stratégies développées dans la baie de Gdansk (Pologne) et le bassin de Marennes-Oléron (France). IFREMER, Actes de Colloques, 13 : 19-28.

Dosdat A., 1992. .L'excrétion chez les poissons téléostéens. II. Le phosphore. La pisciculture Française. 109, p 18-29

Dosdat A., 1992. L'excrétion chez les poissons téléostéens. I. L'azote. La pisciculture Française. 108, p 25-40.

Dosdat A., F. Gaumet & H. Chartois, 1994. Marine aquaculture effluent monitoring : methodological approach to the evaluation of nitrogen and phosphorus excretion by fish. Aquacultural Engineering (in press).

Dosdat A., M. Merceron, M. Kempf, 1992. Aquaculture intensive et environnement. Séminaire MEDRAP. "Aquaculture et Environnement en Méditerranée", Bordeaux Aquaculture, 25-26 mars 1992 : 2 p + illustr.

Dosdat A., M. Merceron, M. Kempf et J.L. Mauvais, 1993. Fish farming regulation with reference to environmental problems in France. P. 88-92 in Rosenthal H. & V. Hilge (Edit.)

Fish farm effluents and their control in EC countries. Workshop, Hamburg Nov. 92, Report, March 1993:205p.

Feuillet-Girard M., Héral M., Abrioux M.F., Fontugne , 1993. Carbone organique dissous et particulaire de la colonne d'eau et de l'interface eau-sédiment du bassin de Marennes-Oléron : influence des huîtres. Océanologica acta (in press)

Gaignon J.L., L. Quéméner et A. Le Roux, 1993. Effets de la diminution de la photopériode lors d'une smoltification précoce chez le saumon atlantique *(Salmo salar)*. Bull. Fr. Piscic., 330.

Gaumet F., A. Dosdat & E. Desbruyeres, 1993. Monitoring of marine fish excretion : methodological approach and application to ammonia production by fasted turbot. Int. Conf. World Aquaculture'93, Torremolinos, Spain, May 26-28, 1993. European Aquacult. Soc. spec. Publ. 19, 1993 : 376 (abstract poster).

Goulletquer P., Héral M., Rothschild B.J., 1993. Causes of decline of oyster production *Crassostrea virginica* in the Maryland portion of the Chesapeake Bay : a litterature study. Haliotis in press, 28 p.

Goulletquer P., Prou J., Héral M., 1993. Aspects biométriques et biochimiques de la croissance de l'huître *Crassostrea virginica* en élevage suspendu à Solomons (baie de Chesapeake). Haliotis in press, 10 p.

Goux-Plaire S., 1992. Devenir des rejets solides des pisciculture marines intensives. Mém. Maïtr. Oc. biol. UBO Brest, oct. 1992 : 13 p. + tab.

Guezennec L., J. Prou, M. Héral, D. Razet, S. Bougrier et P. Soletchnik,1992. Ecophysiologie *in situ* de l'huître *Crassostrea gigas* dans un milieu macrotidal (bassin de Marennes-Oléron - Chapus 1991). Rapport CEE AQ 2500 (1) : 6-41.

Hamon, P.Y.,1993. Les milieux lagunaires et la conchyliculture. In: Aquacultura e zonas humidas litorais, Seminário euromediterrânico, 5-7 julho, 1993, Inip, Lisboa, Portugal, 10 p.

Héral M. et J-P. Berthomé,1991. Water quality criteria for shellfish molluscs : the example of french monitoring. Aquaculture and the Environment. N. De Pauw and J. Joyce (eds.). European Aquaculture Society Special Publication n° 16, Gent, Belgium : 15 p.

Héral M., 1993. Etude de la faisabilité d'élevage d'huîtres en eau profonde dans le pertuis charentais. Rapport IFREMER, 30 p.

Héral M., 1993. Influence des facteurs environnementaux sur l'élevage des Mollusques Bivalves. Conférence introductive IXème congrés national de la Société Française de Malacologie et Symposium International Malacologie et Environnement.

Héral M., 1993. Mortalités de Ronce les Bains, état au 23 juin 1993. Rapport IFREMER, 3 p.

Héral M., 1993. Why carrying capacity models are useful tools for management of bivalve molluscs culture ? in NATO ASI Series, vol. G33, Bivalve Filter Feeders in Estuarine Coastal Ecosystem Processes. Edit. R.F. Dame. Springer-Verlag Berlin Heidelberg : 455-477.

Héral M., Prou J., Heurtebise S., Bougrier S., Razet D., 1993. Etat du bassin de Marennes-Oléron en mars 1993 : croissance, qualité, stocks en élevage, mortalités, influence de la Charente, besoins nutritionnels des huîtres, courantologie, compétiteurs, sédimentologie. Rapport IFREMER 87 p.

Hussenot J., 1992. Stimulation de la productivité naturelle par enrichissements minéraux et organiques : étude en mésocosmes naturels. Rapport IFREMER DRV-RA-92-15, 96p.

Hussenot J., Martin J-L., Feuillet-Girard M., Gautier D., 1994. Assessment of the quality of sediments in aquaculture using fast and simple techniques. European Aquaculture Society Meeting, 23-25 March 1994, Bordeaux (France).

Hussenot., Martin J.L., Gouleau D., Ravail B., Eveno A. 1991. Effects of a complement diet managed like an organic stimulant on ponds sediment. E.A.S. Special publications, Aquaculture and environnement, 14, 159-160.

Huttel C., 1992. Elevage du loup : contribution à l'étude du suivi des paramètres de l'eau en circuit fermé et des rejets solides (MES). Mém. DUST Génie hydrosanit. & aquacole USTL Montpellier, juin 1992 / 55 p. + annexes.

Jegou F., 1992. L'excrétion chez le turbot : analyse méthodologique préalable. Mémoire DUT, IUT Brest/Biol.appl., Rapport IFREMER/DRV Brest, Juin 1992 : 30 p.

Jorand G., 1992. Etude de la toxicité de l'ammoniac en élevage de poissons marins. Mémoire DUT, IUT Lannion/Mesures phys., Rapport IFREMER/DRV Brest, Juin 1992 : 30 p.

Keita D., 1992. Mise au point d'une méthode HPLC de dosage de l'Oxytétracycline dans l'Huître (*Crassostrea gigas*). Application à la cinétique de décontamination des huîtres polluées par des effluents de pisciculture de marais maritimes. D.E.A. de Biologie et Agronomie : option Biologie Aquacole.

Kempf M., 1993. Prise en compte du risque environnemental en aquaculture marine. Séminaire IFREMER-UAP, Paris 23-24 oct. 1993.

Kempf M. & J. Hussenot, 1992. Aquaculture et environnement, Séminaire Tunis 18-22 nov. 1991. Rapport IFREMER/DEL Brest 92.04 & CREMA DRV/RA 92.04, Janvier 1992 : 31 p + annexes.

Kempf .M., Merceron M., Dosdat A., 1993. Pisciculture marine et environnement en France. Spécificité par rapport à l'eau douce. Séminaire Aquaculture et Environnement, Nantes, 6-7 octobre 1993, 7p.

Larvor H., Cuif J.P., Devauchelle N., Dauphin Y., Denis A., Gautret P. and Marin F., 1993. Development of a brown internal coloration in the scallop shell *Pecten maximus* study of microstructural characteristics and analyses of crystal organic matrices. Bulletin Océanographique de Monaco.

Le Bris H., 1992. Influence des effluents piscicoles de marais maritimes sur l'environnement conchylicole. 1°Partie : influence de l'antibiothérapie pratiquée en pisciculture de marais maritimes sur l'environnement conchylicole. Rapport de contrat SMIDAP-ENVNantes, 37p.

Le Bris H., 1993. Influence des effluents piscicoles de marais maritimes sur l'environnement conchylicole. 2°Partie : influence des rejets de germes fécaux issus de piscicultures de marais maritimes sur la salubrité des mollusques filtreurs. Rapport de contrat, SMIDAP-ENVNantes, 28p.

Le Bris H., Maffart P., 1993. Influence des rejets de substances médicamenteuses antiparasitaires par les piscicultures de marais maritimes sur l'environnement conchylicole. Rapport de contrat SMIDAP-ENVNantes, 42p.

Le Bris H., Pouliquen H., Debernardi J.M. et Buchet V., 1992. Antibiothérapie en pisciculture de marais maritimes. Risques pour la conchyliculture? Communication au deuxième colloque national d'Ichtyopathologie, Paris, 3-4 décembre 1992.

Le Bris H., Pouliquen H., Debernardi J.M., Buchet V. et Pinault L., 1994. Preliminary study on the kinetics of oxytetracycline in shellfish exposed to an effluent of a land-based fish farm : experimental approach (submitted to Mar. Env. Res.).

Lemarie G., E. Gasset, D. Cam & E. de La Fonchais, 1992. Modélisation de la consommation en oxygène du loup (*Dicentrarchus labrax* L.) et de la daurade (*Sparus auratus* L.). Ichtyophysiologica Acta 15 : 55-68.

Maffart P., Le Bris H., Bocquene G., Blanc G., Buchet V. et GalganiI F., 1993. Experimental study on the influence of a dichlorvos treatment on the acetylcholinesterase activity of sea bass (*Dicentrarchus labrax*). European Association of Fish Pathologists. Sixth International Conference, "Diseases of fish and shellfish", Brest, France, septembre 5-10, 1993.

Martin J.L., Baud J.P., Russu P., Severin P., Haure J., Hussenot J., Mornet F., Gouleau D., 1990. La qualité du milieu dans un système expérimental semi-fermé d'élevage intensif de la palourde japonaise. Rapport interne IFREMER, RIDRN-90-53-RA-L'Houmeau.

Martin J.L., Baud. J.P., Russu P., Gouleau D., Hussenot J., 1991. Evolution of the water quality in intensive rearing raceways of the Manila clam Ruditapes philippinarum. E.A.S. Special publications, Aquaculture and environnement, 14, 205-206.

Martin J.L., Sornin J.M., Marchand M., 1991. The significance of oyster biodeposition in concentrating organic matter and contaminants in the sediment. E.A.S. Special publications, Aquaculture and environnement, 14, 207.

Massuyau L., 1991. Contribution à l'étude d'une méthode de recherche de résidus de chloramine T dans les produits d'aquaculture. Thèse de doctorat vétérinaire, Nantes.

Mazouni N., 1991. Mise au point d'un système d'étude in situ et continu du métabolisme de *Crassostrea gigas*. Validation d'un modèle de filtration et respiration. Rapport de DEA, Aix-Marseille II : 37 pp.

Mazouni N., Courties C., Deslous-Paoli J.M., Vaquer A., 1993. Phytoplanktonic size spectrum modifications induced by shellfish cultures in Thau lagoon. Congrès de cytométrie en flux et de cytométrie en image, Montpellier, 2-4 décembre 1992 (poster et présentation orale) : in press.

Mazouni N., Geringer d'Oedenberg M., 1992. Les crises dystrophiques en milieu lagunaire : programme d'étude des flux à l'interface cultures/eau/sédiments. J. Rech. Oceanogr., 17 (3-4) : 84-85.

Merceron M., 1991. Seawater quality and summer mortalities of Atlantic salmon farmed in France. *In* De Pauw N. & Joyce J. (Compilers), Aquaculture and the Environment" (Dublin, 1991), Int. Conf. Exhib. of European Aquaculture Society, spec. Publ. 14 : 216-217 (L'article faisant l'objet de la contribution orale comprend 3 p. et 12 fig.).

Merceron M., 1991. Water quality and summer mortalities of sea farmed Atlantic salmon (*Salmo salar*) - A site comparison. ICES C.M. 1991/F 33 : 9 p., 8 fig. h.t.

Merceron M., 1991. Interrelations environment-intensive marine fish farming. *In* : Eurasean Aquaculture Workshop, Nantes Sept 1991 : 4 p., fig.

Merceron M., Dosdat A. & Kempf M, 1992. Interactions entre environnement et pisciculture marine intensive : la problématique française. Bordeaux Aquaculture, 25-27 mars 1992 : 1 p (résumé), (contrib. : 5 p.).

Metailler R., 1993. Relation nutrition/environnement aquatique : digestibilité, excrétion. Journ. Nutrition des Poissons, Bordeaux Biotechnica 11-12 février 1993.

Moreau C., 1993. Caractéristiques et gestion des eaux souterraines salées de la Baie de Bourgneuff : synthèse des connaissances et standardisation de protocoles communs d'analyse des pararmètres de qualité. Rapport du Laboratoire de Biologie Marine (Univ.Nantes) au SMIDAP, 41p.

Oberdorff, T. and Porcher, J.P. 1994. An index of biotic integrity to assess biological impacts of salmonid farm effluents on receiving waters. Aquaculture, vol. 119, n° 2/3, p. 219-235.

Perraudeau Y., 1992. Les difficultés de l'ostréiculture : banalisation, asymérie croissante du marché et montée de la grande distribution. Economie et Gestion Agro-alimentaire n°22, p. 5-12.

Person Le Ruyet J., H. Chartois & E. Desbruyeres, 1993. Comparative acute toxicity of ammonia to fish juveniles. Aquaculture 93, Torremolinos, Spain, May 26-28, 1993. European Aquacult. Soc. spec. Publ. 19,1993 : 434 (abstract poster).

Person-Le Ruyet J., H. Chartois, E. Desbruyères et J.L. Thomas, 1994. Ammonia acute toxicity in turbot (*Scophthalmus maximus*) juveniles. European Aquaculture Soc. spec. Publ. Proceedings of the turbot workshop.

Pichot P. Juge C., 1991. La crise dystrophique (malaïgue) de l'été 1990 dans l'étang de Thau (Hérault). Poster à la réunion des Océanographes de France. Le littoral et ses contraintes, Nantes, juillet 1991.

Pichot P., 1991. Thau : élevage des mollusques. Historique. In Ecothau, synthèse des résultats, Jouffre D. et Amanieu M. ed : Univ. des Sc. Tech. du Languedoc, Montpellier : 32-34.

Pouliquen H., 1991. Mise au point d'une méthode de dosage CLHP de l'Oxytétracycline dans l'eau de mer. Application à la cinétique de décontamination de l'eau de mer polluée par des effluents de pisciculture contenant de l'oxytétracycline. D.E.A. de Physico-Chimie des Bioproduits, option qualité des bioproduits.

Pouliquen H., 1993. Mise au point et validation d'une méthode de dosage de l'acide oxolinique dans l'eau de mer, le sédiment, l'huître creuse *Crassostrea gigas*. et la palourde *Ruditapes philippinarum*. Contrat IFREMER/ENVNantes (33 p).

Pouliquen H., Keita D. et Pinault L., 1992. Determination of oxytétracycline in marine shellfish (*Crassostrea gigas*, *Ruditapes philippinarum* and *Scrobicularia plana*) by high-performance liquid chromatography using solid phase extraction. Journal of Chromatography. **627** : 287-293.

Pouliquen H., Le Bris H. et Pinault L., 1992. Experimental study of the therapeutic application of oxytetracycline, its observations in sediment and sea-water, and implications for farm culture of benthic organisms. Marine Ecology Progress Series,. **89** : 93-98.

Pouliquen H., Le Bris H. et Pinault L., 1992. Experimental study of the decontamination kinetics of seawater polluted by oxytetracycline contained in effluents released from a fish-farm located on salt-marshes. Aquaculture, **112** : 113-123.

Pouliquen H., Le Bris H., Keita D. Buchet V. et Pinault L., 1993.Determination of Oxytetracycline in shellfish (*Crassostrea gigas, Ruditapes philippinarum* and *Scrobicularia plana*) by high-performance liquid chromotography-application to an experimental study performed in shellfish exposed to a seawater effluent containing ocytetracycline. Ed. Haagsma N., Ruiter A. et Czedik-Eysenberg P.B., Euroresidue II, Conference on residues on veterinary drugs in food, 553-557. Veldhoven, Netherland, 3-5th May 1993.

Pouliquen H., Pinault L. et Le Bris H., 1992. Determination of oxytetracycline in sea water and sediment by HPLC. VIth Symposium of the World Association of Veterinary Laboratory Diagnosticians, Lyon, 1992.

Pouliquen H., Pinault L. et Le Bris H., 1993. Determination of oxolinic acid in seawater, marine sediment and japanese oyster by high performance liquid chromatography. Journal of Liquid Chromatography *J* (in press).

Pouliquen Y., 1993. Approche méthodologique des bilans N et P du turbot. Mém. IUT Strasbourg, 2° an.

Prou J., Barillé L., Héral M., Ratiskol G., Soletchnik P., Bougrier S., Razet D. et Geairon P., 1993. Influence du cycle semi-diurne et vives-eaux - mortes-eaux sur la disponibilité du matériel particulaire et son utilisation par une population de *Mytilus edulis*. Haliotis, in press.

Prou J., Barillé L., Raillard O., Soletchnik P., Bacher C., Bougrier S., Héral M., Geairon P., 1993. Modélisation de l'écosystème du bassin de Marennes-Oléron. Rapport Région Poitou-Charentes, RIDRV 93, 141 p.

Prou J., Dardignac-Corbeil M.J., 1993. Recruitment of mussels in the Pertuis breton (France) in these last years. A preliminary analysis of the influence of temperature and sunshine. In : Spatfall and recruitment of mussels (*Mytilus edulis*) and cockles (*Cerastoderma edule*) on different locations along the european coast. ICES CM/K : 62 Shellfish committee.

Raillard O., 1991. Etude des interactions entre les processus physiques et biologiques intervenant dans la production de l'huître *Crassostrea gigas* (Thunberg) du bassin de Marennes-Oléron : essais de modélisation. Thèse Université de Paris VI, Océanographie biologie : 216 p.

Raillard O., 1992. Modélisation de la production ostréicole à Marennes-Oléron : introduction d'un modèle de croissance phytoplanctonique. Rapport CEE AQ 2500 (1) : 367-439.

Raillard O., D. Razet, J. Prou et M. Héral, 1991. Modélisation de l'écosystème du bassin de Marennes-Oléron. Convention Région Poitou-Charentes 1991, RIDRV-91-07-RA/LA TREMBLADE, 179 p.

Raillard O., Deslous-Paoli J.M., Héral M., Razet D., 1993. Modélisation du comportement de nutrition et de croissance de l'huître japonaise *Crassostrea gigas* du bassin de Marennes-Oléron (France). Oceanol. Acta : 16(1) : 73-82

Raillard O., Menesguen A., 1993. An ecosystem "box model" for estimating the carrying capacity of the shellfish system of Marennes-Oléron Bay. Mar. Ecol. Prog. Series, in press.

Rothschild B.J., Ault J.S., Goulletquer P., Héral M., 1993. The decline of Chesapeake Bay oyster population : a century of habitat destruction and overfishing. Mar. Ecol. Prog. Series, in press.

Roy S., Mayzaud P., Souchu P., 1991. Environnement physicochimique et trophique d'un site mytilicole, Iles-de-la-Madeleine (Québec) : II-Matière particulaire, composition biochimique et productivité primaire. In Therriault J.C. ed., "Le golfe du Saint Laurent : petit océan ou grand estuaire ?", publ. spec. can. sci. halieut. aquat., 113 : 219-230.

Rybarczyk H., Desprez M., Ducrotoy J.P., Olivesi R., Jamet F., Elkaim B., 1993. The dynamics of nutrients and faecal bacteria in a macrotidal estuary : the Bay of Somme (France). Neth. J. Aqua. Ecol., vol. 27, p. 395-404.

Salaun G., 1992. Caractérisation de l'origine piscicole des rejets solides des élevages en mer par l'intermédiaire des métaux. Mémoire DUT, IUT Brest/Biol.appl., Rapport IFREMER/DEL Brest, Juin 1992 : 22 p. + figs et annexes.

Soletchnik P., Geairon P., Renault T., Cochennec N., Héral M., 1993. Relations entre la présence de Chlamydie like et l'état nutritionnel de l'huître *Crassostrea gigas* : influence sur les bilans énergétiques. Rapport IFREMER, 14 p.

Soletchnik P., Héral M., Razet D., Bougrier S., Geairon P., 1993. Bilan énergétique *in situ* de l'huître creuse (*Crassostrea gigas*) en baie de Marennes-Oléron (France) : Exemple de la période de forte croissance printanière. Submitted to Aquatic Living Resources.

Souchu P., Mayzaud P., 1991. Inorganic nutrient composition of rainwater in Magdalen Island (Québec, Canada). Impacts on the marine primary production. Atmos. Res. : 543-554.

Souchu P., Mayzaud P., Myrand B., 1991. Cycles de l'azote et du phosphore dans la lagune de Grande-Entrée (Québec, Canada), en relation avec les mortalités massives de moules (*Mytilus edulis*). Atelier de travail sur la mortalité estivale des moules aux Iles-de-la-Madeleine. Québec, 23-25 avril 1991. CAPQ Québec : 196 pp.

Souchu P., Mayzaud P., Roy S., 1991. Environnement physicochimique et trophique d'un site mytilicole, Iles-de-la-Madeleine (Québec) : I-Evolution estivale des composés de l'azote, du phosphore et du silicium. In Therriault J.C. ed., "Le golfe du Saint Laurent : petite océan ou grand estuaire ?, publ. spec. can. sci. halieut. aquat., 113 : 209-218.

Tournier H., Deslous-Paoli J.M., 1992. Variations spatio-temporelles estivales de l'oxygène dans les secteurs conchylicoles de l'étang de Thau. Actes du colloque Le littoral, ses contraintes environnementales et ses conflits d'utilisation", Nantes, 1-4 juillet 1991, Amiard J.C., Robert J.M. eds, Isomer univ. de Nantes : 121-124".

Vale C., Hussenot J, Falcao M., Martin J.L., 1991. Interrelationship between sediment-water interface biogeochemistry and aquaculture : a case study. Seminario sobre aquacultura mediterranica 91, Liboa, 11-13 dezembro 1991.

Vale C., Hussenot J, Falcao M., Martin J.L., 1992. Dawn-dusk chemical variations near the sediment-water interface of a clam-growth bank of Ria Formosa. Proceedings seminario sobre aquacultura mediterranica 91, Liboa, 11-13 dezembro 1991. Public. Avul. INIP, 19, 71-79.

Vernier N., 1991. Impact du vent sur les échanges entre la Méditerranée et l'étang de Thau. Conséquence pour la concentration en Tributyl Etain de l'étang. Mémoire de Diplôme d'Agronomie Approfondie. Institut National Agronomique de Paris-Grignon.

Videau C., Merceron M., 1992. Impact de la pisciculture marine intensive sur l'environnement. Revue bibliographique. Rapport IFREMER DEL.Brest-92-13, 105p.

Zurburg W., A. Smaal, M. Héral et N. Dankers, 1992. *In situ* estimations of uptake and release of material by bivalve filter feeders in the bay of Marennes-Oléron. ECSA/ERF 22 Plymouth sept. 92 , in press.

Zurburg W., Smaal A., Héral M., Prins T., 1993. Seston dynamics and feeding by bivalves in the bay of Marennes-Oléron (France). ESCA Neth. J. Aquat. Ecol., in press.

Sweden (compiled by Hans Ackefors, Stockholm)

Ackefors, H. and M. Enell. 1990. Discharge of nutrients from Swedish fish farming to adjacent sea areas. Ambio 19, 1:28-35.

Ackefors,H., N.Johansson and B. Wahlberg, 1991. The Swedish compensatory programme for salmon in the Baltic: an action plan with biological and economic implications.- ICES mar. Sci.Symp., 192:109-119.

Boetius,I., K.O. Wahlström and C. Gelin, 1992. Experimentally induced sexual maturity in farmed European eel *Anguilla anguilla* (L.). Irish Fish. Invest. Series A.(freshwater), No 36: 121-125.

Börjesson,H. , Norrgren,L. Lundström,J. Andersson,T. and P-A- Bergqvist. 1993. Abnormal mortality of youlsac larvae of feral Baltic salmon. Poster vid EAFP sixt international conference " Disease of fish and shellfish" 5-10 Sept. 1993 Brest, Farnkrike.7

Enell and H. Ackefors. 1991. Belastning av fosfor and kväve från fiskodlingar i Norden på omgivande havsområden.- Nordiska Ministerrådet. Nord 1991, 10:83-101. Havbrug og miljö. Havbrugets påvirkning af den omgivende miljö. Eds. Hoffman,E., R. Persson, E. Gaar and G. Stein- Jonsson.

Enell M. and H. Ackefors, 1992. Development of Nordic salmonid production in aquaculture and nutrient discharge into adjacent sea areas. Aquaculture Europe Vol. 16(4): 6-11.

Enell M. and H. Ackefors, 1991. Nutrient discharges from Aquaculture Operations In Nordic Countries into Adjacent Sea Areas. C.M. 1991/F:56, Ref. MEQC. 17 pp.

Eriksson, T. and Eriksson, L.-O., 1991. Spawning migratory behaviour of coastal released Baltic salmon (*Salmo salar*). Effects on straying frequency and time of ascendance. Aquaculture 98:79-87.

Forurensning fra nordisk akvakulture- mengder, effekter og tiltak.(Pollution from Nordic Aquaculture- quantities, effects and ?
93:357-372.Nordiske Seminar - og Arbejdsrapporter. 1992:571 (In Danish)

Haux,C. Hansen,T., Stefansson,S.O. Taranger,G.L., Walther,B.T. and Björnsson B.T., 1991. Photoperiodic control of plasma gonadotropin levels and reproduction in adult Atlantic salmon. In: Reproductive Physiology of Fish. Proc. of the 4th ISFR. p 26.

Hilmarsson, S., Moksnes, E., Björnsson B.T. and Norberg,B., 1991. Induction of vitellogenin synthesis in juvenile striped wolffish (*Anarhicas lupus* L.) In: Reproductive Physiology of Fish. Proc. of the 4th ISFR. p 322.

Holmgren , K., H. Wickström and K. Fredga, 1992. Growth of eel in a mesoscale experiment. Irish Fish. Invest. Series A.(freshwater), No 36: 88-101.

Höglund J., J.Andersson, H. Wickström and M. Reizenstein, 1992. The distribution of *Anguillicola* in Sweden and its association with thermal discharge areas. Irish Fish. Invest. Series A.(freshwater), No 36: 143-150.

Johansson,L. and Kiessling, SA.. 1991. Effects of starvation on rainbow trout. II. Eating and storage qualities of iced and frozen fish. Acta Agric. Scand. 41:207-216.

Johansson,L., Kiessling , A. and Carlsson, R., 1991. Eating quality and growth of rainbow trout (*Oncorhynchus mykiss* Walbaum) on feed with different admixtures of leaf nutrient concentrate. J. Sci. Food Agric. 57:217-234.

Kiessling, A. Kiessling,K-H.., Storebakken,T. and Åsgård,T., 1991. Changes in structure and function of the epaxial muscle of rainbow troout (*Oncorhynchus mykiss*) in relation to ration and age.II.

Kiessling,SA., Åsgård,T., Storebakken,T., Johansson,L. and Kiessling,K.H., 1991. Changes in the structure and function of the epaxial muscle of rainbow trout (*Oncorhynchus mykiss*) in relation to ration and age II: Chemical composition. Aquaculture, 93:373-387.

Mäkinen,T., (editor). Marine Aquaculture and Environment. Nord. 1991:22. 126 pp ISBN (Sweden) 91 7996 348 x.

Pickova,J. and Larsson,P.O. 1992. Rearing experiments with cod. Comparison between Baltic cod and Skagerrak coastal cod. ICES Doc. C.M. 1992/F:12

Stefansson,S.O., Björnsson,B.T.,Hansen,T., Haux,C.,Taranger,G.L. and Saunders, R.L., 1991. Effect of photoperiod during parr-smolt transformation on sexual maturation in Atlantic salmon. In: Reproductive Physiology of Fish. Proc. of the 4th ISFR. p. 173.

Stefansson,S.O., Björnsson,B.T.,Hansen,T., Haux,C.,Taranger,G.L. and Saunders, R.L., 1991. Growth, parr-smolt transformation and changes in growth hormone in Atlantic salmon (*Salmo salar*) under different photoperiods and subsequent survival, growth and incidence of early maturation in sea water. Can. J. Aquat. Sci. 48:2100-2108.

Taranger,G.L., Haux, C., Walther,B.T. Stefansson,S.O. Björnsson, B.T. and Hansen, T., 1991. Photoperiodic control of growth , incidence of sexual maturation and ovulation in adult Atlantic salmon. In: Reproductive Physiology of Fish. Proc. of the 4th ISFR. pp 145-147.

Wallin, M., L. Håkansson och J. Persson, 1992. belastningsmodeller för närsaltsutsläpp i kust-vatten. Speciellt fiskodlingars miljöpåverkan. (Nutrient loading models for coastal waters- especially for the assessment of environmental effects of marine fish farms. Nordiske Seminar- og Arbejdsrapporter 1992:502. Nordisk Ministerråd. ISBN Sverige 91 7996 422

United Kingdom (compiled by Brian Spencer, Conwy)

Alvarez, J.C. 1993. Spanish grower plans big increase in production. Fish Farming International, July,pp. 46-47.

Anderson, I. 1993. Aliens slip through the international safety net. New Scientist, July 3rf, p.5.

Anonymous, 1993a. Israel's fish at risk from escaping sturgeon. New Scientist, July 10th, p. 10.

Anonymous, 1993b. Seagulls do the dirty on Dutch shellfish trade. New Scientist, Sept. 11th, p.8.

Aqua-Fact 1993. Sources of impact and Envrionmental Impact Assessments. Aqua-Facts Reprot, Aqua-Fact International Services Ltd.

Bailly, D. 1989. Economic and social aspects of shellfish basin management. In OECD pp. 314-326. Aquaculture - A review of recent experience. OECD, Paris.

Bary, B.M. 1986. Ireland's Oceanography - a help or a hindrance for fish farming? European Aquaculture Society, Special Publication 12: 94-126.

Bayne, B.L., Hawkins, A.J.S. 1992. Ecological and physiological aspects of herbivory in benthic suspension-feeding molluscs. pp. 265-288. In: D.M. John, S.J. Hawkins, J.H. Price (eds.). Plant-animal interactions in the marine benthos. Clarendon Press, Oxford.

Bederman, D.J. 1990. International control of marine "pollution" by exotic species. Ecol. Law Q. 18(4): 677-717.

Bidwell, R. 1992. Sustainability: The link between conservation and economic benefits. Environ. Impact Assess. Rev. 12: 37-47.

Buchanan, J. 1993. The importation of half-grown Pacific oysters for relaying in Ireland. Scottish Fish Farmer August, pp. 2-5.

Clement, O. 1989. Aquaculture: a bright future for the wetlands of Western France? pp. 122-128. In: OECD. Aquaculture - a review of recent experience. OECD, Paris.

Costanza, R., Kemp, W.M., Boynton, W.R. 1993. PRedictability, scale and biodiversity in coastal and estuarine ecosystems: implications for management. Ambio 22(2-3): 88-96.

Dahlback, B., Gunnarson, L.A.H. 1981. Sedimentation and sulphate reduction under a mussel farm . Mar. Biol. 63: 269-275.

De longh, H.H., Van Zon, J.C.J. 1993. Assessment of impact of the introduction of exotic fish species in north-east Thailand. Aquacullture and Fisheries Management 24: 279-289.

Department of the Envrionment 1992. Coastal zone protection and planning. CM 2011, HMSO, London.

Edwards, E. 1993a. Species introductions face tough controls. Fish Farming International 20(6): 17.

Edwards, E. 1993b. Farmers are facing tighter controls. Fish Farming international August, pp. 44-45.

Eng, C.T. 1989. The environmental impact of aquacullture and the effects of pollution on coastal aquaculture development in Southeast Asea. Mar. Poll. Bull. 20(7): 335-343.

Eno, C., Mitchell, R. 1989. The conservation implications of the introduction of the non-native Manila clam for shellfish farming. NCC Special Report, Petersborough.

Earll, R. 1992. A sustainable shellfish aquaculture Industry. Marine Conservation Society Conservation Position Statement.

Fetterolf, C.M. 1993. The Laurentian Great Lakes: Can further introdcutions of exotic species be controlled? Paper presented at the FSBI Annual Symposium, Conwy, UK.

Fish Farmer 1993. "Catch 22" on effluents in EC. Fish Farmer May/June, pp. 10-11.

Fish Farming I nterenational 1993. Capacities of coasts will restrict shrimp farm developments. Fish Farming International July, pp. 66-67.

Fountaine, T.D., Stewart, D.J. 1992. Exploring the effects of multiple management objectives and exotic species on Great Lakes food webs and containment dynamics. Environmental Management 16(2): 225-229.

Frid, C.L.J., Mercer, T.S. 1989. Envrionmental monitoring of caged fish farming in macrotidal environments. Mar. Pollut. Bull 20(8): 379-383.

Galbraith, C. 1992. Mussel farms: their management alongside Eider ducks. Nature Conservancy Council, Petersborough.

Gubbay, S. 1992. Progress and opportunities for advancing marine nature conservation through coastal zone management in the United Kingdom. Aquait Conservation: Marine and Freshwater Ecosystems 2: 357-367.

Gubbay, S. 1993. Coastal zone management and the North Sea ministrerial conferences, WWF, London.

Hickey, M., Hurst, J.W. 1989. Molluscan shellfish introductions. J. Shellfish Res. 8(2): 465-466.

Hogger, J.B. 1986. Aspects of the introduction of "signal crayfish", Pacifastacus leniusculus (Dana) into the southern United Kingdom. Aquaculture 58(1): 27-44.

Holmer, M., Kristensen, E. 1992. Impact of marine fish cage farming on metabolism and sulphate reduction of underlying sediments. Mar. Ecol. Progr. Series 80(2): 191--201.

Institute of Offshore Engineering 1991. A review of the nature conservation implications of molluscan shellfish farming. A Report prepared for the NCC.

Iwama, G.K. 1991. Interactions between aquaculture and the environment. Crit. Rev. Environ. Control 21(2): 177-216.

Lee, S.Y. 1992. The management of traditional tidal ponds for aquaculture and wildlife conservation in Southeast Asia: problems and prospects. Biological Conservation 63: 113-118.

Leonard, D.L. 1989. The quality of shellfish growing waters on the east coast of the United States. World Aquaculture 20(3): 54-55.

Lim, S. 1991. Environmental impact of salmon farming on the benthic community in the Bay of Fundy. Bull. Aquacult. Assoc. Canada 9(3): 126-128.

Lloyd, M.G., Livingstone, L. 1991. Marine fish farming, planning policy and the environment. Scottish Geographical Magazine 107(1): 52-57.

Lumb, C. 1989. Self-pollution by Scottish salmon farms? Mar. Pollut. Bull. 20(8): 375-379.

Mazurie, J., Claude, S., Flassch, J.P., Pageot, R., Glize, P. 1993. Epidemiology of the Brown Ring disease of the Manila clam, *Tapes phillipinarum*, in teh main natural stocks and cultivation areas in France, from 1987 to 1992. European Aquaculture Society Special Publication 19: 37.

McCoy, H.D. 1989. Commercial aquaculture zones. A legislative proposal. Aquaculture Maganzine 15(6): 39-46.

McNab, A. 1987. An environmental assessment of fish farms. Cobham Resource Consultants, Abingdon, UK.

Meikle, S., Spencer, R. 1992. Shellfish farming and the environment in Scotland. Scottish Wildlife and Countryside Link, Perth, UK.

Mestel, R. 1993. Foreign sea life floods through the Golden Gate. New Scientist, August 21st, p.7.

Mills, E.L., Leach, J.H., Carlton, J.T., Secor, C.L. 1993. Exotic species in the Great Lakes: A histor of biotic crises and anthropogenic introductions. J. Great Lakes Res. 19(1): 1-54.

Milne, H., Galbraith, C. 1986. Predation by eider ducks on cultivated mussels. Department of Zoology, Aberdeen University, Scotland.

Ministry of Agriculture Fisheries and Food, 1982. Bonamia, a new threat to the native oyster fishery. Fisheries Notice 71, Lowestoft, Scotland.

Mojica, R., Nelson, W.G. 1993. Environmental effects of a hard clam (Mercenaria mercenaria) aquaculture site in the Indian River Lagoon, Florida. Aquaculture 113. 313-329.

Pemberton, D., Shaughnessy, P.D. 1993. Interaction between seals and marine fish-farms in Tasmania, and management of the problem. Aquatic Conservation 3: 149-158.

Peterson, C.H., Summerson, H.C., Fegley, S.R. 1987. Ecological consequences of mechanical harvesting of clams. Fisheries Bull. 85(2): 281-298.

Priyan, R.D., Smith, H.D. 1993. EIA as a mangement tool for the use of chemicals for fish farming in UK. European Aquaculture Society, Special Publ. 19: 501.

Scottish Fish Farmer 1993. Irish fingers burnt over French oysters. Scottish Fish Farmer, June, p.5.

Shpigel, M., Fridman, R. 1991. Propagation of the Manila clam in the effluent of fish aquaculture ponds in Eilat, Israel. Aquaculture 90: 113-122.

Silkin, V.A., Pautova, L.A. 1993. Effect of aquaculture on the environment: impact of plantation of Japanese scallop on taxonomic structure and species succession of phytoplankton. European Aquaculture Society, Special Publication 19: 80.

Tisdell, C. 1991. Development of aquaculture and the environment: coastal conflicts and Giant Clam farming as a case. Intern. J. Environmental Studies 39: 35-44.

Toba, D.R., Chew, K.K., Thompson, D. 1991. Effects of substrate modification on the growth and survival of planted Manila clam seed *(Venerupis japonica)*. J. Shellfish Res. 10(1): 291-298.

Tsutsumi, H. 1991. Benthic faunal succession in a cove organically polluted by fish farming. Mar. Pollut. Bull. 23: 233-238.

Turrell, W.R., Gillibrand, P.A. 1992. Assessing the environmental effect of new and existing fish farms in Scottish sea lochs. SOFD Fisheries Research Services, Repot 3/92.

Walker, T.A. 1993. Island scallops: Farming the Japanese scallop in British Columbia. Aquaculture Magazine, May, pp.38-39.

Wallin, M., Hakanson, L. 1991. Nutrient loading models for estimating the environmental effects of marine fish farms. Nord. 22: 39-55.

Wiegardt, L.J., Bourne, N. 1989. Introduction and transfer of molluscs in the northeast Pacific. J. Shellfish Res. 882): 467-478.

Willan, R.C. 1987. The mussel Musculista senhousia in Australasia: another aggressive alien highlights the need for quarantine at ports. Bull. Mar. Sci. 4182): 475-489.

Appendix 1: Studies related to environmental aspects of Mariculture

Listing of completed, on-going and new projects

During the intersessional period new projects have been initiated on which brief information is provided. As far as possible, the earlier listings have been updated. Projects which have been listed as completed in 1992 are only given by title without any further notes unless late publications have appeared in the literature. Unfortunately, information on progress and completion of listed projects has not been obtained for all those reported in the 1992 Working Group Report. The numbering system has been maintained in order to permit project identification with the former listing and to allow also updating at a later date. Projects which have not yet been reported in any previous Working Group report have been assigned continuing numbers, appear at the end of the table.

No	Project Description	Completion Date	Country and Reference, if any
(1)	Investigation into the effects of fish cage culture on: benthos, hypernutrification, eutrophication, wild fish populations, and bacteria.	Dec. 1990	Denmark **results not reported to WG**
(2)	Algarve: Environmental studies at Faro-Olhao sea agoon "Ria Formosa". Regular monitoring of phyto-plankton; bacterial population in the lagoon, in bivalves; sediment - water column exchange of oxygen and nutrients	mid 1991	Portugal **results not reported to WG**
(3)	Mondego estuary: Regular monitoring of phyto-, zoo-and ichthyoplankton, and of physical conditions; studies on water exchange rates and fish pathology.	mid 1991	Portugal **results not reported to WG**
(4)	Calibration and validation of two ecosystem simulation models with which the carrying capacity for mollusc shellfish culture can be assessed in the Waddenzee and the Oosterschelde estuary.	1991-1994	Netherlands

Research into modelling of the ecosystems of the Wadden Sea, carried out by the Institute for Forestry and nature Research (IBN-DLO), the Netherlands Institute for Sea Research (NIOZ) and the National Institute for Coastal and Marine Management (RIKZ) is continuing. Special attention is also paid to modelling of the role of bivalves: mussels and cockles as well as non-commercial species, as a food resource for birds. Contact: B. Ebbinge (IBN), H. Lindeboom, NIOZ and J. Coosen (RIKZ). Completion date: n.a. Status: on-going

(5)	Research to assess the influence of two types of mollusc dredges, used for for musseland oyster cultivation, on the substrate of natural intertidal mussel beds and cultivation plots.	1992	Netherlands

Status: concluded: Contact person M. van Stralen, RIVO-DLO

(6)	Measurement of in situ production of nutrients and consumption of particulate food by mussels and the communities on cultivation plots.	1996	Netherlands

Status: on-oing , Contact: A., Smaal (RIKZ)

(7)	Research into suitable sites for mussel	completion date: 1996	Netherlands

cultivation in the Oosterschelde in relation with current velocity and food availability.
Status: on-going, reports not yet available. contact: R. Dijkema, see member list

---

(8) Development of a model for regional planning and site selection of mariculture in the coastal zone. The aim is to avoid brackish areas prone to eutrophication effects caused by net cage culture. Measurements of bottom dynamics, hydraulics and biological parameters in the vicinity of fish farms are made. 1990 Finland
Ervik, et al., 1987
Håkansson et al.1988,
Mäkinen (ed.)1991
completed, further reports see Lit-list

---

(9) Project has been deleted from the earlier listing ***(dublication of no 8)***

---

(10) Antibiotics in farmed fish, wild fauna and sediment, and degradation rates of chemicals completed 1988 Finland
Status: terminated; no info on reports

(11-13) No information available, ***completed during 1990*** United States

---

(14) Status reported in Country report 1992 Eastern Canada

---

(15) Letang Inlet aquaculture project continuing
anticipated completion date 1996 Eastern Canada
A summary of the findings to date include: (a)predictions from the hydrodynamic model of regions, (b) nitrogen input by salmon farms; (c) benthic oxygen uptake under fish farms; (d) repsiration of the caged salmon. Details see country report in App. 4.of the 1992 WG-Report. A Technical Report on "Modelling Benthic impacts of Organic Enrichment from Marine Aquaculture" was published in 1994 (Can. Tech. Rep. Fish. Aquat. Sci. 1949, see Literature list)
Contact person: B.T. Hargrave, P.D. Keizer, D.C. Gordon, W. Silvert, all in Habitat Ecology Division, Bedford Inst. Oceanogr., PO Box 1006, Dartmouth, NS Can B2Y 4AZ

---

(16) The effect of blue mussel culture on the benthic environment in Nova Scotia and Prince Edward Island begun 1991
completed 1993 Eastern Canada
Status: No information available to WG in 1994

---

(17) The cause of summer kill in cultured blue mussel begun in1989
completed in 1990 Eastern Canada
Status: Reports are available from Dep Fish. , PEI, Canada

---

(18) Phytoplankton profiles ..... completed1992 Eastern Canada
Status: no references on reports and no contact address presently available to WG

---

(19) Cross contamination of oysters..... commenced in 1989 Western Canada
Status: terminated in 1992, Report see ICES/CM1991: F.23.

---

(20) Plankton watch for marine aquaculture..... Western Canada
Status: terminated 1993; Internal reports available, contact E.A. Black (address see membership list)

(21- 22) Completed, no longer listed,. ***see 1989 WG report*** Western Canada

---

(23)A winter disease profile, survey of a quarter of existing fish farms Western Canada
completed1990, internal reports available, contact E.A. Black, see membership list

---

(24) Antibiotic resistance of pathogens in the vicinity of fish farming completed in 1992 Western Canada
contact E.A. Black: see 1992 report and membership list

---

(25) Marine anemia: a case study of disease transfer between wild and cultured fish..... 1992 Western Canada
Work ongoing

(26) The use of pigments and oxytetracycline to differentiate wild and cultured salmonids..... Western Canada

Work ongoing

(27) A review of the impacts of salmon farming on the phytoplankton..... 1989 Western Canada

Finished and reported in 1990 working group report.

(28) A study of the enriching effects of two salmon farms. 1989 Western Canada

Finished and reported in 1990 working group report.

(29) Serological test for Paralytic Shellfish Poison (PSP)... 1989 Western Canada

Finished and reported in 1990 working group report.

(30) Plankton response to commercial fish feed nutrients. 1990 Western Canada

Finished and reported in 1990 working group report.

(31) Phytoplankton identification video Western Canada

The video is still available from Univ British Columbia, Media Services Department, Vancouver, B.C..Finished and reported in 1990 working group report.

(32) Surveying algal blooms: A compilation and analysis of data on the 1989 Heterosigna bloom 1990 Western Canada

Status: finnished. Contact E.A. Black, see WG Membership Isting in Annex

(33) Experimental demonstration of the existance of Heterosigma toxin. 1990 Western Canada

Status: Finnished and published: Black et al., 1991. J. Appllied Ichthy.

(34) Respiratory response of salmon exposed to Heterosigma akashiwo 1989 Western Canada

Finnished and reported in 1990 working group report

(35) Characterization of the agent causing fish mortalities in Heterosigma blooms. 1989 Western canada

Work continued

(36) Monitoring of shellfish growing areas for Paralytic shellfish poisoning. ongoing Western Canada

This is an ongoing Fisheries Inspection Branch program which issues annual reports covering the occurrence and levels of PSP contamination in various shellfish species along BC's coast.
Contact: E.A. Black, B.C. Ministry of Aquaculture and Fisheries, Victoria, B.C.
Contact Mr. R. Chang, D.F.O. Inspection Branch, 2250 Boundry Rd., Vancouver, B.C., Canada, V5M 4L9

(37) A review of the impacts of salmon farming on benthos. 1989 Western Canada

Finished and reported in 1990 Working Group report

(38) A survey of the effect of B.C. salmon farming on the benthic environment. 1991 Western Canada

Contact E.A. Black

(39) Rate of recovery of the benthic community from the impacts of fish farm sedimentation. 1991 Western Canada

Thesis expected 1992. Contact E.A. Balck

(40) Monitoring of shellfish growing waters for bacterial contamination..... ongoing Western Canada

Contact Mr. B. Kay - as above

---

(101) Chemotherapeutica in fish farming. Optimization of dosage and compounds — completed 1991 — Norway

Several publications have appeared during the intersessional period. Contact address: Svein Olav Hustvedt, AKVAFORSK, Boks 10, 1432 Ås-NLH, Norway

---

(102-106) Projects have been deleted from this list because no further information on their progress could be traced during the intersessional period — Norway

---

(107) Hitra-disease among salmonids, environmentally mediated effects, physiology and morphology — ongoing, until 1992 — Norway

No status report available. Info should be available from the Veterinarinstituttet, Norges Veterinarhogskole, Oslo, Norway

---

(108-114) Projects have been deleted from this list because no further information on their progress could be traced during the intersessional period — Norway

---

(115) The role of benthic fauna in decomposition of organic waste from aquaculture — completion date 1992 — Norway

In this project the dose-response relationship between sedimentation and benthic community is presently studied. No reports have yet been made available

---

(116) Project is deleted from this list because no further information on their progress could be traced since its early listing — Norway

---

(117) Genetic influence of escaped farmed fish on wild populations of Atlantic salmon — completion date 1992 — Norway

No status report available. Info should be obtainable from: Petter Larsson, Zoologisk Museum, Universitetet i Bergen, Museplass 3, 5007 Bergen, Tel. 05-212905 and/or from NINA, Tungesletta 2, N-7047 Trondheim, Tfl. 07-913020

---

(118) Control of escaped farmed fish — completion date 1992 — Norway

No status report available. Info should be obtainable from: Bror Johnsson, Norsk Institutt for Naturforskning, Tungesletta 2, 7047 Trondheim, Tfl. 07-913020

---

(119) Escaped farmed fish - influence on populations of wild Atlantic salmon — completion date 1992 — Norway

No status report available. Info should be obtainable from: Bror Johnsson, Norsk Institutt for Naturforskning, Tungesletta 2, 7047 Trondheim, Tfl. 07-913020

---

(120) Project has been deleted from this list — completed 1990 — Norway

Information on the outcome of the project available from D. Furevik, Havforskinst. Postboks 1870, N-5024, Bergen-Nordnes

---

(121) Development and transfer of resistance against antibiotics — completion date 1992 — Norway

No status report available. Info should be obtainable from: Kåre Fossum, Norges Veterinærhøgskole, Postboks 8146, Dep. 0033 Oslo 1, Tlf: 02-693690

---

(122) The parasitic biology of Caligus elongatus and Lepeophtherius salmonis on farmed salmon untreated for infestation. — completed1990 — Ireland

The objective of this study is to find a method to control sea lice populations without resorting to environmentally damaging pesticides. Information is being collected on the natural rhythm of infestations and parasitic intensity, and population turnover time at different temperatures. A thorough understanding of these processes will, it is hoped, enable more effective physical or biological control of epizootics of these parasites.
Results published: Tully, O. 1989. The succession of generations and growth of the calligid copepod Calligus elongatus and Lepeophtheirus salmonis, parasiting salmon smolts (Salmo salar). J. mar. biol. Assoc. 69: 279-287.

---

(123) The detection of Dichlorvos in the marine environment, its effects on marine ecosystems and lethal and sublethal effects on fish, crustaceans and bivalves. completed1990 Ireland

Results have been reported at conferences, 3 publications appeared: Tully, O. 1999. Detection of dichlorvos in the marine environment and its toxicity to bivalves, crustaceans and fish. Shellfish Res. Lab. Carna, lab Rep. Series B, No. 0062: 11-22.

---

(124) The impact of tributyltin (TBT) residues on mollusc spawning and survival completed 1989 Ireland

(No report has become available)

---

(125) Uptake of antibiotics from salmon farms by edible molluscs completion date 1990 Ireland

(Project has been posponed)

---

*(126) Laboratory studies of the toxicity and sublethal effects of dichlorvos and possible alternatives for sea lice treatment. Field and laboratory investigations of the impact of cichlorvos treatment on non-target organisms, including adult and larval molluscs and crustaceans. completion date unknown Scotland

There is no information on status and interim results of the project available

---

*(128) Recovery of environments exposed to TBT: as part of an on-going monitoring of the impact of TBT on marine life. was active in 1992 Scotland

There is no information on status and interim results of the project available

---

*(130) An investigation into hypernutrification eutrophication with the aim of determining the holding capacity of sea lochs. Hydrographic and modelling studies of sea lochs. The impact of farming operations on benthic communities ***completed*** Scotland

Report : R.J. Gowen and I.A. Ezzi 1992: "Assessment and prediction of the potential for hypernutrification and eutrophication associated with cage culture of salmonids in Scottish coastal waters." Report available from: Dunstaffnage Marine Laboratory, Oban, Scotland, 136 pp.

---

(131) project terminated in 1988, Thesis prepared by F. Johnson, available from Stirling University, Scotland

---

Projects listed as NEW in the 1992 WG report

---

*132 Effects of cage culture in tropical marine environments 1990-1992 Contact: H. F. R. Germany Rosenthal, Kiel P. Krost, Kiel

The study takes place in the Gulf of Acaba (Eilat, Red Sea) as part of the German-Israeli Cooperation Program and uses newly developed vidio imagery technique in combination with well established methods to budget environmental parameters altered by cage culture of sea bass and sea bream.

Study completed in1993. First internal report available, publication planned in 1994

---

*133 Kiel cage performance The project aimed at optimizing feeding strategy under widely fluctuating temperatures and oxygen levels (farm situated in the waste heat plume of a coastal power station. 1990-1991 completed in 1992 F.R. Germany

Projects reports (in german) are available from the Dep. of Fishery Biology, Univ. Kiel. Interim results were presented as Doc. ICES. C.M. F:1990. For further details see country report.in WG Rep 1992

---

*134 Sedimentation under cages in a non-tidal inlet — 1991, completed — F.R.Germany

Changes in sediment geochemistry and in benthos composition have been demonstrated. A publication is presently under preparation. contact: H. Rosenthal, Dep. Fishery Biology, Univ. Kiel., Manuscript submitted to J. appl. Ichthyology 1994

---

*135 Effects of intermittant (tidal) oxygen depletion on Pacific salmon
Aim: establishing an ethnogram that permits to identify early warning sings in stressed fish — 1991-1993 — F.R.Germany, Western Canada

contacts: Dr. U. Waller, Dep. Fishery Biology, Univ. Kiel. For further details see country report for Germany ; Publication in preparation, expected to appear in 1995

---

*136 Oyster culture site selection and monitoring program for New Brunswick — Eastern Canada, begun in 1988, anticipated completion 1995

A collaborative program involving the New Brunswick Dep. of Fisheries &Aquaculture, Canada Dep. of Fisheries and Oceans, &the Environmental Res.Unit of the Université de Moncton with the oyster growers. For details see Canadian Country Rep. Contact Person: Dr. A.Boghen, Dep.Biology, Université de Moncton, Moncton, New Brunswick.

---

*137 Determination of metabolites produced by three marine, non-salmonid fish species — ongoing — France

Investigation on nitrogen end products by marine fish — contact Mr Dosdat IFREMER

---

*138 Modelling of nutrient effluents in marine fish farms — ongoing — France
contact: Mr. Dosdat, IFREMER

Study conciders turbot and sea bass; conditions followed are: Fish farm management, nutritional requirements and resulting environmental parameters

---

*139 Reduction of fish farm effluents through improved nutrition — ongoing — France
contact: Mr. Dosdat, IFREMER

Study on nitrogen digestibility of feeds and their energy content; estimation of marine fish phosphorus metabolism, excretion and requirements.

---

*140 Potential interaction between shellfish and finfish culture — ongoing in 1994 — France
contact: Mr. Merceron, IFREMER

Study on accumulation of antimicrobials in farmed shellfish, Analysis for pathogenic bacteria, Study on transfer of faeces &organic matter from various origin (eg shellfish, finfish, phytoplankton, sewage) in relation to suspended solid output from finfish culture

---

*141 Characterisation of organic matter derived from fish faeces under culture conditions — ongoing in 1994 — France
contact: Mr. Dosdat, IFREMER

The studies considers sedimentation rates from turbot and sea bass farms as well as leaching of material (laboratory study).

---

* 142 Impact of nutrient release on the environment (Channel, Mediterranean) — ongoing in 1994 — France
contact: Mr. Merceron, IFREMER

The study employs hydrodynamic and primary production models for macro-tidal Atlantic environments as well as Mediterranean situations

---

*143 Causes of summer mortality in Atlantic salmon smolts — completed — France
contact:M. Merceron, IFREMER, Brest

The study is concerned with the "fade disease" , a condition in which fish show mortality and very low appetite

---

*144 Preliminary research on indsutrial offshore fish farming in the Mediterranean coastal zone — completed — France

contact: A.Febvre, IFREMER, Chemin de Maguelone, 34250 Palavas les Plots

---

*145 Estimation of nutritional needs and quantification of wastes for cultured shellfish species — ongoing — France
contact: Mr. Heral, IFREMER

Studies on nutritional requirements of oysters, mussels and Manila clam and their competitors (Crepidula, zooplankton, etc) in relation to environmental factors (salinty, temperature, food quality)

---

*146 Nutrient flux in coastal areas (Northern Brittany) completed France
contact: Mr. Piriou, IFREMER Brest, DEL, BP 70, 29280PLOUZANE
Modelling of nutrient flux between open ocean and inshore areas, including estuaries. Models aimed at describing the evolution of impacts in order to improve ecosystem management approaches in relation to human resource uses

---

*147 Evaluation of the return of escaped salmon to the River Polla 1989-1990 Scotland
contact: Dr. Youngson, Aberdeen
The project has been extended to include the second year following their escape. Evaluation of the genetic consequences of the spawning of escaped salmon in the Polla in 1989 and 1990. publications have appeared in 1993-1994

---

*148 Distribution of the progeny of female salmon which have escaped from aquaculture ongoing Scotland
contact: Dr. Youngson, Aberdeen
Fry bearing canthaxanthin were detected in 14 of 16 western and northern Scottish rivers. Overall, 5% carried canthaxanthin. publications see literature listing 1994

---

*149 Studies of structuring among wild salmon populations ongoing Scotland
contact Dr. Youngson, AberdeenSOAFD Marine Laboratory

---

*150 Investigation of the factors affecting the rate of recovery of the benthic environment at abandoned fish farm sites **new project** four years from1992 onward Scotland
Contact: Dr. A. Bullock , Dunstaffnage Marine Lab Oban
Interim reports not expected prior to fall 1993 /spring 1994

---

*151 Development of analytical methods for the determination of antibiotic residues in sediment and biota at Scottish fish farms, including field studies at 3 farms in Shetland **completed** Scotland
Report available from: J.C. McKie, SOAFD Marine Laboratory, Aberdeen

---

*152 Development of mathematical models of water circulation and dispersion in Scottish sea lochs, to assist in the assessment of the carrying capacity of lochs for farmed fish ongoing Scotland
Contact address: Dr. I.M. Davies, SOAFD Marine Laboratory, Aberdeen

---

*153 Development of mathematical models of the interaction between sea bed sediments and water quality in Scottish sea lochs new project start 1992 Scotland
Contact address: Dr. I.M. Davies, SOAFD Marine Laboratory, Aberdeen

---

*154 Improvement in the control measures for furunculosis continuing Scotland
Objectives: (a) Development of an effective vaccine and optimising immunisation regimes; (b) Identification of more effective antimicrobial compounds; (c) Improvement in epidemiological knowledge in wild and farmed populations with the objective of improved husbandry methods of control. Contact Address: Dr. A.L.S. Munro, SOAFD Mar. Lab., PO Box 101, Victoria Rd, Aberdeen AB9 8DB

---

*155 Vaccination of salmon against sea lice continuing Scotland
Objective: To develop an effective vaccine against sea lice infestation. Contact Address: Dr. A.L.S. Munro, SOAFD Mar. Lab., PO Box 101, Victoria Rd, Aberdeen AB9 8DB

---

*156 Diseases in wild and farmed fish continuing Scotland
Objective: Establish if any correlation exists between disease in farmed fish and the recent decline in catches of wild salmon and sea trout. Contact Address: Dr. A.L.S. Munro, SOAFD Mar. Lab., PO Box 101, Victoria Rd, Aberdeen AB9 8DB

*157	Examination of the fatty acid and pigment composition of feral fishes at and remote from fish farm sites to determine if wild fish populations are consuming uneaten commercial salmon feed at salmon farms.	1992	Western Canada

A report is expected by September 1992. For detailed information contact Dr. D. Hay, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C.

*158	An examination of the behavior of fish in and around salmon culture cages in response to a number of biotic and abiotic stimuli.	1992	Western Canada

A report is expected in Nov.1992. For detailed information contact Dr. K. Groot, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C.

*159	Determination of whether the disease marine anemia may be transmitted from farmed salmon to Sockeye salmon or other wild non—salmonid population. Also some initial work on tests for the sub—clinical occurrence of this disease.	1993	Western Canada

A report is expected in April 1993. For detailed information contact Dr. M. Kent, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C.

*160	Determination of the mechanism of fish mortalities associated with blooms of the algae Heterosigma akashiwo.	1993	Western Canada

A report is expected in April 1993. For detailed information contact Dr. N.J.C. Whyte, Dep.of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C.

*161	A Study of how the timing of fish feeding affects growth of cultured salmon and the amount of waste feed produced.	1993	Western Canada

A report is expected in April 1993. For detailed information contact Dr. H. Krieberg, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C.

*162	Field and Laboratory test to determine if the Pacific Oyster is likely to take up lipid and water soluble antibiotics from the medicated fish feed used on samlon farms.	1991	Western Canada

A report has been recieved and is summarised in ICES CM 1991. For further details contact E.A. Black (for address see WG membership list).

*163	A survey for the occurrence of farmed Atlantic salmon in the rivers of B.C.	1993	Western Canada

A report is expected in April 1993. For detailed information contact Dr. K. Groot, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C.

*164	An examination of the frequency ofoccurrence of salmon which have eaten commercial salmon feed on the redds of wild salmon populations.	1993	Western Canada

A report is expected in April 1993. For detailed information contact Dr. N.J.C. Whyte, Department of Fisheries & Oceans, Pacific Biological Station, Nanaimo, B.C.

*165	A study of the effects of crowding, starvation and stress on the severity, time to onset and incidence of Marine Anemia.	1993	Western Canada

A report is expected in April 1993. For detailed information contact Dr. M. Kent, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C.

*166	A Study to examine the viability of progengy from the hybridization of Atlantic and Pacific Salmon.	1994	Western Canada

A report is expected in April 1994. For detailed information contact Dr. R. Devlin, Dep.of Fisheries & Oceans, West Vancouver Laboratory, West Vancouver, B.C.

*167	A study of the site characteristcs associted with salmon farm sites which have little sedimentation under the cages.	1994	Western Canada

A report is expected in April 1994. For detailed information contact C. Backman, B.C. Ministry of Agriculture Fisheries and Food, Courtney, B.C.

---

*168 A survey of the seasonal occurence of diseases on salmon Farms in B.C. 1993 Western Canada

A report is expected in September 1993. For detailed information contact Dr. R. Armstrong, B.C. Ministry of Agriculture Fisheries and Food, Abbotsford, B.C.

---

*169 A Survey of the types and frequency of predation on farmed salmon, and the effectiveness of mitigative techniques. 1993 Western Canada

A report is expected in September 1993. For detailed information contact W. Harrower, B.C. Ministry of Agriculture Fisheries and Food, Courtney, B.C.

---

*170 A review of the effect of algal blooms on the shellfish industry in B.C. with discussion of possible mitigative measures. 1993 Western Canada

A report is expected in September 1993. For detailed information contact Dr. W. Heath, B.C. Ministry of Agriculture Fisheries and Food, Courtney, B.C.

---

*171 Development of a ensiling technology to dipose of fish mortalities on salmon farms. 1993 Western Canada

A report is expected in September 1993. For detailed information contact J. Willow, B.C. Ministry of Agriculture Fisheries and Food, Victoria, B.C.

---

*172 Response of benthic comminuties to organic enrichment from salmon cages. Dates 1990-1992 Maine, USA

Includes sediment trap data, microbiological processes, effects on benthic species composition.

Contact: Dr. Les Watling and Robert Findlay, University of Maine , Tel: (207) 563-3146 Darling Marine Center, Walpole, Maine 04573 U.S.A.

Status: measured rates of carbon accumulation were much less than predicted by existing models. Low current sites exposed to waves were compared with high current, sheltered sites.

---

*173 Rigorous evaluation of the role of computer models in the environmantel regulation of net-pen aquaculture, uses physical computer models at two contrasting Maine sites to aid in "bay-wide" regulation of salmon farms in Maine. Dates: 1992-1993 Maine, USA

Contact: Dr. Vijay Panchang and Carter Newell, Dept. Civil Engineering, University of Maine , Phone (707) 581-1110, Orono, Me. U.S.A. 04469

---

*174 Underwater video assessment of the effects of trout cages on lobster populations. Dates: 1990-1991 United States

Contact: Dr. Robert Bayer, Dept. Animal, Veterinary and Aquatic Sciences, University of Maine, Orono, Me.04469 Phone (707) 581-1110

Status: There was an increase in the number of lobsters near a small trout culture operation.

---

*175 Development of a model to seed mussel bottom leases to their carrying capacity. Dates: 1987-1991 United States

Contact: Carter Newell, Great Eastern Mussel Farms, PO BOX 141, Phone 707-372-6317, Tenatz Harbor, Me. U.S.A. 04860

Site specific two-dimensional flow models coupled with vertical transfer of particulate food and mussel growth predicts optimal seeding density for mariculture sites. A separate finite difference model predicts depletion contours in relation to current speed, water depth and mussel biomass.

---

*176 Antibacterial agents in the marine environment. completion Dec 1993 Norway

Description: Investigation on: 1) the stability of several antibacterial agents in sea water and marine sediments, 2) metabolism of oxylinic acid and flumequin in salmon, 3) investigation of residues in wild fish sampled in farms with feed-collector/detector. Contact person: Arne Ervik Inst.of Mar. Research, Norway

*177 Effects of chemotherapeutics on the environment of fish farms — completed Apr 1993 — Norway

Investigate the decomposition of different antibacterial agents in use. Develop toxicological environmental tests to predict the effects of new agents. contac person H. Hektoen, NIVA, Postboks 69, Korsvoll, 0808 Oslo 822

*178 Genetic adaptations among strains of salmon. — 1992-93 — Norway

Modelling different impact of the genetic properties. Contact person: H.B. Bentsen, AKVAFORSK, N-6600 Sundalsøra

*179 Identification of escaped farmed salmon: studies of DNA — 1992-94 — Norway

Ongoing: contact person K. Hindar, NINA, Tungesletta 2, 7047 Trondheim

*180 Sediment- chemical studies of the recovery of fish farm sites — 1992-93 — Norway

Investigation of the correlation between pH, Eh and pS in the sediment and remineralization of organic materials.
Contact- M. Frog, Nordlandsforskning, Postboks 6003, N-8016 Mørkved

*181 Effects of salmon lice infection from fish farms on wild populations of salmon — 1992-94 — Norway

Ongoing: contact P.J. Jakobsen, Zoologisk Museum, Museplass, N-5007 Bergen

*182 Epidemioologic investigations of connections between environmental factors. — 1992-94 — Norway

Ongoing: contac person H. Hektoen, NIVA, Postboks 69, Korsvoll, 0808 Oslo 822

*183 Analysis of the reason for different resistance towards furunculosis in salmon. — 1992 — Norway

Ongoing; contact person T. Gjedrem, AKVAFORSK Postboks 10, N-1432 Ås - NLH

*184 Furunculosis in populations of wild salmon — 1991-93 — Norway

Ongoing: contact person B. Johnsson, NINA, Tungesletta 2, 7047 Trondheim

*185 Fish health and infrastructure in fish farming industry. — 1991-93 — Norway

Ongoing: contact person Fiskerisjefen i Møre og Romsdal, N-6000 Aalesund

*186 Environmental hygiene in fish farming . — 1992-94 — Norway

Ongoing: contact J. Glette, Havfforsk.Inst.Postboks 1870, 5024 Bergen-Nordnes

*187 Survival and transport of Areomonos salmonicida n the marin environment. — 1991-93 — Norway

Ongoing, contact person: J. Goksøyr, IMP Allegt 70., N-5000 Bergen

*188 Spread of furunkulosis by latent carriers — 1991-93 — Norway

Ongoing, contact person S. Høie

*189 Stock assessments of mussels and cockles in the Dutch coastal waters in order to determine the carrying capacity for molluscs-eating birds — 1995 ongoing — Netherlands

Ongoing, Contact person. Dr. Renger Dijkema (see Country Rep in WG Rep 1992)

*190 Stadies into waste production of intensice eel culture reccirculating systems — 1994 — Netherlands

Starting in 1992, contact Dr. Renger Dijkema (see Country Rep in WG Rep 1992)

NEW Projects (1994): not in previous WG Reports

191 Modelling carrying capacity of Marennes-Oleron Basin. ongoing France
Natural environment processes (advection, primary production, competitors) and molluscs physiological parameters (filtration rates, faeces and pseudo-faeces formation) are investigated.
Contact: Mr. Heral, IFREMER/CNRS, CREMA, 17137 L'HOUMEAU

---

192 Environmental quality monitoring network (RNO) of the french coast. ongoing France
Seawater quality parameters through 130 stations in France, metallic and organic contaminants in living animals, sediment quality.
Contact: Mr. Claisse, IFREMER, Nantes Center, BP 1049 , 44037 NANTES

---

193 Microbiological monitoring network (REMI) of shellfish farming zones. France
Aimed at keeping the sanitary level of products on 300 sites.
Contact: Mrs. Miossec, IFREMER Nantes Center, BP 1049 , 44037 NANTES

---

194 Phytoplancton monitoring network (REPHY) of coastal zone. France
System aimed at alerting in case of toxical risk for human and marine health on 30 sites in researching toxic species.
Contact: Mrs. Belin, Nantes Center, BP 1049 , 44037 NANTES

---

195 Shellfish health and growth monitoring network (REMORA). France
Test oysters are placed in 15 ongrowing sites and observed once a year. Give an integrated value of the environmental quality.
Contact: Mr. Mazurie, IFREMER, BP 26, 56470 LA TRINITE SUR MER

---

196 Carbon, nitrogen and phosphorus mass balance in a shellfish semi closed basin (Thau lagoon). France
Environmental modelling of shellfish interactions, modelling oxygen cycles, evolution of suspended micro organisms.
Contact: Mr. Deslous-Paoli, IFREMER, 34200 SETE

---

197 Recycling systems as a tool to reduce fish farm effluents. France
Improvement of biofilters, selection of nitrification bacterial strains, development of denitrification reactors, secondary treatments in order to reduce fish farm loadings and permit farming activity onshore in land-based facilities.
Contact: Mr. Blancheton, IFREMER, GIE RA, 34250 PALAVAS LES FLOTS

---

198 Self pollution assesment concerning ammonia and oxygen. France
Effects of ammonia and oxygen levels on physiological status of marine fish.
Contact: Mrs. Person, IFREMER Brest DRV , BP 70, 29280 PLOUZANE

---

199 Fish farming chemotherapy France
Behaviour of antibiotics & other vetproducts in marine &freswater environments.
Contact: Mr. Le Bris, Ecole Veterinaire de Nantes, BP 3013 44087 NANTES

---

200 The status of salmon and trout stocks in the Baltic and on the west-coast of Sweden. Sweden
Objective: Annual assessment of salmon- and trout stocks. Continuing, no time limit.
Project leader: Lars Karlsson Salmon Research Institue, S-810 70 Älvkarleby, Sweden

---

201. Population genetic investigations of salmon and trout. Ongoing Sweden
Objective: By studying the genetic variation of natural and hatchery raised smolts to get knowledge for managing and conserve the genetic diversity. No time limit.
Project leader: Håkan Jansson,Salmon Research Institute S-810 70 Älvkarleby Sweden

---

202 The migration pattern of salmon at delayed release. Time frame:1990-1996 Sweden
Objective: To determine if delayed release of smolts is profitable to promote fisheries.
Project leader: Curt Eriksson, Salmon Research Institute, S-810 70 Älvkarleby,Sweden

203. Strategies to prevent disease dispersal when stocking white fish in areas close to salmon and trout rearing. Time frame: 1992-1995 Sweden

Objective: To minimize the risks for spreading diseases to salmonin in connection with cultivation of white fish for stocking purposes.
Project leader: Nils Johansson,Salmon Research InstituteS-810 70 Älvkarleby,Sweden

---

204 Reproduction problems in conncetion with M 74, an unidentified disease - 6 different projects. started 1993 termination?? Sweden

Objectives: 1)To elucidate the cuauses and mechanisms behind M 74-mortality. 2) To get knowledge for prognoses and selection of females which will produce offsprings with M-74 mortality. 3) To elucidate causes and develop methods and culture technique to decrease juvenile mortality among individuals with partial M74 mortality. T
Project leader Hans Börjesson, Salmon Research Institute, S-810 70 Älvkarleby, Sweden

---

205. Many projects in tropical areas dealing with fishculture, integrated shrimp farming, farming in mangrove areas, environmental impacts of aquaculture. 1992 plus Sweden

Project leader : Nils Kautsky , Stockholm University, S-10691 Stockholm, Sweden

---

206. Toxic environmental pollutants- collection, extraction, separation, toxicity testing and chemical characterisation of liphopjhilic extracts from abiotic and biotic samples from the Baltic. started 1994 continuing Sweden

Project leader: Dag Broman, Stockholm University, S-10691 Stockholm, Sweden

---

207 Altered bleaching process- Changes in the water recipient. started 1993 continuing Sweden

Project leader: Dag Broman.
Stockholm University, S-10691 Stockholm, Sweden

---

208. Biological effects of fractionated extracts from sediment including identified and unidentified organic compounds and chemical characterisation of potent fractions. started 1993, ongoing Sweden

Project leader: Dag Broman, Stockholm University, S-10691 Stockholm, Sweden

---

209. Stocking a coastal Baltic Sea area with pikeperch- a possibly economically profitable way to improve water quality. Proposed project, not yet implemented Sweden

Project leader Sture Hanson, Stockholm University, S-10691 Stockholm, Sweden

---

210. Restoration of coastal waters and fiords by the application of mussel farming. Sweden
Project leaders: Haamer, Edebo,Molander,Oskarsson.
Proposed project, soon to be implemented
Gothenburgh University, Department of Oceanography, Box 4038, S-400 40 Göteborg, Sweden.

---

211. The distribution of *Angillicola* in Sweden and its association with thermal discharge areas. Sweden

Project leaders: Inge Boethius, Jan Höglund and K. Holmgren. The national Vetrinary Institute, Swedish National Environmental Protection Agency, Coastal Laboratory, Institute of Freshwater Research. Time frame 1989- until present; Published papers; see reference list.

---

212 A study on the relation between eutrophication of the Wadden Sea and growth and condition of mussels. completion Dec1994 The Netherlands

Exact landing statistis of mussels make good time-series possible of mussel condition in a number of production areas since the 1950's, which time-span covers the period of increase and supposed decrease of eutrophication.
Contact: M. van Stralen (RIVO-DLO) Status: new, Completion date: 1994

---

213 Monitoring programmes for stocks of cockles and mussel seed are carried out yearly, to provide information on the amount of cockles and mussel seed available to the fishery and to wild birds. The Netherlands

Contact: R. Dijkema (RIVO-DLO) Completion date: perpetuous ,Status: on-going

---

214 National monitoring programmes for bacterial water quality, toxic phytoplankton and biotoxins, which are financed by both the government and the shellfish industry. Completion date: perpetuous The Netherlands

Contact: R. Dijkema (RIVO-DLO) Status: on-going

---

215 Research into effluent characteristics of intensive fish farms (mainly recirculating eel farms) at the RIVO-DLO in IJmuiden is being continued. Completion date: 1997 The Netherlands

Contact: A. Kamstra (RIVO-DLO)

---

216 Development research into the culture of turbot (*Scophthalmus maximus*) is carried out at the RIVO-DLO in IJmuiden 1994- 1997 The Netherlands

A pilot plant for commercial production of turbot, using power plant cooling water, was built and will be started in 1994. Contact: A. Kamstra (RIVO-DLO), Ijmuiden

---

217 Research into suitability of sites for mussel culture in the Wadden Sea Completion date: 1994 The Netherlands

Contact (M. van Stralen (RIVO-DLO) , IJmuiden

---

218 Study on the status of Marine TBT antifouling contamination in Aquaculture areas. 1993 Ireland

Status: paper in press Minchin and Duggan.

---

219 Introductions of exotic species associated with Pacific Oyster transfers from France to Ireland. Ongoing Ireland

Status: Preliminary report to ICES 1993 Statutory Meeting.

---

220 STRIDE Pollution control of freshwater fish, farm effluents 1994 Ireland

Status: Report in preparations (Dr. M. Costello TCD).

---

221 Cleaner fish technology as an alternative to pesticides 1993 Ireland

Status: Completed (Dr. M. Costello TCD).

---

222 The developing of a vaccine for *furunculosis* caused by *A. salmonicida* in Salmonid fish. 1995 Ireland

Scientist in charge Prof. T.J. Foster TCD.

---

223 Fate and sinks of malachite green in the natural environment natural environment. 1994 Ireland

Scientist in charge Dr. James Wilson TCD.

---

224 Study of the rates of recovery in shallow embayments following intensive Aquaculture activities over a 10 year period. 1994 Ireland

Salmon Research Agency Dr. Ken Whelan (projects 7-11)

---

225 Research into the fate of antibiotic residues in the Marine Environment 1994 Ireland

Salmon Research Agency Dr. Ken Whelan (projects 7-11)

---

226 Research into the residency time of certain pathogens under hypoxic and oxic sediment conditions in marine fish farms. report in press Ireland

Salmon Research Agency Dr. Ken Whelan (projects 7-11)

---

227 The role of bioturbaling animals in the fate of antibiotic residues in the marine environment. Ongoing Ireland

Salmon Research Agency Dr. Ken Whelan (projects 7-11)

---

228 A study of temporal changes in the genetic Ongoing Ireland

composition of juvenile salmon populations from selected rivers adjacent to fish farms.

Salmon Research Agency Dr. Ken Whelan (projects 7-11)

228	Vaccination trials	no info presently available	Ireland
229	Phytoplankton species associated with imports of the Pacific Oyster*Crassostrea gigas*, from France to Ireland.	Ongoing	Ireland
	Preliminary Report to ICES 1993		
230	Studies on Sea Trout and interactions with Salmon farms	Report tabled	Ireland
	Publications available, Coyne et al., 1994; Kerry et al., 1994		
231	Fate and impact of antimicrobial agents in marine fish farms Studies on the concentration of the agents and the frequencies of resistance in sediments with respect to area, depth and finess. Influence of sedimentation quality on these factors.	Ongoing	Ireland
	Coyne et al., 1994; Kerry et al., 1994		
232	Reduction in the biological activity of antimicrobial agents in the aquatic environments. Impact of chemical and physical parameters.	Ongoing	Ireland
	Contact: Dr. Peter Smith UCG		
233	Studies of antimicrobial agent resistance in marine micro-flora. Methods of quantitation; factors leading to elevated frequencies. Genotypic and phenotypic characterisation of the resistances selected.	Ongoing	Ireland
	Contact: Dr. Peter Smith UCG		
234	Studies on the development of new techniques of measuring concentrations of biologically active antimicrobial agents in the marine environment.	Ongoing	Ireland
	Contact: Dr. Peter Smith UCG		
235	The influence of benthic fauna on remineralization of organic material from aquaculture.	April 1993	Norway
	Investigation of the quantification of organic material and on the connection between load and effect.		
236	Genetic influence of escaped salmon on strains of wild salmon.	1994	Norway
	Investigation of the spawning success of escaped farmed salmons to evaluate potential genetic interactions with wild salmons.		
237	The fatty acid profile in brain tissue is used as an identification parameter.	1994	Norway
238	Transfer of resistance against antibacterial agents in *Aeromonas salmonicida*.	1995	Norway
	Characterization of two transferable resistance plasmids identified in the furunculosis bacteria.		
239	Transfer of disease between salmon and different marine fish species.	1995	Norway
	Surveillance of escaped farmed salmons.		
240	Investigation of the relative abundance of escapees caught in the sea and in the rivers.	1995	Norway
241	Surveillance, migration and survival of escaped farmed salmon.	1995	Norway
242	Reproductive threat of cultured salmon to wild populations.	1996	N orway

243	Reproductive isolation mechanisms between wild and farmed salmon.	1996	
244	Investigation of the negative effect of escaped farmed salmon on the redds of wild salmon.	1994	Norway
245	Development and transfer of antibiotic resistance.	1993	Norway
246	Pharmacokinetics of different antibacterial agents.	1995	Norway
247	Ecological impact of antibacterial agents and antiparasittic agents used in fish farming industry	1993	Norway
248	Ecological & physiological consequences of sea lice on salmonids in fjords. ***Alternative treatment of salmon lice.***	1994	Norway
249	Studies on environmental suitable methods to reduce the sea lice problem ***Both chemical and biological methods are investigated.***	1993	Norway
250	Biological delousing of salmons. Use of wrasse as cleaner fish.	1993	Norway
251	Preventive and integrated treatment of sea lice. ***Quantifying the effect of syncroniced treatment.***	1995	Norway
252	Impact and performance of Atlantic salmon cage farming in Chile ***Contact: H. Rosenthal, Institute for Marine Research, Kiel University***	1993-1994	Germany
253	Geochemistry of sediments under a cage farm in Kiel Fjord ***Contact: H. Rosenthal, Institute for Marine Research, Kiel University***	1993-1994	Germany
254	Bacteriology of caged fish and sediments under farms along the Baltic coast of Schleswig-Holstein and Mecklenburg-Vorpommern ***Contact: H. Rosenthal, Institute for Marine Research, Kiel University***	1994-1996	Germany

Appendix 2

Working Group on "Environmental Impact of Mariculture"

List of WG Membership, and participation of invited experts and observers in 1994

Professor Dr. H. Ackefors
Dept. of Zoology
Stockholm University
10691 Stockholm, Sweden
Tel: ++46 8 164020
Fax: ++46 8 167715

Dr. David Alderman
Ministry of Agricult., Fishery & Food
Fish Diseases Lab.
14 Albany Rd
Weymouth, Dorset DT 4 9TH
United Kingdom
Tel: ++44 305 772137
Fax: ++44 305 770955

Mr. Jan. Aure
Institute of Marine Research
PO Box 1870
5024 Bergen - Nordnes, Norway

Dr. E. A. Black
Aquaculture and Commercial
Fisheries Branch
808 Douglas Street
Victoria B.C. V8W 2Z7 Canada
Tel: ++?? 604 387 9686
Fax: ++?? 604 356 7280
E-Mail: EBLACK@GALAXY.GOV.BC.CA

Prof. B. v. Bodungen
Institute for Baltic Research
Seestrasse 15
18119 Warnemünde, Germany
Phone: ++49 3 81 5197 200

Mr. P.B. Brito
IPIMAR
Avenida de Brasilia
1400 Lisbon, Portugal

Dr. T. Cross
Dept. of Zoology
University College Cork
Cork, Ireland

Dr. Ian M. Davies
Marine Laboratory
PO Box 101
Victoria Road
Aberdeen AB9 8DB
United Kingdom
Tel: ++44 224 876 544
Fax: ++44 224 295511

Mr. R. Dijkema
Netherlands Institute of
Fisheries Research
PO Box 77
4400 AB Yerseke, The Netherlands
Tel: ++ 31 1131 2791
Fax: ++31 1131 3477

Mr. Antoine Dosdat
IFREMER
Brest Center
Living Resources Dept.
BP 70
Aquaculture Laboratory
29280 Plouzane, France
Tel: ++33 98 224396
Fax: ++33 98 224547

Ms J. Doyle
Dept. of the Marine
Fisheries Res. Centre
Abbotstown
Dublin 15, Ireland
Tel: ++353 01 8210111
Fax: ++353 01 8205078

Dr. L. A. Dushkina
VNIRO
Russian Federal Res. Inst. of
Fisheries & Oceanography
17, Verkhne Krasnoselskaya
Moscow B-107140
B.C. MAFF, Russia

Ms. M. Engelstad
EWOS Aqua A/S
PO Box 424
1471 Skårer, Norway

Mr. Arne Ervik
Institute of Marine Research
Division of Aquaculture
PO Box 1870
5024 Bergen - Nordnes
Norway
Tel: ++47 55 238300
Fax: ++47 55 238333

Dr. Richard FitzGerald*
Aquaculture Development Centre
University College Cork
Cork, Ireland
Tel.: ++353 21 276871 Ext.4936
Fax: ++353 21 274034

Appendix 2

Working Group on "Environmental Impact of Mariculture"

List of WG Membership, and participation of invited experts and observers in 1994

Mr. E. Gaard
Fiskirannsoknarstovan
PO Box 3051, Noatun
FR-110 Torshavn
Faroe Islands
Denmark

Dr. Richard Gowen
Dept. of Agriculture of N.I.
Aquatic Sciences Research Div.
Newforge Lane
Belfast, Northern Ireland
United Kingdom

Ms. M. da Graça Cabeçadas
IPIMAR
Avenida de Brasilia
1400 Lisbon, Portugal

Mr. K. Grave
Norwegian College of Vet. Medicine
POBox 8146 Dep.
0033 Oslo 1, Norway

Dr. M. Héral
IFREMER
B.P. 133
17390 La Tremblade, France
Fax: ++33 46 361847

Mr. Marc Kempf*
IFREMER
Brest Center
Div. Environment Littoral
BP 70
29280 Plouzané, France
Tel.: ++33 98 224322
Fax: ++33 98 224548

Mr. H. Kryvi
Ministry of the Environment
PO Box 8013, Dep.
0030 Oslo, Norway
Tel.: ++47 22 345891
(or: ++47 55 237787)
Fax: ++47 22 349560

Dr. Reinhard Lauterbach
Landesforschungsanstalt für Landwirtschaft & Fischerei, Mecklenburg-Vorpommern, Inst. für Fischerei
An der Jägerbäk 2
18069 Rostock-Marienehe
Germany
Fax.: xx49 381 82 091

Dr. Tony Lewis*
Dept. of Civil Engineering
Hydraulics & Maritime Res. Centre
Munster Institute
Cork
Ireland

Dr. Timo Mäkinen
Finnish Game &Fisheries Res. Inst.
Fisheries Division
PO Box 202
SF-00151 Helsinki
Tel: ++358 0 624211
Fax: ++358 0 631513

Mr. P. Margonski
Sea Fisheries Institute
Gdynia, Poland

Mr. J. Menezes
Inst. Nacional de Investigação das Pescas INIP
Avenida de Brasilia
1400 Lisbon
Portugal

Mr. M. Merceron
IFREMER
Brest Center
Environment Dept.
BP 70
29280 Plouzané
France
Tel: ++33 98 224347
Fax: ++33 98 224548
E-Mail: merceron@ifremer.fr

Mr. Pedro Monteiro
Sea Fisheries Res. Institute
Private Bag X2
Cape Town 8012
South Africa
Tel.: ++27 21 4396160
Fax: ++27 21 4399345
E-Mail:
MONTEIRO@SFRI_2.SFRI.AC.ZA

Mr. Carter Newell
Great Eastern Mussel Farms
PO Box 141
Long Cove Road
Tenants Harbor ME 04860, USA
Tel: ++1 201 312 6317
Fax: ++1 201 312 8256

Appendix 2

Working Group on "Environmental Impact of Mariculture"

List of WG Membership, and participation of invited experts and observers in 1994

Dr. Brandon O'Connor*
Aquafact International Services Ltd.
12 Kilkeerin Park
Liosbaun, Galway
Ireland

Mr. W. Pelczarski
Sea Fisheries Institute
ul. Kollataja 1
81-372 Gdynia, Poland

Mr. M.M. Roberge
Dept. of Fisheries & Oceans
POBox 5667
St John's, Nfld A1C 5X1
Canada

Prof. Dr. Dr. H. Rosenthal (Chairman)
Institut für Meereskunde an der 81-322
Universität Kiel
Düsternbrooker Weg 20
24105 Kiel , F.R.Germany
Tel.: ++49 431 5973916
Fax.: ++49 431 565876

Mr. F. Ruano
Inst. Nacional de Investigação
das Pescas INIP
Avenida de Brasilia
1400 Lisbon
Portugal

Dr. Heye Rumohr*
Institute of Marine Science
University of Kiel
Düsternbrooker Weg 20
24105 Kiel, Germany
Fax.: ++49 431 565876

Dr. William.S. Silvert *
Dept. of Fisheries & Oceans
BIO-HED
PO Box 1006
Dartmonth NS B2Y 4A2
Canada
Tel.: ++1 902 426 1577
Fax: ++1 902 426 2256

Mr. Pete Smith
Fish Diseae Group
Dept. of Microbiology
University College Galway
Galway, Ireland
Tel.: ++353 91 24411 Ext. 2370
Fax: ++353 91 750541

Mr. B.E. Spencer
MAFF Fisheries Lab.
Benarth Road
Conway Gwynedd LL32 8UB
United Kingdom
Tel: ++44 492 593883
Fax: ++44 492 592123

Mr. J. Stellwagen
DIFTA
NorsØcentret
9850 Hirtshals
Denmark

Dr. E. Verspoor
Marine Laboratory
PO Box 101
Victoria Road
Aberdeen AB9 8DB
United Kingdom

Appendix 3

Tentative Agenda of the Working Group Meeting, Cork 1994

ICES Working Group on Environmental Interactions of Mariculture

Cork, Ireland, March 28-31, 1994

Tentative Agenda

Day 1

1 Opening of the Meeting

2. Adoption of the agenda

3. Introduction of Participants

4. Tabling of Documents

5. Brief review of the history of the Working Group and Introductory remarks to the new "Terms of References"

6. General discussion of TORs

7. Report and notes from international and inter-governmental activities regarding "Environmental issues of mariculture."
   - EC-Workshop on "Fish Farm Effluents and their Control in EC Countries"
   - World Aquaculture Society 25th Meeting New Orleans
   - GESAMP Working Group Meeting (January 1994)
   - News from EIFAC
   - Aquaculture and the Environment, The shaping of public policy" (Woods Hole, September 1993)

8. Assembling country reports, updating list on completed, ongoing, and new research projects related to environmental issues of mariculture

Day 2

8. Discussion on integrated modelling-monitoring systems (Norwegian example)S

9. Sea-lice and marine salmon cage farming (Discussion on present perceptions of the interactions between fish farming and brown trout infestation: the case of Ireland and Norway)

10. Discussion on "Interactions between types of mariculture and other coastal zone uses" (Drafting statements for the report)

11. Discussion of supporting information to be provided to other WGs:

    (a) Working Group on "Transfers and Introductions..."
    (b) Genetics Working Group
    (c) NASCO guidelines (reference to salmon working group)

12. Sub-group meetings and drafting sessions
    (a) monitoring,
    (b) modelling,
    (c) particle-bound contaminants and
    (d) coastal zone management strategies.

Day 3

13. Continuation of subgroup meeting

14. Full WG Discussions on sub-group findings: draft editing

Day 4

15. Special Session with NASCO representative

16. Further aspects of Coastal zone management issues; discussion on needs for expertise inputs intersessionally (preparation of an action list)

17. Identification of research priorities and preparation of the Special Session of the Mariculture Committee on "Coastal Zone Management"

18. Discussion on present environmental regulations in ICES countries

19. Formulation and discussion of recommendations

20. Miscellaneous

Appendix 4:

Country Reports

Country Report: Federal Republic of Germany

prepared by

Harald Rosenthal
Institut für Meereskunde
University Kiel

Reinhard Lauterbach, D. Jansen
Landesforschungsanstalt für Landwirtschaft und Fischerei
Mecklenburg-Vorpommern, Rostock

Mariculture production has declined along the German coast since unification but seems to have reached a stable production with some new activities emerging in 1994 along the Baltic coast. Present production figures for rainbow trout in cages along the Baltic Coast of Mecklenburg-Vorpommern is shown in Table 1

Table 1: Rainbow trout production at the coast of Mecklenburg-Vorpommern between 1988 and 1993. * = feeds of former GDR standards; ** = feeds with reduced phosphorus content.

Year	Production (t/yr)	nutrient output poshporus (t/yr)	nutrient output nitrogen (t/yr)
1988	814	40.0	124.0
1989	570	28.0	86.8
1990	480	23.5	73.1
1991	200	2.2	14.1
1992	140	1.5	9.9
1993	125	1.4	8.8

Substantial changes have occurred after unification regarding the nutrient output from cage farms because of the improved feed quality of recent products.

Along the Schleswig-Holstein coast, there are a few farms producing marine finfish or freshwater fish in slightly brackish waters. While at the Kiel fjord a trout cage farm continues to produce about 20 tonnes of 3-4kg fish annually, a turbot hatchery provides juveniles for grow-out to Spain while a private farmer at the westcoast raises glasseels in a recirculation system.

One farm on the Island of Sylt cultures Pacific oysters in the Wadden Sea on trays and racks. Seed oysters are imported from Ireland.

Mussel culture in extensive beds continued to be the largest production in German coastal extensive culture with 12 licenses granted.

Major research issues

Turbot hatchery expanded its activity to include mass rearing trials on cod in an evaluation programme on possible coastal ranching of juvenile cod. Present focus is

on differences in performance of eggs and larvae derived from North Sea and Baltic spawning stocks. (e.g. Buyoancy of eggs, etc.).

Studies are presently underway to determine the geo-chemistry of sediments accumulated under the Kiel cage farm. Microbiological studies of fish and sediments uder cages are also untertaken in established and new cage sites at two farms along the coast of Mecklenburg-Vorpommern and Schleswig-Holstein.

A number of improvements of conventional sedimentation models have been made to reflect changing current speed and current direction with tidal changes, different sinking rates of faeces and pellets, changing feeding rates of wild fish on lost pellets, bottom topography and turbulance near the bottom surface.(see Appendix I).

Country Report. Finland

by

Kari Ruohonen and Timo Mäkinen

Finnish Game and Fisheries Research Institute
Evo State Fischeries and Aquaculture Research Station
Helsinki

I PRODUCTION

I.1. Fish farms and the production

Produktion of fish for human consumption decreased from 1991 output to 17 909 ton (99% rainbow trout) in 1992. Only 3 236 tons of this was reared in fresh water and 82% of the fish was produced in net cages in brackish water. The value of the food fish output in 1992 (calculated as the producer price) was 68 million USD (1 USD = 5.5 FIM).

The amount of rainbow trout exportet was increasing since mid 1980´s ans was approximately 3000 tons/a ungutted fish till beginning of 1990´s (Table 1). Less gutted fish is eported nowadays than in the beginning; in 1990 already half of the amount consisted of filet. Because of the devaluation of the finnish currency a new increase of export is waited to take place in coming years.

Table 1. The export of rainbow trout in Finland in 1986-1992, gutted weight

Year	Export t/a
1986	236
1987	782
1988	3830
1989	3073
1990	3057
1991	1179
1992	1709

In 1992 the total number of fish farms in Finland reduced somewhat and it was 360 (445 in inland water) and in addition natural rearing ponds were used with a total area of 9 110 hectares. The rainbow trout is practically the only fish species farmed for food in Finland, although a few attempts have been made to develop the farming of Baltic salmon, whitefish and artic char in net cages in brackish and fresh water. There is also a growing branch of crayfish farming.
Fish for stocking are produced either intensively in land-based fish farm (mostly salmonids) or extensively in large ponds with a natural food supply (mostly whitefish, grayling, pike and pike-perch and some cyprinid species). Many farms producng rainbow trout also rear other salmonids for stocking. In 1992, the number of salmonids produced for stocking purposes, excluding newly hatched larvae, was 13.5 million. The natural freshwater rearing ponds produced about 49 million mostly one-summer old juveniles. In 1992, the value of juvenile production of rainbow trout was about 13 million USD and that of other species produced for stocking purposes in natural waters about 19 million USD.

1.2, Introductions

During 1992 and 1993 eel juveniles were importet (114 000 and 122 000, respectively) from Swedish quarantine for stocking purposes of some small lakes in southern Finland.

II FISH DISEASES

No new dangerous fish diseases were observed in 1993. 23 % of Finnish fish farms have voluntarily joined the Fish Health control system conducted by National Veterinary Institute.

At the beginning of 1980´s vibriosis was the most important fish disease in Finland. Vaccination against vibriosis has been fairly effective and thus other bacterial diseases have now become more important.

Furunculosis occurs not only in coastal regions but also in some freshwater hatcheries. Furunculosis was diagnosed in 43 and 40 different farms during 1992 and 1993, respectively. Most of the farms are situated in the archipelago and the coastal area of the Baltic sea, where also most of the rainbow trout production takes place. Effective vaccines against furunculosis are not yet available and thus therapeutic antibiotics are commonly used with results in residues and eventual bacterial resistance.

Bacterial kidney disease (BKD) was diagnosed on one farm in 1992 and on two farms 1993, all of which are on the island of Ahvenanmaa. The mainland is still free of BKD. Transport of eggs and live fish from Ahvenanmaa to the continent is prohibited.

IPN virus was isolated seven times during 1992 in comparison to 7 isolations from different farms during 1990 and one in 1991. No isolations were detected in 1993. There has not been clinical signs of IPN.

The use of antibiotics in Finnish fish farming was approximately 500 kg in 1993.

III RESEARCH

3.1. Mariculture

Mariculture research station eas founded in the beginning of 1993 under the government of Finnish Game and Fisheries Research Institute. It is located in the south-western archipelago of Finland about 40 km west from the city of Turku.

The project on the use of Baltic herring in rainbow trout feeds continued (see Ruohonrn & Vielma 1993), Experiments were undertaken to clarify the role of dietary water on the digestion and gastric adaptation of rainbow trout, to compare the excretion of phosphates and ammonium of rainbow trout fed on chopped herring or artificial dry food, and to give recommendations on the use of binding agents in moist pellets. In collaboration with National Health Institute and National food administration, the accumulation of environmental toxines from the diet to the rainbow trout was studied. A primer on the formulation and use of moist pellets in rainbow trout farming has been published by Finnish Game and Fisheries Research Institute. The primer is intented to Finnish fish farmers.

A project on feeding techniques in cage farming has been going on during 1993 (see Mäkinen et al. 1993).

3.2 Land-based fresh water farms

National Board of Waters and Environment published a recommendation report about environmental monitoring of fish farms. Recommendations include fresh water farms as well as farms in coastal, brackish waters.

Vacuum removal of sludge from fish tanks was studied at a governmental freshwater farm (Vielma, 1993). In the system, the feed and fish faeces are allowed to settle in a fish tank and than the particles are vacuum drained separately with the outlet water. The effluent system to recipient waters resulted in a 21% reduction in phosphorus load from the fish farm. The total cost of this treatment amounts to 6-8% of the fish produced. For efficient nutrient removal, uneaten feed should be removed from the fish tanks several times per hour.

3.3 Environmental changes threatening fish farming

Increased mortality of eggs and newly hatched larvae has been observed in salmon egg bathces supplied from natural spawning populations. In Finland, culturing of brood stock for egg production at fish farms is a common practice and only some eggs are taken from natural spawners. In cultured brood fish eggs or newly hatcherd larvae no increased mortality has been observed.

The reasons for the observed increase in mortality of eggs and embryos derived from wild fish is probably a phenomenon called M74 disease which has been described also from the Swedish side of the Baltic Sea. The actual cause of this mortality in M74 will be the main focus of the research activities which will be implemented in Finland in the near future.

The relevant Finnish literature on aspects related to environmental issues of mariculture has been incorporated into the respective section of this report.

Country Report: France

by

Antoine Dosdat, Marc Kempf and Michel Merceron
IFREMER

French aquaculture is characterized by a great diversity of species, as well as by the coexistence of traditional activities (marine shellfish, freshwater fish culture) with more recent and still developing ones (marine fish culture, new practices in shellfish

growing, human food algae, new freshwater species, etc.). Traditional cultures are the main contributors to the tonnage produced. Another noticeable point is the importance of the western part of the country, which carries the main part of the production (>80%) : the Channel-Atlantic coast for shellfish, and nearby rivers for freshwater salmonid farming. On the Mediterranean coast, marine fish farming of bass and bream as well as shellfish production by new methods (mussels on longlines in open waters) are developing.

PRODUCTION

The significant figures of the sector are summarized on the following table., the present status and evolution appearing later on according to the species.

FRENCH AQUACULTURE PRODUCTION (1993)

Species	**Production (t)**	**Financial turnover (million FF)**
Marine fish	**3 815**	**253**
Seabass	& 2 215	191 (*)
Seabream		
Salmonids	1 200	34
Shellfish	**202 350**	**2 181**
Japanese oyster	140 000	1 680
Mussel	60 000	420
TOTAL	**206 165**	**2 434**
Freshwater fish	***60 000***	***1 500***
Rainbow trout	*50 000*	*1400*

(*)= fingerlings included

MOLLUSCS

The Japanese oyster (*Crassostrea gigas*)dominates French aquaculture production. All of it is consumed in France, which is thus the main oyster farming and consuming country in Europe.

Oyster farming is basically a traditional, artesanal, family scale activity. Because of this, it shows some structural difficulties which influence both market prices and management of farming zones. Attempts by the producers to obtain labels of quality and origin are aimed at improving the market price. Some farming zones are overloaded, and ,consequently, oyster growth rates are decreasing. On the other hand, due to "remote settlement" techniques, use of hatchery-originated seed is increasing (presently 10% of seed production).

FLAT OYSTER (*Ostrea edulis*)

The farming of this species is still affected by parasitic diseases, which broke out in the '80 's (*Marteilia and Bonamia*). This explains the persistant low level of its production (1993 = 2000 t).

MUSSELS (*Mytilus edulis, M. galloprovincialis*)
The French market is much more open for mussels than it is the case for Japanese oysters. Mussel farming production (about 60 000t) only supplies half of the national consumption. The difference is covered by wild stock fishing and imports from neighbouring countries (Netherlands and Spain). Due to natural productivity fluctuations and lack of stock management, fishing yields are irregular and may disrupt the market equilibrium (60 000t landed in 1993).

OTHER SPECIES (clam, scallop)
Farming of the Manila clam (*Ruditapes philippinarum*), an introduced species, was strongly hit by the unexpected success of its reproduction in the natural environment (1993 production = 300 t). Now, the yields come more and more from fishing.
The scallop, *Pecten maximus,* is farmed up to the juvenile stage, as a support of a seeding-recapture activity on its natural fishing ground (1993 = 50 t produced by this technique).

MONITORING NETWORKS
Shellfish for human consumption are controlled according to the French and European regulatory requirements. Both the shellfish and surrounding water quality are monitored on the shellfish sites during the growing phase. Oysters and mussels also constitute a useful material for monitoring levels and trends of environmental quality parameters. Finally, the growth rates of the commercially exploited species are followed up on the main culture grounds, according to a standardized methodology; this has been in practice for the Japanese oyster since 1993, and will be operating for the mussel from 1994.
All these networks are managed by IFREMER :
- REMI (microbiology) : faecal bacteria, *Salmonella*
- REPHY (phytoplankton) : blooms, toxic species, toxicity tests
- RNO (environment quality) : levels and trends of pollutants in water, sediment and living material
- REMORA (molluscs) : growth, mortality and flesh quality of molluscs.
As regards the monitoring of risks to human health, signs of toxicity of unknown origin have appeared on several shellfish growing sites since 1993-1994.

MANAGEMENT OF GROWING ZONES
A carrying capacity model was set up by IFREMER in order to improve the management of the Marennes-Oleron bay, the largest oyster production area in France, which is partly affected by overstocking. This model is now being applied to other sites and species (oysters + cultivated mussels + wild mussels).

CRUSTACEANS
The Japanese shrimp (*Penaeus japonicus*) is cultivated as a complement to other uses of marine salt marsh ponds. This production is low (30 t) and risky. Two nurseries supply the necessary juveniles.

ALGAE
Undaria pinnatifida, a human food algae from Asia, is beginning to be cultivated (10 t), but the development of this activity is still facing market problems in France and Europe.

MARINE FINFISH
SALMONIDS
Because of the climate and the sites, as well as the northern European mass production, the classical species are only grown in small quantities (Atlantic salmon,

rainbow trout; Pacific salmon, *Oncorhynchus kisutch* is no more cultivated). The brown trout (*Salmo trutta fario*), better adapted to local Channel-Atlantic conditions, appears now as a replacement species, whose production is developing. This species is mainly devoted to transformation industry (1993: Atlantic salmon = 400 t; rainbow trout = 600 t; brown trout = 200 t).

BASS AND BREAM

Sea bass (*D.labrax*) and sea bream (*S. auratus*) production is expanding, especially on the Mediterranean coast (1991 = 700 t; 1992 = 1,300 t; 1993 = 2,200 t). Nevertheless, one important hatchery and growing farm is located on the Channel using heated water from an electricity plant. The development of these species is hampered by the difficulty of obtaining new coastal sites (land use conflicts and environment protection pressure), as well as by price lowering due to regional competition for a limited market (15,000 t produced in the whole Mediterranean in 1992), and currency devaluation in the main consuming countries.

TURBOT

The turbot (*S. maximus*), an Atlantic species, still shows a small but expanding production (1991 = 60 t; 1992 = 130 t; 1993 = 400 t), and has also to face the site and market problems as the precedent species. Wild stock fishery yields also contribute to the price fluctuation.

FRESHWATER FISH

The freshwater production is much larger than the seawater one, and involves mainly the rainbow trout. This activity started intensive developing thirty years ago, and now represents the highest production in Europe (50,000 t in 1993). Three western regions supply the bulk of this production : Normandy, Brittany and Aquitaine, the two latter being responsible for more than half of the total. Freshwater trout farming also has to face the general decrease of the salmon price. The response is a diversification towards large sized fish for the transformation industry (8,000 t > 1 kg in 1993), as well as towards marine fish growing (brown trout, turbot, bass), at least for the major farming groups.
Freshwater fish farming is also being extended to new species : Siberian sturgeon, European catfish.

INTENSIVE FISH FARMING AND THE ENVIRONMENT

Some information about the interactions between intensive fish farming and the environment are worth noting :
The legislation concerning the so-called "classified installations", i.e. those able to pollute, was recently revised (Dec.1993). It applies to fresh and seawater fish farms. According to it,the marine fish farms producing over 20 t/year require a licence, which needs a previsional impact study. The extent of this study is open to local administrative practices.
- A Working Group on "regulatory aspects" was constituted in 1993. It concerns both fresh and salt water environments and its members belong to public administrations, research bodies (lawyers, scientists) and professional organizations.
- An applied research programme on intensive marine fish farming and the environment was launched by IFREMER and collaborators in 1992-1993. Two main items concern (1) the quantification of feed originated wastes from southern European species such as bass and turbot and (2) the environmental impact of the farming activity (especially by enrichment).

- Research on the effects of veterinary products in fresh and seawater is increasing. It is carried out mainly by the Veterinary School of Nantes.
- Applied research on land-based farm waste water treatment is also increasing, both for fresh and seawater. In the latter case, it includes recirculation.

CONCLUSION

French aquaculture, all species together, constitutes an economically significant activity and represents the largest European production in gross weight. It is equally important for land use and management, both for the countryside and the coastal zone. Mariculture has its main productions directly in the sea. It is very sensitive to the quality of the latter and should be concerned by the environment for its own interest. So, mariculture itself is also an element for environmental monitoring and protection. These points should be brought more actively to the attention of public opinion and also be taken into account in the evolution of the legislation and its application.

Country Report Ireland

by

Jacqueline Doyle,
Fisheries Research Centre,
Dublin, Ireland

1. Production trends (tonnes)

Finfish	**1992**	**1993**
Atlantic Salmon	9231	12,366
Rainbow trout sea cage	600	677
Rainbow trout freshwater	700	906
Shellfish		
Pacific Oyster *C. gigas*	1750	N/A
Native Oyster *O. edulis*	334	N/A
Mussels Suspended *M. edulis*	5090	N/A
Mussels Bottom	8730	

1.1 There has been a significant increase in the production of farmed Salmon despite losses due to novel disease processes during the year. One case involved the isolation of an, as yet, unidentified bacterium associated with mortalities of up to 100% of large Salmon at sea. A second study resulted in the recurrence of an encephalitis in Salmon Smolt shortly after they were put to sea, with 100% mortalities of approximately half a million fish over a period of 6 weeks.

Other economically important notifiable diseases reported include Yersinia ruckeri, IPN and furunculosis.

1.2 Shellfish sales were disrupted by the annual occurrence of Diarrheic Shellfish toxicity DSP associated with Dinophysis species on the southwest and west coasts.

1.3 The further expansion of Salmon farming is being curtailed by the collapse of wild sea trout fisheries lice associated with heavy burdens of juvenile in the west coast and declines of catches in south west and north west areas. Analyses indicated that variations in lice infestation levels on sea trout demonstrated their maximum range in the vicinity of Salmon cages, whereas at distances remote from cages the overall infestation levels were always at the lower end of the observed range.

During 1993 the level of monitoring of sea lice infestations on farmed Salmonids was increased. All farms were inspected in April, May and June and again in the Autumn and Winter.

Monitoring at selected sites was continued throughout the Summer. As a precaution a control area of the West coast have been identified as an area for the protection of wild salmonids in which Salmon Aquaculture is prohibited for the time being.

2. Administrative Measures

2.1 Other issues of environmental concerns are the persistence of antibiotics in sediments and biota adjacent to fish farm sites. Routine environmental monitoring of water quality parameters in continuing as part of the licence conditions. The monitoring programme is under review. Because of major changes in farm management practices in the past two years it now seems more appropriate to move towards annual site audits to assess the impact on benthos and sediments.

2.2 Fallowing strategies augmented by harrowing practices have been introduced to try and break disease cycles with some success. Single Bay management strategies are being encouraged where there are multiple farms located.

3. Studies related to Environmental aspects of Mariculture in Ireland include

No	Project Description	Completion Date
1	Study on the status of Marine TBT antifouling contamination in Aquaculture areas	1993
Status:	**paper in press Minchin and Duggan.**	
2	Introductions of exotic species associated with Pacific Oyster transfers from France to Ireland.	Ongoing
Status:	**Preliminary report to ICES 1993 Statutory Meeting.**	
3	STRIDE Pollution control of freshwater fish farm effluents	1994
Status:	**Report in preparations (Dr. M. Costello TCD).**	
4	Cleaner fish technology as an alternative to pesticides	1993
Status:	**Completed (Dr. M. Costello TCD).**	
5	The developing of a vaccine for furunculosis caused by *A. salmonicida* in Salmonid fish.	1995
Scientist in charge Prof. T.J. Foster TCD.		

6 Fate and sinks of malachite green in the natural environment 1994
Scientist in charge Dr. James Wilson TCD.

7 Study of the rates of recovery in shallow embayments following intensive Aquaculture activities over a 10 year period. 1994

8 Research into the fate of antibiotic residues in the Marine Environment 1994

9 Research into the residency time of certain pathogens under hypoxic and oxic sediment conditions in marine fish farms. report In press

10 The role of bioturbaling animals in the fate of antibiotic residues in the marine environment. Ongoing

11 A study of temporal changes in the genetic composition of juvenile salmon populations from selected rivers adjacent to fish farms. Ongoing
Salmon Research Agency Dr. Ken Whelan (projects 7-11)

12 Vaccination trials no info presently available

13 Phytoplankton species associated with imports of the Pacific Oyster*Crassostrea gigas*, from France to Ireland. Ongoing
Preliminary Report to ICES 1993

14 Studies on Sea Trout and interactions with Salmon farms Report tabled
Publications available

15 Fate and impact of antimicrobial agents in marine fish farms Ongoing
Studies on the concentration of the agents and the frequencies of resistance in sediments with respect to area, depth and finess. Influence of sedimentation quality on these factors.
Coyne *et al.*, 1994; Kerry *et al.*, 1994

16 Reduction in the biological activity of antimicrobial agents in the aquatic environments. Impact of chemical and physical parameters. Ongoing

17 Studies of antimicrobial agent resistance in marine micro-flora. Methods of quantitation; factors leading to elevated frequencies. Genotypic and phenotypic characterisation of the resistances selected. Ongoing

18 Studies on the development of new techniques of measuring concentrations of biologically active antimicrobial agents in the marine environment. Ongoing
15-18 Ref. Dr. Peter Smith UCG

Country Report: The Netherlands

by

Renger Dijkema
Netherlands Institute for Fishery Research (RIVO-DLO)

Prodution trends

Production figures for season 1993-1994 (partly estimates):
(Values in metric tons)

Molluscs		
Mussels (*Mytilus edulis*) ,	Consumption:	39,520
	Seed mussels:	37,200
Oysters: *Ostrea. edulis*		n.a
Crassostrea gigas		n.a.
Cockles (*Cerastoderma edule)*		44,700
Cut trough shell *(Spisula subtruncata)*		58,333
Finfish		
Rainbow trout *(Oncorhynchus gairdneri)*		20
Sea bass *(Dicentrarchus labrax)*		<1

After a period of 3 years with poor mussel and cockle spatfall, a good yearclass of mussel seed in 1991 provided sufficient prime material for the industry. However, mussel recruitment in 1992 and 1993 has been poor again. Mussel production in 1993 was somewhat lower than in 1992. Recruitment of cockles, however, was satisfactory.

The molluscan industry in 1993 had to deal with new national legislation, mainly aimed at protecting natural values in the coastal area. The two main production areas, the Wadden Sea and the Oosterschelde, had earlier been declared natural reserves. Additionally, in order to safeguard the undisturbed development of eelgrass fields, mussel and cockle banks, and also food supply for birds, a part of the intertidal fishing areas for mussel seed and cockles were closed, and a part of the cockle stock will have to be be spared in years of low cockle avaiability for birds, mainly eiderducks (*Somateria mollissima)* and oystercatchers (*Haematopus ostralegus).* This has led to restrictions for the fishery for seed mussels and cockle fishing in the Wadden Sea. On basis of yearly stock assessments, fishing plans are made every year by the industry, which have to be agreed upon by government.

Intensified regulations concerning the sanitary pureness of shellfish waters were implemented, following new EC legislation. The existing monitoring programmes for bateriological water quality and for the occurrence of (potentially) toxic phytoplankton and shellfish biotoxins in the coastal water were intensified. The number of production areas covered were increased, as was the sampling frequency.

Country Report: Norway

by

A Ervik and Kryvi
Bergen, Norway

PRODUCTION TRENDS

The statistics on salmonid and marine species production in 1993 is presented in Table 1. In 1992 the production of salmonid fish reached 140.000 tonnes. Atlantic halibut from aquaculture was marketed for the first time in 1993.

Table 1 Production statistics of salmonides and marine species in 1993.

Species	Tonnes
Salmon	170.000
Rainbow trout	7.000
Arctic char	1.000
Halibut	8.5
Cod	0.5

USE OF ANTIBIOTICS

Table 2 provides information on the use of antimicrobial agents in Norwegian aquaculture in 1993.Last year the use of antibiotics dropped to less than 25 % that of the amount used in the previous year, the dominating drugs being oxolinic acid and flumequine. The low consumption reflects the good health status of the fish raised in 1993, which is also demonstrated in the high production figures obtained.

Table 2. Use of antibiotic substances (kg) in Norwegian aquaculture 1986 - 1993.

	1986	1987	1988	1989	1990	1991	1992	1993
Oxytetracyclinklorid	15410	27130	8220	5014	6257	5751	4113	583
Nifurazolidon	1610	15840	4190	1345	118	131	-	78
Oxolinic acid		3700	9390	12630	27659	11400	7687	2554
Trimetoprim+sulfadiazin (Tribrissen)	1000	1900	670	32	1439	5679	5852	696
Flumequin	-	-	-	329	1959	3837	9833	2177
Florfenikol	-	-	-	-	-	-	-	56
Total	18020	48570	32470	19350	37432	26789	27485	6144

REGULATION

Work to improve the regulation system for aquaculture in Norway is going on. The present procedures are time consuming involving several authorities and are environmentally inconsistent To simplify the procedures emphasis is laid on coastal zone planning, therebye settling the different interests before the conflicts emerges. The LENKA methology is applied in this work. To make the regulation procedure more environmental consistent an improvement of the method for quantification of local and region environmental impact is needed.

As part of this work a system for regulating the environmental impact from fish farms is being developed. The system consists of two integrated parts: a monitoring program and a simulation model. The system is called MOM, an acronym for monitoring - fish farms - modelling in Norwegian The aim of MOM is to identify and regulate the most important local effects, and emphasis is placed on impact rather than effluent. It is required that the system must be flexible and can adapt to changes in legislation and include new research results. The monitoring program and the model are based on the same parameters, but to ensure cost efficiency the number of monitored parameters are kept low. The main emphasis of the system is placed on the monitoring program which is adjusted to the exploitation of the farm site. The model will be used to predict environmental impact of a given farm at a given site and for evaluating the consequences of altered operation procedures on the farm. The model will be linked to the model developed for land-locked fjords (Aure & Stigebrandt 1990). The environmental quality standards will be based on the objectives of long term exploitation of the sites without severe deterioration. This implies that macrofauna must be present in the sediments, and accumulation of organic waste and residues of antibacterial agents must not exceed predefined levels.

Selection of environmental impact to be controlled

The environmental impact from aquaculture is varied, and for practical regulation purposes it is desirable to focus on the main effects. The following criteria were applied in selecting the type of impact to be regulated:

- the relationship between load and environmental impact must be known.
- the impact must have significance for both fish production and the environment.
- the impact must be quantifiable and suitable for regulatory purposes.

Pelagic impact parameters are characterized by large and rapid fluctuations, making them less suitable for regulatory purposes. Impact on the benthic system is less dynamic, and accordingly the emphasis has been placed on benthic enrichment. However, the model includes effects on both sediment and the water column.

The monitoring program

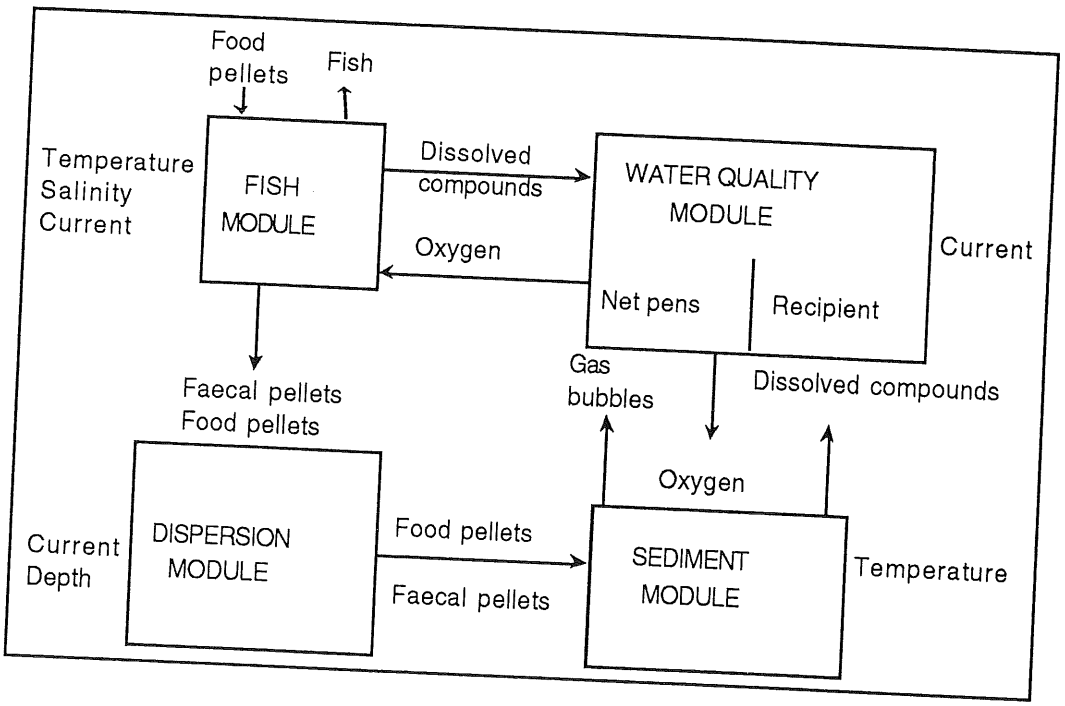
In MOM we have defined three categories of exploitation of sites, and for each a corresponding level of surveillance is applied. The monitoring program consists of three types of investigations (A ,B and C) which are carried out on every level of surveillance, but at different frequencies (Table 3). The level of surveillance will be determined by modelling, but can be altered by the results of monitoring.

Table 3 Frequencies of the different investigations applied at different levels of surveillance

	Investigation		
	A	B	C
Surveillance level 1	*	0.5/PC	8. years
level 2	*	1/PC	5. years
level 3	*	2/PC	2. years

* Continuously PC: Production Cycle

Investigation A is part of an extensive compulsory internal management control carried out by the fish farmer. The aim is to enable the farmers to keep record of their feeding regime. The investigation is performed by continuous measurements of the particulate output (excess feed and faecal pellets) from the farm by sediment traps positioned under the net cages.



d

Investigation B is a study of the sediment chemistry and will be carried out by experts. The goal is to give the authorities and the fish farmers a impression of the local benthic impact. Apart form being part of the monitoring program, this investigation must be performed as a baseline survey before establishment of new farms, and as an initial investigation of operating farms at the initiation of the MOM system.

Investigation C is a fauna investigation in the farm area. The investigation will be performed by experts and give an impression of the long term impact on the sediment. The investigation is costly and will only be performed with years interval.

The model

The task of the model is twofold; 1) to simulate the environmental impact of a fish farm on a site, and 2) to determine farming procedures which will prevent the impact to exceed the environmental quality standards. To obtain this the model must simulate both the amount, theispersion and the effect of the effluent. The model consists of 4 modules (Fig. 1).

The *Fish module* simulates effluent of dissolved and particulate material and the oxygen demand of the fish in relation to composition and amount of feed, fish size and biomass, temperature, and uptake, incorporation and excretion of food by the fish. The *dispersion module* simulates the dispersion and sedimentation rates of food and faecal pellets in relation to farm area, current velocity and direction and depth. The *sediment module* simulates the accumulation and degradation of organic material in relation to loading, temperature and benthic fauna. The *water quality module* simulates oxygen and ammonia concentrations and primary production in the cages and the recipient in relation to hydrodynamic and topographic factors.

Aure, J. & A. Stigebrandt. 1990. Quantitative estimates of the eutrophication effects of fish farming in fjords. Aquaculture,90:135-156.

Norwegian research projects:

176	**Antibacterial agents in the marine environment.** Investigation on: 1) the stability on several antibacterial agencies in sea water and marine sediments, 2) metabolism of oxylinic acid and flumequin in salmon, 3) investigation of residues in wild fish sampled in farms with feed- collector/detector.	Dec. 1993 2 years
	The influence of benthic fauna on remineralization of organic material from aquaculture. quantification of organic material and on the connection between load and effect.	April 1993
177	**Effect of chemoterapeutica on the environment of fish farms.** Investigate the decomposition of different antibacterial agents in use. Develop toxicological environmental tests to predict the effects of new agents.	Dec. 1993
	Evaluation of the genetic interaction with wild stock of atlantic salmon.	1996
	Genetic influence of escaped salmon on strains of wild salmon. Investigation of the spawning success of escaped farmed salmons to evaluate potential genetic interactions with wild salmons.	1994
178	**Genetic adaptations among strains of salmon.** Modelling different impact on the genetics....	1993
	Genetic effect of escaped farmed salmons on wild strains: development of an analytical tool and statistical analytical methods.	1993
179	**Genetic effects of escaped farmed salmons on wild strains:** studies of DNA. Development of genetic markers to identify individuals and different populations.	1993
	Identification of farmed and wild salmon. The fatty acid profile in brain tissue is used as an identification parameter.	1994
	Transfer of resistance against antibacterial agents in *Aeromonas salmonicida*. Characterization of two transferable resistance plasmids identified in the furunculosis bacteria.	1995
	Transfer of disease between salmon and different marine fish species.	1995
	Surveillance of escaped farmed salmons. Investigation of the relative abundance of escapees caught in the sea and in the rivers.	1995
	Surveillance, migration and survival of escaped farmed salmon.	1995
	Reproductive threat of cultured salmon to wild populations.	1996
	Reproductive isolation mechanisms between wild and farmed salmon.	1996
	Escaped farmed salmon; influence on wild populations. Investigation of the negative effect of escaped farmed salmon on the redds of wild salmon.	1994
180	**Studies on the rehabilitation of the sediment of farming sites.** Investigation of the correlation between pH, Eh and pS in the sediment and remineralization of organic materials.	1993
	Kinship between genes carrying antibacterial resistance.	1995
	Development and transfer of antibiotic resistance.	1993
181	Effects of infections of salmon lice from fish farms on wil d populations.	1995
	Pharmacokinetics of different antibacterial agents.	1995
	Ecological impact of antibacterial agents and antiparasittic agents used in fish farming industry.	1993
	Ecological and physiological consequences of sea lice on salmonids in fjords.	1994
	Alternative treatment of salmon lice. Studies on environmental suitable methods to reduce the sea lice problem. Both chemical and biological methods are investigated.	1993
	Biologic delousing of salmons. Use of wrasse as cleaner fish.	1993
182	Epidemiological investigations of the interaction between environmental factors and the occurance of diseases.	1995 (prelim. report)
	Preventive and integrated treatment of sea lice. Quantifying the effect of syncroniced treatment.	1995

Country Report : Sweden

by

Hans Ackefors
Department of Zoology
University of Stockholm
Sweden

Swedish aquaculture in 1992

Summary: The yield of Swedish aquaculture in 1992 was 4,906 metric tonnes of fish for consumption; converted to round fresh weight this is equivalent to 5,782 metric tonnes. The dominating species was rainbow trout (5124 tonnes). Additionally, 1,353 tonnes of cultivated blue mussels were harvested. The value of the total Swedish aquaculture production amounted to about 133 mio SEK.

Mariculture production reached 2,154 metric tonnes of rainbow trout, 388 tonnes of salmon and 1353 tons of blue mussels.

The number of enterprises engaged in aquaculture in 1992 was 726, of which 211 produced fish for consumption and 3 produced blue mussels. 157 establishments cultivated fish fry for stocking of natural waters and grow-out units.

The compensatory programme for releasing smolts of salmon and brown trout comprised 3.1 million in numbers, of which 2.5 million were salmon. Smolts of salmon and trout were released, mainly into rivers systems draining to the Baltic Sea.

Ongoing Aquaculture Research Work in 1993

by
P.O. Larsson

The development of Swedish oyster cultivation continued at Tjärnö Marine Biological Laboratory. In 1993 the activity was focused on hatching, on-growing and settling experiments in the new (built in 1992) hatchery for bivalves.

At the Institute of Marine Research , Lysekil, further research and development work was done with hatching and rearing systems for cod, plaice and turbot, intended to produce fish mainly for stock enhancement. Part of the work (regarding hatching of cod) is in cooperation with the Ar Laboratory in Gotland, Stockholm University. A few hundred 12-17 cm cod of the Skagerak coastal (fjord) cod stock were tagged and released in a fjord near Lysekil. About 300 juvenile cod of the Baltic eastern stock, 12.5-18 cm length, were marked with Carlin tags, transported to the coast of the Bothnian Sea and released there. Another 300 cod, 8.0-12.5 cm in length, were marked with Alizarin red, kept in a fish farm at the coast of the Bothnian Sea for some time to study the adaption problems to the low salinity and then released.

Cod yolk-sac larvae from the Lysekil hatchery were released to "fjord-like" basins in the Baltic proper (about 1.2 million) and the southern Bothnian Bay (about 600,000), part of them marked with Alizarin red. The predator situation in those areas are believed to be favourable for the cod larvae, giving a reasonable survival, compared to experinces from experiments in USA and Norway.

About 350 individuals of plaice, 15-25 cm in length, produced at the Lysekil hatchery were tagged (Floy T-bar tags) and released at the coast in Lysekil.

At the Ar laboratory research continued on the basic mechanisms in cod (egg/larvae) adaptation to the troublesome environmental conditions in the Baltic, especially low salinity and oxygen content, making mariculture activities still more difficult with Baltic cod than with Atlantic cod.

The Salmon Research Institute, Älvkarleby, continued experiments with delayed release of salmon (post-) smolts at the Baltic coast. Recapture rates continue to be high in several experiments, while some release sites (and short delay) have given low recapture rates, down to 10%. Apart from that, empahsis has been given to diseases, especially "M74" (see below), number of genetic projects were started, regarding several aspects related to the aquaculture activities.

The Institute of Aquaculture in Umeå has concentrated its activities on freshwater species like Arctic char and noble crayfish, but some basis research on Baltic salmon has bearing on the delayed release experiments with that species. Net-pen rearing of Arctic char at the coasta of the Bothnian Sea and the Bothnian Bay has been considered but still not tested.

At the Department of Zoophysiology, University of Göteborg, research continued on nutrition and reproductive physiology of fish. The species in focus are salmonids and flatfishes, i.e. turbot and halibut. The work involves quantification of reproductive hormones, controlling the initiation and development of sexual maturation and ovulation. Further, characterization of requirements of essential fatty acids for female broodstock, egg and larvae. The transfer of fatty acids from the female to the eggs is of special interest.

The Department of Physiological Botany, Uppsala University, has continued R&D on cultivation of marine algae. A long standing research activity is aimed at understanding the molecular details of immune reactions and defence towards parasites in crustaceans but also to other invertebrate animal. With the great commercial interest in shrimp culture this type of research may lead to better conditions for culture of marine animals.

The production in metric tonnes by commercial aquculture enterprises in 1990-1992 in Sweden is shown in the table below. Production of the most important species- rainbow trout- has decreased during the period.

Species	1990	1991	1992
Rainbow trout	7,100	5,800	5,100
Blue mussel	1,200	1,600	1,350
Atlantic salmon	600	270	390
Eel	180	160	200

Copensation releases of hatchery-reared salmon smolts were about 2,25 million individuals to the Baltic and 133,000 at the west-coast of Sweden. About 560,000 sea-trout smolt were relaeased to the Baltic and 21,000 at the wets-coast of Sweden.

Diseases

The so called M74-disease, which is a disease acting at and killing off yolk-sac fry of Baltic salmon, has increased considerably during the last years. In 1992 50-80% (variation between river stocks) of yolk-sac larvae fry suffered from this abnormal mortality in the hatcheries for Baltic salmon. In 1993 a further increase with 10-15%-units was recorded. The disease is believed to be connected to high load of contaminants in parential fish, and the Swedish Environment Protection Agency and the Salmon Resaerch Institute appointed a group of experts, who have evaluated available data and proposed a strategy for further research activities, which will be given very high priority.

The National Vetrinary institute is, apart from routine work with diseases in fish farms, running three projects of interest to mariculture. With BKD in salmonids new diagnostic methods are being developed and immunological reactions studied. Vibrivaccin for oral distribution to salmonids is under development as is a vaccin for the same disease in eel.

Regulation of fish farming in Sweden

In 1993 National Fishery Board and Environment Protection Board issued new application forms for fishfarming and freshwater crayfish farming in Sweden. Below the background infromation and the application form is translated and summarized.

According to the Fishery Ordinance a permission is always required to establish a farming operation. The application is evaluated by the County Board and is especially concerned with rules for fishfarming technique, stocking of fish and moving of from fish one place to another. Health control in the operation is taken care by a special body " Fiskhälsan". Farmers can signed a contract for sampling and advice for monitoring their operation. Farmers with a site where there is a risk for spreading diseases from cultivated to feral fish are obliged to join " Fiskhälsan".

According to the Environment Protection Act and the Environmnent Protection Ordinance farmers intending to produce more that 10 metric tonnes must apply for a license. A notice to the authorities is necessary for farmers with a production between 500 kg and 10 metric tons. Below is outlined the necessary information which must be giveb when farmers apply for a license. Farmers with a license have to pay annually a fee of 75 SEK/ metric tonnes of production.

According to the Nature Conservation Act there has to be a special investigation if the operation is sistuated within a special protected coastal area or if operations are planned to be located within or besides a nature conservation area. According to Swedish law the protected area comprises a 100 m width land and a 100 m water strip, respectively.

The Water Act requires a special permit to defer surface- and ground water to land-based operations. In addition, other legal acts may apply for fish farming. Conditions arising from land ownership, waters used by professional fisherman, navigational waters, conservation areas, leisure activities, industrial discharges and effluents from communal treatment plants and intake for drinking water may be subjects for conflicts.

Application forms for fishfarming to be submitted to the National Fishery Board and to the Environment Protection Board. *(Summary of the official form to be filled by potential farmers).*

1. **Applicant, address etc.**
2. **The site of the operation**
   A special map should accompany the application with details of ownership of the water etc.
3. **Description of the water area**
4. **Type of farming**
   1.Cagefarming No of cages, surface area, water volume, depth of the cages.
   2.Overwintering Cages will be moved or not, note number of cages surface area, volume, waterdepth of cages, feeding regime, amount fish
   3.Landbased operation Type (troughs, basins, ponds), No, Surface, volume.
   4.recirculating system Rate of recirculation(%) groundwater, community water, sea, lake or running water (m^3/s).
5. **The size of the operation, cultivated species and use of feed**
   1.Production of 1) foodfish 2) fish for stocking 3) spawning fish 4) egg
   2. Species and strain
   3.Maxium net production
   4.Maxium amount of stored fish
   5.Production plan
   6.Type of feed Dry feed, semimoist, wetfeed
   7.Estimated feed usage at maximu production
6. **Technical design**
   1. A sketch of the operation
   2.Descritpion of feeding regime and sewage treatment technique
7. **Processing of fish**
   1. A detailed description of processing technique(dressing,filetting, smoking, manually, machinery. Where does it take place? What do you do with the offall?
8. **Fishhealth control**
   Will the operation be connected to the official health control.
9. **Nearby operations**
   Are farms in the same lake or closer than 20 km in coastal areas? ownership?
10. **Land and water use in the nearby area? Describe type**
11. **Environmental conditions**
    A: Surface area (ha), water supply (m3/year), lake volume(m3), turnover time (year), average depth (m), current conditions.
    B: Bottom type (mud,clay, sand,gravel,stone,rock)
    C: Water criteria
       1.Watertransparency (Secchi depth) (m),
       2. Phosphorous (ug/l)
       3. Nitrogen (ug/l)
       4.Oxygen condition (mg/l) satiation level (%) in summer & late winter
       5. Water data from the water source (Phosphorous, Nitrogen as above)

12. Description of consequences for the environment
Report on environmetal impact, health & conservation of natural resources and dimension of potential environmnetal effects. Potential conflicts should be reported here.

13. Consultations with neighbours and others and information
1.County Board, Environmental and health advisory body and other bodies on regional and local levels. People should be imformed by announcement in papers, flyers etc.

Swedish Reports on aquaculture, coastal management,pollution

Fishfarming and environment

1.Anon., 1993; Fiskodling-Planering, tillstånd, tillsyn Naturvårdsverket 93:10, 99pp. (Fishfarming- Planning, licenses, supervision) (In Swedish.)

Content
Preface
Fishfarming
Fish diseases
Fishfarming and navigation
Fish as food- foodhygien
Fishfarming and nature conservation
Site location
Probation of fishfarming activities (according to various Swedish laws).
Description of conditions
Supervision
Literature
Appendices
1. Fishfeed-overview of the market
2. Technology for sewage treatment
3. Proposal for logbook for cage farming
4. Proposal for logbook for land-based farming
5. Proposal for environmental report

Summary: Since July 1981 Swedish fishfarmers are obliged to have a licence according to The Enviroment Protection Act. You also need to have a permit according to The Fishery Ordinance. In this booklet potential and present fishfarmers are given advices and knowledge on environmental issues in relation to fish farming. The general advices are separated according to messages given by the various authorities. Thus National Fishery Board, The Body for Fishhealth, The Food Authority, Environment Protection Board and The Navigation Board have issued their own chapters in the booklet.

Coastal management including mariculture

2. Anon. 1993; Kust och Hav i Översiktsplaneringen
en sammanställning av metoder och kunskaper. Boverket, ISBN 917147 088-3, 182 pp (Planning of Coastal zone and Sea areas - A compilation of methods and knowledge) (In Swedish)

Content

Introduction
Pre-requisites for planning
Concepts of sea areas
Swedish coasts and archipelagos
Environment in coastal zone and sea areas
From fishing village to a costal community
Demand for coastal- and sea areas
Legal pre-requisites
Coastal- and sea areas- a common heritage
On planning in coastal- and sea areas
Demands for overview plans
The process of planning
Examples of planning
References

Summary: This report is divided into three parts: 1) Overview of cultural, social, natural scientific and legal pre-requisites for planning the use of land and water resources in coastal and sea areas. 2) Guidance in the planning of a coastal community. Which are the specific pre-requisistes for planning and which knowledge is necessar for planning? 3) Examples are given from planning in various coastal communties according to the Law "PBL".

3. Örnsköldsviks kommun, 1988; Skiss till Översiktsplan för kustvattenområdet i Örnsköldsviks kommun (Outline for the coastal area of Örnsköldsvik community)(In Swedish)

This report deals with

Leisure buildings
Professional fisheries
Aquaculture
Industrial discharges
Storage of wood
Port for leisure boats

4. Lysekils kommun, 1990; Översiktsplan 90, Kustvatten och Hav.
Länstyrelsen i Göteborg and Bohuslän, Havsresursdelegation, Naturvårdverket, Boverkhet. (Coastal waters and sea areas, The County Board of Göteborg and Bohus, Swedish Marine resources Commission)(In Swedish)

Content

Pre-requisites for planning
Concepts
Demand for coastal waters and sea areas
Environmental Description of Coastal water and Sea areas.
Outline for planning of coastal waters and sea areas
Programme of measure to reduce the environmental impact on the sea areas

Subject; All Swedish coastal communities are obliged to design a plan for their present and future activities.The plan for Lysekil community is considered to be one of the best plans for a coastal community in Sweden. The first chapter describes the general conditions in the sea , beginning with watercirculation, bottom conditions, the biology of the sea, the water quality. The second chapter deals with the environmental conditions in the coastal waters and the sea outside Bohuslän, the county where Lysekil is situated. The chapter describes the watercirculation, the freshwater supply to the coastal waters of Bohuslän, the biology and the biological production in Bohuslän, the water quality of Bohuslän and a programme for controle of the quality of coastal waters.

5. Anon.,1984; Kommunöversikt Strömstads kommun
Länstyrelsen i Göteborgs och Bohuslän. Strömstads kommun.(Overview of the coastal community Strömstad., The County Board of Göteborg and Bohus)(In Swedish)

The report describes

1. The Swedish interest of areas in the community
2. The Regional interest of areas in the community
3. The interest of the community for special areas
4. Description of the area
5. Fishing
6. Aquaculture
7. Energy production
8. Navigation

6. Anon., 1992. Fiskodling i Kalmar Län. Utveckling 1980-1990
Miljöriktlinjer till 1999. Länstyrelsen i Kalmar Län((Fishfarming in the County of Kalmar. Development 1980-1990. Directions for environment up to 1999, The County Booard of Kalmar). In Swedish).

Short summary: The purpose with report is to give directions for environmetal issues for aquaculture to find out what is acceptable from the environmetal point of view in the county in a wider perpective that what is the case when a case is tested according to the Environment Protection Act.

7.. Coastal and Marine Management in Sweden. 1989?, Swedish
Marine Resource Commission. 37 pp

1. Introduction
2. Coastal and Marine Planning and Management
3. Pollution industry in coastal and marine areas
4. Recent Innovations in coastal Planning and Management
5. A case Study- Bohuslän.

Models for nutrient discharges in coastal waters

8.Wallin, M., L. Håkansson och J. Persson, 1992. Belastningsmodeller för närsaltsutsläpp i kustvatten. Speciellt fiskodlingars miljöpåverkan. (Nutrient loading models for coastal waters- especially for the assessment of environmental effects of marine fish farms). Seminar- og Arbejdsrapporter 1992:502. Nordisk Ministerråd. ISBN Sverige 91 7996 422 2. (In Swedish with an English Summary).

Content

1. Introduction
2. Purpose
3. Sampling and analyses

4. Description of areas
5. Eutrophication in marine envirnonment
6. The dose of nitrogen and phosphorous
7. The sensitivity of the area
8. Collected dose and effect data
9. The treatment of data and results
10. Models and loading diagram
11. Discussion
12. Summary
13. References

Subject: The authors aim to characterize a potential site for aquaculture by using certain empirical data. The overall aim has been to attempt to develop new scientific criteria, methods and models from the planning of coastal waters. The " sensitivity" of different coastal areas to nutrient loading (nitrogen and phosphorous) has been studies in particular. **Methods:** Sampling was done in three subareas of the Baltic during July-September period.
Sediment traps were deployed to get total sedimentation. Water samples for nitrogen, phosphorous, chlorophyll-a and oxygen analyses were collected 2-3 times per sampling period. Simultaneously, measurements of temperature, salinity and Secchi depth were made. The bottom dynamic conditions (the distribution of areas of accunmulation, erosion and transportation) have been determined from echosounding records and surface sediment samplings. **Results:** The load models developed by means of indirect dose parameters (nitrogen and phosphorous concentrations in the surface water) indicate important coast-ecological relationships. Secchi depth and chlorophyll show a close relationship with the total nitrogen content in the surface water. Load models have been derived for the effect parameters Secchi depth, chlorophyll-a and sedimentation 3 m below the water surface. Secchi depth correlates well with most other parameters that describes the nutrient level/ trophic level of coastal waters. If the model conditions are fulfilled, we can use, e.g. the Secchi depth model in order to assess the environmental impact of nutrient discharges from fish farms in coastal areas. This model or parts of it have been published earlier in various publications.

Pollution

9.Anon., 1990, Marine Pollution ´90. Action Programme
Swedish Environmental Protection Agency.
ISBN 91-620-1084-0, 165 pp.

Content

1. Stable organic compounds
2. Nutrients
3. Metals
4. Oils
5. Shipping and fisheries
6. International work to combat marine pollution
7. Research, monitoring and information
8. Readiness in the face of acute threats to the marine environment

Focal points

This reports deals with all sea areas surrounding Sweden. It should be considered as a report on the state of affairs "on the way to" 1995, when the first stage goal to have

been achieved. In the beginning it is asked " How Healthy is the Sea?" The paper discuss load and effects, the present situation and assessment of the risk, and environmental goals.

10. Lindahl,A.H., G.Persson and H. Olsson, 1993. Eutrofiering av svenska kustområden samt omgivande hav: tillstånd, utveckling, orsak och verkan. Naturvårdsverket Rapport 4151, ISBN 91-620-4151-7, 85 pp. (Eutrophication of Swedish coastal areas and surrounding seas: present state, development, reason and effect).(In Swedish).

Content

Summary
Some principles
The eutrophication of the large sea basins and their development
Eutrophication in coastal areas
The Swedish supply of nutrients to surrounding areas
The supply of nutrients from landareas and the atmosphere
The eutrophication of sea- and coastal areas in relation various strategies

Country Report: United Kingdom

Written material has been contributed intersessionally by Dr. Brian Spencer (MAFF, Conwy, UK) for England and during the meeting by Dr. Ian Davis for Scotland. The information provided is summarized below

England and Wales

by

Brian Spencer
MAFF
Fisheries Laboratory, Conwy
Gwynedd LL32 9UB

Production and regulations

Flat oyster production remains at a fairly low level of several hundred tonnes per annum. The Solent Fishery is the sole source of wild oysters used for relaying on fisheries on the east coast of Essex.

Hatchery production of seed bivalves concetrates on Pacific oyster and Manila clams with annual yields of marketable oysters and clams at ca 600 tonnes and 50 tonnes, respectivey.

Classification of shellfish growing waters for the UK, as a requirement of EC Directive, has new been completed.

New fish and mollusc health and disease regulations (EC Directive) were introduced in 1993.

The United Kingdom Digital Marine Atlas has been developed and is regularly updated as a reference work on all aspects of the coastline and seas around the British Isles which will be of use to the scientific, educational, government and commercial sectors. It contains a wide diversity of themes including distribution charts of sea-use, biological, fisheries and conservation information and geo-referenced directories which present detailed information on demand.

Research topics associated with marine aquaculture in England and Wales (Fisheries Laboratory, Conwy)

1: Environmental impact of clam cultivation. The study is in year 3 of a four year programme. Changes in infauna composition of the sediment at an intertidal site in the R Exe show that increased numbers of some invertebrate species (e.g. worms) is associated with the presence of the covering plastig netting used to protect clams from predation.

2. Levels of interebreeding in commercial hatchery populations of *Crassostrea gigas* were assessed.

3 Environmental studies with Manila clams, *Tapes philippinarum,* held at relatively low temperatures of 3-9°C for eleven weeks showed that mortalities occurred only at 3°C. A comparison with the native clam, *T. decussatus,* is underway.

4. A survey of natural spatfalls of Pacific oysters, *Crassostrea gigas,* in English waters was submitted for publication (reference : "Spatfalls of the non-native Pacific oyster, *Crassostrea gigas,* in British waters" by Spencer, B.E., D.B. Edwards, M.J. Kaiser, and C.A. Richardson,. Aquatic Conservation).

5. Toxic algae and their effects on coastal zone fisheries - obtain, and develop methods of culture of *Alexandrium tamarense* and conduct preliminary investigations into factors affecting culture performance and uptake by different bivalve species.

References provided have been incorporated under Section 16 of this WG report.

Scotland

by

Ian Davies
The Scottish Office Agriculture and Fisheries Department
Marine Laboratory, Aberdeen

1. Fish and shellfish production
All data in this report are preliminary.

In 1993, salmon production was undertaken by 144 companies (146 in 1992), operating at 369 sites. The total production was 48,591 tonnes (36,101 tonnes in 1992), although 3.549 tonnes were destroyed due to the MV Braer oil spill incident. The overall survival of 1991 year-class smolts was 66.9%, a modest improvement over the previous two years. (61.6% in 1992 and 57.9% in 1991). 20.5 million smolts were placed in the sea in 1993 (20.5 million in 1992, 20.2 million in 1991).

The relatively small industry growing rainbow trout in salt water produced 425 tonnes in 1993.

Shellfish cultivation was carried out by 332 registered busimesses, of which 205 farms produced shellfish for sale, either for ongrowing or for consumption. The production for consumption in 1993 was 207.5 tonnes of Pacific oysters, 9.5 tonnes of native oysters, 708 tonnes mussels, 31.5 tonnes queen scallops, and 21.1 tonnes scallops.

Discussion
The significant incre3ase in rainbow trout production recorded in 1992 was sustained in 1993 whith a further modest increase. More bigger trout are being produced and a significant proportion of production is for the restocking trade.

Salmon production in 1003 at 48,691 tonnes was the greatest yet recorded. This tonnage was achieved with much the same cage capacity and smolt in put as in

previous years. The remakable increase in tonnage was due solely to the grilse and pre-smolt harvest of the 1992 smolt input, the salmon component of the 1991 smolt input being similar to that of 1992. The returns show that 54% of the 1992 smolt has been harvested and the mea weight of the fish is uß 22%. industry comment has indicated that a dramatic control of furunculosis has increased survival and reduced stress and inappetence allowing fish to grow faster. It has been speculated that survival of the 1992 year class into 1994 has been good. As the 1993 year class appears to be growing and surviving as well as the 1992 year class the indications are for a bigger tonnage in 1994.

It is noticeable that the increase in tonnage and numbers of salmon harvested are not uniform on a regional basis, but are centered on Highland, Western Isles and Strathclyde. These regions appear now to be reaching the levels attained in Shetland, which is maintaining its previous hih standard. However, there is scope in all regions to strive to attain even greater survival. In individual cage populations survivals greater than 90% are often recoded and this should be the standard for all sites within the industry. Because disease control is clearly so important the number of sites apparently not following fallowing principles is clearly of concern.

Scottish farmed shellfish production decreased (copmared to 1992) for all species, with the exception of Pacific oysters. These overall changes were caused by annual fluctuations in output by a small number of companies, and loss of stock through storm damage, gear damage by fishing vessel, and predation by ducks, crabs and starfish.

A buoyant British market existed for Pacific oysters and mussels grown entirely in suspended cultivation, while a competitive European market resulted in reduced sales of scallops, dredged mussels, and dredged mussels fattened in suspended cultivation prior to sale. Poor weaather also affected growth and condition of flat oysters during 1993, resulting in a considerable drop in annual production.

Shellfish marketing cooperatives were instrumentall in developing markets within Britain during 1993, by offering high quality products throughout the year.

2. Sea loch management agreements

It has become apparent over a number of years that if a number of fish farm sites share the same body of water there is potential for interactions between them, particularly regarding disease transfer. This is perhaps more obviously the case in freshwater systems, where the quality of the water supply to a farm has long been recognised as paramount, and management strategies have been evolved to reduce the likelihood of disease transfer.

In the sea, the likelihood of interactions between farms will generally decrease with increasing distance of separation, but in sheltered inlets such as Scottish sea lochs, or fjords, the reduced rate of water exchange will tend to decrease the dispersion of disease agents, and increase these interactions.

A few years ago, it became clear that there was a need to limit the transfer of disease and parasites between farms. In sea lochs where all sites are operated by one company, this could be arganised relatively easily, but more formal arrangements are necessary where more than one company is involved. The agreements which have evolved are known as Sea Loch Management Agreements, and are private

arrangements organised by the fish farm operators themselves. They are not enforced by regulatory authorities or government departments. Typically, agreements coveer such factors as:

a)' definition of the area covered by the agreement
b) a requirement to introduce only healthy new stock
c) single generation stocking at each site and throughout the agreement area
d) all in - all out stocking and harvesting
e) specification of fallowing periods
f) exchange of information on parasite infestations and diseases
g. coordination of control measures against disease and parasites, for example coordination of the timing of treatments in adjacent farms against sea lece infestations, or coordination of the choice of antibiotics to control furunculosis.

These agreements therefore can cover aspects related to disease control (e.g. coordination of treatments) and also to environmental quality (e.g. fallowing periods), providing aspects of a dual useful approach. Experience indicates that this form of cooperation between operators can make major contributions to fish health, reduction in chemical (medicine) usage, and farm profitability through improved survival and growth of fish.

3. Developments in the Scottish shellfish industry

There are a number of continuing developments in the Scottish shellfish industry, concerned with new species or cultivation techniques.

a. Several Orders

These are legal arrangements that remove (i.e. sever) the public right of fishing for particular marine species in defined areas. The main objective of these Orders in Scotland is to permit the development of bottom culture of bivalves, scallops in particular. Orders are needed because the general legal, position is that once an animal is on the sea bed it can be collected an removed by anyone who can find it. This is clearly a discouragement to farmers wishing to lay young scallops (which have cost them money to collect, husband, and distribute) in defined areas, and to return and collect them when they have reached marketable size. Orders prohibit certain activities in the defined areas, such as types of fishing, and gives some protection against other activities that might damage the stock.

The procedures surrounding the granting of a Several Order are long and complex, and can result in a Public Enquiry at the cost of the applicant. It is a reasonable indication of the difficulties involved to say that 25 applications for Several Orders have been received, but only 2 granted (one for a small experimental area, the other for a commercial business). It is unlikely that more than 10 areas will exist in the next year or so. The main objections are from wild fishermen who object to restriction of access to traditional fishing grounds.

Apart from laying the scallops on the sea bed, a farmer will also take some measures to reduce predation on his stock by crabs, lobsters, or starfish. Small fences on the sea bed have been tested , but the main control method used is capture and removal of crabs and lobsters by creeling (potting), and possibly removal of starfish by divers.

b. Investigations of the culture of Manila clams has largely ceased, as the temperatures have been found to be low to achieve adequate growth rates under commercial conditions.

c. Investigations of the potential of *Venerupis* has been inhibited by a lack of a reliable source of disease-free spat.

d. There is some interest in the cultivation of black sea urchins. The attraction is that the animals are of high value in countries such as Japan, and the characteristics (colour, texture, etc) of Scottish urchins is particularly attractive to this market. The feed on macro-algae.

Operations are ony in a small-scale research phase. More information is available from The Director, Dunstaffnage Marine Laboratory, Oban, Argyll, Scotland.

Country Report: United States of America

by

Carter R. Newell

1. Production and number of fish farms. In 1993, Maine was the leading producer of fish with 15.5 million pounds, 700,000 pounds of which were steelhead trout and the remainder Atlantic salmon. Fish was grown in 18 farms, 70 separate lease sites with 1268 acres in production. In Washington state, approximately 9-10 million pounds were produced by 4 companies with 6 farms active.

2. Research on the environmental impact of net-pen aquaculture.

a. Two contributions to the report "Modelling benthic impacts of organic enrichment from marine aquaculture" (Hargrve, B.T. ed., 1994, Can. Tech. Rep. Fish. Aquat. Sci. 1949 xi + 125 p) were made from the U.S., summarizing the workshop held at St. Andrews, N.B. on May 13, 1993 in which a review of current approaches to modelling the environmental impacts of fish farms were reviewed.

1. The effect of benthic carbon loading on the degredation of bottom conditions under farm sites (J.W. Sowles, L. Churchill and W. Silvert; contact J. Sowles, Maine DEP, State House Stn. 17, Augusta, Me. 04333). In the paper, a model was developed to evaluate the carbon accumulation and benthic deterioration under Maine fish farms, based on 23 fish pen systems in Maine. The model also shows how the bottom conditions change over time.

2. Toward a process level model to predict the effects of salmon net-pen aquaculture on the benthos (R.H. Findlay and L. Watling; contact L. Watling, Dept. of Oceanography, University of Maine, Walpole, Me. 04573). In the paper, a comparison of the maximum rate of oxygen demand generated by the waste stream at Maine production facilities allowed the prediction of the development of Beggiatoa-type mats, indicative of deteriorated benthic conditions under the pens.

b. Proceedings of the U.S.-Israel Workshop on Mariculture and the Environment, June 8-10, 1992, Elat, Israel,Eds. G.W. Kissil and Lea Sa'ar. U.S. Contributions include:

1. Effect of mariculture autopollution on benthos associated with pen culture. L. Watling and R.H. Findlay, University of Maine, Walpole, Me. 04573. The paper documents lower carbon deposition rates than predicted, attributed to husbandry practices, biological and physical interactions.

2. Analysis of autopollution using remotely operated vehicles (ROV). L. Stewart, National Undersea Research Center, University of Connecticut.

c. Paper in press: Environmental impact of salmon net-pen culture Maine marine benthic communities: A case study. R.H. Findlay, L.Watling, L.M. Mayer, Darling Marine Center, University of Maine, Walpole, Me. 04573. Estuaries. Studies in Maine indicated that beneath net-pens, microbial and macrofaunal communities were shifted towards communities associated with organic enrichment but seasonal trends and storm-related resuspension events also significantly affected these communities.

d. Application of mathematical models in the environmental regulation of net-pen aquaculture. 1993. V.G. Panchang, G. Cheng and C.R. Newell. 105 p. Final report to NOAA/NMFS, published as a Maine Sea Grant Technical Report (contact Maine Sea Grant, Coburn Hall, University of Maine, Orono, Me. 04469). Site-specific mathematical computer flow models were developed at two contrasting sites in Maine (one dominated by high tidal currents, the other by wind-driven flows and wave-induced velocities) where 2-dimensional flow models were combined with a waste-particle transport model to predict accumulation of organic deposits beneath net-pens. Field data were used to force, calibrate and verify the various models. The paper also includes a table which can be used to determine wave height and bottom velocities based on wind speed.

A shorter version of the paper was presented by the same authors at the December, 1993 Dartmouth Modelling workshop and at the Indian National Conference on Harbor and Ocean Engineering (June, 1994), entitled: Modeling hydrodynamics and aquaculture waste transport in Maine embayments (contact V. Panchang, Civil Engineering Dept., University of Maine, Orono, Me. 04460).

3. Conference entitled: Aquaculture and the Marine Environment: the Shaping of Public Policy (August 30 - September 1, 1993). Marine Biological Laboratory, Woods Hole, Mass.) Contact: H. Halvorson, Policy Center for Marine Biosciences and Technology, U. Mass., Dartmouth, Mass. The conference, and short proceedings, dealt with the following areas: waste management; the interaction of aquatic species with native populations; aquaculture's role in the economics of coastal communities; educational needs. With regards to aquaculture waste management, the following actions were recommended:

1. Regulators need to better coordinate efforts to determine criteria for acceptable or unacceptable mariculture sites. They should use the best available scientific information in these efforts.
2. Agencies making these determinations should take into consideration the needs of the industry.
3. Agencies need to better apply pertinent monitoring criteria. These should recognize the high costs associated with monitoring.
4. Programs which work with growers to optimize site production using Best Management Practices should be encouraged.
5. The impact of drug residues and pesticides on human health should be examined by the EPA and FDA.
6. Consumer education is needed in the areas of public health.

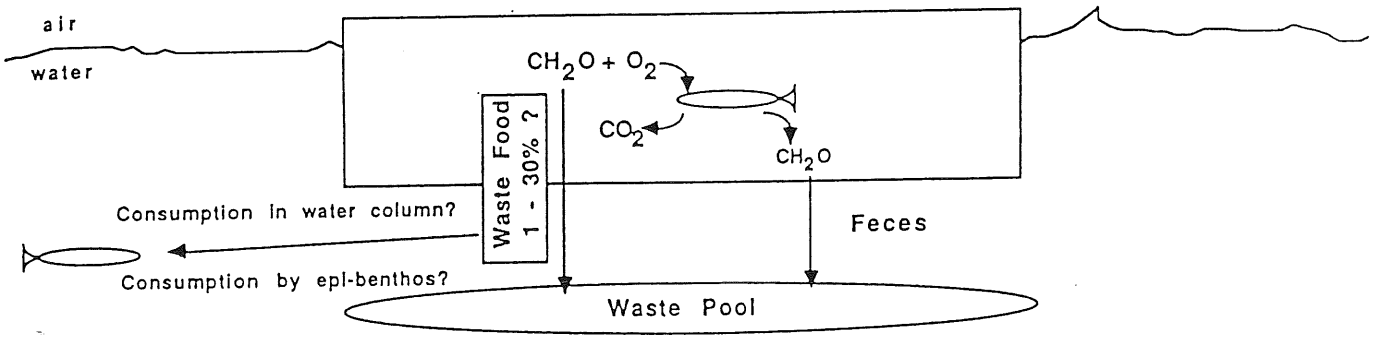
4. The U.S. Joint Subcommittee on Aquaculture has supported initiatives to develop FDA approval of new animal drugs for aquaculture. Using the process of INAD (investigative new animal drugs), coordination of resources among companies, states

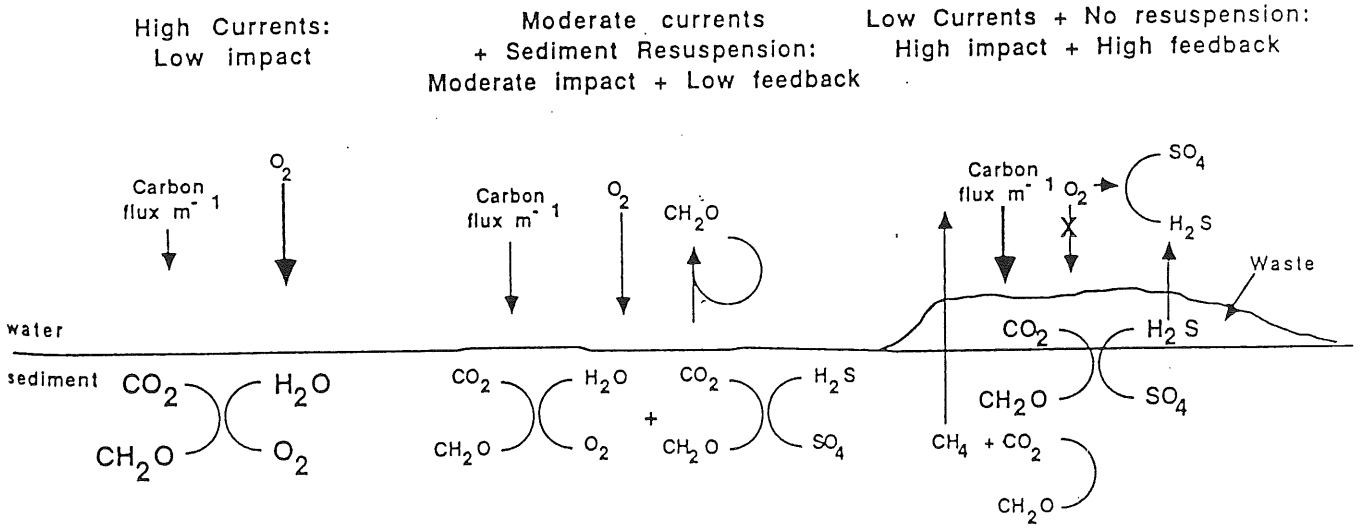
and countries is needed to harmonize pharmaceutical applications in aquaculture. Another initiative is to reduce regulatory priority of so-called drugs such as oxygen, carbon dioxide, garlic, onions and ice which are in general use and are not considered to be public health risks. As far as antibiotic use by fish farmers is concerned, BMP's should be stressed. Contact: Dr. Hugh Mitchell, Connors Aquaculture, Estes Head, Eastport, Me. 04631.

5. The U.S. Department of Agriculture Regional Aquaculture Centers has an inter-regional aquaculture waste management project, in which national research priorities have been determined. These include:

a. Reduction of waste generation (including phosphorous pollution, improving feeding practices, and changes in feed formulation).
b. Interception of waste, and transformation into useful by-products.
c. Regulation of waste discharge/public policy education.

For more information, contact Gary Jensen, National Aquaculture Program Leader, USDA Extension Service Room 3865, S. Bldg, Washington, D.C. 20250.





Appendix V

A DISCUSSION PAPER
ON

DEVELOPMENT OF BIOLOGICAL CRITERIA FOR GAUGING ENVIRONMENTAL IMPACTS OF AQUACULTURE

James E. Stewart
Habitat Ecology Division
Biological Sciences Branch
Department of Fisheries and Oceans
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, NS B2Y 4A2

Aquaculture, as a commercial venture, is now being pursued in areas where it has not existed previously. As mariculture has expanded from its initial tentative trials, requiring a minimum of space, it has become increasingly a serious and significant competitor, of traditional and established users and activities, for space in the coastal zone. To win acceptance for aquaculture there is a need and an explicit demand to demonstrate convincingly that this activity need not and will not jeopardize other legitimate uses of the coastal areas through causing significant alterations in or deterioration of environmental quality.

To be able to offer such assurances, credible, and readily applicable methodology must be available to permit authorities to assess and predict reasonably accurately what the consequences of various loadings will be. Unfortunately, there is no model or system currently available to predict or indicate the limits to the assimilative capacity of the various culture locations or the full consequences of exceeding these limits. Work and studies undertaken, over the past decade, to fill this gap, has resulted in a variety of hydrographic and other numerical models. The hydrographic models are able to display the movement of waters within specified bays and inlets and the other numerical models can be used to calculate and predict the output in the form of nutrient, pollutant, and oxygen concentrations for specific aquaculture loadings; taken together, the models can be used to show the concentrations and trajectories at particular geographical points in relation to time, currents, and tides. They do not, however, possess a biological component to illustrate the consequences for the biota, i.e. the ecosystem in general or the organisms being cultured. The thrust of this discussion and proposal concentrates on how this missing element could be supplied from existing information and used to complement the hydrographic and numerical models and extend their usefulness and secondarily suggests the use of the farms, after their establishment, as environmental sentinels.

A. Biological Criteria for use in Predicting Consequences

Loadings of the kind practiced in aquaculture, especially in fin fish culture, will result in nutrification and pollution through release of surplus food and faecal material (Fig. 1), other agents and materials used in these operations will add to the totals. As nutrification and pollution increase, stresses are imposed on the biological systems lowering the physiological condition and impairing the capacity of organisms to resist diseases thereby increasing the susceptibility of the organisms to infectious diseases and parasitism, increasing the likelihood of the growth of troublesome algae, resulting in decreased rates of growth and increased mortality rates. The most immediate effects will probably be felt closest to the sources of the nutrification and pollution; ie. upon the farms themselves. Since there are a considerable number of locations in the North Atlantic littoral and also in the Pacific, where the farm operations have been followed closely and detailed measurements have been made, a considerable body of data on this topic has accumulated internationally, eg., as assembled and distributed in a preliminary form by Wheatley et al., (1993).

The utilization of these data to develop and use the biological connection for purposes of prediction stems from the premise that repeated occurrences of infectious diseases, significant and sustained increases in infestations with larger parasites (internal and external) and the frequent and or chronic appearance of troublesome algae or algae hitherto absent coupled usually with reduced growth and increased mortality rates, are clear signs of major stress. These features (disease prevalence, algae, reduced growth, increased mortality rates) taken collectively or in various combinations indicate that the load limits of the system have been exceeded. (A detailed picture of the relationship of diseases to the characteristics of the host/pathogen and the environment is illustrated in Fig. 2). Accordingly, it is proposed that the extensive international body of data underlying these indicators be examined and analyzed for use in conjunction with hydrographic and numerical models as biological criteria to gauge load limits for aquaculture operations throughout the north temperate zone. In summary, the environmental conditions leading to increased stress impair growth and predispose the cultured organisms to disease; chronic and increasing levels of disease, impaired growth, and increasing mortalities are overt indicators of the degree of stress imposed.

To achieve this, it is proposed that the relevant bodies of data be assembled from the various national sources by the members of two working groups of the International Council for the Exploration of the Sea (ICES), i.e. the Working Group on the Pathology and Diseases of Marine Organisms and the Working Group on Environmental Interactions of Mariculture. Upon assembly of these data it is proposed further that the two groups, working jointly and or cooperatively, should determine the best approach to analyzing the information and utilizing the results in keeping with the principles enunciated here. Further, it is suggested that any analysis should consider at a minimum three spatial scales; 1) Internal Impacts ie., fish within the cages, 2) Local Impacts ie., effects in the immediate vicinity of the cages, and 3) Regional Impacts ie., effects on a whole bay or inlet.

It is presumed that an analysis of these data would show a reasonable correlation between the biological criteria and such indices as the nutrients (N and P) released from the farms and perhaps oxygen levels. These biological criteria consist of disease occurrences (treated collectively as infection frequencies and levels rather than as individual diseases), the occurrence and persistence of troublesome algae (not necessarily at bloom concentrations, but at levels sufficient to be a problem), the growth rates of the cultured species and their mortality rates. It is recognized that these relationships will be modified by and will need to be matched to prevailing temperatures and salinities. Further, it is anticipated that the match when illustrated graphically will not show a sharp and irrefutable end point, but rather will demonstrate a gradual transition showing that as aquaculture loading increases the nutrient levels will increase along with oxygen consumption and as critical zones develop and are entered, the infection rates, algal levels, and mortality rates will rise more steeply while the growth rates will decline more dramatically. Thus, the resulting curve would be expected to exhibit a succession of zones ranging from low fish loading levels with little impact and very few to none of the consequences described above, to commercially serious effects at higher loadings. The adverse consequences would reach critical values at some level of fish loading and the course would proceed from that zone to higher and higher levels of negative consequences. The critical zone would be defined as that level of reduced growth and increased mortality rates which was sufficiently large to offset or prevent any gain emanating from the expansion and the increased investment in capacity. This could also be called the Zone of Jeopardy where the safety margins are minimal and the result of even small unexpected increases, in adverse conditions, could have a major negative impact on the entire operation. Thus, by drawing upon the extensive data now in existence (on diseases, algae, growth rates, mortality rates, nutrients, pollutants, etc.) in many of the ICES countries it should be possible to construct these curves for varying conditions of temperature and salinity and use the results to predict the consequences of different aquaculture loadings, especially for salmonid culture. It should be possible to use the same principles and approach for other fin fish species as the need and occasion arises and with suitable modifications apply them also to gauge the impact of shellfish culture.

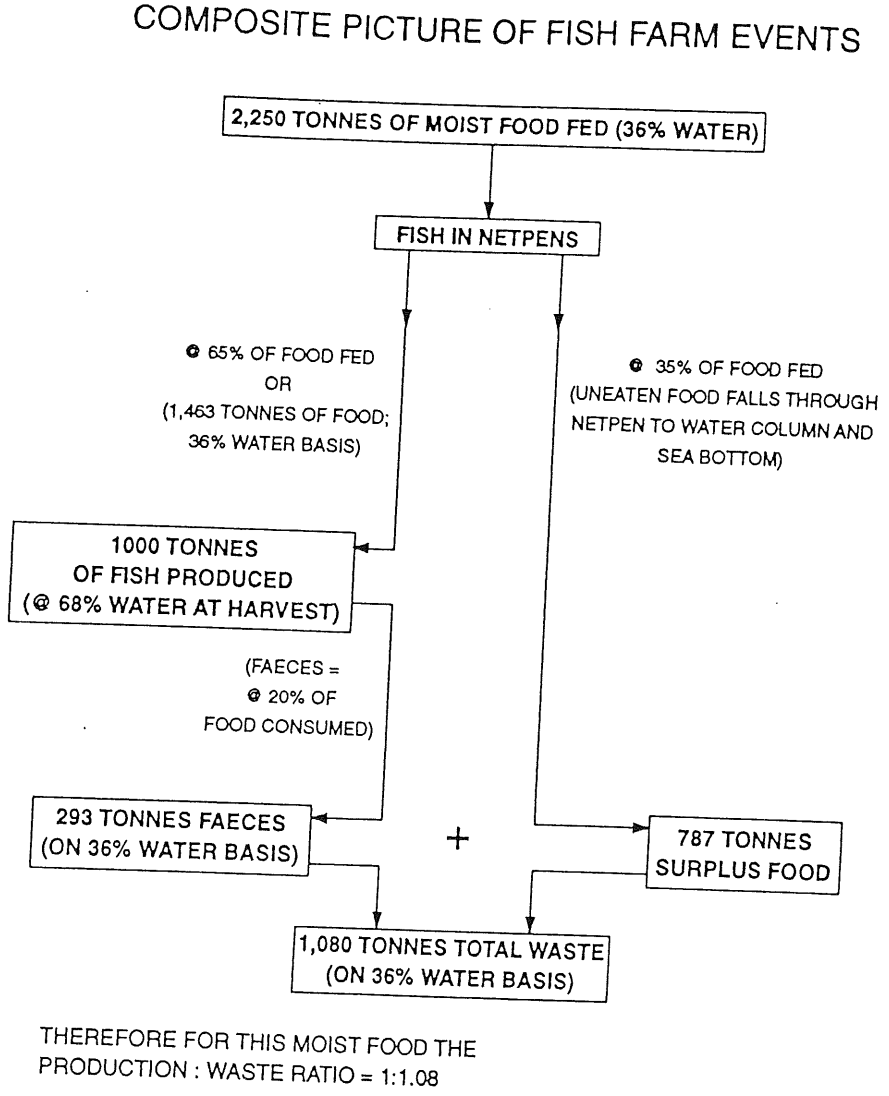


Figure 1. Representation drawn from Atlantic Canada data.

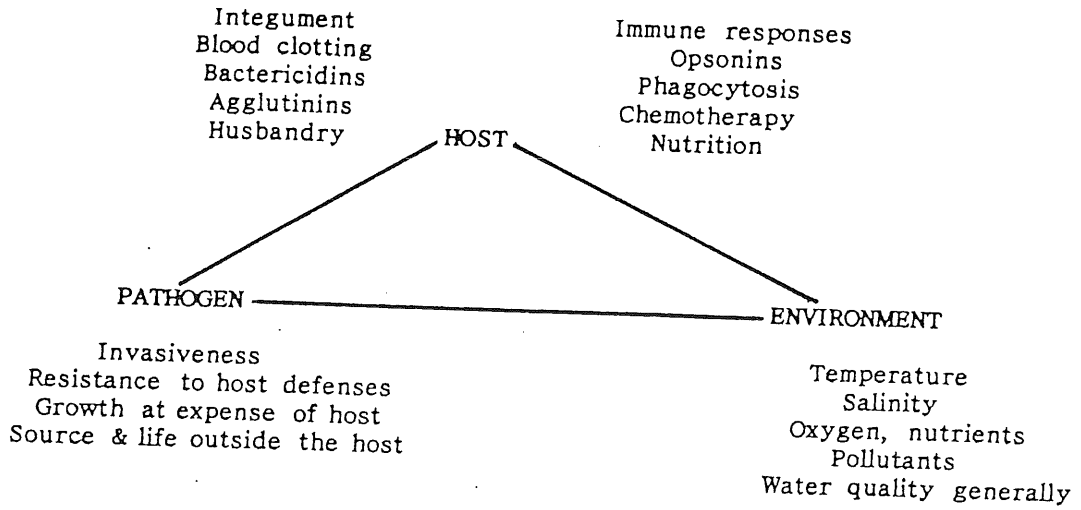


Figure 2. Relationship of infectious diseases to host/pathogen characteristics and the environment.

Once these relationships have been established, as a form of calibration exercise for the numerical models, it should then be possible to use the numerical and hydrographic models, independently, to assess and predict the consequence any particular loadings will have on the farms themselves; the farms would be expected to be the first to be affected and to be hit the hardest. The predictions would serve not only the aquaculture operations, but would also enable regulators to extend these assessments to gauging the aquaculture impact on the local ecosystems.

This calibration exercise, plus the models and the predictions, used with skill and sound judgement should allow the matching of aquaculture farm loadings to assimilative capacities with reasonable built-in safety margins based upon solid foundations. If applied in this manner the resulting farms should, from a technical point of view, be more successful (assuming the most appropriate husbandry is practiced) and should, in fact, also perform the function of monitors or sentinels to indicate the health of the environment generally. A fish farm should be the best environmental monitor and indicator it is possible to construct since it is also an integrating device for the substantive activities occurring in the area. Healthy, prospering aquaculture operations should be an assurance of the health of the ecosystem generally.

B. Monitoring: Use of Farms as Environmental Sentinels

The basis for utilizing aquaculture farms as a form of "mine canary" or similarly to the "increases in fish mixed function oxidase" as monitoring systems is bolstered by widespread experiences. Over the years many aquaculture ventures have been established in different locations around the world, and after a period of apparent initial success, have been abandoned. Unfortunately, when operations are terminated it is rare for a thorough post mortem examination to be conducted. When whatever information available is examined, however, no examples surface which show that the initially successful operations were terminated because they caused clear and unacceptable damage to the local ecosystem. In fact, it is usually the operation itself or its products which have been affected adversely thereby making the venture unsuccessful or bringing into play regulations aimed at safeguarding the ecosystem or other aquaculture ventures eg., closures as a result of the occurrence of infectious diseases within the farm(s).

A short list selected at random could include the abandonment by Norway and Sweden of their attempts to grow mussels commercially. Although the Swedish annual mussel production had reached a level of several thousand tonnes the repeated occurrences of the algally caused Diarrhetic Shellfish Poisoning eventually forced both countries to abandon mussel rearing as commercial ventures in their coastal zones.

In Norway, operations at more than 20 salmonid farms were terminated in 1988 for a minimum of two years because of the introduction, via imported smolts, of a biotype of *Aeromonas salmonicida* (the causative agent of the fatal infection, furunculosis) more virulent than any previously experienced in Norway. The total damages were estimated to exceed 100 million U.S. dollars. In Scotland the practice of fallowing has been adopted for the relatively shallow lochs to allow the farm sites to recover from the local depositions of waste and also the high level of parasitism of their cultured salmon with sea lice which increases with continued occupation of the farm sites. In addition to the problems of osmoregulatory failure and anaemia caused by sea lice, recent findings in Norway have shown that sea lice can be carriers of *Aeromomas salmonicida* (Nese and Enger, 1993) and potential vectors for the spread of furunculosis and Infectious Salmon Anaemia. (Nylund et al., 1993 cited in Hodneland et al., 1993).

Paralytic Shellfish Poisoning now occurs intermittently in and among the massive Spanish mussel culture operations, where it had not been experienced previously. Fortunately, it has, to date, also always disappeared within a few weeks and thus has not disrupted operations sufficiently to cause severe economic dislocations. In the Japanese pearl culture operations in Mie Prefecture the operations were

being influenced negatively after many years of production at the same site by the inclusion of a pigment in the cultured pearls which increasingly gave a yellowish cast to the pearls. The goal for pearl production is to produce a gem which is 1)spherical, 2)has good lustre, 3)is of large size and 4)has a pinkish cast (with the obvious exception of unique gems such as the treasured black pearls). The scientists attributed the production of the pigment and reduced sizes to a condition termed "senescence of the grounds" i.e. feedback from the accumulations on the floor of the bay deposited from the pearl culture rafts. This caused costly revisions to the culture procedures and considerable relocations to eliminate the problem.

The rapidly expanded salmonid farming in the Sechelt Inlet, a well protected, but poorly flushed fjord, in British Columbia was heavily affected by algae (*Heterosigma* sp. and *Chaetoceros* sp.) in 1989. It is believed that the Fraser River plume as it turns northward had several effects i.e. it tended to pin the waters in Sechelt Inlet reducing flushing action, creating the stability favouring algal growth and also supplying nutrients to stimulate these two algae in particular. Studies are being conducted with *Heterosigma* sp. to learn more about its possible toxins (E. Black, Personal Communication); the damage done by *Chaetoceros* sp. is better understood. Even nominal numbers of *Chaetoceros* (5 per ml of seawater) are sufficient to stimulate in response to gill damage the production of massive amounts of mucus which inhibits oxygen uptake converting the fish to anaerobic metabolism and leads ultimately to death caused by 1) microbial infections of damaged gill tissue, 2) hemorrhage of gill capillaries or 3) suffocation by the excess mucus (Yang and Albright, 1992). In addition Albright et al. (1993) extended the studies to show that, in actual culture operations, chinook and coho salmon suffered increased mortality rates from vibriosis and bacterial kidney disease when small numbers of *Chaetoceros concavicornis* were present to provide portals of entry for the infectious agents.

Because of the problems with algae the insurance rates for aquaculture operations conducted in Sechelt Inlet increased substantially. This had the effect of reducing culture operations rather quickly to less than a third of what they had been prior to the occurrence of the algal problems. Many operations were moved farther up the Straits of Georgia to cooler and better flushed waters or to other locations giving more desirable conditions (E. Black, Personal Communication).

The conditions which lead to algal blooms are also conditions which contribute to poor conditions for fish generally, i.e. warmer waters, increased nutrient levels and water column stability. The increased nutrients would be expected to increase the level of the algal growth leading to damage from toxins,such as the algal hepatotoxin, microcystin, or microcystin-like toxin now confirmed as the cause of Netpen Liver Disease in caged Atlantic salmon (Andersen et al., 1993), or to a suppression of oxygen levels upon the termination and subsequent decay of the bloom.

The list could be extended considerably, but these few examples adequately illustrate the point and demonstrate the range of problems, species affected and the diversity of the geographical areas involved. As Braaten et al. (1983) pointed out, after a few years operation at a single site the accumulation of wastes and concomitant release of nutrients, noxious gases and other pollutants will produce conditions which cause discomfort in the fish, changed behaviour and reduced growth; typically, in their experience with cultured fish, these changes included reduced appetite, gill damage, reduced resistance to disease and increased mortalities. They stated the weakened fish would be particularly vulnerable to infections or parasites although the ultimate reason for an outbreak of disease may be difficult to pinpoint. They also reinforce the point made earlier that the first and usually the main victims are the aquaculture ventures themselves and underscore the validity and the suitability of the aquaculture operations as environmental sentinels.

REFERENCES

Albright, L.J., C.Z. Yang, and S. Johnson. 1993. Sub-lethal concentrations of the harmful diatoms, *Chaetoceros concavicornis* and *C. convolutus*, increase mortality rates of penned Pacific salmon. Aquaculture 117: 215-225.

Anderson, R.J., H.A. Luu, D.Z.X. Chen, C.F.B. Holmes, M.L. Kent, M. LeBlanc, F.J.R. Taylor, and D.E. Williams. 1993. Chemical and biological evidence links microcystins to salmon "Netpen Liver Disease". Toxicon. 31: 1315-1323.

Braaten, B., J. Aure, A. Ervik, and E. Boge. 1983. Pollution problems in Norwegian fish farming. ICES F:26, Mariculture Committee, mimeo.

Hodneland, K., A. Nylund, F. Nilsen, and B. Midtun. 1993. The effect of Nuvan, azamethipos, and hydrogen peroxide on salmon lice *(Lepeophtheirus salmonis)*. Bull. Eur. Ass. Fish. Pathol. 13: 203-206.

Nese, L., and O. Enger. 1993. Isolation of *Aeromonas salmonicida* from salmon lice *Lepeophtheirus salmonis* and marine plankton. Dis. Aquatic. Org. 16: 79-81.

Nylund, A., C. Wallace, and T. Hovland. 1993. The possible role of *Lepeophtheirus* (Kroyer) in the transmission of Infectious Salmon Anaemia. *In*: Pathogens of Wild and Farmed Fish: Sea Lice. G. Boxshall [ed.]. Ellis Horwood Ltd.

Wheatley, S.B., F.D. Menzies, M.F. McLoughlin, and E.A. Goodall. 1993. An epidemiological investigation of diseases of farmed Atlantic salmon *(Salmon salar* L.) using a relational data base. Int. Counc. Explor. Sea F:23. Mariculture Committee, Mimeo.

Yang, C.Z., and L.J. Albright. 1992. Effects of the harmful diatom *Chaetoceros concavicornis* on respiration of rainbow trout *Oncorhyncus mykiss*. Dis. Aquatic Org. 14: 105-114.

General

Hakanson, L., A. Ervik, T. Makinen and B. Moller, 1988. Basic concepts concerning assessments of environmental effects of marine fish farms. Nordic Council of Ministers, Copenhagen. 103 pp.

Makinen, T. (ed.), 1991. Marine aquaculture and environment. Nordic Council of Ministers, Copenhagen. 126 pp.

Appendix VI

MARICULTURE AND THE ENVIRONMENT
The Saldanha Bay System Programme

The principle which underlies the approach of this research programme is the view that in marine aquaculture the resources which need to be utilized and managed in a sustainable way are the aquatic environments within which the production units are located. This is in contrast to wild stock fisheries where the utilization is focused on the individual species and where environmental variability is unaffected by this activity. Marine aquaculture has a range of requirements from the aquatic systems within which they are located; unpolluted water, adequate food and oxygen supply, a degree of protection from oceanic storms and toxic phytoplankton events and, related to all the above, an element of predictability in respect of variability of the environment. Problems arise when the production exceeds a certain magnitude, the carrying capacity of the system, and begins to negatively impact on some property of the system which made it initially suitable for mariculture. This property could be food supply in the case of mussels or water quality, oxygen concentrations, in the case of finfish.

All these aspects of the interaction between mariculture and the environment are first order factors in determining three essential requirements for the installation of a production unit: 1: suitability of the area; 2: the carrying capacity and 3: the risk associated with environmental events with potentially catastrophic consequences for the production unit.

Concern has been expressed within both DEA and the industry that little information existed and no focused work was being done at the appropriate scales, with which to develop policy to ensure sustainable use of the scarce resource: bay or estuary systems

Developing a strategy to address these issues on the scale of southern Africa but in the specific shorter term context of Saldanha Bay is the goal of the Saldanha Bay System programme.

Saldanha Bay

Saldanha Bay is the centre of the fledgling South African mussel industry. Its suitability for this type of mariculture is based on its strong link to the highly productive west coast upwelling system from whence the phytoplankton which feed the mussels are derived as well as its apparent low risk of toxic phytoplankton blooms. Being physically constrained in both circulation and exchange rates with the coast, Saldanha Bay has a maximal rate of food supply which would govern the carrying capacity and stocking density. Experience in the major shellfish production centres in France and Spain have shown that exceeding the carrying capacity leads to: retarded growth rates, slower recoveries after spawning and lowered resistance to disease, all of which can threaten the economic viability of all the units within the system. Other problems which arise in Saldanha Bay and similar systems are the conflicting uses of the system by other human activities which impact on water quality. These could include the use of Tri-butyl Tin (TBT) antifouling compounds by ships, the accidental and deliberate inputs of polycyclic aromatic hydrocarbons (PAH's), pathogens and fish processing wastes. All these human derived inputs have an impact on the risk associated with a financial investment in such a system and hence its sustainable use. Constraining the scales of spatial and temporal variability in Saldanha Bay and predictively modelling the impacts of interactions between human activities and the bay system is

Research Institute's Working Group on the Interactions between Mariculture and the Environment.

The Working Group:

The Working Group was started towards the end of 1991 as part of a plan to develop a more functional approach to marine resource management by SFRI. This and other interdisciplinary working groups provide the Director of the SFRI with the scientific basis to facilitate a more complete approach to the development of sustainable utilization policy and strategies. The Working Group comprises scientists from the SFRI and outside Institutes in several disciplines relevant to developing a holistic approach to the interaction between mariculture and the environment. To allow development of a focused approach, industry and special interest groups also have observer status. The overall relationship between the WG and its main components is shown on Fig.1.

The working group defined the goals and objectives of a research programme aimed at addressing the most pressing key questions: what is the carrying capacity of mussels in Saldanha Bay and what stocking density strategies maximize their growth rates ?; how do natural and human- derived physical and chemical processes impact on the food supply dynamics and mussel growth rates ?; can these relationships between mussel culture and the environment be predicted sufficiently accurately to allow both successful long term Bay management and optimal mussel growth rates ?

Specific projects of the programme were found to be beyond the scope of the work carried out by the SFRI or outside its human resource constraints. These projects were

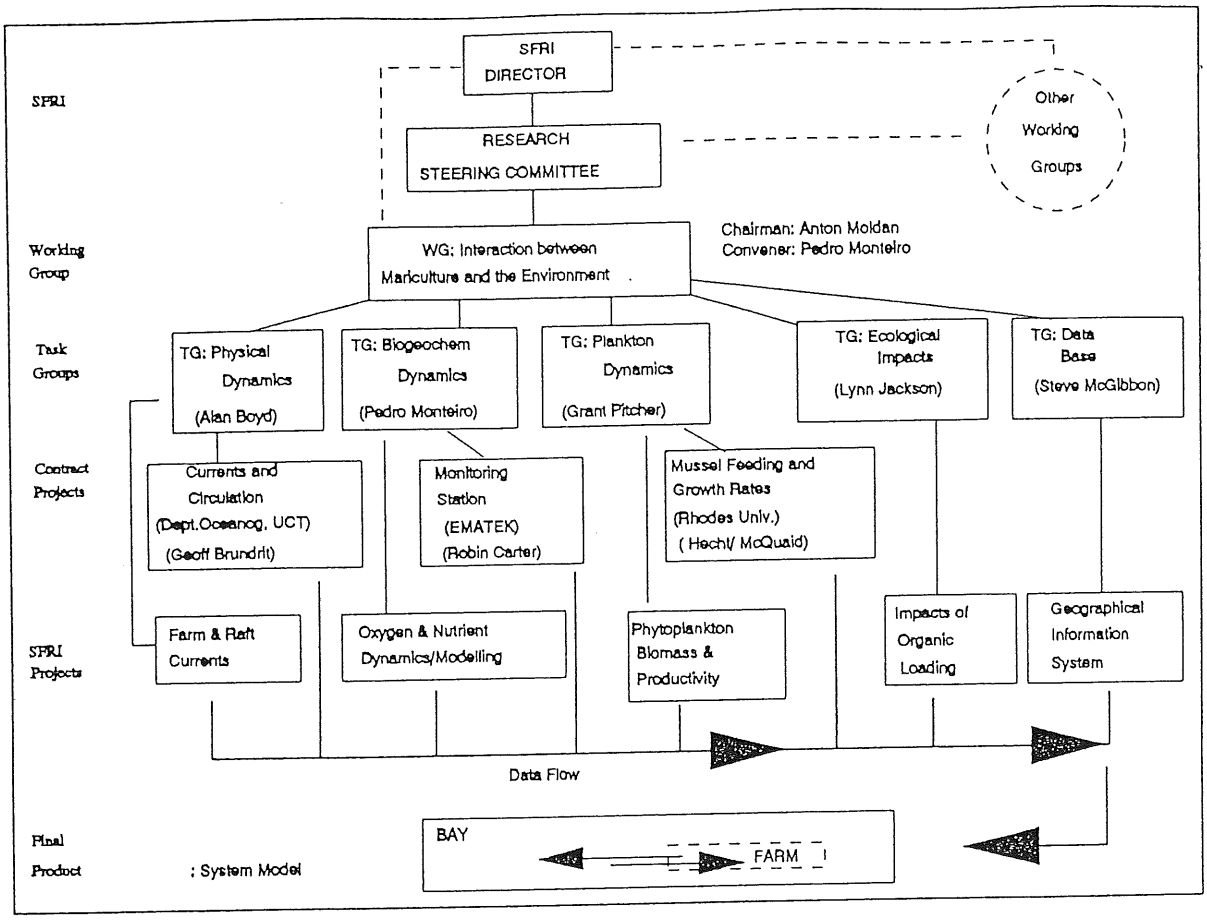


Figure 1. Position of the three working groups within SFRI structure

which had the expertise to deal with them. The tendered proposals were evaluated scientifically by the Research Steering Committee who then advised the Director accordingly. Ultimately, the contracts were awarded to the best proposals within the budget constraints. Three contracts which were awarded: the currents and circulation project was tendered to the Department of Oceanography at UCT; the installation and data collection from the monitoring station at North buoy was awarded to EMATEK, Stellenbosch; the farm scale study of mussel growth rates in relation to stocking densities was awarded to the Dept of Icthyology and Fisheries Science at Rhodes University. Further details on the interrelationships between the projects and the Working Group are provided in Figure 1. This process was completed in early 1993, after which the scientific programme got under way.

The Research Programme

The research programme tackles the processes which drive food supply variability within the system on two main scales : the Bay-scale and the farm-scale. All processes (Physical, bio-geochemical and plankton dynamics) are studied within both scales. Bay-scale dynamics which with the coastal processes drive the food supply are studied with a three-pronged strategy: Spatial variability and process rate measurements, comprise two of the angles, are carried out in the course of three 7-10 day field trips (July, December and February). These intense sampling periods are linked on a temporal scale by a monitoring station, the third angle, which provides hourly data (surface and bottom) for temperature, salinity, oxygen and pH. The farm-scale sampling is focused on the rates of food uptake by mussels and associated growth rates. It is essential to understand how these respond to physically or ecologically driven changes to the food supply. The field programme for this scale is under way. The overall programme will be completing its first annual cycle by February 1994. The sampling period runs for two years and the third and final year will be dedicated to the modelling process. The ultimate objective of this approach is to build two separate models within each scale and subsequently to nest the farm scale model within the bay scale. This will allow a predictive view of the interaction between mussel growth rates and the spatial and temporal dynamics of phytoplankton within any part of Saldanha Bay. It is the quantitative insight into this interaction which will then allow carrying capacity and stocking densities to be defined more reliably and in a site-specific way.

Other associated products which are expected from this research effort are an understanding of the puzzling low incidence of toxic red tides within

the Bay, the relationship between fish factory activity, low oxygen events and undesirable algal growth, and generally the fate and impacts of discharges into the Bay. Members of the Working Group have started to develop close links with the international community with the experience of the French and the global perspective of ICES being of special interest. Specific findings of special interest to farmers will be published periodically in this newsletter as they arise.

Pedro M.S. Monteiro
Sea Fisheries Research Institute
Private Bag X2, Roggebaai 8012.

E-mail: monteiro@sfri_2.sfri.ac.za

FIRST AFRICAN FISHERIES CONGRESS

Nairobi is the venue for the **FIRST AFRICAN FISHERIES CONGRESS** to be held in Kenya at the Kenyatta International Conference Centre between **1 to 5 August 1994.**

Prospective delegates from South Africa should contact Colin Buxton, Department of Ichthyology & Fisheries Science, Rhodes University, PO Box 94, Grahamstown 6140, or write to the Chairman, Local Organising Committee, First African Fisheries Congress, PO Box 81651, Mombassa, Kenya.

All aspects of fisheries science will be covered such as: reproduction and genetics, aquaculture, nutrition and food utilization, capture fisheries, post-harvest technology, diseases, physiology, ecology, biodiversity, exclusive economic zone (EEZ), fisheries and biotechnology.

WHEN IN KNYSNA VISIT THE ANGLING MUSEUM OF THE J.L.B. SMITH INSTITUTE

The Institute has established a Museum on the History of Angling and Fishing Methods of Africa in the coastal town of Knysna on the Garden Route. This is the first Angling Museum in Africa, and one of only four in the world.

The Angling Museum is a place of enlightenment, education and fun for adults and children, as well as an important archive of the artifacts of one of mankind's oldest activities. It is a living, interactive museum that, when completed, will include many colourful displays of fishing tackle new and old, an exhibition on the coelacanth, a computerised fish information centre, reading room, children's underwater discovery centre, cafe and natural history giftshop.

One of the aims of this Museum is to sensitise people to the delicate relationship between humans and the aquatic environment. The Museum promotes angling as a sustainable and enjoyable pastime for the whole family.

SPOTTED GRUNTER AQUACULTURE - ARE WE ON THE RIGHT TRACK?

For the last two years we have been evaluating the aquaculture potential of the spotted grunter. Prior to initiating the research we undertook a market survey of whether grunter would sell for a reasonable price in order for a commercial operation to make a profit. Based on this survey we went ahead and have so far established that the species is indeed suitable for aquaculture. We will report on some of our results in the next issue of the newsletter.

Anyhow, we were beavering away when one day when I received this telephone call. It went like this;

"Howzit Prof, I hear you ou's are farming grunter". "No" I replied, "we have just started doing some preliminary investigations to ascertain the suitability of the beast for aquaculture". "Ah come on Prof stop bullsh---- me man, I've got connections all over the place and they tell me you ou's already have fish for sale. I'm desperate my man and just for your information they fetch a damn good price overseas. Listen, I'm prepared to pay your price". This was music to my ears and I asked where he was getting the fish from. "Listen Prof, I don't ask you whether you've got a skelm so don't ask me were I get the fish from, except to say that they are available and in demand". I then asked the gentleman what he was prepared to pay? "Prof, I'll give you between R22 and R26 a kilo, but I'd need about two tons a month and the fish must all be between 500 and 750 g". With regret I replied, "I wish that we had progressed to the stage were I could supply you but we honestly are still at the very early

MARICULTURE PROTOCOL

Mariculture has now been recognised as a growing industry which generates a number of benefits for the local economy as well the fishing industry. There is no doubt that as our natural marine resources are coming under increasing pressures from commercial, artesanal and recreational exploitation, greater emphasis needs to be placed on the development of the mariculture industry in order to relieve these pressures on natural stocks. The Department of Environment Affairs, whose responsibility it is to co-ordinate mariculture activities, is therefore committed to the promotion of mariculture in South Africa through rational management which must ensure that growth can take place in a sustainable manner.

A number of authorities presently have a regulatory role to play in the management of this industry, depending on the sphere of activity. This can sometimes lead to some confusion for the prospective mariculturist. This protocol is designed to inform the mariculture community of the regulatory requirements in establishing a new venture.

Establishment of mariculture operation

The Chief Directorate: Sea Fisheries of the Department of Environment Affairs acts as the 'lead agency' for the co-ordination of all applications for mariculture activities in South Africa. Any new applicant must in the first instance supply the following information to the Chief Directorate:

1. The scientific name of each species for which an application is made.
2. Origin of the stock (local or imported).
3. If foreign species are being considered, state measures to be taken to avoid introduction of exotic parasites and pathogens, and measures to be taken to avoid establishment of introduced species in the wild.
4. Details of method of cultivation.
5. Details of any chemicals (antifouling paints, antibiotics, pesticides, etc) that are being considered for use in the operation.
6. Detailed map (1:10 000 SAN) indicating the site where the proposed farming operations will take place.
7. Quality of seawater and or degree of pollution in the proposed area of operation.
8. Marketing strategy.
9. Facilities and job opportunities that will be created.

Once the information listed above has been received, the applicant will be informed of other regulatory provisions that will be required, in terms of the legislation listed below, before a permit to cultivate, harvest and sell the species in question can be granted by the Chief Directorate.
An initial application must be made to:

Director: Sea Fisheries Research Institute,
Private Bag X2,
Roggebaai, 8012.

Attn: Mr A.Moldan.

Tel: (021) 439 6160 or 439 7782.

Site selection

In terms of the Sea Shore Act (No. 21 of 1935) any person wishing to establish a mariculture operation on the sea shore between the high and low water marks of the sea, in the water or on the bed of the sea below the low water mark and within the 12 n mi territorial waters of the Republic, including the water and the bed of the tidal portion of a river or tidal lagoon, must enter into a Lease Agreement with the Cape Provincial Administration for the use of that area. Private waters contained in an artificially created marinas are excluded from this provision. The following body must be contacted if the proposed activity is to take place in the Cape Province:

Chief Director: Cape Nature Conservation,
Cape Provincial Administration,
Private Bag X9086,
Cape Town 8000.

Attn: Miss J Nicholson.

Tel: (021) 483 3199.

On receipt of an application to lease an area of water described above, the Chief Directorate will consult the local authority (Municipality or Regional Services Council) before entering into such an agreement. The proposed mariculture operation will be advertised, at the expense of the applicant, in the Government Gazette and in not less than one local newspaper. A period of 30 days will be allowed for possible objections, whereafter the application will be submitted to the MEC for Nature Conservation for consideration. Should the MEC approve the application, a Lease Agreement will be entered into with the applicant. Applications for port areas, under the jurisdiction of Portnet, must be submitted to Portnet who will approach the Chief Directorate for comment. Portnet will enter into a Lease Agreement with the applicant should the application be approved by all relevant authorities.

In the Natal Province, the Sea Shore Act is administered by the local authority with jurisdiction over a particular coastal area. A lease agreement for a mariculture operation must be entered into directly with the relevant local authority. Such an authority will consult the Natal Parks Board before entering into such an agreement.

If a mariculture operation is proposed within an area 200 feet above the high water mark and in an area designated as an Admiralty zone/crown land, permission needs to be obtained from the Department of Public Works.

Importation of foreign species

Import permit. In terms of Section 47(j) of the Sea Fisheries Act (No. 12 of 1988) anyone wishing to import or export any living marine organism must obtain a permit from the Chief Directorate: Sea Fisheries.

In terms of the Import and Export Control Act (No. 45 of 1963) anyone wishing to import live fish eggs, live molluscs or live crustacea need to apply for an import permit. Live fish do not require an import permit in terms of this Act. Permits can be obtained from:

Director of Import and Exports,
Private Bag X192,
Pretoria 0001.

Attn: Mrs. Haasbroek.

Tel: (012) 310 9604

Permit for introduction of exotic species.
In terms of the Agricultural Pests Act (No. 36 of 1983) anyone wishing to introduce foreign species for mariculture purposes needs to consult the Department of Agriculture's Directorate of Plant and Quality Control in order to determine whether a permit is required. Each case is dealt with individually depending on the particular circumstances.

Director: Plant and Quality Control,
Private Bag X258,
Pretoria 0001.

Attn: Mr MA Holtzhausen.

Tel: (012) 206 3278.

Processing and marketing

Permit for freezing or canning of products.
In terms of the Standards Act (No.35 of 1962) a permit, issued by the South African Bureau of Standards, is required if the product is to be frozen or canned. Fresh products do not require such a permit. In order to obtain a permit, compulsory specifications for the processing of the product need to be complied with. These specifications can be obtained from:

South African Bureau of Standards,
Liesbeeck Parkway,
Rosebank 7700.

Attn: Mr PJ Truter.

Tel: (021) 689 5511.

Specifications for marketing products. In terms of the Foodstuffs, Cosmetics and Disinfectants Act (No.54 of 1972) any person marketing seafood for human consumption needs to ensure that the product complies with pathogenic and chemical standards, eg for bacteria, heavy metals, etc. Details of these standards can be obtained from:

Director: Foodstuffs, Cosmetics and Disinfectants,
Department of National Health,
Private Bag X828,
Pretoria 0001.

Attn: Mr T van de Venter.

Tel: (021) 325 5100.

Specifications for processing of products. In terms of the Health Act (No. 63 of 1977) any person processing or transporting products for human consumption needs to comply with specifications concerning the hygiene of the products. Details of these specifications can be obtained from:

Director: Public Hygiene,
Department of National Health,
Private Bag X828,
Pretoria 0001.

Attn: Mr DJ van Rooyen.

Tel: (012) 325 5100.

Water supply

Permit for water usage. In terms of Section 12 of the Water Act (No. 54 of 1956) any person wishing to use, on land, more than 150 cubic metres per day of fresh or seawater for industrial purposes (mariculture included), must apply for a permit for such usage from:

Cape: Department of Water Affairs
Private Bag X9075,
Cape Town 8000.

Attn: Dr J Lusher.

Tel: (021) 45 7025.

Natal: Department of Water Affairs,
PO Box 1018,
Durban 4000.

Attn: Mr L Gravelet-Blondin.

Tel: (031) 306 1367.

Permit for effluent discharge
In terms of Section 21 of the Water Act (No. 54 of 1956) any person wishing to discharge an effluent, arising from an industrial process (mariculture

included), back to the sea must obtain an exemption permit from:

Cape: Department of Water Affairs,
Private Bag X9075,
Cape Town 8000.

Attn: Dr J Lusher.
Tel: (021) 45 7025.

Natal: Department of Water Affairs,
PO Box 1018,
Durban 4000.

Attn: Mr L Gravelet-Blondin.
Tel: (031) 306 1367.

Anton Moldan
Sea Fisheries Research Institute
Private Bag X2, Cape Town 8012

Appendix VII

NORTH ATLANTIC SALMON CONSERVATION ORGANIZATION

ORGANISATION POUR LA CONSERVATION DU SAUMON DE L'ATLANTIQUE NORD

APR63.065

INTERACTIONS BETWEEN SALMON AQUACULTURE AND THE WILD SALMON STOCKS

A Position Paper by the North Atlantic Salmon Conservation Organization presented to the meeting of the ICES Working Group on Environmental Interactions of Mariculture, Cork, Ireland, 28-31 March 1994

1. In recent years there has been a dramatic expansion in salmon aquaculture, that is the culture or husbandry of Atlantic salmon, with the development of salmon farming. The industry has expanded from a production of 10 tonnes in 1970 to 220,000 tonnes in 1992. Changes in fishery regimes in the North Atlantic together with advances in smolt rearing techniques have also led to increasing interest in salmon ranching. However, the present period of low marine survival is a negative factor and at present ranching may be considered to be on a pilot scale. To date Iceland is the only country bordering the North Atlantic where private sea ranching has been developed with approximately 6 million smolts being released annually.

2. The salmon farming industry produces a high quality product with all year round availability which has had a marked impact on the wild salmon market with possible benefits to the wild stocks in terms of the level and pattern of exploitation. The industry is a big export earner and creates valuable employment opportunities in remote rural communities. However, concomitant with the dramatic growth in production of farmed salmon there has been increasing concern about possible adverse effects on the wild stocks, expressed by both governmental and non-governmental organizations. The Declaration of the International Conference on Responsible Fishing held in Cancun, Mexico in 1992 for example, encompassed the use of aquaculture practices which are not harmful to ecosystems, resources or their quality.

3. Since 1988, the Council of NASCO has devoted considerable time to the question of interactions between aquaculture and the wild stocks. In 1989 NASCO held a meeting in collaboration with ICES to assess the genetic threats. At this meeting a number of views were expressed concerning the nature of the impacts. These ranged from no impact (or even benefits) to serious impacts although the only evidence presented suggested that adverse effects were possible. The need for further research was stressed and the desirability of formulating a Code of Practice or recommendations designed to safeguard the wild stocks was identified. In both 1989 and 1990 NASCO held Special Sessions on the impacts of aquaculture and in 1991 "Guidelines to minimise the threats to wild salmon stocks from salmon aquaculture" were adopted

11 Rutland Square Edinburgh EH1 2AS Scotland UK
Tel: 031-228 2551 Telex: 94011321 NASC G Fax: 031-228 4384

for use on a voluntary basis by the Parties. These Guidelines include four main elements:

- Measures to reduce the possible genetic and ecological impacts
- Measures to minimise the possible adverse effects from introductions and transfers
- Measures to minimise disease and parasite interactions
- Measures to minimise the impacts on the aquatic environment

These Guidelines were widely circulated to agencies in both the Pacific and Atlantic areas and have been generally well received. However, the degree to which they have been implemented is not known.

4. At its 1993 meeting the Council again reviewed the interactions between aquaculture and the wild stocks. Evidence was presented which showed that farmed fish occur on the marine feeding grounds, in fisheries and on the spawning grounds of wild salmon. In some rivers up to 90% of the fish are of farmed origin and interbreeding between wild and farmed salmon has been observed. The ICES Study Group on Genetic Risks to Atlantic Salmon Stocks stressed the need for management decisions designed to reduce impacts to be based on the information which exists now. They also recommended the widescale use of sterile fish by the salmon farming industry. There is also concern about the possible transfer of diseases and parasites from aquaculture to the wild stocks. The Council of NASCO believes that the latest information suggests the need for stronger measures as a matter of priority and has agreed that the issue should be addressed by twin approaches which should proceed concurrently and should include specific questions to ICES on the nature of the impacts. However, in line with the precautionary principle, the Council agreed that it shouldn't wait for the results of the scientific advice but should establish a Working Group to consider, in active cooperation with appropriate interests, how salmon aquaculture can be conducted in a way designed to remove adverse impacts on the wild stocks. This Working Group has met twice and has made considerable progress. Recommendations have been drafted by the Group and these identify four major areas where progress should be made:

- improvements in the containment of farmed fish
- improvements in the prevention of diseases and parasites
- the use of areas for the protection of wild salmon
- evaluation by NASCO of the future use of sterile fish by the salmon farming industry

The Working Group has also formulated an Agreement containing a set of principles and practical measures designed to minimise the impacts. This Agreement will be considered by the Council of NASCO at its annual meeting in Oslo in June.

5. In conclusion, the Council of NASCO has serious concerns about the possible impacts of salmon aquaculture on the wild stocks. It has recognised that there are major gaps in our knowledge of these impacts but is now considering practical measures designed to remove the potential threats until such time as our understanding of the nature of these interactions is further advanced.

Appendix VIII

Working Group: Interactions between mariculture and the environment

(Sea Fisheries Research Institute Cape Town, South Africa)

Chairperson: Mr Anton Moldan
Convener: Mr Pedro Monteiro
(monteiro@sfri_2.sfri.ac.za)

Projects List: 1994

The projects listed below comprise the scientific component of the Saldanha Bay Environmental Programme devised by the WG. The main goal of this programme is to formulate a system model with which to determine carrying capacity in respect of mussel farming and optimize yields. The overall approach is described on a separate document and the list below places the titles into the two main spatial sampling scales: Bay and Farm Scales. The duration of the programme is 3 years from 1993 to 1995, where the first two years are planned for the data collection and the third for the modelling of the data. Each project includes the name of the responsible scientist and his/her Internet address.

Physical Dynamics:

Bay Scale:

1: Circulation and flushing rates of Saldanha Bay: Drogue, sea level monitoring and meteorological based study to model water exchange and circulation.
Prof. G.B. Brundrit, University of Cape Town, elley@physci.uct.ac.za

2: Boundary forcing dynamics between the shelf and Saldanha Bay: Current meter based study.
Mr. Grevill Nelson, Sea Fisheries Research Institute, gnelson@sfri.sfri.ac.za

3: The stratification dynamics of Saldanha Bay: Makes use of a monitoring station providing stratified temperature and salinity hourly data to constrain and model the development and variability of the seasonal thermocline.
Prof. G.B. Brundrit, University of Cape Town, elley@physci.uct.ac.za

Farm Scale:

1: Hydrodynamics of farm and raft scale. Makes use of drogues to investigate the flow retardation and modification associated with the siting of rafts and varying rope densities.
Dr Alan Boyd, Sea Fisheries Researsch Institute, ajboyd@sfri.sfri.ac.za

Biogeochemical Dynamics:

Bay Scale:

1: Nitrogen cycling in Saldanha Bay. Makes use of measurements obtained of the most important fluxes of nitrogen, a limiting nutrient, within the Bay (sedimentation, benthic-pelagic remineralization) to model its dynamics.
Mr Pedro Monteiro, Sea Fisheries Research Institute, monteiro@sfri_2.sfri.ac.za

2: Oxygen variability in Saldanha Bay: Oxygen is used in this case as an indicator of changing dynamics of natural and anthropogenic eutrophication. The variability is being simulated using a dynamic model approach which is checked against hourly data collected from a monitoring station.
Mr Pedro Monteiro, Sea Fisheries Research Institute, monteiro@sfri_2.sfri.ac.za

3: The source and input rates of organic carbon and nitrogen into the sediments of Saldanha bay: This project makes use of variations in the natural abundance of the isotope ratios of carbon (13C:12C) and nitrogen (15N:14N) to identify the source and relative magnitudes of particulate organic loading.
Mr Pedro Monteiro, Sea Fisheries Research Institute, monteiro@sfri_2.sfri.ac.za

Phytoplankton Dynamics:

Bay Scale:

1: Seasonal and vertical variations in the rates of primary production in Saldanha Bay: Makes use of size fractionated 14C uptake rates to measure primary production in samples incubated in situ under a range of seasonal conditions.
Dr Grant Pitcher, Sea Fisheries Research Institute, pitcher@sfri_2.sfri.ac.za

2: Nitrogen uptake dynamics by phytoplankton: Makes use of size fractionated 15N labelled ammonium and nitrate to quantify the uptake kinetics under the same conditions as the carbon based production measurements.
Mr Pedro Monteiro, Sea Fisheries Research Institute, monteiro@sfri_2.sfri.ac.za

3: The interannual variability of toxic and non-toxic red tide species along the Cape west coast and Saldanha Bay: A monitoring station in the Bay is part of a network of sampling stations which provide daily samples for taxonomical and monitoring purposes.
Dr Grant Pitcher, Sea Fisheries Research Institute, pitcher@sfri_2.sfri.ac.za

4: Chlorophyll variability in Saldanha Bay: daily samples are taken from three depths at the monitoring station in Saldanha Bay and analysed to provide a chlorophyll-based measurement of the temporal variability of phytoplankton biomass. Samples which provide spatial dimension to the chlorophyll variability are also taken during intensive field studies three times a year.
Dr Grant Pitcher, Sea Fisheries Research Institute, pitcher@sfri_2.sfri.ac.za

Farm Scale:

1: The removal of suspended particles by mussels from the water flowing through the farm and rafts. This process is investigated through a series of intensive sampling

periods where the impact of mussel feeding is measured by both particle size and volume changes as well as size fractionated chlorophyll.
Mr Kevin Heasemen/Dr Grant Pitcher, pitcher@sfri_2.sfri.ac.za

Mussel Growth Dynamics:

Farm Scale:

1: The relationships between food supply (quantity and quality), stocking densities (rope and raft) and the growth rates, condition and yield of mussels.
Mr Kevin Heaseman, Rhodes University, pitcher@sfri_2.sfri.ac.za

Ecological Impacts:

Bay and Farm Scales:

1: The impact of mussel rafts on the benthic community structure of Saldanha bay. This project makes use of k-dominance plots to assess the relative impact of organic loading on the benthic communities.
Dr Lynn Jackson, Sea Fisheries Research Institute, ljackson@sfri_2.sfri.ac.za

Data base:

All the data is being compiled into a purpose-devised GIS format (ARCINFO) from where it will be available to all users and interested parties.
Prof. G.B. Brundrit, University of Cape Town, Department of Oceanography, elley@physci.uct.ac.za

Appendix IX

COMMENTS ON CHAPTER "MODELLING" of the Draft Technical Report on "Management of the Environmental Impact of Marculture"

A survey of the literature shows that a great number of models aimed at predicting aquaculture impact are now available all the world round. Two categories of model are generally used: near-field models that are site specific and far-field ones concerning an embayment for example`.

All these models are very often well adapted to localized and specific aims. Nevertheless, they cannot be used on a wider basis. In the same time, the parameters they integrate are not relevant for application elsewhere. A great need for intercalibration of these specific models is to be high lighted, in order to give them the necessary credibility by non specialist users (scientists, farmers, regulatory agencies).

Some far-field — holding and carrying capacity — models use a modular approach, in which sub-models can be separately run. Again, a coordination of these sub-model in the framework of integrated ones is required. This is specially needed in the case of utilization of expert systems and Geographic Information Systems that are powerful tools for coastal management decision makers.

For the moment, available models or sub-models mainly deal with physical, chemical, biological and ecological components. But these models are rarely fitted to describe the interactions between natural environment and farming operations. For example, model applications to shellfish culture emphasize the effect of the environment (phytoplankton) on mollusk growth but do not really take into account the impact of benthic enrichment. Conversely, fish models rarely include the effect of environment on fish growth or health. Finally, socioeconomic extensions are required to facilitate sound choices in regulatory agencies concerned with coastal management .

Although model are powerful tools for predicting impact levels, they cannot be used without any contribution from field monitoring. A constant coming and going between experts and modellers is necessary (1) to improve the reliability of the prediction given by the model, (2) to give applicable interpretation of the results by connecting effects to prediction, and (3) to focus on the critical parameters and their value, at least when a monitoring programme is to be defined, in a sense that a model will never say what is acceptable or not. Importance of a model has to be realistic in relation to the importance of the problem.

The use of models often requires high competence, and a very few among them can easily be used by non-specialists. Some of the models have not yet reached a high degree of operational use. Hydrodynamic models generally are more mature than ecological ones. In order to improve models apllicability, especially to make them more user-friendly for the most obvious customers such as farm managers, but also

consultants, coastal zone planning administrators and other coastal resource users, the training of these customers must be made a priority, in order to develop the desirable and appropriate level of utilization of such predictive models. This training must include the capacity to interpret the results, every model necessarily being an approximation of the reality.

Antoine DOSDAT; 30/03/1994

Appendix X

Updated chapter V of the draft Technical Report on

"The Management of the Environmental Impacts of Mariculture"

Monitoring

5.1. Introduction

REVISION OF INTRODUCTORY TEXT TO SHOW THE REASONS FOR CONCERNTRATING ON MONITORING BENTHIC IMPACTS RATHER THAN WATER COLUMN FOR COASTAL FISH FARMING AND MONITORING BOTH FOR SHELLFISH FARMING.

[From a number of studies (Brown et al., 1987; Weston, 1990) many of the effects of fish farm waste on the benthos are well documented and it is clear that most fish farms will have a localised impact on the benthos. It is important therefore, to ensure that monitoring programmes do not develop into research projects to assess what has already been documented. The probable scale of effects should have been established in a site evaluation, and the acceptability of the impact agreed before the development proceeds. The aim of monitoring should therefore be to confirm the predicted area of enrichment, and ensure that the zone does not spread and that more subtle changes do not occur on a larger scale.]

It is important to define the purpose of a monitoring programme before it is designed, to ensure that the appropriate parameters are monitored and that once implemented, the results obtained serve the aims for which the programme was intended. Thus, the purpose of monitoring for regulatory purposes is environmental protection.

The aim of the monitoring programme is to confirm that the control measures taken are being successful in ensuring that the values of particular critical environmental parameters do not breach predefined quality standards for the areas concerned. These standards may be related to natural conditions in the area, or have been derived from other considerations.

With respect to some potential impacts, for example, nutrient enrichment of the water column and organic enrichment of the benthos, there are no internationally accepted environmental quality standards, since the ecological bases for establishing an 'acceptable level of change' have not been formulated. Furthermore, since the establishment of a mariculture operation involves an assessment of other issues, (for example social and economic) in addition to ecological the responsibility for setting acceptable levels of change resides with individual governments and regulatory authorities of each ICES state. This section of the Technical Report is therefore restricted to providing methods and approaches for monitoring changes in nutrient levels and dissolved oxygen, changes in phytoplankton biomass and enrichment of the benthos.

The following impacts of bivalve culture are relevant as far as monititoring is concerned;

Impacts on benthos, sediment accumulation, sediment chemistry and changes in composition and biomass of macrofauna.

Impact on the water column, depletion of food for filterfeeding organisms , affecting the carring capacity of the water body. This can affect growth and condition of the cultivated stock and has been supposed to affect wild filter feeders in the surrounding area

5.2. Baseline and Benchmark Surveys

An essential component of any monitoring programme for regulatory purposes is a baseline survey, done prior to the establishment of the operation. It is important to distinguish between a baseline survey and an assessment of a site for its mariculture potential. For existing operations, a benchmark survey should be designed to identify changes in the intensity and spatial scale of any impact relative to conditions which are regarded typical for the area.

The aims of a baseline or benchmark study are:

1) to provide reference data which can be used to establish an appropriate monitoring programme and reference data with which to compare data collected from a monitoring programme.

2) to determine suitable locations for sampling and reference or control stations.

Depending on the scale of the proposed project any baseline or benchmark study should at least include an assessment of those parameters which might be selected for a subsequent monitoring program. Thus, in the event of a change in environmental conditions, when it may prove necessary to increase the range of parameters monitored, reference data would be available. It is suggested that the following physical, chemical and biological characteristics of a site should be included in a baseline or benchmark survey.

5.2.1 Physical characteristics

The topography of the area in which the fish farm is located should be examined. Substrate type (erosional, depositional, transport and transport type), water depth, tidal amplitude, and the location of shallow sills and deep basins should be recorded because these features will influence the locations of sampling stations. An assessment of the presence of a surface brackish layer (its thickness and persistence throughout the year) and the depth of the euphotic zone in summer are required as these features will influence the selection of depths from which water samples are collected. Measurements of current speed and direction will allow the prediction of probable direction and extent of dispersal of organic waste to be made and this will be of value in siting benthic sampling stations. Calculation of the renewal rate and retention time is also essential to determine the spatial and temporal impacts. These data may have already been collected as part of the site selection and modeling exercises as outlined in the earlier chapters 3 and 4.

5.2.2 Chemical characteristics

With respect to sediments, a baseline survey should include, an assessment of:

- sedimentary redox potential(vertical profiles);
- carbon;
- nitrogen; and,
- selected heavy metals(copper/zinc).

5.2.3 Biological characteristics

The biological characteristics which should be assessed are the community structure of the macrofauna (diversity, abundance and biomass, indicator species or taxa).

5.3. Some Basic Requirements of Monitoring Programmes

It is recommended that the level of monitoring should be related to the size of the farm, the hydrography of the area and the predicted scale of any potential impact **(e.g Arne Ervik's exploitation figures, see this WG Report p.).** With respect to monitoring benthic enrichment, only a low level of monitoring is necessary in areas where the seabed is well scoured.

Identification of changes will require statistical analysis of the data and this necessitates that the required number of samples is collected and replicate analyses undertaken. Furthermore, a monitoring programme must be designed in such a way as to take into account seasonality and the short term spatial and temporal variation in the parameters being monitored.

It is essential that reference stations be established at a sufficient distance from the operation to act as a control but should as far as possible have similar characteristics to the other stations. It must be acknowledged that given the known patchiness of such benthic descriptors as macrofaunal assemblages, depth of the redox potential discontinuity, organic carbon levels and quantitative granulometry, it may be difficult to identify such a control site.

Monitoring is costly both to the authorities and the industry. It is therefore essential that data be analysed and reported so that appropriate regulatory action can be taken and/or modification made to the monitoring program. In certain cases, verified models may reduce monitoring requirements.

Though mollusc growth is achieved with out use of external feed of veternary products the basic requirements for monitoring the environmental impact of bivalve culture operations do not differ essentially from those for monitoring fish farms. In monitoring standing stock biomass of cultivated and wild stocks, attention should be paid to the large variation in space and time in the biomass of bivalve populations.

5.4 Monitoring benthic changes

For regulatory purposes there are a number of parameters which can be measured to monitor changes in the benthic ecosystem and these are listed below.

Organic Carbon and Nitrogen
Hydrogen sulphide
Sedimentary redox potential
Sediment accumulation and sedimentation rate
Grain size evolution
Macrobenthic community structure

The location of sampling stations can present a problem when a fish or shellfish farm consists of several large cage groups, rafts or longlines which are separated by 50 m or more. In such cases it has been recommended that each cage group should be considered as a separate production entity.

The distance between sampling stations will be determined by the spatial scale of the impact and the outermost station should be outside the area affected by the farm. As an example, at a farm where the zone of enrichment does not extend beyond 15 m, samples for redox measurements should be taken at distances of 0, 10, 25, 50 and 150 m along transects extending out at right angles from the cages and along the axis of the main current.

5.4.1. Sediment chemistry

Redox potential measurements are a useful means of providing an overview of benthic enrichment in soft sediments (Pearson and Stanley, 1979). Typically vertical profiles are measured and Pearson and Stanley (1978) suggest that the potential at a depth of 4.0 cm in the sediment should be used for comparative purposes rather than the sediment surface which may be disturbed and hence more variable.

Organic carbon and nitrogen measurements may be made in sediments at the same sampling points, although it should be noted that there are considerable variations in carbon and nitrogen levels in both enriched and undisturbed sediments.

5.4.2. Macrofauna

The most sensitive indicator of benthic enrichment is the benthic macrofauna. It is usual to collect between 3 and 5 grab samples at each station (to define variability) along a transect extending out from the farm and through the area of maximum spread of waste. In deep basins, samples should be taken at the maximum depth.

The number of stations and the distances between stations should reflect the size of the enriched area. Typical spacing of stations along the transect might be at the edge of the cages, at the anticipated edge of the enriched area, and in an adjacent non-impacted area. Stations should be located in areas where the water depth and sediment particle size are similar. Frequency of benthic macrofauna sampling should be carried in relation to the level of exploitation.

Where fallowing and harrowing practices are implemented amended monitoring strategies will be required. Where abandoned sites are to be reoccupied a revised benchmark study should be undertaken.

When monitoring bivalve stocks, their considerable variations in time should be taken into account. Baseline and benchmark studies should therefore not only be based on recent stock assessments, but also on historical information. Stock assessments can be carried out in a number of ways, depending on, for instance, species, area size, water depth and manpower. Grid or random sampling methods can be used: on foot, from small boats or using research or chartered fishing vessels. Areal photography can also be used. It may be useful to combine assessments used for management purposes with regular surveys by the industry, not only to save costs, but also to obtain bilaterally acknowledged information. Stock assessments strategy should take into account the patchiness of wild bivalve populations. Sampling should be done when recently settled spat is big enough to be quantified. Sampling mussels in moderate regions in winter may pose problems as mussels then stay below the sediment and may be missed.

5.4.3. Other Sources of Information

Farm records from Ireland

A diving survey employing video or sediment profile imagery (SPI), still photography and diver-taken core samples can be used to document the impact of organic enrichment from fish farms.

SPI samples are taken under the cages, rafts or longlines and at intervals, away from the structures in the direction of the current and at a control site. Images are analyzed using a computer based image analysis system for the following: grain size, depth of the redox potential discontinuity, presence of subsurface methane, faunal information, thickness of organic material, presence of microbial mats. The results combine to give a clear picture of the health of the sea floor under and in the vicinity of farming structures. Annual site audits using low cost photography of the site sea bed and environs combined with redox values of the sediments provide a useful record of the impact of the farming activity.

5.5 Monitoring of nutrient levels and changes in phytoplankton biomass

5.5.1. Introduction

Nutrients and phytoplankton were historically considered as being important environmental descriptors for fin fish impact assessment. Given the seasonal, fortnightly and even daily variations in levels of these parameters, it is now considered that they cannot be used with any meaningful reliability to monitor impacts from fin fish production sites. Indeed, examination of long-term nutrient and phytoplankton biomass can be greater at considerable distances from the production site than at the cages themselves. These data are however essential elements for monitoring large scale impacts from shellfish cultivation sites and changes in phytoplankton biomass of a whole waterbody.

Bivalve cultures may, through the filtering activity of bivalves, influence the concentrations of particulate food for filter feeders (mainly phytoplankton) in the local water body. This may particularly be the case in water bodies with a low carrying capacity for shellfish culture. As filtration rates of bivalves are well-known, it is possible to calculate beforehand if a certain bivalve culture has a potential to substantially

influence the biomass of phytoplankton and hence the carrying capacity of the water body. A possible decision to monitor could be based on the outcome of this calculation.

5.5.2. Dissolved nutrients

It is important to consider when water samples for nutrient analysis and phytoplankton biomass estimation should be taken, since this will have a bearing on the level of change which can be detected. Both nutrients and phytoplankton biomass have marked seasonal cycles, and there are large variances associated with the annual means. It is important therefore to reduce the variance associated with a data set by selecting a period of time when levels of nutrients and biomass are relatively stable, thereby allowing small significant changes to be identified.

During the winter, nutrient levels generally show only small fluctuations. Thus, it is during this time that any effect of a fish farm on the nutrient status is most likely to be identified.

Sampling stations should be located at farms and control stations. This will enable the spatial scale of changes in nutrient levels within a waterbody to be evaluated and also temporal changes in the level of nutrients at the control station to be identified. It is therefore important that the control station be located in a position which reflects the conditions of the waterbody as a whole.

5.5.3. Phytoplankton biomass

A reduced supply of suspended food for filter feeders as result of "overgrazing" of the seston by cultivated stock may not only affect growth and condition of the cultivated shellfish, it can also influence food conditions for "wild" filter feeders in the neighbourhood. It seems likely that effects on cultivated stock become apparent in an earlier stage than those on wild fauna. Thus, an upper limit of the cultivated stock biomass would automatically be created. Effects of depletion of suspended food on wild stock have, as far as known, not been documented. This subject requires further research before conclusions can be drawn as to the necessity of monitoring for that purpose. Monitoring seston concentrations at shellfish farms would therefore primarily serve to protect the production level and product quality of the culture.

Monitoring of the phytoplankton biomass should be restricted to the summer, when the level of biomass is relatively stable compared to other times of the year and growth is most likely to be limited by nutrients. Sampling could be conduced monthly and water samples collected from 4 depths, determined by the physical structure of the water column and the depth of the euphotic zone. Sampling should be confined to the euphotic zone but samples should not be taken from the surface of the water column. A typical depth range would be 2, 3, 5 and 7 m. As with nutrients, such a sampling regime would generate 16 estimates of chlorophyll for each station in any one year and this should be adequate for statistical analysis.

Appendix XI

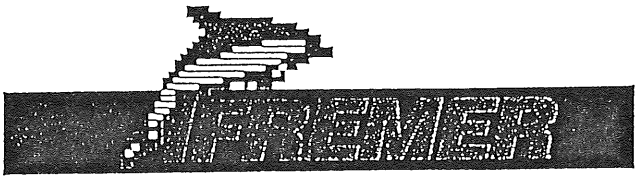
"CARTOGRAPHIE DES ZONES SENSIBLES
A L'EUTROPHISATION ;
CAS DES COTES BRETONNES"

(C.E.E. - IFREMER - Région BRETAGNE)

Auteurs :	Jean-Yves PIRIOU	IFREMER
	Philippe MEROT	INRA
	Anne-Marie JEGOU	IFREMER
	Pierre GARREAU	IFREMER
	Catherine YONI	UBO
	Pierre WATREMEZ	BRGM
	Marc URVOIS	BRGM
	Bernard HALLEGOUËT	U.B.O.
	Pierre AUROUSSEAU	ENSAR
	Yves MONBET	IFREMER
	Charles CANN	CEMAGREF

(N.B. : Signification des sigles et adresses en dernière page de ce rapport)

Coordination assurée par Jean-Yves PIRIOU.



Centre de Brest

BP 70 - 29280 PLOUZANÉ
Tél. 98 22 40 40 - Télex 940627
Télécopie 98 22 45 45

Décembre 1993

"MAPPING OF EUTROPHICATION-SENSITIVE ZONES" THE CASE ON BRITTANNY COASTS

C.E.E.-IFREMER - BRITTANY Region
1991-1993

Synthesis by : IFREMER - Centre de Brest - DEL
B.P. 70 - 29280 PLOUZANE
(FRANCE)

Objectives and achievements :

This study purported to map eutrophication-sensitive zones on the Breton coasline, to list observed pollution and determine what measures are required to preserve and restore the zones in question, for the three partner-organizations involved. As well as mapping seaweed proliferation sites, the following tasks were also specifically planned for :

- drawing up a hydrodynamic model for the North Breton coastline ;
- making an inventory of land-generated nitrogen and phosphorous flows ;
- coastal sediment mapping.

IFREMER drew up a precise map of green macrophyte seaweed proliferation sites over the entire Breton coastline (with semi-quantitative indexes) as well as a simplified map of microalgae proliferation zones (red tides). The hydrodynamic model IFREMER made for the northern coast of Brittany was complemented by a mapping study of water surface temperatures over the entire Breton coastline. The University of Western Brittany (UBO) made a highly detailed mapping synthesis of coastal sediment. An inventory of nitrogen and phosphorous flows was taken on the 27 control-rivers found all along the Breton coastline. They were chosen for the heterogenous nature of their coastal impact and for assumedly large differences in the types and activities of their watersheds.

In order to make recommendations to reduce nutrient loading, we felt that some additional studies were needed to assess the various watershed sensitivities to nutrient transfer, particularly that of nitrogen, the determining nutrient factor for green macrophyte seaweed proliferation.

Specific studies were assigned to INRA, ENSAR, the University of Brest and the University of Nantes to appraise watershed activities and nutrient transfers. These were carried out following consultation of the numerous organizations concerned : Chambers of Agriculture, Côtes d'Armor SDAE, Loire-Brittany Water Agency, DIREN of Brittany, LMHN Laboratory at Dinard, etc.

Thus, the following were drawn up for the 27 control watersheds
- complete nitrogen and phosphorous assessments
- soil saturation potential indexes
- subsoil type indexes
- effective rainfall averages
- nitrogen and phosphorous flow at outlets.

Fore more detailed understanding of phenomena on a small-scale, ENSAR compared two watersheds, based on soil mapping for which the Rennes Pedology Workshop supplied the elements for analysis. With the same objective, CEMAGREF refined understanding of the phosphorous transfer between a watershed and the sea sediments in a eutrophicated bay. Meanwhile, CEVA analyzed nutrient factors within the sea sediment - water - Ulva cycle on the same site.

In order to extrapolate results to the scale of Brittany, INRA ran a specific bibliographic study enabling risks of phosphorous exportation to the shore to be itemized, and the "Saunier Water and Environment" consultancy ran another study singling out the specific flow from each of the 200 Breton coastal watersheds.

Finally, BRGM and IFREMER performed computerized mapping of general data from the sea area and Breton watersheds using a Geographical Data System.

Results and recommendations :

It is not easy to draw up a synthesis of the 16 specific studies carried out by various organizations. On one hand, we have too much data covering all of Brittany to be able to classify them in relation to each other, and on the other hand, we lack small-scale explanations for some phenomena (e.g., natural denitrification).

However, this study succeeded in determining with adequate precision, which Breton coastal sites are sensitive to eutrophication. Specific studies on watersheds showed up the main elements influencing the vulnerability to nitrogen loss to the shore.

In the coastal area, zones regularly affected by Ulva proliferation (see map in appendix) have now been well mapped with indexes showing the relative levels of average biomass reached on each site. The three simultaneous requirements for Ulva proliferation have been clearly identified : coastal hydrodynamic and significant direct nitrogen input in late spring. Hydrodynamic models on the North Breton shoreline showed up the sensitive coastal zones where water is trapped on the coast. This trapping is revealed by various complementary data : low current residual (map attached), high residence time, and low maximal currents. The parts of sensitive zones geographically located below hydrographic zero are potentially favourable to Ulva, those above hydrographic zero (further off shore) are favourable to microalgae development. But it is also necessary to have a significant direct nitrogen input in late spring, which does not occur everywhere (e.g., southwestern part of Mont Saint Michel bay, Pléneuf-Erquy beach, northern part of Douarnenez bay). Satellite images of surface water temperature in early summer (see map in appendix) provide an overall view of this phenomenon on the scale of Brittany. The heterogeneity noted can be partially explained by hydrodynamics (trapping, thermal front, horizontal stratification). The zones which are warmest in spring are generally the most vulnerable to eutrophication, providing they have sufficient nutrient input.

For Ulva, nitrogen is the limiting element. For phytoplankton, it is sometimes nitrogen and sometimes phosphorous, depending on the site, the season in question or the microalgal species. Overall, northern and western Brittany are more sensitive to Ulva proliferation on sheltered, highly coastal sites, while the southern coast (especially the south-east) is rather sensitive to phytoplankton proliferation (red tides) in a less coastal sector. These microalgae proliferations, while usually non-toxic, can be harmful when they occur under specific weather conditions (calm water with stratification). They often develop offshore in sectors whose limits have not been clearly defined. We have not targeted the origins of nutrient inputs with certainty. The limiting nutrient factor fluctuates, even within a defined zone.

For all the above reasons, we did not link the watershed vulnerability study to phytoplankton red tide input, but only to the nitrogen input on green tide coastal sites which are well identified and whose functioning is now well understood, overall. In fact, the specific study on the Lannion bay site showed that Ulva essentially feed by means of the bio-available phosphorous stock formed in sea sediment by natural and man-caused

input. The stock is so great that it alone could provide feeding potential for Ulva biomasses over several decades. Whereas, for nitrogen, measurements have proven that maximal June Ulva biomasses fluctuate in direct relation with local instantaneous nitrogen input from late spring, only at this time of year.

On land, watershed vulnerability studies with regard to Ulva eutrophication were thus turned to finding explanations for the nitrogen flow levels in late spring. Studies show that one of the main explanatory factors comes from the geological nature of sub-soil which influences flow variations throughout the year. A granite-type subsoil will tend to maintain the flow in periods close to low water (late spring and summer). At the same time, nitrate concentrations in water at the outlet are fairly stable, while those of a schist-type (impermeable) watershed will drop more readily in spring. This means that for the same annual average of nitrogenous flows, a granite-type watershed will have a rather high flow in late spring, whereas a schist-type watershed will have a relatively low nitrogenous flow in that season.

The second main explanatory factor is also a natural one : that of rainfall. The amount of effective rain affects the replenishment of groundwaters in granite-type watersheds. Therefore, this influences spring flows at the outlet as well as nitrogen flows. As for schist-type watersheds, winter rains runoff and are diluted at sea, with no effect on the spring period. In this case, nitrogenous flows in spring are strongly guided by some sudden momentary, heavy rains.
Specific low water flows (VCN 30-5) are good growth indicators for these two main factors : effective rainfall controls average annual flow, geology influences distribution of this flow over the year.

The third explanatory factor is linked to the nature of soil. Whether a granite or schist-based zone, the proportion of wetlands (with denitrifying potentiality) will influence the spring drop in nitrate concentrations of surface waters.

The fourth factor is man-caused : this being nitrogenous excesses related to human activities. In Brittany's case, excesses are generally and essentially of agricultural origin. According to measurements taken in 1991, these nitrogenous excesses only appear to be a supplementary element of discrimination, once a preliminary ranking of the preceding natural factors has been performed. However, in evaluating risk, they can become the main factor in rainy spring periods which eliminate the natural variability of watersheds. Moreover, this should not hide that fact that nitrogenous excesses also play a major part in increasing average annual concentrations of nitrates in freshwater. However, for average spring weather conditions, natural watershed sensitivity to nitrogenous pollution seems to be an indispensable factor to be taken into account when ranking the causes of coastal eutrophication.

Many sectors in western Brittany, with a granite-type subsoil and high effective rainfall, are naturally very sensitive to nitrogen loss in spring. Those in the northeastern area with

a schist-type subsoil, are hardly sensitive to normal conditions (other than spring rainstorms).

The combination of these two main factors (geology and rainfall) is effectively expressed in watersheds by varying values of specific flows. The low water values (map attached) are clearly differentiated to better show the natural sensitivity conditions in Breton zones to nitrogen loss in dry periods. However, the surface area of each watershed clearly influences to overall low water flow at the outlet.

Being aware of these natural differentiations which run strongly to type (see sensitivity diagram), recommendations to reduce spring nitrogen flows in watersheds which feed into coastal sites which are sensitive to Ulva proliferation, will therefore vary from watershed to another (or from one geographical sector to another). For instance, in a sensitive watershed (with a high specific flow at low water) the priority will be to limit nitrogen washout in autumn and winter through rigorous crop and fertilization control without excess. In a slightly sensitive watershed (with low flow at low water) recommendations would run to adapting ground layouts to withhold hypodermic run-off during heavy spring rains. Hedgerows set perpendicular to slopes will check runoff. Low-lying wetland areas, no longer cultivated, must be preserved as buffer zones in order to fully play their part in sedimentation and water purification.
Adapted, non-excessive fertilization on the lands under cultivation will enhance the effect of rehabilitated, or better used, natural landscape conditions.

The "flexible management" principle presented by the results of this study, is currently being implemented in programme projects for small agricultural watersheds, aiming to test effects or measures which are well adapted, *a priori,* to natural sensitivity criteria defined here.

In a broader context, this study localizes vulnerable zones in terms of coastal eutrophication in Brittany, for the objectives of regulations recommended by the European "Nitrate Directive".

Appendix XII

ICES Working Group on "Environmental Interactions of Mariculture"

Working Group Meeting 1994,
March 28-31, Cork, Ireland

List of Relevant Literature
(partially annotated)

prepared by

Harald Rosenthal
Abteilung Fischereibiologie
Institut für Meereskunde
Universität Kiel
Federal Republic of Germany

Subject areas covered

General

Conflicts /interactions (socio-economic interactions)

Environmental issues / Interaction with wild-life

Environmental issues / Feed / excretion / leaching / nutrients

Environmental issues / Mitigation techniques/Effluents/Treatment

Environmental Interaction : Ecosystems/Diseases/Benthos

Use of Chemicals / Antimicrobials

Enhancement/Ranching/native-cultured stock interaction/exotics

Planning tools / Coastal Zone Management

Integrated systems/ aquaculture as a mitigation strategy

Monitoring

Modelling

General

Boyer, J.N., Van Toever, W., Jansen, M.E. 1994. Effect of photoperiod on growth of Artic char under commercial production conditions. The Progressive Fish Culturist **Volume !!!** 44-46.

Braaten, B. 1992. Forurensning fra nordisk akvakultur - mengder, effekter og tiltak. NIVA (Nordisk Institutt for Vannforskning), Nordiske Seminar- og Arbejdsrapporter 1992: 571, pp1-104.

Fisheries and Oceans Canada. Atlantic Fisheries Adjustment Program, Aquaculture Science Project Reports 1990-91.

Fisheries and Oceans Canada. Atlantic Fisheries Adjustment Program, Aquaculture Science Project Reports 1991-92.

Fisheries and Oceans Canada. Atlantic Fisheries Adjustment Program, Aquaculture Science Project Reports 1992-93.

Halverson, H.O., 1993. Aquaculture and the Marine Environment: The shaping of Public Policy. Workshop, August 30-Sept1, 1993. Marine Biological Laboratory, Woods Hole, MA. 30 pp.

Hecht, T., Britz, P.J. 1992. The current status, future prospects and environmental implications of mariculture in South Africa. Suid-Afrikaanse Tydskrif vir Wetenskap 88: 335-342.

Ramster, J. 1988. Marine resource atlases: An idea that has found its time. ICES, CM 1988/A:5 (Consultative Committee).

Thomson, A.J., McKinnell, S. 1993. Summary of reported salmon (*Salmo salar*) catches and sightings in British Columbia in 1992. Can. Manusc. Rep. Fish. Aquat. Sci. 2215: 15 p.

Conflicts /interactions (socio-economic interactions)

Bailey, C. 1988. The social consequences of tropical shrimp mariculture development. Ocean and Shoreline Management 11: 31-44.

Clark, J.R. 1991. Environmental planning for aquaculture in the coastal zone. pp. 109-134. In: Hargreaves, J.A., Alston, D.E. (Eds.). "Status and potential of aquaculture in the Caribbean. Advances in World Aquaculture, Vol. 5, World Aquaculture Society).

Conte, F.S., Manus, A.T. 1980. Aquaculture and coastal zone planning. Cooperative extension Sea Grant Marine Advisory Program, University of California, 21 pp.

DeVoe, M.R. 1991. Regulatory aspects of aquaculture development. pp. 135-164. In: Hargreaves, J.A., Alston, D.E. (Eds.). "Status and potential of aquaculture in the Caribbean. Advances in World Aquaculture, Vol. 5, World Aquaculture Society).

DeVoe, M.R., Mount, A.S. 1989. An analysis of ten state aquaculture leasing systems: issues and strategies. J. Shellfish res. 8(1): 233-239.

DeVoe, M.R., Pomeroy, R.S., Wypyszinski, A.W. 1992. Aquaculture Conflicts in the eastern United States. World Aquaculture 2382): 24-25.
Issues: (1) Recreation (fishing, swimming, boating); (2) commercial fishing; (3) Limited space (minimum number of adequate site locations); (4) Development (industrial, residential, land use issues); (5) Environmental/resource concerns (water availability, pollution, wetland impact, exotic species); (6) Aesthetics; (7) lack of lead agency (confusing permit process, too many government agencies); (8) theft and vandalism.
Institutional solutions: (a) consider aquaculture in coastal zone and local planning; (b) define aquaculture as agriculture; (c) specify geographic zones for aquaculture; (d) establish aquaculture leasing programmes; (e) define the regulatory role (and coordinating mechanism) of agencies; (f) identify a lead agency for aquaculture; (g) develop consistent federal/state regulations; (h) develop state aquaculture plans.
Political solutions: (I) Establish state-wide aquaculture advisory councils; (II) involve industry in state decision-making process; (III) elect supportive public officials; (IV) Educate legislators and agency officials; (V) Educate aquaculturists regarding public concerns.

Dickson, F. 1992. Aquaculture conflicts in Pacific Canada. Shellfish and marine plant aquaculture in British Columbia - conflicts and solutions. World Aquaculture 23(2): 28-29.
Siting issues: (1) floating culture operations (scallop, nori) include displacement of other site users (recreational boaters, commercial and sport fishermen, commercial marine operators); (2) upland owners = aesthetic concerns, water access rights, native Indian concenrs about loss of aboriginal rights; (3) bottom culturists (oyster, clams) face siting conflicts with commercial and recreational fishermen wishing to harvest on the same beaches.
Status of action: CRIS completed in five zones in the province; intended to assist prospective aquaculturists in locating their operations with minimal conflict, generating maps showing three zones of aquaculture opportunities: conditional, limited, no.
Coastal Zoning, as opposed to CRIS, is a planning tool utilized to promote the orderly development of nearshore waters. Coastal zoning is currently an emotional issue in British Columbia, with local governments being pressured to exclude aquaculture operations.
Note: The inter-agency referral system, used in conducting site specific assessments, give each concerned Provincial government agency, and where appropriate, local government and interest groups, a chance to review and comment on aquaculture applications. CRIS should lead to a more controlled and accepted industry. A logical extension of this process is the development of "mariculture zones or parks" where aquaculture is the major accepted use. Conflict resolution can be significantly enhanced where the current industry can demonstrate it can effectively manage itself and adopt good neighbour practices.

Fridley, R.B. 1992. Mariculture issues in the United States. World Aquaculture 23(2): 20-22.
Land and water use planning is a significant constraint to mariculture development. The issues: (1) Land and water use (leasing and permitting); (2) use conflicts (common property resources and privatization), (3) regulatory framework and attitudes. Suggested solutions: (a) offshore production systems; (b) submerged nearshore production systems; (c) ocean ranching, onshore recirculating or intensive production systems, (d) economical piping/pumping system for onshore culture.

Hankins, J. A., Bullock, D.G. 1994. A national overview of state regulatory approaches for aquaculture effluent discharges. World Aquaculture '94, Book of Abstracts. New Orleans, p. 218.
A thirty question telephone survey was developed with a focus on collecting background information, current permit and regulation data and opinions regarding future actions. Key contacts in each state consisting of permit writers, extension agents, state aquaculture coordinators and trade association officers were identified and verified. Participants identifed 478 public and more than 9,900 private sector aquaculture facilities and more than 80 state-level aquaculture related organisations nationwide. Responses indicated that 34 states utilized the basic 40 CFR "bright-lines" for determining discharge permit requirements while the remaining 16 states have more stringent regulation requirements. Seven of the EPA non-delegated states expressed plans for seeking regulatory primacy in the near future. Thirty states charge a fee for aquaculture related NPDES permits. Two states reported utilizing solely technology based standards to limit effluent while 18 states utilize only water quality based standards. All remaining states use a combination approach to achieve the most stringent limitation. Specific parameters that are most commonly limited include: total and settleable solids, pH, dissolved oxygen, and temperature. Less commonly limited parameters include: BOD, ammonia nitrogen, nnitrite-nitrate nitrogen, total phosphorous and TKN. Nearly two-thirds of the states do not consider influent concentraations when evaluating facility effluent discharges level limits. Influent testing is required in some special situations such as shellfish waters. Seven states classify aquaculture waste solids as industrial waste while 33 specifically have classed it as agricultural waste. All state will currently allow land application of waste solids with some restrictions.

Hanson, A.J., Koessoebiono, 1977. Settling coastal swamplands in Sumatra: a case study for integrated resource managment. Center for Natural Resource Management and Environmental Studies, Bogor Agricultural University, Indonesia, 46 pp.

Meltzoff, S.K., LiPuma, E. 1986. The social and political economy of coastal zone management. shrimp mariculture in Ecuador. Coastal Zone Management Journal 14(4): 349-380.

Murai, T. 1992. Aquaculture conflicts in Japan. World Aquaculture 23(2): 30-31.
Aquaculture production in 1988 = 1.43 mio tonnes; over 30 species.
Problem areas: (1) raw or minced fish as feed cause serious benthic pollution near yellow tail cage sites (e.g. accumulation of undigested bones!!); (2) waste effluents (sewage and industrial) cause problems to aquaculture, claimed to cause local red tides; (3) land reclamation (1500 ha per year) for industry and residential development pushes aquaculture out of several areas; (4) conflicts with fishermen and sportfishing; (5) boaters disturb farms with their wake.

Pollnac, R.B. 1991. The role of sociocultural factors in aquaculture development projects. pp. 165-191. In: Hargreaves, J.A., Alston, D.E. (Eds.). "Status and potential of aquaculture in the Caribbean. Advances in World Aquaculture, Vol. 5, World Aquaculture Society).

Pollnac, R.B. 1992. Multiuse conflicts in aquaculture: sociocultural aspects. World Aquaculture 23(2): 16-19.
Conflict aquaculture vs fishing; multi-use conflicts; aquaculture vs subsistence; aquaculture vs agriculture; aquaculture vs aquaculture = intensive shrimp culture ponds often developed inland from and higher than traditional and semi-intensive fish ponds. The waste-water discharge from shrimp ponds flows often into the intake canals of the other ponds adversely affecting production. The introduction of aquaculture often puts the small guy against the big guy. In most cases the big guy wins, resulting in an even larger income differential. This is referred to as social stratification.

Siddall, S.E. 1991. Aquaculture and coastal resource management. pp. 90-108. In: Hargreaves, J.A., Alston, D.E. (Eds.). "Status and potential of aquaculture in the Caribbean. Advances in World Aquaculture, Vol. 5, World Aquaculture Society).

Shaw, J.A., Muir, J.F. 1987. Salmon. Economics and marketing. Croom Helm, 270 pp.
International trade in salmon has developed considerably with increased supplies allowing the development of new markets. Implications on wild salmon fisheries are discussed.

Skladany, M. 1992. Conflicts in southeast Asia: an institutionalist perspective. World Aquaculture 23(2): 33-35.
Conflict issues: (1) property rights; (2) unequal resource distribution; (3) overproduction for a limited world market.
Notes: (a) in most Southeast Asian nations the state owns the coastal areas; (b) shrimp culture has creaated use conflicts that have wide social impacts. Major use conflicts in Southeast Asian aquaculture stem from international class interests behind the adoption of capital-intensive production practices, highly evident in coastal aquaculture development where (I) the struggle over property rights results in the transformation of highly complex, multiple-resource use systems into single purpose private property, (II) auqauclture resoruces are diverted away from more pressing problems inland towards these efforts in coastal areas, (III) overproduction for a limited world market.
Suggested solutions: Although use conflicts are clearly recognized on the institutional level, mechanisms to resolve these conflicts are lacking. The mitigation of use conflicts faces formidable opposition from vested institutional and class interests who may be threatened by the restructuring of formal and informal legal, planning, management and social development initiatives. Hopefully, activities such as the ASEAN Coastal Resource Management Project (CRMP) will indentify means by which to mitigate aquaculture use conflicts. Concerted involvement of a relatively neutral international organisation which can assert a more socially defined mode of aquaculture development may be required, so that the benefits of such activities are available to a wider society, rather than certain "classes" and "individuals".

Stansfeld, J.R.W. 1985. The effect of the competition of farmed salmon in the market place on the present state of commercial salmon fisheries. In: The Status of the Atlantic Salmon in Scotland, Februaryy 1985. Ed. D. Jenkins, W.M. Shearer. ITE Symposium Nop 14, Banchory 13-14.
The author showed that the advent of a large supply of high quality, fresh farmed salmon available throughout the year has had a marked effect on the traditional salmon markets, particularly the market in frozen salmon, which had been supply driven. In Scotland, price reductions have resulted in many marginal netting stations closing or working shorter seasons resulting in a change in the pattern of exploitation favourable to the development of ranching, particularly given tghe large numbers of smolts being produced.

Tuomi, A.L.W. 1987. Canada's Atlantic Salmon recreational fishries and their future: an economic overview. Atlantic Salmon Federation Special Publication Series 14 (St. Andrews, New Brunswick).
The author speculated that the traditional commercial fishery in Canada would end because of the advent of salmon farming.

Wildsmith, B.H. 1992. Aquaculture conflicts in Atlantic Canada. World Aquaculture 2382): 26-27.
Siting issues: (1) Statutory requirements; (2) Public rights, namely, the public right to navigate and the public right to fish; (3) Private rights, namely, the rights of adjacent riparian land owners and others with a special interest in the public rights, and aboriginal/treaty rights; (4) Other public policy interests, such as the social acceptability of an operation to the local community.
Conflict resolution through decision-making: adopt decision-making model in the land use arena = (a) advanced planning - ministerial approval; (b) articulation of criteria - factor analysis; (c) public consultation/involvement; (d) initial decision with written reasons (professional decision-maker); (e) appeal process with written reasons (Minister or Board).
Note: The notion of discretion means there is, in law, no uniquely right answer to the question of apprival for a given site.

Wint, S.M.E. 1991. Governmental policies and programs for aquaculture development. pp. 61-89. In: Hargreaves, J.A., Alston, D.E. (Eds.). "Status and potential of aquaculture in the Caribbean. Advances in World Aquaculture, Vol. 5, World Aquaculture Society).

Wurts, W.A. 1991. Basics of aquaculture site selection. World Aquaculture 23(3): 42-
Issues addressed: (1) water quality, general comments, some data on pH, total hardness, alkalinity; (2) soils; focus on pond construction; 20% clay minimum; (3) topography, need for slope (optimum 0.2%,no greater than 2%), adequate drainage area, site should be above 25-year flood plain.

Environmental issues / Interaction with wild-life

Bjordal, Å., Johnstone, A.D.F. 1993. Lokal movement of saithe (*Polachius virens* L.) in the vicinity of fish farm cages. Mar. Sci. Symp. int. Counc. Explor. Sea 196: 143-146.

Bjordal, Å., Skaar, A.B. 1992. Tagging of saithe (*Polachius virens* L.) at a Norwegian fish farm: preliminary results on migration. Comm. Meet. int. Coun. Explor. Sea C.M.-ICES/G:35.

Booth, Jacqueline;Rueggeberg, Harriet,1989. Marine birds and aquaculture in British Columbia:Assessment and management of interactions, Phase II Report: Assessment of geographical overlap. Environment Canada Technical Report Series No. 73 !!!!

Ruggeberg, Harriet;Booth, Jacqueline,1989. Marine birds and aquaculture in British Columbia: Assessment and management of interactions, Phase III Report: Preventing predation by scoters on a West Coast mussel farm. Environment Canada Technical Report Series No. 74 !!!!

Hansen, L., Lund, R.A., Hindar, K. 1987. Possible interaction between wild and reared Atlantic salmon in Norway. ICES C.M. 1987/M:14. (Anadromous & Catadromous Fish Committee).
The authors expressed concern that an increased output of reared fish might lead to higher fishing effort in mixed stock fisheries resulting in over-exploitation of wild salmon stocks.

Huner, J.V., Fleury, B., Romaire, R.P., Sherry, T. 1994. observations on avian predation in southern Louisiana (USA) crawfish culture systems with emphasis on wading birds. World Aquaculture '94, Book of Abstracts. New Orleans, p191.
Procambarus aquaculture has increased in southern Louisiana from less than 1000 ha in the 1960s to about 50,000 ha in 1993. High stocking densities attract wading birds. Conflicts have arisen between conservationist and farmers over the impact of the very visible colonial wading birds on crawfish production. Modelling wading bird predation scenarios using "CRAWPOP" suggest that heavy wading bird predation in the fall after ponds are filled and during the winter can have a negative impact on crawfish production. However, the wading birds may have a positive impact on production by removing "exxcess" crawfish when ponds are drained by preventing overpopulation and stunting in the following year. Yellow-crowned night heronsm white ibises, great egrets have seen dramatic population increases in recent years. They feed exclusively on crawfish. Other waders feed more heavily on invertebrates other than crawfish and prefer fishes and amphibians. Loss of crawfish pond systems as a consequence of the negative impact of protected colonial wading birds will likely have dire consequences on the region's wetland fauna. Many native and migratory wetland birds, especially waterfowl, make use of crawfish ponds for feeding, resting, and nesting habitat. Significant numbers of amphibious reptiles, amphibians, and mammals depend on crawfish ponds for habitat. Finally, fishes, especially desiraable game species, feed heavily on prey in crawfish pond effluents throughout the crawfish production season. This problem is compounded by the loss of Louisiana's coastal marsh ecosystems , the natural habitat for these species.

Sea Trout Working Group 1993. Report to the Minister for the Marine, 18.-21. Oct., 24.-25. Nov.1993s, 127 p.**Sea Trout Working Group** 1993. Report to the Minister for the Marine, 18.-21. Oct., 24.-25. Nov.1993s, 127 p.

Environmental issues / Feed / excretion / leaching / nutrients

Frechette, M., Booth, D.A., Myrand, B., Berard, H. 1991. Variability and transport of organic seston near a mussel aquaculture site. ICES mar. Sci. Symp. 192: 24-32.

Grenz, C., Masse, H., Morchid, A.K., Parache, A. 1991. An estimate of the energy budget between cultivated biomass and the environment around a mussel-park in the northwest Mediterranean Sea. ICES mar. sci. symp. 192: 63-67.

Riche, M., Griffin, M., Brown, P. 1994. Effect of dietary phytaase pretreatment on phosphorus leaching from rainbow trout feces. World Aquaculture '94, Book of Abstracts. New Orleans, p. 231.
Results indicate that fecal phosphorus in the phytase pretreated diets was significantly lower at time zero. Fecal total phosphorus from treatment was signicantly lower tha from soy bean concentrate alone. However, significant increases in orthophosphate appearing in the effluent and it is concluded that phytase pre-treatment significantly increases the amount of orthophosphate leached within one hour.

Environmental issues / Mitigation techniques/ Effluents/Treatment

Adler, P.R., Summerfelt, S.T., glenn, D.M., Takeda, F. 1994. Development of a mechanistic model to predict plant productivity and water quality of aquacultural effluents treated in a thin-film reactor. I. concept development. World Aquaculture '94, Book of Abstracts. New Orleans, p. 219.
Thin film technology is a hydroponic plant production system in which water flows by plant roots as a thin film, typically down some typ of trough system. Lettuce was selected for production in the thin-film hydroponic system for reuse of the aquaculture effluent.

Harrell, R.M., Van Heukelem, W., Urban, J.A. 1994. Wastewater effluent characterization in brackish wateer Maryland hybrid striped bass production ponds. World Aquaculture '94, Book of Abstracts. New Orleans, p. 223.

Hinrichts, D., Webb, J., Rosati, R., Foley, P. 1994. Efflunet characterization from the production of Oreochromis niloticus in a modified red Ewald-Style recirculating system. World Aquaculture '94, Book of Abstracts. New Orleans, p. 222.
Project goals and objectives: characterize effluents from 18,500 L recycling system to (1) determine dissolved oxygen level, ammonia, nitrite, hardness, BOD and others, (2) determine trends in effluent characteristics when compared to fish loading rates, feed input rates, system biomass, and make-up water volume.
Results: Survival rate was 93%, total fish biomass gain from 27.4g to 660 g individual average weight in 3.5 months; Data are provided in a table.

Hundley, P.L. 1994. Solids removal for 24 million LPD hard clam seawater system. World Aquaculture '94, Book of Abstracts. New Orleans, p. 31.
experimental filter studies, using various mechanical devices.

Jacobsen, P., Liltved, H. 1988. Thermal disinfection of seawater for aquacultural purpose. Aquacultural Engineering 7: 443-447.

Ketola, H.G. 1994. use of enzymes in diets of trout to reduce environmental discharges of phosphorus. World Aquaculture '94, Book of Abstracts. New Orleans, p. 211.
experimental approach.

Landesman, L. 1994. The negative impacts of tropical aquaculture development. World Aquaculture '94, Book of Abstracts. New Orleans, p. 160.
Most of the expansion in Southeast Asia and Latin America has resulted from shrimp farming, often in ponds excavated in coastal mangrove environments. The intensive production of shrimp has led to pollution from pond effluents, land subsidence, saltwater contamination and the destruction of mangrove wetlands. The capture of wild penaeid post-larvae to stock these ponds has affected the abundance of penaeid species in the shrimp fisheries of the affected countries. If antibiotics are used in shrimp feeds then resistant bacterial strains can arise. There are also socio-economic impacts. Mangrove destruction has reduced nursery areas for fish and shrimp fisheries affecting the livelihood of artisanal fishermen. Five strategies to mitigate the harmful effects of intensive aquaculture development are proposed and described in detail.

Løland, G. 1993. Current forces on, and water flow through and around, floating fish farms. Aquaculture International 1: 72-89.
The wake generated by a screen or a net is analysed by the linear free-wake equations in conjunction with an eddy viscosity formulation. The behaviour of the near and far-field wake is investigated, and a relationship between the drag coefficient and the wake velocity is derived. A method for calculating the current forces experienced by the net structure and the resulting deformation is derived and compared with model tests. The effects of the wake behaviour and the deformation of the net cages, on the design and operation of floating fish farms are discussed and some recommendations are given.

Rosenthal, H., Hilge, V., Kamstra, A.(eds.) 1993. Proceedings of the Workshop on Fish Farm Effluents and their Control in EC Countries, 205 p.

Summerfelt, S.T., Adler, P.R. 1994. Development of an illuminated, attached-algae, fluidized reactor for treating phosphate in aquacultural effluents. World Aquaculture '94, Book of Abstracts. New Orleans, p. 301.
The study claims that a fluidized bed will maximize periphytic algae tretment efficiency by providing long cell residence times, greater surface area per unit volume, and better hydrodynamics for mass transfer. The objective of the study was to devvelop a novel phosphate treatment process. The results are described on the basis of biomass production and removal efficiency, however, no cost analysis is included.

Summerfelt, S.T., Adler, P.R., Summerfelt, S.R. 1994. Development of a mechanistic model to predict plant productivity and water quality of aquacultural effluents treated in a thin-film reactor. World Aquaculture '94, Book of Abstracts. New Orleans, p. 220.

Summerfelt, S.T., Hankins, J.A., Holland, K.H. 1994. A hydroacoustical waste-feed controller. World Aquaculture '94, Book of Abstracts. New Orleans, p. 32.
Precise control of feeding is aimed for by this technique in order to decrease nutrient release from fish tanks. The method detects uneaten feed but requires feeds that do sink with feeders located near to the tank outlet.

Environmental Interaction : Ecosystems/Diseases/Benthos

Ecosystems

Asmus, H. 1987. Secondary productionof an intertidal mussel bed community related to its storage and turnover compartments. Mar. Ecol. Progr. Series 39: 251-266.

Asmus, R.M., Asmus, H. 1991. Mussel beds: limiting or promoting phytoplankton? J. exp. Biol. Ecol. 148: 215-223.
Subject: Seasonal variation of phytoplankton over an intertidal mussel bed was measured in the Wadden Sea near the island of Sylt between February 1984 and April 1985. **Method:** To quantify the uptake of phytoplankton by a mussel bed, an open flow-through system, the Sylt flume, canalized the tidal water over a bed of *Mytilus edulis.* Changes in the content of phytoplankton in the water passing through the flume were used to calculate phytoplankton uptake over three tidal cycles in the summer of 1986. **Results:** Phytoplankton biomass was reduced by 37%±20% between the inflow and outflow of the flume. This figure includes active filtration of mussels and sedimentation. It was assumed that the released ammonium wouled be taken up entirely by phytoplankton. The potential primary production induced by the nutrient release of the mussel bed is higher than the uptake of phytoplankton by the mussel bed. It is also possible that mussels extract N from particulate organic material other than phytoplankton. While mussels strongly reduce phytoplankton biomass, mussel beds als have the potential to significantly promote primary production.

Dame, R.F., Dankers, N. 1988. Uptake and release of materials by a Wadden Sea mussel bed. J. Exp. Mar. Biol. Ecol. 118: 249-256.

Diseases

Armstrong, R. 1989. Fish Health Workshop, Campbell River, November 29, 1989.

Austin, B., Al-Zahrani, A.M.J. 1988. The effect of antimicrobial compounds on the gastrointestinal microflora of rainbow trout, *Salmo gairdneri* Richardson. J. Fish Biol. 33: 1-14.

Brouha, P. Year!!! A penny per pound to complete the fish therapeutants strategy. Fisheries 18(12).

Blackburn, T., Henry, !!! Year!!! Microbial food webs in sediments. In: M.A. Sleigh (Ed.). Microbes in the Sea, Chapter 2. **Publisher + Pagenumber!!!**

Boyd, E.F., Hiney, M.P., Peden, J.F., Smith, P.R., Caugant, D.A. 1994. Assessment of genetic diversity among *Aeromonas salmonicida* isolates by multilocus enzyme electrophoresis. Journal of Fish Diseases 17: 97-98.

Brackett, J. 1991. Potential disease interactions of wild and farmed fish. Bulletin of the Aquaculture Association of Canada, Edition 91-3: 79-80.

Elston, R.A., Kent, M.L., Harrell, L.H. 1987. An intranuclear mocrosporidium associated with acure anemia in the Chinook Salmon, *Oncorhynchus tshawytscha*. J. Protozool. 34(3): 274-277.

Enger, O., Gunnlaugsdottir, B., Thorsen, B.K., Hjeltnes, B. 1992. Infectious load of *Aeromonas salmonicida* subsp. *salmonicida* during the initial phase of a cohabitant infection experiment with Atlantic salmon, *Salmo salar* L. Journal of Fish Diseases 15: 425-430.

Gaskin, J., Latchford, J. 1993. How oxytetracycline affects prawns. Fish Farmer, January/February:

Gerundo, N., Alderman, D.J., Clifton-Hadley, R.S., Feist, S.W. 1991. Pathological effects of repeated doses of malachite green: a preliminary study. Journal of Fish Diseases 14: 521-532.

Jarp, J., Tangen, K., Willumsen, F.V., Djupvik, H.O., Tveit, A.M. 1993. Risk factors for infection with *Aeromonas salmonicida* subsp. *salmonicida* in Norwegian freshwater hatcheries. Diseases of Aquatic Organisms 17: 81-86.

Karreman, G., Kenney, A. 1992. Cooperative assessment of salmon health: management of comparative production and health data across companies in the British Columbia salmon farming industry. Bulletin of the Aquaculture Association of Canada, Edition 92-3: 79-81.

Kent, M.L. (no year indicated) The impact of diseases of pen-reared salmonids on coastal marine environments. Department of Fisheries and Oceans, Biological Sciences Branch, Pacific Biological Station, Nanaimo, B.C. V9R 5K6.

Kent, Michael L. 1990. A new disease of pen-reared chinook. The Fish Farm News, May 1990: 18-19.

Kent, M.L., Groff, J.M., Traxler, G.S., Zinkl, J.G., Bagshaw, J.W. 1990. Plasmacytoid leukemia in seawater reared chinook salmon *Oncorynchus tshawytscha*. Dis. Aquatic Org. 8: 199-209.

Kent, M.L., Bagshaw, J.W., Newbound, G.C., Traxler, G.S., Dawe, S.C., Roome, J.R., Eaton, W.E., Groff, J.M., Speare, D. 1991. Plasmacytoid Leukemia (Marine Anemia): Viral of microsporidian Etiology? Fish Health Section-American Fisheries Society Newsletter 19(2).

Klontz, G.W., Chacko, A.J., Beleau, M.H. 1980. Environmental gill disease (EGD): what it is and what to do about it. Proc. No. Pac. Aquaculture Symp., August 1980, Anchorage Alaska.

Lecomte, J., Arella, M., Berthiaume, L. 1992. Comparison of polyclonal and monoclonal antibodies for serotyping infectious pancreatic necrosis virus (IPNV) strains isolated in eastern Canada. Journal of Fish Diseases 15: 431-436.

MacKinnon, B.M., Piasecki, W. 1992. Reproduction in *Caligus elongatus,* or: How sea lice become so numerous! Bulletin of the Aquaculture Association of Canada, Edition 92-3: 20-21.

McAllister, P.E., Schill, W.B., Owens, W.J., Hodge, D.L. 1993. Determining the prevalence of infectious pancreatic necrosis virus in asymptomatic brook trout *Salvelinus fontinalis*: a study of clinical samples and processing methods. Diseases of Aquatic Organisms 15: 157-162.

Miller, H.J., Black, E.A. 1992. The effect of consumption of woody debris on the health of marine cage reared salmon. Bulletin of the Aquaculture Association of Canada, Edition 92-3: 76-78.

Mortensen, Stein H. 1993. Passage of infectious pancreatic necrosis virus (IPNV) through invertebrates in an aquatic food chain. Diseases of Aquatic Organisms 16: 41-45.

Nielsen, B., Olsen, J.E., Larsen, J.L. 1993. Plasmid profiling as an epidemiological marker within *Aeromonas salmonicida*. Diseases of Aquatic Organisms 15: 129-135.

Ristow, S.S., de Avila, J., LaPatra, S.E., Lauda, K. 1993. Detection and characterization of rainbow trout antibody against infectious hematopoietic necrosis virus. Dis. Aquatic Org. 15: 109-114.

Salonius, K., Iwama, G.K. 1991. Stress and immune function of coho salmon juveniles. Bulletin of the Aquaculture Association of Canada, Edition 91-3: 47-49.

Samuelsen, O.B., Lunestad, B.T., Husevag, B., Holleland, T., Ervik, A. 1992. Residues of oxolinic acid in wild fauna following medication in fish farms. Diseases of Aquatic Organisms 12:111-119.

Sorum, H., Kvello, J.H., Hastein, T. 1993. Occurrence and stability of plasmids in *Aeromonas salmonicida* ss *salmonicida* isolated from salmonids with furunculosis. Diseases of Aqauatic Organisms 16: 199-206.

Spanggaard, B., Jorgensen, F., Gram, L., Huss, H.H. 1993. Antibiotic resistance in bacteria isolated from three freshwater fish farms and an unpolluted stream in Denmark. Aquaculture 115: 195-207.

Thuvander, A., Wichardt, U.P., Reitan, L.J. 1993. Humoral antibody response of brown trout *Salmo trutta* vaccinated against furunculosis. Diseases of Aquatic Organisms 17: 17-23.

Traxler, G.S., Roome, J.R., Kent, M.L. 1993. Transmission of infectious hematopoietic necrosis virus in seawater. Diseases of Aquatic Organisms 16: 111-114.

Yang, C., Albright, L. 1992. The mode of action of harmful *Chaetoceros* phytoplankters on rainbow trout. Bulletin of the Aquaculture Association of Canada, Edition 92-3: 73-75.

Benthos

Watling, L., Findlay, R.H. 1992. Effect of mariculture autopollution on benthos assicated with pen culture. pp. 56-65. In: Kissil, G.Wm., Saar, L. (eds.). Proc. US-Israel Workshop on Mariculture and the Environment, Elat, IOLR, June 8-10, 1992.

Ye, L.-X., Ritz, D.A., Fenton, Lewis, M.E. 1991. Tracing the influence on sediments of organic waste from a salmonid farm using stable isotope analysis. J. exp. mar. Biol. Ecol. 145: 161-174.

Use of Chemicals / Antimicrobials

Alderman, D.J., Clifton-Hadley, R.S. 1993. Malachite green: a pharmacokinetic study in rainbow trout, *Oncorhynchus mykiss* (Walbaum). Journal of Fish Diseases 16: 297-311.

Andresen, A.T., Rasmussen, K.E. 1990. Automated on-line dialysis and column-switching HPLC determination of flumequine and oxolinic acid in fish liver. J. liqu. Chromatogr. 13: 4051-4065.

Barnes, A.C., Lewis, C.S., Amyes, S.G.B., Hastings, T.S. 1991. Susceptibility of Scottish isolates of *Aeromonas salmonicida* to the antibacterial agent amoxycillin. ICES, CM 1991/F:28 (Mariculture Committee Theme Session O)>

Beaulieu, A.J. 1992. Aquaculture, FDA and Drug Approval. INAD Workshop, Auburn University, Auburn, AL.

Bjorklund, H., Bylund, G. 1990. Temperature-related absorption and excretion of oxytetracycline in rainbow trout (*Salmo gairdneri* R.). Aquaculture 84: 363-372.

Bjørklund, H., Bondestam, J., Bylund, G. 1990. Residues of oxytetracycline in wild fish and sediments from fish farms. Aquaculture 86: 359-367.

Bjørklund, H., Eriksson, A., Bylund, G. 1990. Residues of oxytetracycline in wild fish and sediments from fish farms. Aquaculture 86: 359-367.

Bjørklund, H., Råberg, C.M.I., Bylund, G. 1991. Residues of oxolinic acid and oxytetracycline in fish and sediments from fish farms. Aquaculture 97: 85-86.

Black, E.A., Little, J.M., Brackett, J., Jones, T., Iwama, G.K. 1991. Co-culture of fish and shellfish: the implications for antibiotic contamination of shellfish. ICES, C.M. 1991/F:23 (Mariculture Committee Ref. Theme Session 0).

Burridge, L.E., Haya, K. 1993. The lethality of Ivermectin, a potential agent for treatment of salmonids against sea lice, to the shrimp *Crangon septemspinosa*. Aquaculture 117: 9-14.

Brackett, J. 1989. Review of regulation, withdrawal times, tolerance levels and residue assay methods for finfish therapeutants. 1989 Industry-Government meeting to discuss a proposed approach to regulation of drug and chemical use in the British Columbia Aquaculture Industry.

Brown, A.G., Grant, A.N. 1993. Clinical efficacy of injectable amoxycillin against furunculosis in Atlantic salmon broodstock. The Vetrinary Record 133: 373.

Carr, W., Brock, J., Swingle, J. 1994. An experimental trial of oxytetracycline as a therapy for black spermatophore disease in P. vannamei. World Aquaculture '94, Book of Abstracts. New Orleans, p. 229.
Vibrio alginolyticus was the most common bacterial isolate from pond-reared males with reproductive tract syndrome and these bacterial isolates were sensitive to oxytetracycline.

Corliss, J.P. 1979. Accumulation and depletion of oxytetracycline in juvenile white shrimp (*Penaeus setiferus*). Aquaculture 16: 1-6.

Coyne, R., Hiney, M., O'Connor, B., Kerry, J., Cazabon, D., Smith P. 1994. Concentration and persitence of oxytetracycline in sediments under a marine salmon farm. Aquaculture (in press).

Cravedi, J.P., Baradat, M., Choubert, G. 1991. Digestibility, tissue distribution and depletion kinetics of [14C]-virginiamycin and related factors fed to rainbow trout. Aquaculture 97: 73-83.

Cravedi, J.P.,Choubert, G.,Delous, G. 1987. Digestibility of chloramphenicol, oxolinic acid and oxytetracycline in rainbow trout and influence of these antibiotics on lipid digestibility. Aquaculture 60: 133-141.

Enger, Ø., Husevåg, B., Goksøyr, J. 1989. Presence of the fish pathogen Vibrio salmonicida in fish farm sediments. Appl. environ. Microbiol. 55: 3815-2818.

Ervik, A., Thorsen, B., Eriksen, V., Lunestad, B.T., Samuelsen, O.B. 1994. Impact of administering antibacterial agents on wild fish and blue musses *Mytilus edulis* in the vicinity of fish farms. Diseases of Aquatic Organisms 18: 45-51.
ABSTRACT: Using high-performance liquid chromatography, residues of the quinolones oxolinic acid and flumequine have been quantified in muscle of wild fish. The fish were caught 0 or 1 d after terminating medication in the vicinity of 6 fish farms previously employing one of the drugs. The majority of the wild fish (74 to 100% of the catch at the different farms) contained drug residues in muscle. The mean muscle concentration varied from 0.95 to 4.89 $\mu g\ g^{-1}$ (ppm). Using a standard microbiological method, 60% of the examined fish were found to contain faecal material displaying antibacterial activity. The occurence of bacteria resistant to oxolinic acid and oxytetracycline in blue mussels *Mytilus edulis* and in the inyestinal content of fish was also examined. The level of resistant bacteria was higher in samples taken at the farm after medication than in samples collected before medication or from untrated areas.

GomezGill-RS, B., Herrera-Vega, M.A., Romero-Jarero, J., Abreu-Grobois, F.A. 1994. Chemical disinfection of Artemia nauplii. World Aquaculture '94, Book of Abstracts. New Orleans, p. 240.
Tests included hypochlorite, Formaldehyde, Hydrogen peroxide, Oxytetracycline, Nitrofurazone and iodine.

Grave, K., Engelstad, M., Soli, N.E., Hastein, T. 1990. Utilization of antibacterial drugs in salmonid farming in Norway during 1980-1988. Aquaculture 86: 347-358.

Hansen, P.K., Lunestad, B.T., Samuelsen, O.B. 1993. Effects of oxytetracycline, oxolinic acid, and flumequine on bacteria in an artificial marine fish farm sediment. Can. J. Microbiol. 39: 1307-1312.

Hastings, T.S., MacKay, A. 1987. Resistance of *Aeromonas salmonicida* to oxolinic acid. Aquaculture 61: 165-171.

Heinen, J.M., Weber, A.L., Noble, A.C., Morton, J.D. 1994. Tolerance of formalin by rainbot trout and a fluidized-bed biofilter in a recirculating culture system. World Aquaculture '94, Book of Abstracts. New Orleans, p. 230.
The entire system was exposed to progressively higher initial formalin levels of 15, 30, 40, 60, 80, 100, 110, and 120 ppm at temperatures of 16-18°C without flushing ("indefinite" treatments). The biofilter did not exhibit obvious damage. Some fish were killed at 120 ppm at 17.3°C but not at 110 ppm. Formalin at 120 ppm required about 11 hours to disappear from the system. After the last treatmen, No2-levels rose temporarily to 0.5 mg/L, whereas normal levels had been 0.05-0.2 mg/L. Frequent formalin exposure may therefore have resulted in enough cumulative mortality of Nitrobacter sp bacteria to cause the nitrite rise.

Hustvedt, S.O., Storebakken, T., Salte, R. 1991. Does oral administration of oxolinic acid or oxytetracycline affect feed intake of rainbow trout. Aquaculure 92: 109-113.

Hustvedt, S.O., Salte, R., Kvendset, O., Vassvik, V. 1991. Bioavailability of oxolinic acid in Atlantic salmon (*Salmo salar* L.) from medicated feed. Aquaculture 97: 305-310.

Inglis, V., Millar, S.D., Richards, R.H. 1993. Resistance of *Aeromonas salmonicida* to amoxicillin. Journal of Fish Diseases 16: 389-395.

Jacobsen, P., Berglind, L. 1988. Persistence of oxytetracycline in sediments from fish farms. Aquaculture 70: 365-370.

Jones, T.O. 1990. Uptake and Depuration of the Antibiobics, Oxytetracycline and Bomet-30R in the Pacific Oyster, *Crassostrea gigas* (Thunberg). MSc-Thesis, Universtiy of British Columbia. **Pagenumbers!!!**

Koenings, J.P., Lipton, J., McKay, P. 1986. Quantitative determination of oxytetracycline uptake and release by juvenile sockeye salmon. Transactions of the American Fisheries Society 115: 621-629.

Kusser, W.C., Newman, S.G. 1990. Detection of oxytetracycline residues in fish tissues using a sensitive bioassay. Journal of Fish Diseases 13: 545-548.

Lanzing, W.J.R., Hynd, J.S. 1966. Tetracycline distribution in body tissues of marine fishes. Aust. J. Sci. 29(6): 177-178.

Le Bris H., Pouliquen H., Debernardi J.M., Buchet V. et Pinault L., 1994. Preliminary study on the kinetics of oxytetracycline in shellfish exposed to an effluent of a land-based fish farm : experimental approach (submitted to Mar. Env. Res.).

Maffart P., Le Bris H., Bocquene G., Blanc G., Buchet V. et Galganil F., 1993. Experimental study on the influence of a dichlorvos treatment on the acetylcholinesterase activity of sea bass *(Dicentrarchus labrax)*. European Association of Fish Pathologists. Sixth International Conference, "Diseases of fish and shellfish", Brest, France, septembre 5-10, 1993.

Marking, L.L., Howe, G.E., Crowther, J.R. 1988. Toxicity of erythromycin, oxytetracycline, and tetracycline administered to lake trout in water baths, by injection or by feeding. The Progressive Fish-Culturist 50: 197-201.

Massuyau L., 1991. Contribution à l'étude d'une méthode de recherche de résidus de chloramine T dans les produits d'aquaculture. Thèse de doctorat vétérinaire, Nantes.

Meyer, F.P. 1989. Solutions to the shortage of approved fish therapeutants. Journal of Aquatic Animal Health 1: 78-80.

Park, E.D., Lightner, D.V., Stamm, J.M., Bell, T.A. 1994. Evaluation of Sarafloxycin as an antibacterial for use in penaeid shrimp *(Penaeus vannamei)* aquaculture. World Aquaculture '94, Book of Abstracts. New Orleans, p. 271.
Objectives of study: (1) To determine the levels of sarafloxaxin-HCL palatable to penaeid shrimp when incorporated into their feeds, (2) to establish if these levels are toxic to penaeid shrimp and, therefore, to determine their safety for shrimp use, (3) to determine approximate withdrawal times of sarafloxacin from shrimp tissues following medicated feeding. Methods: 15 days medicated feeding, 5% body weight once per day, at 200 mg/kg of feed (1x), and 5x, 10x, and 50x this dose level, were evaluated in the penaeid shrimp Penaeus vannamei. Results. A significant reduction in

sarafloxacin medicated feed palatability was noted with increasing dose rate. No differences in mortalities or signs of morbidity were noted in any of the treatments. However, feed conversion ratios showed a marked increase at dose levels 5x, 10x, and 50x, with sarafloxacin tissue t(1/2) being approx. 13.4 hours. Sarafloxacin tissue levels were below detectable limits by day 3,7,7, and 14 days post medicated feeding in the 1x, 5x, 10x, and 50x treatments, respectively.

Pouliquen H., 1993. Mise au point et validation d'une méthode de dosage de l'acide oxolinique dans l'eau de mer, le sédiment, l'huître creuse *Crassostrea gigas*. et la palourde *Ruditapes philippinarum*. Contrat IFREMER/ENVNantes (33 p).

Pouliquen H., Keita D. et Pinault L., 1992. Determination of oxytétracycline in marine shellfish (*Crassostrea gigas*, *Ruditapes philippinarum* and *Scrobicularia plana*) by high-performance liquid chromatography using solid phase extraction. Journal of Chromatography. **627** : 287-293.

Pouliquen H., Le Bris H. et Pinault L., 1992. Experimental study of the therapeutic application of oxytetracycline, its observations in sediment and sea-water, and implications for farm culture of benthic organisms. Marine Ecology Progress Series,. **89** : 93-98.

Pouliquen H., Le Bris H. et Pinault L., 1992. Experimental study of the decontamination kinetics of seawater polluted by oxytetracycline contained in effluents released from a fish-farm located on salt-marshes. Aquaculture, **112** : 113-123.

Rogstad, A., Ellingsen, O.F., Syvertsen, C. 1993. Pharmocokinetics and bioavailability of flumequine and oxolinic acid after various routes of administration to Atliantic salmon in seawater. Aquaculture 110: 207-220.

Samulelsen, O.B., Lunestad, B.T., Husevag, B., Holleland, T. , Ervik, A. 1992. Residues of oxolinic acid in wild fauna following medication in fish farms. Dis. Aquat. Org. 12: 111-119.
Dispersion of oxolinic acid and occurrence of Aeromonas salmonicida in wild fauna were studied in animals captured in the vicinity of 2 aquaculture facilities during and after medication with this drug. Consumption of antibacterial agents in aquaculture has reached a considerable level. The major part of the drugs used reach the environment, either directly due to excessive feeding and reduced appetite of the cultured fish, or indirectly after having passed through the fish. Some of the drugs entering the environment are taken up by exploitable wild fish, shellfish and crustaceans., resulting in concentrations far above those accepted in food for human consumption in Norway. The concentration of oxolinic acid in muscle and liver was higher in pelagic fish like coalfish and mackerel. The mean concentration of all positive samples at the day of medication termination were 4.38 µg/g and 0.42 µg/g at two different farms. We found a simultaneous occurrence of oxolinic acid and the fish pathogenic bacterium Areomonas salmonicida in the but of both cultured and wild fish. This may lead to development and dispersion of resistant bacteria. Blue mussels Mytilus edulis harvested at one of the farms contained an elevated level of bacteria resistant to oxolinic acid.

Samuelsen, O.B., Torsvik, V., Ervik, A. 1992. Long range changes in oxytetracycline concentrations and bacterial resistance towards oxytetracycline in fish farm sediments after medication. The Science of the Total Envrionemnt 14: 25-26.

SeaTek 1992. Final report antibiotic resistance and distribution of human pathogens in bivalve molluscs in the vicinity of fish farms. Final Report for contract KA601-0-3391, British Columbia Ministry of Agriculture and Fisheries.

Snieszko, S.F. 1959. Antibiotics in fish diseases and fish nutrition. Antibiotics and Chemotherapy 1(9):541-544.

Sohlberg, S., Czerwinska, K., Rasmussen, K., Soli, N.E. 1990. Plasma concentrations of flumequine after intra-arterial and oral administration to rainbow trout (*Salmo gairdneri*) exposed to low water temperatures. Aquaculture 84: 355-361.

Sohlberg, S., Aulie, A., Soli, N.E. 1994. Temperature-dependent absorption and elimination of flumequine in rainbow trout (*Oncorhynchus mykiss* Walbaum) in fresh water. Aquaculture 119: 1-10.

Stern, S., Stamm, J. 1994. Efficacy of SARAFIN® for control of bacterial disease of shrimp. World Aquaculture '94, Book of Abstracts. New Orleans, p. 228.
Sarafloxacin hydrochloride is a new arylfluoroquinone antibacterial which is being developed for control of bacterrial disease of farmed shrimp. The compound is rapidly and extensively bactericidal through its inhibitory action on the

essential bacterial enzyme DNA gyrase. The efficacy of sarafin against the primary bacterial pathogens of farmed shrimp has been proven in a laboratory model. The substance was more effective than oxolinic acid.

Tibbs, J.F., Elston, R.A. 1989. Studies on the accumulation of antibiotics in shellfish. Northwest Environmental Journal 5(1): 161-162.

Tong, S., Hetrick, F.M., Roberson, B.S., Baya, A. 1990. The antibacterial and antiviral activity of herbal extracts for fish pathogens. J. Ocean Univ. Qingdao/Qingdao Haiyang Daxue Xuebao 20(2): 53-60.

Ueno, R., Uno, K., Aoki,T. 1992. Determination of oxytetracycline in blood serum by high-performance liquid chromatography with direct injection. Journal of Chromatography 573: 333-335.

Uno, K., Aoki, T., Ueno, R. 1992. Pharmacokinetic study of oxytetracycline in cultured Rainbow Trout, Amago Salmon, and Yellowtail. Nippon Suisan Gakkaishi 58(6): 1151-1156.

Wahl, D.H., Stein, R.A. 1987. Application of liquid Oxytetracycline in formulated feeds to mark and treat tiger muskellunge (Northern Pike x Muskellunge). The Progressive Fish-Culturist 49: 312-314.

Walisser, J.A., Burt, H.M., Valg, T.A., Kitts, D.D., McErlane, K.M. 1990. High-performance liquid chromatographic analysis of Romet-30 in salmon following administration of medicated feed. Journal of Chromatography 518: 179-188.

Enhancement/Ranching / native-cultured stock interaction/exotics

Bannister, R.C.A., Howard, A.E. 1991. A large-scale experiment to enhance a stock of lobster (*Hommarus gammarus* L.) on the English east coast. ICES mar. Sci. Symp. 192: 99-107.

Carrs, D.N. 1990. Concentrations of wild and escaped fishes immediately adjacent to fish farm cages. Aquaculture 90: 29-40.

Craik, J.C.A., Harvey, S.M. 1986. The carotenoids of eggs of wild and farmed Atlantic salmon and their changes during development. J. Fish Biol. 29: 549-464.

Craik, J.C.A., Harvey, S.M. 1987. A biochemical method for distinguishing between wild and farmed salmonid fishes by their carotenoid pigmentation. J. Forensic Soc. 27: 47-55.

Denson, M.R., Smith, T.i.J., Jenkins, W.E. 1994. Overview of a pilot-scale stock enhancement project for red drum, Sciaenops ocellatus, in South Carolina. World Aquaculture '94, Book of Abstracts. New Orleans, p. 317.
Objectives: (1) development and testing of culture techniques, 82) identification of critical stocking parameters; and (3) evaluation of tagging techniques and angler reporting rates. **Methods:** During 1988-1993 aprox. 80,000 tagged red drum were produced and released in South Carolina to develop and test a model to evaluate aspects of a stock enhancement program. Acquisition of wild broodstock and hatchery techniques were implemented. Determination of impact of stocked fish was based on (1) reported captures from recreational anglers, (2) fisheries independent sampling surveys. **Results**: To date there have been 30%more returns from fish tagged with abdominal anchor tags than from those tagged with dorsal T-bar tags. Critical stocking parameters identified include season of stocking and size at release. Early summer releases provided more returns (9.0%) than fish released during all other seasons (3.0%); fish released at a size of 60g had return rates 200% higher than fish released at <40g. Fish released at legal creel length of 35.5 cm were reported captured at rates as high as 20%. Stocked fish have been caught with schools of wild fish and gut contents yield diets similar to those of wild fish. In addition 80% of fish captured were caught within one mile of release site. Growth of stocked and wild fish are similar and some released fish have reached a mature size (about 68.5 cm TI).

Gausen, D., Moen, V. 1991. Large-scale escapes of farmed Atlantic salmon *(Salmo salar* L.) into Norwegian rivers threaten natural populations. Canadian J. Fish. Aquat. Sci. 48: 426-238.

Giske, J., Aksnes, D.L., Lie, U., Wakili, S.M. 1991. Computer simulation of pelagic production in Masfjorden, western Norway, and its consequences for production of released 0-group cod. ICES Mar. Sci. Symp. 192: 161-175.
An ecosystem model including nutrients, phytoplankton, herbivores, two groups of pelagic carnivores, sublittoral gobies and 0-group cod is presented. The model is driven by solar radiation, temperature, freshwater run-off, andd water exchange across the sill. The production of food for 0-group cod, such as sublittoral gobies, pelagic krill, prawns, and mesopelagic fish, is simulated. Simulation illustrate how the different compartments of the system are influenced by alternations in the forcing of the system. Water exchange, especially the renewal of sublittoral water, turned out to be the most important process determining the carrying capacity for young cod. The explanation is that the water renewal suppliess the sublittoral habitat with zooplankton, which is utilized by the prey of young cod.

Gudjonsson, S. 1991. Occurrence of reared salmon in natural salmon rivers in Iceland. Aquaculture 98: 133-142.

Heggberget, T.G., Johnson, B.O. 1982. Infestations by Gyrodactylus of Atlantic salmon Salmo salar L., in Norwegian rivers. J. Fish Biol. 21: 15-26.

Hutchings, P. 1992. Ballast water introductions of exotic marine organisms into Australia. Current status and management options. Mar. Pollut. Bull. 25: 196-199.
A brief summary is provided of the fish species which have been introduced into Australia, probably by ballast water. The documentation of these introductions led to a baseline study of Twofold Bay, southern NSW, being undertaken by the Australian Museum, and subsequently to a review of all the species which had probably been introduced via ballast water into Australia. The discovery of toxic dinoflagellates in the ballast water of a number of ships entering Australia and in the sediment of several harbours in Australia highlighted the seriousness of the problem, especially for the developing aquaculture industry.

Jørstad, K.E. 1994. Cod stock enhancement studies in Norway: genetic aspects and the use of genetic tagging. World Aquaculture '94, Book of Abstracts. New Orleans, p. 127.
Mass release of artificially produced fry can represent a genetic risk to wild, local stocks. Based on initial allozyme screening of about 1200 artificially produced spawners, the development of a genetically tagged strain was performed. The results are discussed in relation to future management of cod stock enhancement activities.

Jørstad, K.E., Skaala, Ø., Dahle, G. 1991. The development of biochemical and visible genetic markers and their potential use in evaluating interaction between cultured and wild fish populations. ICES mar. Sci. Symp. 192: 200-205.
Large-scale fish farming, stock enhancement, and sea ranching programmes may cause unwanted genetic changes in wild populations. This paper focuses on the potential interaction between wild stocks and artificially reared fish, and two examples of genetic markers in artificially developed stocks are given. Teh genetic marker in cod is based on a rare allele at the PGI-1 locus; it is expressed in white muscle. Through the inter se mating of fish heterozygous for this allele, it has been possible to select offspring homozygous for the allele and develop a genetically marked broodstock. A visible genetic marker has been found in fine-spotted brown trout. Such strains offer the possibility to perform gene flow experiments in order to study interaction between escaped farmed or released fish and natural populations.

Kent, D., Drawbridge, M., Ford, R. 1994. A comprehensive assessment program for hatchery-reared white seabass (Atractsocion nobilis) released into the wild. World Aquaculture '94, Book of Abstracts. New Orleans, p. 129.
Use of hatchery reared fish to enhance depleted fisheries. The report summarizes the culture, recapture and assessment studies conducted and proposed by the Ocean Resources Enhancement and Hatchery Program (OREHP) and their use in evaluating the potential for restoration of the depleted coastal marine fisheries. Concern has been raised that such enhancement efforts migh significantly affect wild stocks by flooding the reproductive population with individuals whose genetic variability has been selectively diminished by hatchery protocols. This issue of reduced genetic variability is less of a concern for the reproductively panmictic marine species that are currently being investigated for enhancement. Hatchery fish produced to enhance such populations should attempt to encompass as much of the genetic variability observed in the wild population. This demands a conscientious effort to review the genetic character of the wild population, and a stringent protocol for broodstock management.

Kristensen, P.S., Hoffmann, E. 1991. Investigations on transplantation and culture of blue mussels *(Mytilus edulis* L.) in bottom culture plots in Limfjord, Denmark. ICES mar. Sci. Symp. 192: 87-92.
Transplantations of mussel seed from long lines and natural mussel beds to bottom culture plots were carried out. The seed was laid out at three different densities. On the long lines the seed grew to an average shell length of 17 mm and achieved a mean weight of around 0.90 g four months after settlement. The mean weight of the long-line-grown seed mussels was not significantly different at different levels below the sea surface (3-7 m). Production was between 0.6 and 15.2 kg per m of growth line. Growth of the transplanted mussels was followed throughout the growth season in 1988. The average biomasses and number of individuals per square meter were calculated. No differences were found

in the growth rate of mussels after tranplantation compared with that of the natural stock. After transplantation, 3.5 cm seed mussels grew to the legal size of 4.5 cm in shell length within 6-9 months. The authors conclude that the natural stocks of bottom-living mussels may benefit in terms of growth rate by transplantation to culture plots in shallower water.

Leber, K.M., Brennan, N.P., Arce, S.M. 1994. Marine enhancement with striped mullet: are we replenishing or displacing wild stocks?. World Aquaculture '94, Book of Abstracts. New Orleans, p. 131.
hypothesis tested: (1) cultured fish survive and grow in the wild; (2) cultured fish do not displace wild individuals. Research results show that Mugil cephalus abundances can be substantially increased using information from small-scale pilot releases (1989-1991). The release variables (fish size at release, release microhabitat, release season) had all substantial impacts on survival of cultured fish. The issue on enhancement or replacement of native stocks is presently under study (monthly monitoring).

Leber, K.M., Sterritt, D.A., Arce, S.M., Nishimoto, R.T. 1994. A comparison of growth, survival and dispersal of wild and hatchery-released striped mullet, *Mugil cephalus*, in the recreational mullet fishery in Hilo, Hawaii. World Aquaculture '94, Book of Abstracts. New Orleans, p. 288.
15,000 juvenile cultured mullet were tagged and released in Hilo Bay one week after netting, tagging and releasing of 5000 wild juveniles at the same site. All tagged fish ranged in size from 45 to 110 mm total length. There were no statistical differences in dispersal patterns or growth between year classes or between cultured and wild mullet. Results so far show that wild stocks are not being displaced by the introduction of cultured mullet into the Wailoa River Estuary. The release of juvenile cultured mullet had a tremendous impact on the recreational fishery as fish matured. Currently, over 700 (10%) of the total striped mullet sampled in the recreational fishery from August 1991 through July 1993 were cultured fish released in 1990 and 1991. The largest cultured fish caught was 48 cm in length.

Lura, H., Sægrov, H. 1991. Documentation of successful spawning of escaped farmed female Atlantic salmon *Salmo salar* L., in Norwegian rivers. Aquaculture 98: 151-159.

Medley, P.B., Avault, J.W.Jr. 1994. Production capabilities and economic potential of an Australian red claw crayfish hatchery in the United States. World Aquaculture '94, Book of Abstracts. New Orleans, p. 201.
The Australian red claw crayfish *(Cherax quadricarinatus)* has been considered as a candidate for commcercial aquaculture in the United States because of its notable culture characteristics. However, in most of the United States, over-wintering is necessary since red claw can not withstand winter temperatures. As a result, hatcheries are required to produce juveniles for pond stocking and other markets such as the aquarium trade. The paper reports on producion experiments, showing a significant linear effect regarding spawning frequency and stocking density. Spawning frequency increased with density up to 32 crayfish/m2. Egg hatching success was hampered by fungus *(Saprolegnia* spp.), flatworms *(Diceratocephala boschmai)*, and handling stress.

Nordeide, J.T., Salvanes, A.G.V. 1991. Observations on reared newly released and wild cod (Gadus morhua L.) and their potential predators. ICES mar. Sci. Symp. 192: 139-146.
Comparisons are made between the stomach contents and liver weights of reared newly released cod and wild cod; the stomach contents and abundance of potential predators are described. Reared cod were stocked within a bay of a fjord and fishing was conducted before and after release to capture wid and reared juvenile cod and their potential predators. During the first three days after release, the reared cod fed mainly on non-evasive prey of Gastropoda, Bivalves, and Actinaria. This is in contrast to wild juvenile cod, which mainly fed on Gobiidae, Brachyura, and Mysidacea. The liver weight of the reared and newly released fish was significantly higher than that of wild fish. Large cod, pollack ´, and ling preyed upon the released cod immediately after their release, whereas during the months following release the stomach contents of large predators were dominated by Labridae and Salmonidae. The abundance of predators did not seem to increase within the area of release.

Steffenak, I., Hormazabal, V., Yndestad, M. 1991. Rapid assay for the simultaneous determination of residues of oxolinic acid and flumequine in fish tissues by high-performance liquid chromatography. J. liq. Chromatogr. 14: 61-70.

Toranzo, A.E., Combarro, P., Lemos, M.L., Barja, J.L. 1984. Plasmid coding for transferable drug resistance in bacteria isolated from cultured rainbow trout. Appl. environ. Microbiol. 48: 872-877.

Ungson, J.R. 1994. Current status of the red sea bream *(Pagrus major)* ranching in Japan. World Aquaculture '94, Book of Abstracts. New Orleans, p. 139.
The objectives of the study were to describe the current status of the red sea bream coastal enhancement program in Japan with particular reference to the Kagoshima case which is considered as a success. The effect of fingerling release on the increase in red sea bream catch is veery evident in the Kagoshima case with a correlation of R2 = 0.702.

Webb, J.H., Hay, D.W., Cunningham, P.D., Youngson, A.F. 1991. The spawning behaviour of escaped farmed and wild adult salmon (Salmo salar L) in a northern Scottish river. Aquaculture 98: 97-100.

Webb, J.H., McLaren, I.S., Donaghy, M.J., Youngson, A.F. 1993. The spawning of farmed Atlantic salmon (Salmo salar L.) in the River Polla, Scotland in the second year after their escape. Aquaculture & Fish. Management 24: 557-561.

Webb, J.H., Youngson, A.F., Thompson, C.E., Hay, D.W., Donaghy, M.J., McLaren, I.S. 1993. Spawning of escaped farmed Atlantic salmon, Salmo salar L., in western and northern Scottish rivers: egg deposition by females. Aquaculture & Fisheries Management. 24: 663-670.
In 1991, the progeny of female Atlantic salmon, *Salmo salar* L., were sampled at emergence from sites in 16 rivers in western and northern Scotland. The progeny of farmed females that had escaped from sea-cages were identified by detecting the presence of maternal canthaxanthin in the juveniles' pigment load. Canthaxanthin was detected among fish sampled from 14 of the 16 rivers examined. Overall, 109 of the 2373 fry sampled carried canthaxyanthin with an average frequency over all the rivers examined of 5.1%. This value will underestimate the real frequency of occurrence of the progeny of escaped farmed salmon: some escapees do not contain canthaxanthin and male fish do not contribute to the pigment load of their progeny.

Youngson, A.F., Webb, J.H., Thompson, C.E., Knox, D. (in press). Spawning of escaped farmed Atlantic salmon (salmo salar L.): hybridisation of females with trout (s. trutta L.). Canadian J. Fisheries and aquatic Sciences.

Planning tools / Coastal Zone Management

Barg, U.C. 1992. Guidelines for the promotion of environmental management of coastal aquaculture development. FAO, Fish. Tech. Paper 328: 1-122.
This document is derected to aquaculture development specialists, coastal resource use planers and government officials involved and interested in the planning and management of coastal aquaculture development within the wider context of resource use in coastal areas. It is intended to serve in the promotion of environmental management of coastal aquaculture based on an overview of selected published experiences and concepts. Potential adverse environmental effects of and on coastal aquaculture practices are addressed with consideration of main socio-economic and bio-physical factors. Methodologies are presented for the assessment and monitoring of environmental hazards and impacts of coastal aquaculture. Selected environmental management options are described for application both at policy-level and farm-level.

Caddy, J.F. 1993. Toward a comparative evaluation of human impacts on fishery ecosystems of enclosed and semi-enclosed seas. Reviews in Fisheries SScience 1(1): 57-95.
Fisheries of enclosed and semi-enclosed seas provide the first basis for evaluating human impacts on marine ecosystems. These have become of serious concern before similar changes are detectable in oceanic systems, thus emphasizing their value as laboratories for comparative study of man-induced changes. The paper disucsses the relevance of the cline, oligo-meso-eu-dys-trophic to stressed marine systems, and focusses on impacts on fisheries of enhanced nutrient runoff, noting common features with marine systems subject ot natural enrichment, but also with well-studied freshwater systems. It is suggested that under nutrient enrichment and heavy fishing, both "top down" and "bottom up" trophic mechanisms act in synchrony to change the trophic chain, leading initially to increased fishery productivity of fermerly oligotrophic systems, followed by more drastic and negative changes as nutrient input passes beyond a state tha may be called mesotrophic. A description of human impacts on several semi-enclosed seas emphasizes the Marine Catchment Basin (MCB) concept, noting that ranking by the relative extents of catchemt area and marine basin explains much of the observed impact. A system approach to management of inland and coastal seass is suggested, with priority on the control of nutrient flows between terrestrialo and aquatic systems, and the establishment of accurate statistical systems integrating fisheries and environmental data over whole basins and coastal seas.

Chan, F., Say, P.Y. 1979. Resource potential and policy in aquaculture and marine fisheries in Singapore. pp. 237-236. In: A.R. Lbrero, W.L. Collier (Eds.). Economics of aquaculture, sea-fioshing and coastal resource use in ASEAN. Philippine Council for Agriculture and Resources Research and Development, Laguna.

Chia Lin Sien, Habibullah Khan, Chou Loke Ming, 1988. The coastal environmental profile of Singapore. ICLARM Tech Rep.21: 1-91.
The coastal environmental profile of Singapore is intended to serve the following purposes: (1) to provide policymakers and researchers with a ready source of information, includding a detailed listing of source materials; (2) to describe the coastal changes that have taken place and to suggest factors that have brought about such changes; (3) to highlight the interrelations among the many aspects of coastal zone, including possible conflicts; (4) to raise issues relating to the management of the coastal zone with the intention that the zone be used more optimally, and (5) to eventually help formulate a coastal area management plan for the country.

Chia, L.S. 1985. Utilization and management of Singapore's coastal zone. pp. 51-54. In: Anon. Proceedings of the MAB/COMAR Regional Seminar on Man's Coastal and Estuarine Ecosystems. 13-16. Nov. 1984, Tokyo.

Chua, T.E. 1989. Will coastal area management programs work in South East Asia? ICLARM Conf. Proc. 19: 231-240.

Chua, T.E. 1991. Managing coastal resources for sustainable development. The ASEAN initiative. ICLARM Confr. Proc. 30: 21-35.

Chua, T.E., Pauly, D. (Eds.) 1989. Coastal area management n South East Asia: policies, management strategies and case studies. ICLARM Conf. Proc. 19: 1-254 pp.

Chua, T.E., Scura, L.F. 1991. Managing ASEAN's coastal resources for sustainable development: roles of policymakers, scientists, donors, media and communities. ICLARM Conf. Proc. 30: 1-125 pp.

Chua, T.E:, Sadorra, M.S.m. (eds.) 1987. The coastal environmental profile of Brunei Darussalam: Resource assessment and management issues. Fish. Dep., Ministry of Development, Brunei Darussalam; ASEAN/US Coastal Resoruces Management Project. ICLARM Tech. Rep. 18: 1-193.

Clark, J.R. 1992. Integrated management of coastal zones. FAO Fish. Tech. Paper 327: 167 pp.
The report identifies governmental actions that can lead to effective management of coastal resources and strengthening the national capacity for effective coastal resources management through Integrated Coastal Zone Management (ICZM). This is a system for controlling development and other huma activities that affect the condition of economic resources and the quality of the environment in coastal zones. The overall objective of ICZM is to provide for sustainable use of coastal natural resources and for maintenance of biodiversity. Environment6ally planned development is reputed to add to economic and social prosperity of a coastal community in the long term. The orientation of the report is toward developing countries, particularyl those of the coastal tropics. Fisheries productivity, increased tourism revenues, sustained mangrove forestry, and security from natural hazard devastation are among the practical benefits of ICZM. ICZM incorporates modern principles of planning and resources management, intensive information bases an interdisciplinary processes. A major objective is to facilitate the interactions of different coastal economic sectors (e.g. shipping, agriculture, fisheries) towards optimal socio-economic outcomes, including resolution of conflicts between sectors. ICZM may be initiated in response to a planning in a resource, or a devastating experinece with natural hazards.

El-Gaayar, O.F., Leung, P.-S., Rowland, L.W. 1994. An aquacultural development decision support system (ADDSS): a preliminary design. World Aquaculture '94, Book of Abstracts. New Orleans, p. 104.

Galloway, R.W., Story, R., Cooper, R., G.A. Yapp. 1984. Coastal lands of Australia. Natural Resources Series No 1.53 pp.
This publication describes an information system for Australian coastal lands. Coastal lands were defined as a 3 km wide strip extending landwards from mid tide mark; they were split into 10 km long sections for location of data. The area thus defined is 125 000 km2, Geology, landform, vegetation and land use according to simple but uniform categories were identified on air photographs at a grid of sampling points spaced one per 3 km2. These data plus the distance of each sampling point from the coast were entered in computer files. Population and coastal character for each 10 km section were also listed. Programms have been written to provide any of these data for nominated portions of the coast as printed lists or as computer-generated cartograms. Sixteen vertical air p

Gubbay, S. 1990. A future for the coast? Proposals for a UK coastal zone management plan. A report for the World Wide Fund for Nature from the Marine Conservation Society, United Kingdom 31 pp.

Hanley, J.R., Couriel, D. 1992. Coastal management issues in the Northern territory: an assessment of current and future problems. Mar. Pollut. Bull. 25: 134-142.
The major current and future coastal management issues relevant to the Northern Territory, Australia, are discussed. In general, the coastline is still pristine. Impacts such as reclamation of intertidal land, sewage effluent and urban runoff, and heavy metal pollution are identified as significant issues for the larger coastal population centers of Darwin and Nhulunbuy. In coastal waters, the potential impacts of various existing or proposed fisheries are examined. Future development including industries such as oil and gas extraction and refining, mineral sands, aquaculture, and associated population growth are recognized as producers of potentially important impacts on the existing coastal environment. In the short term, most development appears likely to take place on non-aboriginal land.

Hildebrand, L.P. 1989. Canada's experience with coastal zone management. Halifax, The Oceans Institue of Canada, 118 pp.

Howarth, W. 1990. The law of aquaculture: the law relating to the farming of fish and shellfish in Britain. Oxford, Fishing News, Books Ltd. 271 pp.

Jernelov, A., Marinov, U. 1990. An approach to environmental impact assessment for projectss affecting the coastal and marine environment. UNEP, Nairobi. UNEP Reg. Seas. Rep. Stud. 122: 1-35.

Kam, S.P. 1989. Application of remote sensing and geographical information systems in coastal area management. ICLARM Conf. Proc. 19: 163-171.

Kapetsky, J.M., McGregor, L., Nanne, L. 1987. A geographical information system and satellite remote sensing to plan for aquaculture development: a FAO-UNEP/GRID cooperative study in Costa Rica. FAO Fish. Tech. Pap. 287: 1-51.

Merschrod, K. 1989. In search of a strategy for coastal zone management in the Third World: Notes from Ecuador. Coast. Manage. 17: 63-74.

Paw, J.N., Bunpapong, S., White, A.T., Sadorra, M.S.M. 1988. The coastal environmental profile of Ban Don Bay and Phangnga Bay, Thailand. ICLARM Tech. Rep. 20: 1-78.
The coastal zone of Thailand with a 2,600 km coastline is very rich in natural resources which include fisheries, coral reefs, mangrove forests, beaches and mineral deposits. Over the past decade, rapid increases in population and human activities along the coastal areas have resulted in degradation of these valuable natural resources. Thailand is a participant to the Association of Southeast Asian Nations (ASEAN)- United States (US) Coastal Resources Management Project (CRMP). The project is carried out in the area identified in the title of this report. A project team was formed, consisting of local experts who conducted a preliminary field investigation in the pilot sites in 1986. This publication is the first step towards rational management of the Upper South coastal zone. Recommendations for developing plans to sustain coastal resources use are presented.

Phillips, D.J.H. 1992. The marine environment and its management in Australia: An introduction. Mar. Pollut. Bull. 25: 121.

TISTR (Thailand Institute of Scientific and Cultural Organization). 1984. Land use master plan of coastal area in Changwat Phuket. Thailand Institute of Sci. & Cult. Organization, Thailand. (mimeo).

UNDP, 1991.- Handbook and guidelines for environmental management and sustainable development. New York, United Nations Development Programme, 55 pp., plus annexes.

Integrated systems/ aquaculture as a mitigation strategy of environmental effects

Edwards, P., Pullin, R.S.V. 1990. Wastewater-fed aquaculture. Proc. Intern. Seminar on Wastewater Reclamation and Reuse for aquaculture, Calcutta, India, 6-9 Dec, 1988. XXIX, 296 pp. Environmental Sanitation Information Center, Asian Institute of Technology, Bangkok, Thailand, and ICLARM

Ghate, S.R., Burtle, G.J., Gascho, G.J. 1994. A technique of integrating channel catifhs and soybean production systems. World Aquaculture '94, Book of Abstracts. New Orleans, p. 164.

A trial in Georgia, USA, where withdrawal of large volumes of groundwater for fish production occurs while discharge of nutrient rich pond effluents raise concern about water quality in receiving waters. Objectives: (1) find effects of intermittent draining of intensely stocked and fed channel catfish ponds on water quality; (2) develop a method of integrating crop and fish production by using a portion of discharged pond effluent as irrigation water; (3) collect water quality data to explore the possibility of recycling the drained effluent for fish production, thereby minimizing the effluent discharge to natural streams.

Miltner, M.R., Jones, D.B., Wilson, A. 1994. Rotation of rice *(Oryza sativa)* and a native Florida crawfish, Procambarus alleni, as a sustainable aquaculture alternative in the everglades agricultural area. World Aquaculture '94, Book of Abstracts. New Orleans, p169.

Parker, N.C. 1994. The greening of aquaculture - or - integration of aquaculture with other agro-industrial municipal processes. World Aquaculture '94, Book of Abstracts. New Orleans, p29.
Independent on-site containment or treatment of water is often an added business cost with little to no monetary reurn. On-site recycling or recovery of waste components presents new sources of revenue and lowers the cost of environmental compliance. As the value of fish and fishery products escalates at rates greater than the supply, it is time for aquaculturists to consider new opportunities. Highly integrated systems can be developed to recycle water, recover nutrients, and use low grade thermal energy from other industries such as cattle feedlots, ethanol plants, feedmills, pharmaceutical plants, and power plants.

Rakocy, J.E., Bailey, D.S., Cole, W.M., Shultz, K.A. 1994. Evaluation of two commercial-scale integrated systems for the production of tilapia and hydroponic lattuce. World Aquaculture '94, Book of Abstracts. New Orleans, p165.
Hydroponic vegatables are integrated into recirculating fish culture systems to recover nutrients, improve water quality, extend water use, reduce operating costs, produce valuable by-products.

Rosenthal, H., Hiegel, Ch., Ruinies, A. 1994. Integrated aquaculture systems: a selected bibliography. ATSAF, Bonn, FRG, 42 pp.
The document includes about 550 references dealing with fish-rice culture, fish-livestock and other integrated culture systems.

Monitoring

IOC (Intergovernmental Oceanographic Commission). 1993. Assessment and monitoring of large marine ecosystems. IOC/INF 42: 1-51. (UNESCO).

Molnar, J.J., Duncan, N.L. 1989. Monitoring and evaluating aquacultural projects. In: Montoring and evaluating the impacts of small-scale fishery projects. Pollnac, R.B. (Ed.). International Center for Marine Resource Development at the University of Rhode Island, Kingston, R.I., pp. 28-40.

Modelling

Some references have been included that originate from related disciplines as such material may have relevance to environmental issues of mariculture.

Baretta, J.W., Ruardij, P. 1987. Evaluation of the Ems ecosystem model. Continental Shelf Res. 7(11/12): 1471-1476.

Cranston, R. 1994. Dissolved ammonium and sulfate gradients in surficial sediment pore water as a measure of organic carbon burial rate. pp. 93-120. In: Hargrave, B.T. (Ed.). 1994. Modelling benthic impacts of organic enrichment from marine aquaculture. Can. Tech. Rep. Fish. aquat. Sci. 1949: 1-125.

Ervik, A., Hansen, P.K. Stigebrandt, A., Aure, J., Jahnsen, T., Johannessen, P. 1993. MOM: Modellering - Overvåkning - Matfishanlegg. Et system for regulering av miljøvirkninger fra oppdrettsanlegg. Havforskningsinstituttet, Rapport Fra Senter for havbruk 23: 1-20 [In Norwegian].

Findlay, R.H., Watling, L. 1994. Toward a process level model to predict the effects of salmon net-pen aquaculture on the benthos. pp. 47-In: Hargrave, B.T. (Ed.). 1994. Modelling benthic impacts of organic enrichment from marine aquaculture. Can. Tech. Rep. Fish. aquat. Sci. 1949: 1-125.

Giske, J., Aksnes, D.L., Lie, U., Wakili, S.M. 1991. Computer simulation of pelagic production in Masfjorden, western Norway, and its consequences for production of released 0-group cod. ICES Mar. Sci. Symp. 192: 161-175.
*(Abstract see under "**Enhancement/Ranching / native-cultured stock interaction/exotics**")*

Gowen, R.J., Smyth, D., Silvert, W. 1994. Modelling the spatial distribution and loading of organic fish farm waste to the seabed. pp. 19-30. In: Hargrave, B.T. (Ed.). 1994. Modelling benthic impacts of organic enrichment from marine aquaculture. Can. Tech. Rep. Fish. aquat. Sci. 1949: 1-125.

Hargrave, B.T. (Ed.). 1994. Modelling benthic impacts of organic enrichment from marine aquaculture. Can. Tech. Rep. Fish. aquat. Sci. 1949: 1-125.

Hargrave, B.T. 1994. A benthic enrichment index. pp. 79-91. In: Hargrave, B.T. (Ed.). 1994. Modelling benthic impacts of organic enrichment from marine aquaculture. Can. Tech. Rep. Fish. aquat. Sci. 1949: 1-125.

Jones, K.J., Tett, P., Wallis A.C., Wood., B.J. 1978. Investigation of a nutrient-growth model using a continuous culture of natural phytoplankton. J. Mar. Biol. Assoc. U.K. 58: 923-941.

Landless, P.J., Edwards, A. 1976. Economical ways of assessing hydrography for fish farms. Aquaculture 8: 29-43.

Muschenheim, D., Newell, C.R. 1992. Utilization of seston flux over a mussel bed. Mar. Ecol. Progr. Series 85: 131-136.

Newell, C.R., S.E. Shumway, 1993. Grazing of natural particulates by bivalve mollusce: aspatial and temporal perspective. In: R. Dame (Ed.)., Bivalve Filter Feeders in Estuarine and Coastal Exosystem Processes. NATO ASI Series Vol G33: 85-148.

Panchang, V.G., Cheng, G., Newell, C.R. 1993. Application of mathematical models in the environmental regulation of net-pen aquaculture. Main Sea Grant Tech. Rep. 93-4: 1-105 pp.

Radford, P.J. 1978. Some aspects of an estuarine ecosystem model (GEMBASE). In: Jorgensen, (Ed.). Proceedings of the 1st International Conference on the state of the art of ecological modelling, Copenhagen.

Ross, A.H., Gurney, W.S.C. 1991 (draft manuscript). A strategic simulation model of a fjord ecosystem.
The manuscript at hand is a revised version which had been submitted to Limnology & Oceanography. It needs to be checked whether it had been published.

Silvert, W. 1994. Modelling benthic deposition and impacts of organic matter loading. pp. 1-18. In: Hargrave, B.T. (Ed.). 1994. Modelling benthic impacts of organic enrichment from marine aquaculture. Can. Tech. Rep. Fish. aquat. Sci. 1949: 1-125.

Sowles, J.W., Churchill, L., Silvert, W. 1994. The effect of benthic carbon loading on the degradation of botttom conditions under farm sites. pp. 31-46. In: Hargrave, B.T. (Ed.). 1994. Modelling benthic impacts of organic enrichment from marine aquaculture. Can. Tech. Rep. Fish. aquat. Sci. 1949: 1-125.

Tett, P., Edwards, A., Jones, K. 1986. A model for the growth of shelf-sea phytoplankton in summer. Estuarine Coastal Shelf Sci. 23: 641-672.

Turrell, W.R. 1990. Simulation of advection and diffusion of released treatments in Scottish Sea Lochs. Scottish Fisheries Working Paper No 16/90: 1-18.
Copies available from : Dap Agriculture and Fisheries for Scotland, Marine Laboratory, Victoria Road, Aberdeen.

Turrell, W.R., Munro, A.L.S. 1988. A theoretical study of the dispersal of soluble and infectious wastes from farmed Atlantic salmon net cages in a hypothetical Scottish Sea Loch. ICES, CM 1988/F:36 (Mariculture Committee, Reference E).