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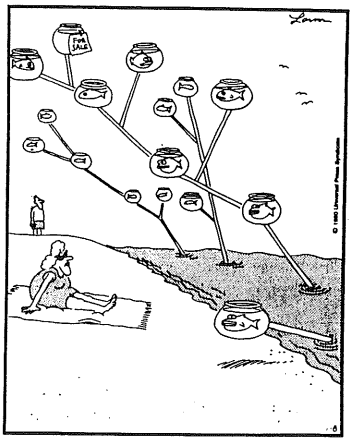
International Council for the Exploration of the Sea

C.M. 1990/F: 12
Mariculture Committee
Ref.: Marine Enviromental Quality Committee
SESSION T

Report of the Working Group on Environmental Impacts of Mariculture

Marine Laboratory,
Department of Agriculture and Fisheries for Scotland
Aberdeen, Scotland, March 27 to 31, 1990



Encroachment of the fish developers

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Introduction

The 1990 meeting of the ICES Working Group on "Environmental Impacts of Mariculture was held in Aberdeen, Scotland, April 27 to 31, at and with the assistance of the Marine Laboratory of Department of Agriculture and Fisheries for Scotland.

Participation

There were 17 participants representing 11 member countries present:

Rosenthal, Harald (Chairman)	Federal Republic of Germany
Gowen, Richard (Rapporteur)	Scotland
Davies, Ian (Rapporteur)	Scotland
Alderman, David(WGPDDMO)	United Kingdom
Aure, Jan	Norway
Black, Edward A.	Canada
Dijkema, Renger	The Netherlands
Doyle, Jaqueline	Ireland
Engelstad, Marit	Norway
Ervik, Arne	Norway
Héral, Maurice	France
McHenery, John G.	Scotland
Munro, Alan L.S.	Scotland
Meceron, Michel, M.	France
Rosell, R. S.	Northern Ireland
Ruano, Francisco	Portugal
Stewart, James E.	Canada

Written country reports were provided by Jesper Hørsted (Denmark), Timo Mäkinen (Finland), Hans Ackefors (Sweden) and Don Weston (USA) who could not attend the meeting. They also prepared material for the technical reports under preparation.

Dr. Topping (Aberdeen) participated during the general discussion on monitoring, providing advice on this subject based on experience gained in related ICES Working Groups.

A list of the Working Group membership is attached to this document as Appendix 2.

Rapporteurs:

Richard Gowen (Scotland) and Ian Davies (Scotland) were appointed as rapporteurs for the Working Group Report.

During the meeting two sub-groups were formed for extended drafting sessions to prepare the draft technical reports on "Chemicals used in Mariculture (chaired by H. Rosenthal) and "Management of the Environmental Impact of Mariculture" (chaired by R. Gowen).

Adoption of the Agenda and assignment to drafting groups:

The tentative Agenda (Appendix 2) was adopted and participants were assigned to the following drafting groups:
"Chemicals used in Mariculture": Alderman, Engelstad, Ervik, McHennery, Mezereau, Rosenthal.
"Management of the Environmental Impact of Mariculture": Aure, Black, Davies, Dijkema, Doyle, Gowen, Héral, Munro, Spencer,

Terms of Reference for the 1990 WG Meeting and Status of the Working Group recommendations

The Chairman reviewed the history of the Working Group and explained the status of recommendations formulated by the Group during its 1989 meeting.

The Parent Committee supported the recommendations of the Working Group on research priorities and considered the terms of references prepared by the Group for its 1990 meeting. It was agreed that the Group should continue to work on a draft technical report on "Management of the Environmental Impact of Mariculture", and complete the draft document on "Chemicals used in Mariculture" including the "Information sheets" on chemicals. Both documents should be prepared in time for consideration by the Mariculture Committee at the 1990 Statutory Meeting, aiming at their early publication. Doubts were expressed whether the terms of reference could be fullfilled during the WG meeting. It was decided to try to finalize the Technical Report on Chemicals first.

Planning of future meetings (ICES policy on future WG meetings)

The Chairman reported on the discussions at the 1989 Statutory meeting regarding the policy on future Working Group meetings. It was noted that the attendance at each Working Group varies greatly and does not always reflect the interest in and the importance of the issues dealt with by the various groups. Travel funds often restrict participation. More difficulties are foreseen in setting priorities as the number of Working Groups increases. Various ideas put foreward by the Chairman of the Consultative Committee were discussed. One of them was to extent the intersessional interval to 2 or 3 years so as to reduce the number of ICES Working Group meetings per year.

It was noted that the Working Group has reached a stage where the available information has been reviewed resulting in the preparation of draft technical reports. As such, members of the Working Group agreed with the recommendation made by the Parent Committee during the 1989 Statutory Meeting of ICES to work by correspondance in 1991 and meet again in 1992. However, it was emphasized that Working Groups from which long-term advice is required may have to meet annually and this issue should be addressed by the Parent Committee at the next Statutory Meeting (October 1990).

It is obvious, for example, that siting and monitoring criteria - issues addressed by the Working Group - will change if other species and other criteria for competitive and multiple use of the resources become apparent. There will be a future need for the Working Group to meet annually in order to keep pace with the development of the industry and identify in time the research priorities needed to safeguard the industry and protect the environment.

WG concern on public use of terminology on "environmental impact" of mariculture

The Group noted that:

during the past few years the current public usage of the term "environmental impact" in relation to aquaculture often implies a negative effect. The implication of a negative effect, however, is only one aspect of the impact a human activity can have on the environment.

The Group, therefore, felt that:

(a) the use of such implied value judgement would be inappropriate in the context of the objectives of the Working Group. In this respect the use of the terms "environmental impact" and "environmental change" do not infer any judgement on the acceptability of an effect.

(b) Since the term "environment" includes both biological and social concerns, it is understood that the Working Group on Environmental Impacts of Mariculture will primarily focus on changes associated with biological processes, with main emphasis on ecological aspects.

Discussion of National Reports

It was decided to attach National Reports as Appendices to the Working Group Report. Working Group members tabled these documents without detailed discussion in order to allow maximum time for drafting sections for the Technical Reports.

Production trends

Mariculture continues to develop rapidly throughout ICES member states. In several countries the growth rate of the industry in 1989 exceeded by far the 1988 figures. Detailed data are included in the National reports (see Appendix 3). Norway, for example, has experienced an increase of salmon production from about 87,000 tonnes in 1988 to around 150,000 tonnes in 1989. Scotland, Canada and Ireland have also seen relatively high growth rates during the same period.

Research Activities

There is still growing concern with respect to environmental issues. There has been a change from some of the early issues such as impact on the benthos which are now well studied and documented to new concerns regarding chemicals and genetic interaction. Legislation regarding siting and monitoring of mariculture is only now becoming established in a number of countries and criteria for proper management need still to be defined and refined. It is likely that national requirements will change over the next few years as the industry expands. In addition a number of research projects have just been initiated and

there is a need to evaluate these in the light of ICES requirements. This increasing activity may require an annual meeting of the Working Group to keep pace with the development. So far, the Work was prepared well ahead for the advice needed within the ICES community and it might be advisable to maintain this status.

In order to facilitate the progress of research work related to environmental issues, an update of last years listing of projects has been prepared and is presented in Appendix 1.

Chemical usage in Mariculture

Although this subject will be extensively discussed in the Technical Report presently under preparation, it was felt appropriate to report on recent developments in controlling the usage of chemicals in aquaculture in Norway. The Working Group, therefore, discussed the presentation by Dr. Marit Engelstad, reporting on the centralized control system for drug use in fish farms. The Norwegian control system and the principles of handling drugs can be described as follows:

All medicated feed products and the formulated fish medicines are considered as pharmaceutical specialities and must have a marketing license issued by the Norwegian Medical Control Authority to permit prescription. Drugs are distributed by or under supervision of one wholesaler - The Norwegian Medical Department, which has the monopoly on raw materials for feed mills and for formulated drugs. This centralized control system makes it easy to obtain total sales statistics in Norway.

The procedures require that all prescriptions are filled in separately by both, the veterinarian and the pharmacy or feed mill. Each prescription form has to be provided in three copies, one goes to the farmer, one will be retained by the Department of Fisheries (Quality Control Laboratory) and one for the Veterinarian, feedmill or pharmacy. The scheme of reporting is outlined in Figure 1.

The prescriptions are standardized and contain the following information:
- Veterinarian, name and ID-number,
- Fish farmer, name and license number,
- Fish species and size,
- Amount/number of fish treated,
- chemical used, strength and formulation,
- diagnosis (reason for application),
- dosage recommendation,
- treatment procedure (start and end),
- Info whether fish were vaccinated against the disease (yes/no),
- recommended withdrawal time (in days after the last day of treatment),
- pharmacy/feed mill (name and address).

All data contained in the prescriptions is immediately fed into a central computer system. The data are used for statistical and research purposes (epidemiological research, quality control and follow-up studies and control measures on residues).

Antibiotics and other chemotherapeutics are by far the most frequently used drugs in fish farming. The amount of pesticides used against salmon lice is also an important figure. The overall amounts used since 1980 are schown in Table 1, while Table 2 indicates the amounts of anaesthetics and disinfectants (including pesticides against sea lice) used since 1984.

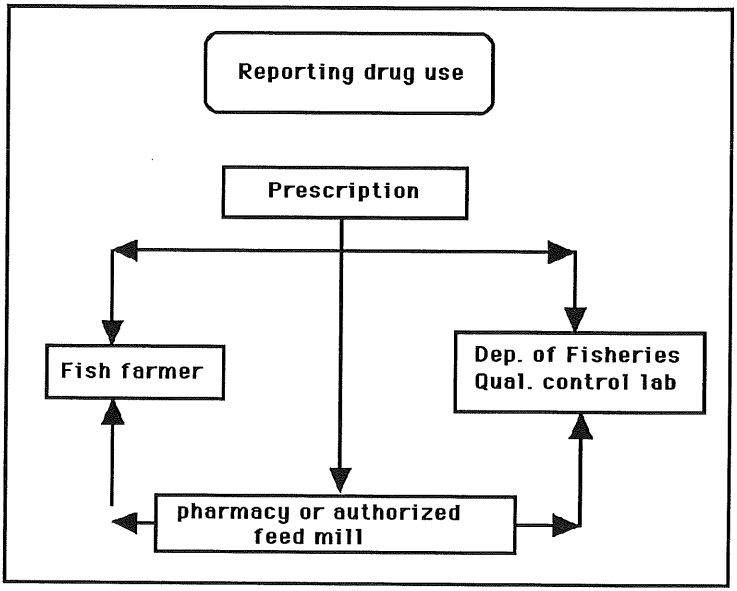

Figure 1: Control of drug distribution and application in Norwegian fish farming. Information routes on prescriptions between farmers, veterinarians, feed mills/ pharmacies and the centralized Quality Control Laboratory

Table 1: Overall use of antimicrobial chemicals in Norwegian fish farming. Amounts are given in kg active substance. (Data from Norsk Medisinaldepot, provided by Arne Ervik)

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
a	2960	3000	4390	6060	8260	12020	15410	27130	18220	5014
b	-	-	1600	3060	5500	4000	1610	15840	4190	1345
c	-	-	-	-	-	-	-	3700	9390	12630
d	300	540	590	910	4000	2600	1000	1900	670	32
e	400	100	70	100	10	80	10	-	-	-
f	-	-	-	-	-	-	-	-	-	329
Total	36660	3640	6650	10130	17770	18700	18030	48570	32470	19350

a = oxytetracycline chloride; b = Nifurazolidon; c = oxilinic acid; d = Trimetoprim + sulfadiazin (Tribrissen); e = Sulfamerazin; f = Flumequin.

Table 2: Statistics on the use of Anesthetics and disinfectants in Norwegian aquaculture (values in kg) (after NMD, provided by M. Engelstad)

Substance \ Year	1984	1985	1986	1987	1988	1989
Anesthetics						
Chlorbutanol	94	235	350	384	725	608
Metacain	3,8	2,8	3,7	6,6	1,8	5,3
Disinfectants, Endo-Extoparasite treatment						
Metrifonat (Neguvon(1))	17460	30458	26869	9328	4760	4596
Dichlorvos (Nuvan(2))	-	-	195	1311	3210	3488
Praziquantal(3)	-	-	9	21	51,(4)	72,(4)
Fenbendazol (5)	-	-	-	20	50	104
Malachitegreen (6) (oxalate)	7,7	16	140	279	151	26

Table includes all drugs sold through pharmacies and feed mills; (1) = Neguvon is also used to treat pigs and fowl. In contrast to fish farming it is not know how much of these substances is used in animal husbandry; (2) = Nuvan was introduced on the Norwegian market in 1980; (3) = small amounts of praziquantal delivered especially in 1984 and 1985, then used later; (4) = includes prziquantal-medicated feeds from feed producers; (5) = Fenbendazole is also used to treat pets and pigs; (6) = Malachite green is also delivered by other sources to fish farms and not only by NMD.

Figures 2 to 4 show in graphical form the development of drug use in Norwegian fish farming very clearly.

From the Figures provided it is obvious that despite the increase in production, the use of chemicals per unit weight of fish produced has declined to such an extent that the overall amount of chemicals employed in fish farming has almost been cut in half since 1987.

Statistically, all fish were treated 1,2 times in 1987. In 1989, however, only 30% of the fish were treated and this reduction in use of antimicrobial chemicals can most likely to be attributed to the new regulations and control measures outlined above.

It is also obvious that the amounts of chemicals used against salmon lice has drastically been reduced. The main reason for this is the shift from Neguvon to Nuvan. Much less treatment volume has to be prepared with the latter because of its high effectiveness.

Data on chemicals used in mariculture have also been provided by several Working Group members and these figures have been incorporated into the country reports.

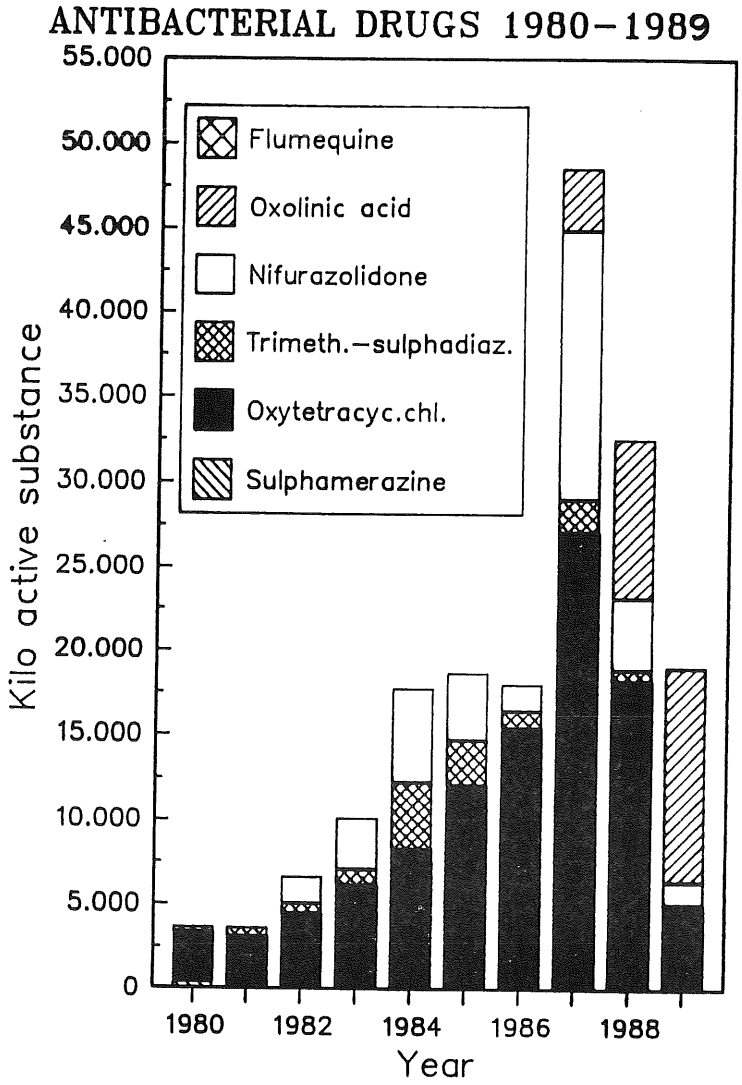

Figure 2: The development of antibacterial drug use in Norway between 1980 and 1989. (From Ensgelstad, 1990)

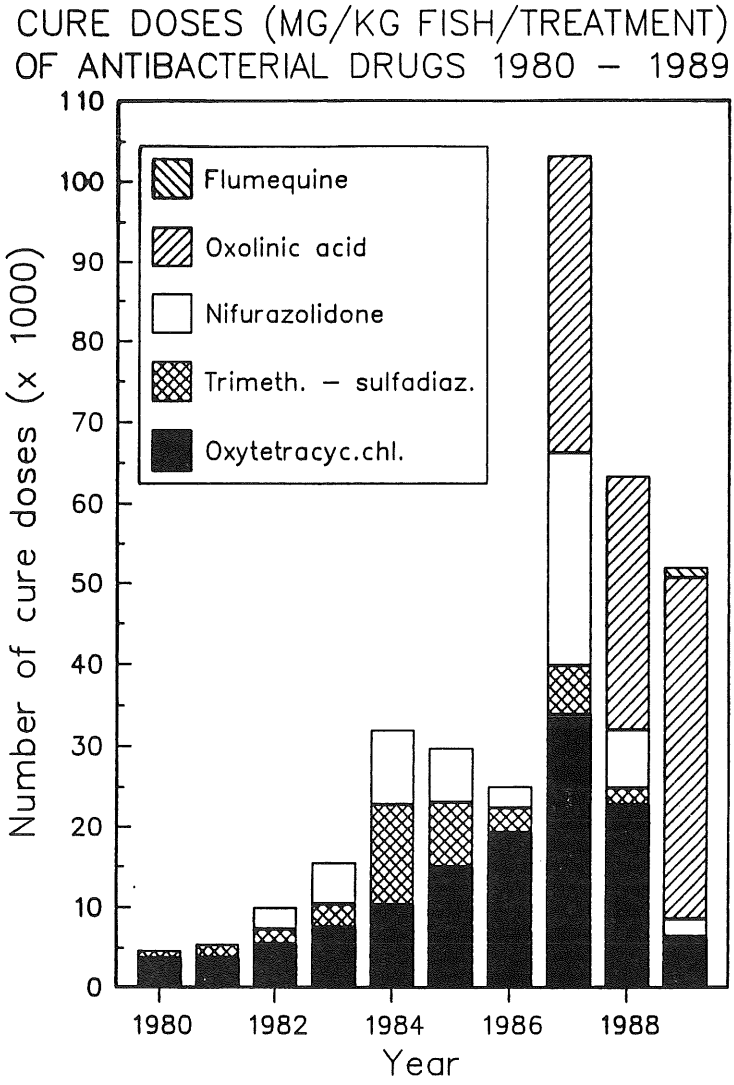

Figure 3: The use of drugs in Norway. The frequency of treatments between 1980 and 1989 in relation to drugs and dosage used (after Engelstad, 1990).

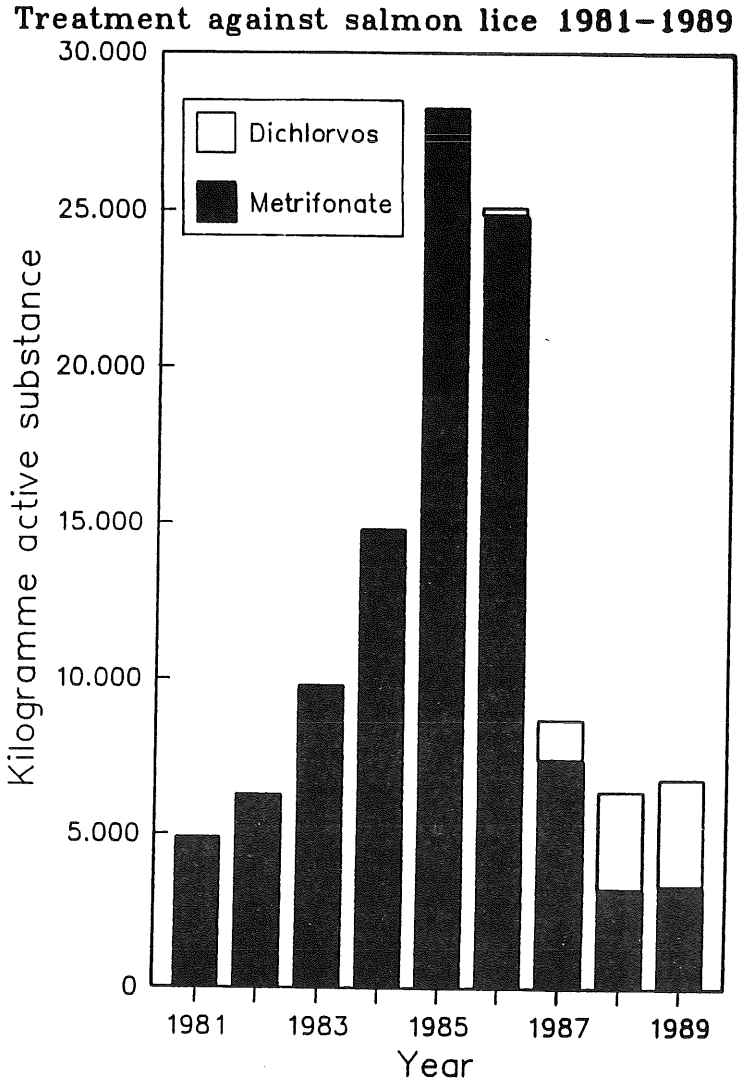

Figure 4: Treatment against sea lice in Norway between 1980 and 1989. Amount of active substance used for both, Dichlorvos and Metrifonate (after Engelstad, 1990)

Preparation of the technical report on chemicals used in mariculture

The Working Group continued to prepare the Technical Report entitled "Chemicals used in Mariculture".

The chairman reminded the Working Group of the draft structure of the technical report on chemicals, as agreed at the last meeting (WG Rep.89, pp. 21,22). In summary, the final document should include sections covering:

1 the use of chemicals in mariculture and reasons for any environmental concern.

2 A description of administrative and record-keeping procedures and a list of chemicals used in ICES member states.

3 Estimates of the total quantity of each chemical used in each country, and also expressed as weight per tonne of fish production.

4 A data sheet on each chemical.

The information included in the data sheet will identify

- the scientific name and trade name of the chemical,
- the chemical formula,
- CAS (Chemical Abstract) numbers,
- synonyms,
- mode of treatment/use
- withdrawal period
- information on environmental issues (when available) including toxicity, environmental persistence and degradation products, bioaccumulation, and stimulation of antibiotic resistance.
- literature citations pertaining to environmental and toxicity issues.

The number of chemicals which are widely used in large quantities in fish farming in ICES countries is limited. Acute toxicity data to marine species are available for some of these chemicals and these have in some cases been used to predict environmental impact. Detailed studies on the impact of chemicals used in mariculture on the marine environment or experimental studies to mimic expected environmental levels and exposures are limited to one compound, dichlorvos. The data collected for this compound have been used by the regulatory authorities in the UK in connection with the licencing procedures. Such data should be gathered for all chemicals released from farms into the marine environment and examined in relation to modelled predictions.

Several members of the Working Group expressed reservations about the inclusion of section 3. They felt that in many countries there was no statutory requirement to maintain records of chemical (including therapeutant) usage, and that any estimates of usage would be subject to considerable uncertainty. The amount of any particular drug used varied greatly from year to year depending upon the amount of fish produced, the incidence of disease and the particular drug selected at any time to treat any particular disease. It was not possible to reliably group chemicals (e.g. antibiotics) into a single category, as the

amount required to achieve an effective dose varied greatly between chemicals and was also dependent upon the physical form in which they were presented to the fish.

A further significant difficulty was the use of "unlicensed" medicines in mariculture in many countries, veterinary surgeons had considerable discretion in prescribing drugs for use on fish that were not specifically licensed for that purpose. In some countries, this was inevitable as no drugs were licensed for mariculture. This could arise either from the recent development of a mariculture industry or from the reluctance of pharmaceutical companies to make the significant investment necessary to obtain licences which could only be applicable to a relatively small market. The same difficulties existed in branches of animal husbandry, where drug use was under control of veterinaries.

In the UK, however, three antibiotics were licenced for use in mariculture. It was anticipated, however, that regulations would soon permit veterinarians to prescribe only licenced antibiotics, thus removing the freedom of prescription that the veterinarians currently enjoyed. It was suggested that the progression from freedom to prescribe any substance, through licencing, to limitation of the available drugs, was to be expected, and that EC legislation might be proposed to control use of drugs on an international basis.

It was recognized that the incomplete nature of the draft Table 3 (quantities of chemicals used, WG Report 1989, F:11, p.30-31) left the matter open to misinterpretation. While some countries appeared to use few chemicals, those who had estimated total usage might find themselves unjustifiably singled out for adverse comment.

It was therefore agreed that an updated Table should be included in the Technical Report on "Chemicals used in Mariculture", but would not include quantitative estimates of chemical usage. It would contain only estimates of the frequency of use (high, medium, low) in each country. It would be necessary to restructure the Table to group together chemicals of similar function (e.g. antibiotics, antimicrobials, anesthaetics, etc.). In addition new paragraphs of text would be prepared to indicate the principal chemicals in use and the range of amounts of some chemicals used, expressed as weight per tonne of fish produced. Additional material on trends of usage, licencing status etc. should also be included.

It was also agreed to expand the layout of the information sheet for chemicals used in mariculture to include CAS and CTRS numbers along with some key references. An example of the principle layout of the information sheet for each group of chemicals is provided in Appendix 5.

Management of the environmental impact of mariculture

The sub-group continued to prepare sections of the Technical Report on the subject. However, it was felt that the material drafted so far is in need of substantial editing. The group, therefore, discussed extensively details for verious sections of the Technical Report and appointed an editorial committee (Gowen, Black, Doyle, Héral, Rosenthal) to finalize the document by correspondance for presentation at the 1990 Statutory Meeting.

The report will include chapters on "the range of impacts associated with mariculture" (quantities of waste and biodeposits produced by mariculture; effects of waste material on ecological processes occurring in the water column), "the interactions between mariculture and wildlife", "the impact of organic waste on the benthic ecosystem"

Detailed text will be provided along with the decision model already outlined in the 1989 Working Group Report, including chapters on

- Project description
- Area and site description
- Identification of potential impacts
- Conditions and constraints on the proposal
- Monitoring
- Evaluation (including modelling)
- legislation in member states.

Models for predicting carrying and holding capacity

Aside from preparing the sections for the Technical Report on "Management of the environmental impact of mariculture" a brief discussion of this specific topic led to several conclusions and pieces of information which the Working Group advocates modellers take into account. Variations in excretion rates of cultured species will always be great; these to some extent, are exagerrated by the use of values based upon individual specimens. For modelling work values for populations are at best and values arrived at by actual measurement for particular situations will be best of all.

Although much useful data can be obtained from the literature it will probably never be possible to adapt it to provide estimates of carrying and holding capacity narrow enough for general application. It will be necessary to make measurements at the location of interest and will probably be also necessary to develop a family of models to cover an entire coastal area.

Data of major importance for modelling salmon cage farming will soon be forthcoming from Norway where detailed measurements of the nutrient flux through sediments for 8 farms over an entire year have been made. Scientists are now preparing these observed values for publication.

Recommendations

The Working Group recommends it meets in mid April 1992 in Berlin, Germany, to undertake the following tasks:

(1) to update the cataloque on ongoing research programmes on environmental issues related to mariculture, and identify research priorities.

(2) to consider the advances made in commercial culture of macro-algae in ICES member countries and asses the need for consideration of environmental issues in this sector of mariculture.

(3) to evaluate and prepare updates of the Technical Reports on Chemicals used in Mariculture" and "Management of the Environmental Impact of Mariculture"

(4) prepare a a status report on ongoing monitoring programmes in each country related to the assessment of the impact of mariculture.

The Working Group further recommends that

the prepared draft Technical Reports on "Chemicals used in Mariculture" and "Management of the Environmental Impact of Mariculture" be considered by the Mariculture Committee for Publication as Cooperative Research Reports.

The Working Group draws attention to the system of reporting use of veterinary drugs in fish farming in Norway. Whilst in many countries new legislation might be necessary to achieve such accuracy in recording use, member states should be urged to examine the Norwegian system and consider how they might collect similar records.

Action list

(1) Since it was agreed (in accordance with the recommendation of the Mariculture Committee) that the Working Group will not meet in 1991, it is recommended that members of the Working Group should identify to the Chairman any new issues arising from the environmental impact of the expanding mariculture industry which should be addressed by the Working Group. These issues/problems to be considered by an ad-hoc meeting of members of the Working Group in attendance at the 1991 Statutory Meeting for incorporation into the terms of reference for the 1992 meeting of the Working Group.

(2) Members of the Working Group should, during the intersessional period, report new and ongoing research programmes, provide information on progress and contribute country reports containing information relevant to the tasks of the Working Group. These should be sent to the Chairman for incorporation into a 1991 Working Group report to be presented to the parent committee at the 1991 Statutory Meeting of ICES. The Chairman will in due time circulate a form providing the principle layout on how data should be collected and repoerws.

(3)E. A. Black (Canada) to act as an intersessional secretary to collect and maintain a list of current references on the environmental impacts of mariculture. Member countries are requested to submit through there national WG members, recent publications. These will be incorporated into the 1991 Working Group Report to be tabled at the Statutory meeting.

(4) R. Gowen, H. Rosenthal, and R. Rosell to prepare and distribute a questionaire on monitoring programmes for mariculture in member countries and collate the information provided for the next Working Group meeting.

(5) Members of the Working Group should identify to the Chairman any new issues arising from environmental impact of the expanding mariculture industry which should be addressed by the Working Group. These issues/problems to be considered by an ad-hoc meeting of members of the Working Group in attendance at the 1991 Statutory Meeting for incorporation into the terms of reference for the 1992 meeting of the Working Gropu.

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Appendix 1

Studies related to environmental aspects of mariculture (Recently completed and on-going)

No	Project Description	Completion Date	Country and References, if any
	Projects not reported previously are indicated by an asterisk (*)		
(1)	Investigation into the effects of fish cage culture on: benthos, hypernutrification, eutrophication, wild fish populations, and bacteria. Laboratory experiments to investigate the nutrient load in relation to temperature, food type and fish size.	Dec. 1990	Denmark
	(no information on its progress in 1988/89 was received)		
(2)	Algarve: Environmental studies at Faro-Olhao sea lagoon "Ria Formosa". Regular monitoring of phyto-plankton; changes in bacterial population inside and outside the lagoon and in bivalves; sediment-water column exchange of oxygen and nutrients; studies on PCB in cultured species and wild populations; studies on water exchangerates; studies on the pathology of clams and otherbivalves; eutrophication, bacteria, chemicals.	3 years	Portugal
	(no information on progress was received during the intersessional period 1988/1989)		
(3)	Mondego estuary: Regular monitoring of phyto-, zoo-and ichthyoplankton, and of physical conditions; studies on water exchange rates and fish pathology.	2 years	Portugal
	(no information on progress was received during the intersessional period 1988/1989)		
(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	Netherlands
	Status: Oosterschelde model: being validated Waddenzee model: being improved, completion 1994 Publications available: Smaal et al. (see litterature list)		
(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.	1994	Netherlands
	Status: first field experiments completed in 1989		

(6)	Measurement of in situ production of nutrients and consumption of particulate food by mussels and the communities on cultivation plots.	1992	Netherlands

Status: on-going

(7)	Research into suitable sites for mussel cultivation in the Oosterschelde in relation with current velocity and food availability.	1991	Netherlands

Status: on-going

(8)	Development of a model for regional planning and site selection for 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 be made.	1989	Finland Ervik et al. 1987 Håkansson et al. in preparation Koivisto and Blomqvist,in print

(the publication by Koivisto and Blomquist is cited in the literature list; a further extended joint publication by Håkanson, L., Ervik, A, Mäkinen, T., Møller, B, 1988 is available entitled "Basic concepts concerning assessment of environmental effects of marine fish farms": see literature list. The final report should be available by 1990, however, no information on the publishing date is presently available)

(9)	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

(Progress according to plan; Final report will be published in 1990 after the termination of the project.)

(10)	Antibiotics in farmed fish, wild fauna and sediment, and degradation rates of chemicals	1988	Finland Björklund et al.1989

(The project was terminated in early 1989; No information on the outcome other than the publication mentioned has become available during the intersessional period)

(11)	Changes in sediment chemistry and benthic infauna beneath a large salmon cage farm (160 pens, 620 t per year). In addition to routine measurements of species composition and abundances, the effects of organic enrichment are being measured by shifts in the vertical distribution of biomass within	March1989	United States

the sediment, gradients in average individual size, and the relative proportion of various feeding guilds. Initial results indicate impacts extending at least 150 m from the farm site.

(Project has been terminated according to plan; publication anticipated during summer 1990).

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(12)	A newly developed model which predicts the dispersion of feed and faeces from salmon net cages is being tested at two Puget Sound farm sites. There are two principal goals: 1) to field verify the model predictions of accumulation rate in the surrounding area; and 2) to determine the effect of any given accumulation rate on the benthic fauna. The model will ultimately be used for site selection, to determine the probable areal extent of benthic impacts.	Oct. 1987	United States (finalized early 1990)

(Study completed in late 1988; report available since early 1989: Weston, D.P., Gowen, R.J., "Assessment and prediction of the effects of salmon net-pen culture on the benthic environment." Washington Dep. Fisheries, Technical Report 414(Ref.M88-2), November 1988,62pp. The research results were used in formulating the final EIS for Washington State in early 1990)

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(13)	Interactions between net-cage culture and phytoplankton blooms are being examined in the laboratory and at four Puget Sound farm sites. The work will include: 1) laboratory investigations on the causes of fish mortality when exposed to *Ceratium* and *Chaetoceros*; 2) studies of environmental factors accompanying blooms; and 3) field studies on the vertical distribution of problem species and the effectiveness of mitigation techniques.	Dec. 1991	United States

(Project delayed. Scheduled to begin in early 1990).

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(14)	An environmental research and monitoring plan was prepared to guide the provincial agency responsible for aqaculture development in New Brunswick. Environmental monitoring, notably phytolankton data for up to 17 stations during 1988 and 1989, was completed.	1989	Eastern Canada D.Wildish, N.B. Wildish + Martin New Brunswick

(Technical Reports soon to be available from Dep. Fisheries and Oceans, see also publications listed in last years WG. report: Wildish et al., 1988, Wildish et al. 1990a; Wildish et al. 1990b; Martin and Widish 1990; Wildish et al. 1990c)

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(15)	The Letang Inlet aquaculture project initiated in 1989 was continued using an ecological model to assist with the assessement of the carrying capacity of coastal inlets for caged salmon aquaculture. The project is focused on	Eastern Canada

the l'Etang Inlet in New Brunswick which is the site for the majority of finfish aquaculture on Canada's east coast. The ecosystems model which is being developed will be used to corellate data from field experiments and information from the literature and to test hypotheses regarding the functioning of this ecosystem. To provide necessary information for the modelling effort, a major field program has begun at a cage farm site in L'Etang Inlet.

Principal Investigators are: D.C. Gordon, W.L. Silvert, B.T. Hargrave, P.D.Keizer, D.J. Wildish, R. Trites, K.Kranck, G. Fader. Information can be obtained from the DFO laboratory in St. Andrews, New Brunswick, and Habitat Ecology Division of the Bedford Institut of Oceanography, Dartmouth, Nova Scotia, Canada.

(16) The effect of blue mussel culture on the benthic environment is under investigation in Nova Scotia and Prince Edward Island	Ongoing	Eastern Canada (G.Daborn, M.Brylinsky)
(17) The cause of summer kill in cultured blue mussel	1989	Eastern Canada

Contact persons : Scarratt, Freeman and Mallet (Halifax, N.S., Canada)

(18) Phytoplankton profiles including identity and abundance of species and factors involved - nutrients, temperature, oxygen, stability of water, chlorophyll, productivity and toxin production in and around shellfish culture sites contrasted with non shellfish sites. - Three year programme. All regions in East coast Subba Rao,	probably1992*	Eastern Canada

contacts: Wildish, Worms, Cembella and Schwinghammer. St. Andrews, NB. Begin of study delayed until 1990.

(19) Cross contamination of oysters and geoducks with antibiotic from cultured salmon feed. The objectives of this project are: (a) deriving methodologies for detection of oxytetra cycline, sulfadimethoxine and Ormetoprim in oyster and geoduck tissues; (b)determining if oysters and geoduck held under laboratory conditions are capable of taking these materials into their tissues from commercial fish feed; and (c) surveying a farm site which has used one of the afore-mentioned therapeutants to determine if the material has been incorporated into the bivalve's tissues.	commenced October 1989	Western Canada Report expected April 1991

(Study progressing according to plan)

(20) Plankton watch for the marine aquaculture industries. The objective of this programme is to assist communications within the marine aqua-culture industries in creating an early response	Ongoing	Western Canada

to phytoplankton looms and to develop an information base which can be used in the development of techniques to mitigate the effects of those blooms.

(Internal reports compiling information derived from industry based phyto-plankton sampling to detect changes in abundance and species composition have been drafted for 1988 and 1989. Insurance companies estimate several million dollar product saved by this programme ; Report for 1989 expected in March 1990).

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(21) Water quality and circulation in fish net cages are examined at two sites for evidence of hydrological isolation of the culture waters and consequent modification of the ambient environmental fluctuations in oxygen and amonia concentraions. In addition water quality in an array of pens would be examined to see if deterioration in water quality was progressive along the array. 1989 Western Canada

(Master Thesis completed in 1989 by Steven Garmican, Univ. British Columbia, Vancouver. There is evidence of temporary oxygen depletion within cages relative to the surrounding environment. Currents on the downstream edge were found to be reduced by 30%, and total ammonia and dissolved oxygen levels in downstream cages suffered progressive decline. Currents, slack tide, time of day, cage configuration are contributing factorsy).

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(22) Sechelt water quality monitoring program. The Sechelt Inlet system is composed of three fjords all emptying out over a single shallow sill. The industry has proposed to farm 3800 tonnes of salmon in the in the system. Five years (1986-1990) of trend monitoring at 11 background sites (mid-channel and near shore) and at two fish farm sites in Sechelt inlet are being done to determine the degree and extent of any water quality changes attributable to finfish aqaculture. Variables include basic oceanographic parameters, detailed nutrient analysis, phytoplankton sampling an identification. Monitoring is being carried out during spring (February -March) and late summer (August-September). 1991 Western Canada

(The anticipated production mentioned above will probably be reached in 1990. The surveys are done twice a year prior to spring bloom and in late summer. Sampling is done at 4 existing farm sites, 3 nearshore control stations and 6 mid-channel stations. Assessment of the data due in 1990; final report expected in 1992. For detailed information contact E.A. Black, Victoria, B.C. Address see WG membership list)

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(23) A Winter disease profile, surveying approximately a quarter of the existing fish farms to determine the diseases present during winter months which may have the potential to be transmitted from the caged fish during the winter months. 1990 Western Canada

(Internal report is expected by the end of 1990. For detailed information contact E.A. Black, Victoria, B.C. Address see WG membership list).

(24) Antibiotic resistance of pathogens in the vincinity of fish farming are examined in fish and human pathogens commonly found in the marine environment, showing a higher level of antibiotic resistance in the vicinity of fish farms than in other nearshore habitats. Populations of pathogens will be sampled from the water, sediments and oysters and geoducks.	1990	Western Canada

(A report is expected by April 1, 1991. For detailed information contact E.A. Black, Victoria, B.C. Address see WG membership list).

(25) Marine anemia: a case study of disease transfer between wild and cultured fish. To use a newly detected disease, marine anemia, as a case study of the transfer of a fish pathogen between wild and cultured fishes.	1992	Western Canada

(This project is a two to three year task. The work began in 1989. The first years work includes: Studiers of the ethology of the disease to identify the pathogenic agent and environmental circumstances which lead to the expression of the disease; examination of the susceptability of various salmonids and other commercial fish species to this diease; a survey to determine the extent of this disease's persence in wild and cultured salmonid stocks. contact: Dr. Michael Kent, Pacific Biological Station Nanaimo, B.C.)

(26) The use of pigments and oxytetracycline to differentiate wild and cultured salmonids which have escaped confinement is examined. This is the first year of a three year programme to evaluate contribution of escaped salmonids to the spawning populations. The object of this years study is to determine the duration of two anthropogenic chemicals (the therapeutant oxyteracycline and certain isomers of the pigments used to colour the fishes flesh) in the flesh in order to evaluate whether the presence of these chemicals can be used to differentiate between wild and escaped farmed fish.	ongoing	Western Canada

The study commenced in 1989. A report on the first years studies is expected in the 1991 fiscal year. Contact: Dr. Ian White, Pacific Biological Station, Nanaimo, B.C.

(27) A review of the impacts of salmon farming on the phytoplankton. To prepare a review (annotated bibliography) and discussion paper of the impacts of marine fish farming and other anthropogenic sources of nutrients on phytoplankton with special reference to those species which might impact upon humans or the environment.	1989	Western Canada

The consultants report was received in March 1989. The report concluded

that while there are examples of marine eutruphication, marine fish farming has not been shown to affect water quality in a manner which would be expected to affect phytoplankton. The report also suggests three possible approaches to a phytoplankton monitoring program.
contact: Dr. Ron Buchanan, B.C. Ministry of Environment, Victoria, B.C.

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(28) A study of the enriching effects of two salmon farms. To examine two fish farms with very different flushing rates to determine if the farms were affecting local levels of ammonia or dissolved organic carbon which might lead to increases in the concentrations of phytoplankon and bacteria in the area of the farms. — 1989 — Western Canada

The work was completed in May 1989. The main conclusions were that increased levels of ammonia and phytoplankton could be assocuiated with low flushing rates on a fish farm site however, the increase in primary production was limited to an area within approximately 10 meters of the cages and was unlikely to be significant to the whole of the water body.
The work represents a MSc. Thesis, ;r. T. Korman, Department of Oceanography, University of British Columbia, Vancouver, B.C.

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(29) Serological test for Paralytic Shellfish Poison (PSP). To examine the potential for the use of the saxitoxin protein response found in shore crabs in the development of a field test for the presence of Paralytic Shellfish Poisoning. — 1989 — Western Canada

The report from this grant showed that while there was a protein response in crab to the presence of saxitoxin, that response was not related to total PSP toxicity. In consequence further funding for this line of inquiry was not considered.
contact: Dr. M. Kitts, Department of Food Sciences, University of British Columbia, Vancouver, B.C.

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(30) Plankton response to commercial fish feed nutrients. To determine which phytoplankton species showed a numerical response to the prtesence of commercial fish feed in marine water. — 1990 — Western Canada

None of the aututrophic species present in the water at the time of the experiment responded, however, one heterothroph species showed a considerable growth in numbers.
contact: Dr. T. Parsons, Department of Oceanography, University of British Columbia, Vancouver, B.C.

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(31) Phytoplankton identification video. A video which can be used to help train salmon farmers in the recognition of live phytoplankton species. — 1989 — Western Canada

The video was completed in September 1989 and is now available from the University of British Columbia, Media Services Department, Vancouver, BC.

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

Field data colected during the bloom has been tabulated; data from the Plankton Watch Program is under analysis; informatioon from the individual farms is beeing collected; a report is anticipated in May 1990.
For detailed information contact E.A. Black, Victoria, B.C. Address see WG membership list

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(33) Experimental demonstration of the existence of a *Heterosigma* toxin. To demonstrate demonstrate whether the lethality of Herterosigma blooms is due to a toxin which is produced by the algae or if mortalities are caused by an environmental response, such as bacterial proliferation, to the presence of the phytoplankton bloom. — 1990 — Western Canada

A report on the findings is expected in the late 1990 - early 1991.

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(34) Respiratory response of salmon exposed to *Heterosigma akashiwo.* To examime the literature on the effects of the red tide organism *Heterosigma akashiwo* on fishes. 7-10 gram salmon were als exposed to the algae and th efishes response in terms of opercular beat frequencies, cough frequencies and time to death were observed. — 1989 — Western Canada

A final report has been submitted. The major findings were: a minimum of 20 to 40 thousand cells per ml. were required to kill fish under laboratory conditions; mortalities occurred without extreme depression of ambient dissolved oxygen levels.
Contact: E.A. Black, B.C. Ministry of Aquaculture and Fisheries, Victoria, BC.

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(35) Characterization of the agent causing fish mortalities in *Heterosigma* blooms. To determine some of the basic properties of the agent causing fish mortalities during *Heterosigma* blooms which may affect the quality or marketability of stock. — 1989 — Western Canada

Studies have just been initiated. A report is not expected before the end of 1990.
Contact: E.A. Black, B.C. Ministry of Aquaculture and Fisheries, Victoria, BC.

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(36) Monitoring of shellfish growing areas for Paralytic Shellfish Poisoning. To monitor harvested shellfish for PSP contamination. — 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 B.C.'s coast.
Contact: E.A. Black, B.C. Ministry of Aquaculture and Fisheries, Victoria, BC.

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(37) A review of the impacts of salmon farming on the benthos. To review the literature and identify the changes in the benthic community and parameters which might be anticipated as a result of fish farming activities. — 1989 — Western Canada

The report suggests that the changes to be anticipated in the bottom community would include: a build up of excess organic material; development of biological mats of the Beggiatoa species; increased sedimentation rates under the fish pens.
Parameters which would be expected to be affected include: dissolved oxygen; the rate of oxygen consumption; the redox potential of the sediments; the percent organic carbon in the sediments; the percent organic nitrogen in the sediments; sulphide content of the waters; phosphorus in the sediments. The sedimentation effects could be expected to extend from a few meters to 50 meters beyond the perimeter of the pens.
contact: Dr. Ron Buchanan, B.C. Ministry of Aquaculture and Fisheries, Victoria, B.C.

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(38) A survey of the effect of B.C. salmon farming on the benthic environment. Assessement of bottom deposits in relation to surface and bottom currents, the operational characteristics of each farm, and the results from sediment trap sampling. Eight farms representing a range of oceanographic conditions will be studied. Assessement will be made of the changes in water quality profiles, as well as the changes in the benthic community, the extent of sedimentation and changes in the chemical and physical parameters of the sediments.	1991	Western Canada

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(39) Rate of recovery of the benthic community from the impacts of fish farm sedimentation. Over an 18 month period laboratory and field studies will examine the response of sediment in fauna and chemistry to the cessation of fish farming.	1991	Western Canada

Contact: E.A. Black, B.C. Ministry of Aquaculture and Fisheries, Victoria, BC.

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(40) Monitoring of shellfish growing waters for bacterial contamination as indicated by the concentration of fecal Coliforms.	ongoing	Western Canada

On-going, Department of the Evironment program wih issues irregular reports covering the levels of fecal Coliform contamination for selected areas of B.C.'s coast.
contact: Dr. Bruce Kay, Department of the Evironment, Vancouver, B.C.

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(41) Mandatory monitoring of waste loading at fish farm sites and trends in water quality in general at fish farms.	ongoing	Western Canada

The regulatory basis for the mandatory reporting of waste laodings was proclaimed in December 1988. Data reporting started in 1989. First analysis of the data expected in 1990.
Contact: Dr. Ron Buchanan, BC Ministry of Environment, Victoria, BC.

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(42) Review of the impacts of freshwater aquaculture on the environment. To review the existing literature on the environmental impacts of freshwater fish farming and identify the principle parameters responsible for those effects.	1989	Western Canada

Contractors report has been accepted. The five most important parameters resposible for the environmental impacts of fresh water fish farming were identified as: soluble reactive phosphorus; total phosphorus; suspended and settleable solids; ammonia; nitrites and nitrates.
Contact: E.A. Black, B.C. Ministry of Aquaculture and Fisheries, Victoria, BC.

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(43) An investigation of the impact of fish farming on the nearshore environment examining a number of fish farm and unoccupied nearshore sites to see if it is possible to detect any differences in their physico-chemical or contaminant profiles which might be associated with the operation of aquaculture facilities. 1989 Western Canada

Consultants report has been submitted. Preliminary indications from the data were that: there was some depression of local oxygen levels at one of the two farm sites studied; benthic macrofauna and fish species composition was more similar between farm sites than between farm and non-farm sites; fish species were more diverse at the farm sites; Copper rockfish caught at the farm site had a higher liver lipid content; liver tissue from rockfish in the vincinity of the farm sites had higher PCB and pesticide levels. Analysis to determine the significance of these findings have to be completed. The final report is expected in late 1990.
contact: Dr. C. Levings, Department of Fisheries and Oceans, Vancouver, B.C.

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(44) An experiment on the contamination of the environment by aquaculture use of copper based anti-fouling preparations. The objective was to determine if the use of copper based antifoulants on salmon cages significantly increased the amount of copper in the water, in salmon flesh, and in mussel and oyster tissue. 1989 Western Canada

The major conclusions are: there was no detectable increase in the bioavailable copper in the water; there was no detectable increase in copper in the salmon flesh; There was some increase in copper content of oyster and mussel tissue however, even these high levels were generally compareable with published data on background levels of copper in bivalves from other coastal regions.
Contact: E.A. Black, B.C. Ministry of Aquaculture and Fisheries, Victoria, BC.

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(45) Culture of oysters in salmon farm effluent. The biological interaction of the cultures is considered by examining the effects of anibiotic cross-contamination from medicated fish fed, on the bivalve growth and condition indexes. 1991 Western Canada

Contact: E.A. Black, B.C. Ministry of Aquaculture and Fisheries, Victoria, BC.

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(46) An assessment on the impacts of fish farming on herring spawning. To determine whether effluent from salmon farms may affect the survival of herring eggs and larvae in close proximity to the pens. 1991 Western Canada

Contact: E.A. Black, B.C. Ministry of Aquaculture and Fisheries, Victoria, BC.

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(47) Predation by cultured salmon on wild organisms. To document the frequency with which caged coho and chinook salmon prey on wild organisms.	1989	Western Canada

Consultants report has been completed. A joint DFO/MAF technical report is being prepared for release in 1990. The major results of this report were: Stomachs from 1705 salmon were examined; 38% contained some wild feed; the greatest portion of thwe prey was invertebrates; invertebrate prey were dominantly caprellid and gammarid amphipods, common members of the net fouling community; 0.6% of the stomachs contained fish remains; herring were the only fish identified in the stomachs.
Contact: E.A. Black, B.C. Ministry of Aquaculture and Fisheries, Victoria, BC.

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(48) Survey of salmon farm waste handling practices. To examine the current waste management practices and alternatives for the farms in the Lower Mainland and Vancouver Regions.	1989	Western Canada

Two studies were contracted. Both were completed in October 1989 and are undergoing internal review.

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(49) Biophysical capability studies of the British Columbia Coast for marine salmon aquaculture. Farm chart preparation and literature searches for biological and oceanographic data, as well as conduct interviews with mariners and governmental personnel concerning biophysical characteristics of sections of British Columbia's coast. The data were mapped to indicate the suitability ("Good", "Medium", "Poor" and "Not Acceptable") of areas to supporting net cage salmon farming.	ongoing	Western Canada

Two reports and map folios have been published (Sunshine Coast to Northern Johnstone Strait, and the Northern Johnstone Strait to the West Coast of Vancouver Island) by MAF on the southern areas.
Two further studies (Central and Northern coasts of B.C. including the Queen Charlotte Islands) are envisioned. The North Coast project was initiated in the late 1989/90 fiscal year and will be completed by December 1990.
Contact: E.A. Black, B.C. Ministry of Aquaculture and Fisheries, Victoria, BC.

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(50) The content of phosphorus in ten commercial brands of feed as well as the metabolic wastes from rainbow trout were investigated. By sequential extraction of phosphorus it was possible to determine the readily soluble fraction. Most feed brands had phosphorus concentrations in excess of 1% dry weight. About one-third of the phosphorus in both feed and faeces was readily soluble in water.	1986	Sweden

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(51) The composition of various types of dry feed has been investigated. It was recommended that the fat content be increased up to 25% and the carbohydrate content be decreased, both for nutritional and environmental reasons. The discharge of nutrients from cage culture	1987	Sweden

can be reduced by 30-40% in the future by changing feed composition and reducing wastage.

(52)	The coastlines of the Bothnian Bay and Bothnian Sea are characterized by many paper mills and mariculture operations. The discharge of nitrogen and phosphorus to the Bothnian Bay from Swedish mariculture operations is 0.6 and 1.9%, respectively, of the total Swedish contribution. In the Bothnian Sea, the corresponding percentages are 0.1 and 0.2%.	1987	Sweden
(53)	This study quantified the pollution by persistent organic substances, metals, nutrients and oil. It was suggested that if all licences given to Swedish aquaculturists were fully utilized, the industry would contribute 6% of the total phosphorus load.	1986	Sweden
(54)	Investigation of the impact of marine fish farms on the receiving water body. Keywords: nutrition salts, sedimentation, material, benthic infauna.	1987	Norway Aure, et al., 1988
(55)	Fate of organic waste from marine fish farms. Keywords: sedimentation, decomposition, ebulition, distribution in the marine food chain.	1990	Norway
(56)	Develop a data base for storage of sensor data from fish farms, in order to obtain time series for scientific analysis.	1989*	Norway
(57)	Develop methods for treatment of fish farm wastes. Describe waste spreading and persistence on the sea floor. Assessment of environmental impact at fish farm drugs. Study at microbiologiocal processes in fish farms deposits on the sea floor.	1990*	Norway

(A first report available in Norwegian language: Vethe, Ø. 1988. Fullskala forsøksanlegg for kompostering fiskeoppdrettsavfall.- GEFO -rapport Nr. 61.031. (Inst. for Georesources and Pollution Research).

(58)	Isolate and investigate potentially toxic flagellates (esp. *Chrysochromulina* sp.).	1991*	Norway E.Paasche, Univ. Oslo
(59)	Studying daily sedimentation rates, studying effects from mud-dredging.	1989*	Norway
(60)	Study central parameters (or growth rate, oxygen consumption, BOD) from rearing of Atlantic salmon in land-based tanks.	1990	Norway Rogaland Research Institute

(several preliminary reports are available in Norwegian).

(61)	Investigations of the effect on fish farms of crude oil exposure. A project studying pollution effects on aquaculture.	1989	Norway

(62) Development of low-pollution fish feeds.	1989	Norway Rogaland Research Institute
(63) Development of an efficient tool of coastal zone planning (LENKA).	1989	Norway ICES 1988/F:11

(Continuation and expansion of other components of the LENKA-project mentioned in this listing)

(64) Investigation of the effect and fate antibiotics.	1991	Norway

(Some results of these studies are included in ICES Doc. C.M. 1988/F:14, see full citation in Literature list).

(65) Effect of local discharges of nutrients and organic matter from marine fish farms upon oxygen conditions in deep water of sill fjords.	Autumn 1988	Norway Stigebrandt, et al. 1988 Aure and Stigebrandt, 1988a; 1988b

(Final report available in Norwegian language from the author; additional papers appeared in scientific journals; see literature list)

(66) Level of drugs in farmed fish, wild fauna and sediment, and degradation rates of the chemicals.	1990*	Norway 3 reports
(67) Investigation into resistant microflora in the sediment beneath fish farms.	1990*	Norway
(68) Investigation on feeding behaviour by hydro-acoustic detection of feed waste.	1989?	Norway Juell, 1988
(69) Development of low density dry feeds	?*	Norway
(70) Through a project known as LENKA, an efficient and standardized methodology for coastal zone planning is under development. The programme is intended to identify areas suitable for mari-culture and avoid areas of probable use conflicts.	1989	Norway several internal working documents Norwegian

The "Frisk Fisk" programme ongoing Norway*

(frisk fisk means healthy fish)

aims to stimulate and coordinate research work related to improvement on the health condition of fish and shellfish. The programme especially emphasizes on promoting research projects that provides knowledge useful in preventing and opposing health problems among cultured species. The programme concentrates on three subject areas:

(1) health and evironment;
(2) diagnostics, epidemology, treatment and fish health management;
(3) immunology, vaccination, pathology and genetics.

Projects listed are grouped according to subject areas.

Subprogramme (1) "Health and Environment"

(71) Alternative teatment of salmon lice. 1992 Norway
Havforskningsinstituttet; Holm, Jens Chr.

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(72) Importance of water quality, especially elevated ammonia levels on the water and the salt balance in Altalntic salmon in culture. 1990 Norway

Info from: Ola B. Reite, Norges Veterinærh¢gskole
Postboks 8146, Dep, 0033 Oslo 1
Tlf 02 693690

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(73) Stress in actively swimming salmon 1991 Norway

Info from: Ole Brix, Zoologick laboratorium,
Universitetet i Bergen, Alle'gt 41,
5007 Bergen, Tlf 05 212243

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(74) Stress in fishes. 1990 Norway

Info from: Per Enger, Biologisk institutt
Universitetet i Oslo, Postboks
1066 Blindern, 0316 Oslo 3
Tlf 02 45 46 71

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(75) Pathogenic phytoplankton in fish farming 1990 Norway*

Info from: Karl Tangen, Trondhjem Biologiske Stasjon
Bynesveien, 7000 Trondheim
Tlf 07 593324

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(76) Drug consumption and residues in farmed fish. 1991 Norway*

Info from: Magne Yndestad, Norges Veterenærh¢gskole
Postboks 8146, Dep, 0033 Oslo 1

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(77) Health in new fish species for aquaculture. 1990 Norway*

Info from: Ragnar Salte, AKVAFORSK
Boks 10, 1432 Ås—NLH
Tlf 09 949060

Subprogramme (2)
"Diagnostics, epidemology, treatment and fish health management."

(78) Development of cold water vibriosis in Salmonids: environmental effects, physiologi and morphology. 1992? Norway*

Info from: Ola B. Reite, Norges Veterinærh¢gskole
Postboks 8146, Dep, 0033 Oslo 1
Tlf 02 693690

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(79) Biological delousing of Atlantic salmon. 1992 Norway*

Info from: Åsmund Bjordal, FTFI,Fangstseksjonen
C.Sundsgt. 64, 5004 Bergen,
Tlf 05 323770

(first reports see ICES Statutory Meeting 1988)

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(80) New methods to control salmon lice 1992? Norway

Info from: Ingvar Huse, Havforskningsinstituttet
Senter for Havbruk, Postboks 1870, Nordnes
5024 Bergen, Tlf 05 238500

(first reports see ICES Statutory Meeting 1988)

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(81) Spread and colonization of fish parasites ongoing Norway*

Info from: Odd Halvorsen, Zoologisk museum,
Universitetet i Oslo, Sarsgt. 1,
0562 Oslo 5, Tlf 02 686960

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(82) Systematics, population genetics and ecology of parasites in salmonids. 1990 Norway*

Info from: Bjørn Berland, Zoologisk laboratorium,
Universitetet i Bergen, Allegt. 41,
5007 Bergen, Tlf 05 212243

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(83) Diseases in farmed fish caused by fungi with special emphasize on Exophiala infections in Atlantic salmon. 1990 Norway*

Info from: Finn Langvad, Institutt for Mikrobiologi
og Plantefysiologi
Universitetet i Bergen, Jahnebakken 5,
5007 Bergen, Tlf 05 212662

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(84) Medication: allotment of fish feed containing antibiotics 1990 Norway*

Info from: Ragnar Salte, AKVAFORSK, Boks 10,
1432 Ås—NLH, Tlf 949060

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(85) Drug metabolism in fish hepatocytes. 1991 Norway

Info from: Inger Nafstad, Norges Veterinærhøskole,
Postboks 8146, Dep,
0033 Oslo 1, Tlf 02 693690

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(86) Identification of vibrio bateria. 1991 Norway*

Info from: Ragnhild Wiik, Institutt for mikrobiologi
og plantefysiologi, Universitetet i Bergen,
Janebakken 55007 Bergen, Tlf 05 21 26 62

(87) Winter wounds in salmonids, pathology and microbiology. 1991 Norway*

Info from: Tore Håstein, Veterinærinstituttet, Postboks 8156, Dep, 0033 Oslo 1, Tlf 02 693690

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(88) Evaluation of different risk factors associated with the outbreak of furunculosis. 1990 Norway*

Info from: Brit Hjeltnes, Havforskningsinstituttet, Senter for Havbruk, Postboks 1870, Nordnes, 5024 Bergen, Tlf 05 238500

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(89) Diagnosis of furunculosis bacteria from healthy infection carriers. 1991 Norway*

Info from: Henning Sørum, Norges Veterinærhøgskole, Postboks 8146, Dep, 0033 Oslo 1, Tlf 693690

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(90) Fish epidemiology, risk factors for ILA. 1992 Norway*

Info from: Ivar Vågsholm, Veterinærinstituttet, Postboks 8156, Dep, 0033 Oslo 1, Tlf 02 693690

Subprogramme (3): "Immunology, vaccination, pathology and genetics."

(91) Development of immune cells in mammals and fish. 1991 Norway*

Info from: Thor Landsverk, Norges Veterinærhøgskole Postboks 8146, Dep. 0033 Oslo 1 Tlf 02 693690

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(92) Disinfection of materials in contact with salmon infected with ILA (Infectious Salmon Anaemia). 1990 Norway*

Info from: Ola B. Reite, Norges Veterinærhøgskole, Postboks 8146, Dep. 0033 Oslo 1, Tlf 02 693690

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(93) Fish immunology. 1992 Norway*

Info from: Trond Jørgensen, FORUT, Postboks 8806 Elverhøy 9001 Tromsø, Tlf 083 85544

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(94) Vaccination of salmon, analysis of immunoresponse and protection; 1990 Norway*

Info from: Curt Endresen, Felleslaboratoriet for bioteknologi, Universitetet i Bergen, Postboks 3152, Årstad 5001 Bergen, Tlf. 05 21010

(95) Variations in resistance against furunculosis. 1990 Norway*

Info from: Trygve Gjedrem, AKVAFORSK,
Boks 10,1432, Ås—NLH, Tlf 09 949060

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(96) Characterization of white blood cells from dometic mammals and fish. 1993 Norway*

Info from: Hans J. Larsen, Norges Veterinærhøgskole,
Postboks 8146, Dep.0033 Oslo 1, Tlf 02 693690

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(97) ILA (Infectious anemia) in farmed salmon 1992 Norway

Info from: Ann Iren Sommer, FORUT,
Postboks 8806 Elverhøy
9001 Tromsßø, TLf 083 85544

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(98) Virus infections among farmed fish. 1992 Norway*

Info from: Karen Elina Christie, Norbio A/S,
Felleslaboratoriet for bioteknologi,
Universitetet i Bergen,
Postboks 3152, Årstad,
5001 Bergen, Tlf 05 200100

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(99) Infectious Anemia of Atlantic salmon (IAS). The etiology of IAS. 1992 Norway*

Info from: Ola B. Reite, Norges Veterinærhøgskole,
Postboks 8146. Dep.
0033 Oslo 1, Tlf 02 693690

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(100) BKD *(Renibacterium salmoninarum)*. Pathology, immunology and epidemiology. 1992? Norway*

Info from: Ole Bendik Dale, Veterinærinstituttet,
Postboks 8156, Dep. 0033 Oslo 1,
Tlf 02 693690

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(101) Chemoterapeutica in fish farming. Optimalization of dosage and compound. ? Norway*

Info from: Svein Olav Hustvedt, AKVAFORSK,
Boks 10, 1432, Ås—NLH, Tlf 09— 94 90 60

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(102) Pathology of bivalve mollusks ? Norway*

Info from: Stein Mortensen, Havforskningsinstituttet,
Senter for Havbruk, Postboks 1870, Nordnes,
5024 Bergen, Tlf 05 238500

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(103)	Vibriosis in marine fish. Info from: Odd Magne Rødseth, Havforskningsinstituttet, Senter for Havbruk, Postboks 1870, Nordnes, TLF 05 238500	?	Norway*
(104)	Virulence factors in fish pathogenes. Info from: Liv J. Reitan, Veterinærinstituttet, Postboks 8156, Dep., 0033 Oslo 1, Tlf 02 693690	1991	Norway*
(105)	Immunology, vaccination, pathology and genetics. Genetic resistance Info from: Terje Refstie AKVAFORSK, 6600 Sunndals¢ra Tlf 073 91897	1992	Norway*
(106)	Working Group on Infectious Anemia of fish. Pathologenicity of IPN serotypes Info from: Brit Hjeltnes, Havforskningsinstituttet, Senter for HavbrukPostboks 1870, Nordnes, 5024 Bergen, tlf 05 238500	1992	Norway*
(107)	Hitra-disease among salonids, environmentally mediated effects, physiology and morphology. Info from: Veterinarinstituttet Norges Veterinarhogskole, Oslo	1992	Norway*
(108)	Feeding and environmental required diseases in salmonids. Akvaforsk	1990	Norway*
(109)	Parasitic ciliates in aquaculture. Info from: Sogn og Fjordane Distriktshogskole.	ongoing	Norway*
(110)	ILA (Infectious Salmon Anaemia)in salmon. Info form: Fellesavdelungen for akvakultur og fiskesjukdommer, NVH/VI	1991	Norway*
(111)	Physiology and stress among salmon Info from: Fysiologisk Institutt; Helle, Karen	1990	Norway*
(112)	**"Environmental impact of mariculture"** is a new program started in 1989. Its goal is to support and coordinate research activity aimed at research	ongoing	Norway*

activity aimed at investigating and reducing undesireable environmental effects of mariculture. The program partly consists of new projects and partly of projects that earlier were included in "Frisk Fish"

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(113) Ecological effects of antibiotics. 1991 Norway*

Info from: Ervik, Arne
Havforskningsinstituttet, Senter for Havbruk,
Postboks 1870, Nordnes,
5024 Bergen, Tlf 05 238500.

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(114) Effects of antibiotics and chemotherapeutants on the environment around fish farms. 1990 Norway*

Info from: Halvor Hektoen, Norsk Institutt
for Vannforskning (NIVA)
Brekkevn 19, 0883 Oslo, Tlf 02 235280

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(115) The role of benthic fauna in decomposition of organic waste from aquaculture. 1992 Norway*

Info from: Ervik, Arne
Havforskningsinstituttet, Senter for Havbruk,
Postboks 1870, Nordnes,
5024 Bergen, Tlf 05 238500.

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(116) Immunology and cell biology in fish ? Norway*

Info from: Sigrun Espelid, FORUT,
Postboks 8806, Elverhøy
9001 Tromsø, Tlf 083 85544

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(117) Genetic influence of escaped farmed fish on wild populations of Atlantic salmon. 1992 Norway*

Info from: Petter Larsson, Zoologisk museum,
Universitetet i Bergen, Museplass 3.
5007 Bergen, Tlf 05 212905.

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(118) Control of escaped farmed fish. 1992 Norway*

Info from: Bror Johnsson, Norsk institutt
for naturforskning,
Tungesletta 2, 7047 Trondheim,
Tlf 07 913020

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(119) Escaped farmed fish — influence on populations of wild Atlantic salmon. 1992 Norway*

Info from: Bror Johnsson, Norsk institutt
for naturforskning,
Tungesletta 2, 7047 Trondheim,
Tlf 07 913020

(120)	Escaped farmed fish Info from: Dag Furevik, Fiskeriteknologisk Forskningsinstitutt, C. Sundtsgt 64, 5004 Bergen, Tlf 05 323770.	1990	Norway*
(121)	Development and transfer of resistance against antibiotics. Info from: Kåre Fossum, Norges Veterinærhøgskole, Postboks 8146, Dep. 0033 Oslo 1, Tlf 02 693690	1992	Norway*
(122)	The parasitic biology of *Caligulus elongatus* and *Lepeophtherius salmonis* on farmed salmon untreated for infestation. 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.	Ongoing	Ireland

Results published: Tully, O. 1989. The succession of generations and growth of the caligid copepod Caligus elongatus and Lepeoptheirus salmonis, parasiting salmon smolts (Salmo salar). J.Mar.Biol.Assoc. U.K. 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.	Completed 1990	Ireland

Results have been reported at conferences; presently 3 papers in press or published:
Tully, O. 1988. 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.
Jackson, D. 1990. (In press). Nuvan toxicity in the marine environment. Paper, presented to the Irish society of toxicology, Athlone, 23-24 march 1990.
Duggan, C. papers in press, entitled: "Oceanical usage in aquaculture" (Proc. conf.: Interactions between aquaculture and the environment. 15-16 April, 1989, Galway.

(C. Duggan, in press, Sublethal effects on Patella vulgalta at 10^{-10} detected)

(124)	The impact of tributyltin (TBT) residues on mollusc spawning and survival. ***(Report not yet available)***	1989	Ireland

(125)	Uptake of antibiotics from salmon farms by edible molluscs.	1990	Ireland*
	(Project was postponed to 1990)		
	Trials on the efficacy of Ivermectin in oral therapy for control of parasitic copepods in European of Atlantic salmon.	Ongoing	Ireland
	(Project continues; a publication has appeared in the Bull. Assoc. Fish. Soc. ....)		
(126)	Laboratory studies of the toxicity and sub-lethal effects of dichlorvos and possible alternatives for sea lice treatment. Field and laboratory investigations of the impact of dichlorvos treatment on non-target organisms, including adult and larval molluscs and crustaceans.	Ongoing	Scotland
	(Report anticipated second half of 1990)		
(127)	Desk and experimental investigations of possible alternatives to dichlorvos in sea lice treatment including studies of the basic biology of the parasites concerned.	Ongoing	Scotland
(128)	Recovery of environments exposed to TBT: as part of an on-going monitoring of the impact of TBT on marine life. Imposex was adopted and *Nucella* is now being used to monitor the recovery of sites where impact had been found. The biological effects techniques are being supported by chemical determination of organotins.	Oongoing	Scotland
(129)	A study of the survival of *Aeromonas salmonicida* in sediments	1990	Scotland
(130)	An investigation into hypernutrification eutrophication with the aim of determining the holding capacity of sea lochs. Hydrographic and modelling studies of sealochs. The impact of farming operations on benthic communities.	Ongoing	Scotland
	(Turrell and Munro, 1988. Further reports expected next year)		
(131)	The release of dissolved forms of nitrogen from sediments enriched by fish farm waste.	1988	Scotland
	(Project has been finalized, resulting in a Thesis prepared by F. Johnson; available from Stirling University, Scotland)		

Appendix 2:

WG Environmental Impact of Mariculture. Members and Participants* 1990

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Appendix 2:

WG Environmental Impact of Mariculture. Members and Participants* 1990

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Appendix 2:

WG Environmental Impact of Mariculture. Members and Participants* 1990

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Appendix 3

Working Group on Environmental Impact of Mariculture

March 27th to April 1st, 1990
Marine Laboratory, Aberdeen, Scotland

Tentative Agenda

(1) Opening of the Meeting

(2) Election of Rapporteurs(s)

(3) Adoption of the Agenda
(assignment to and timing of drafting sessions)

(4) Overview on recent ICES Activities and report on the status of Working Group Recommendations

New decission by the Mariculture Committee on Working Group meetings

(5) Tabling of Documents

(6) Country Reports
- -Production trends
- -Reports on ongoing research programmes
- -Research priorities

updating of Table 1 of earlier WG Reports
(Studies related to environmental aspects of mariculture, recently completed and ongoing)

(7) Preparation of the Technical Report on

Chemicals used in Mariculture

- Discussion on the structure and layout of the report
- Editing of existing text to introduction and the body of the report
- formulating additional text (chemicals commonly and less frequently used)
- updating the list of chemicals (decision on substances to be listed)
- reconsidering and recalculating quantities used in member countries
- discussing the layout and general content of the "information sheets" for individual chemicals
- editing the information sheets (original format to be provided by Dr. Don Weston): chemical properties, reactions, toxicity, ecological effects, concerns on resistance and toxicity of degradation products,etc)
- Drafting the concluding section

(8) Preparation of the Technical Report on

Management of the environmental impact of mariculture

- General discussion on the content of the document
- Drafting the introduction
- Reconsidering the "Decision Path"
- Final discussion on Monitoring issues
- Drafting sessions for chapters on site selection and monitoring
- Discussing and drafting a chapter on "Carrying and holding capacity"
- additional issues related to management (coastal zoning?)
- Discussion on the content of the concluding chapter

(9) Reports on other international activities related to issues on Environmental Impact of Mariculture

- EIFAC Working Party on "Fish Farm Effluents"
- WHO Codex Committee on Fish and Fishery Products
- Bellagio-Conferences 1990: Environmental Impact of Aquaculture in 3rd World countries

(10) Discussion on proposed theme sessions for the ICES Statutory Meetings 1991/2

(11) Recent relevant literature

(12) Conclusions and recommendations

(13) Miscellaneous and date of next meeting (1992!!!)

Canada

by

James E. Stewart

Department of Fisheries and Oceans, Halifax

and

Edward A. Black

British Columbia Ministry of Agriculture and Fisheries

Aquaculture in Canada, preliminary statistics for 1988. The production is devided into the different Provinces. For a summary of 1989 production figures see following page.

Province	Mussels	Oyster	Salmon	Trout Rainbow	Trout Speckled	Provincial Total
Nova Scotia	306 455000	130 208000	27 229000	184 1,193000	11 67000	658 2,152000
New Brunswick	(20) (33000)	(313) 619800	3477 40,000000	15 (70000)	- -	(3825) 40,722800
P.E.I.	1442 2,383000	1462 2,899000	- -	14 68000	- -	2922 5,350000
Newfoundland	225 (337500)	- -	10 100000	20 (100000)	- -	255 (537500)
Quebec	92 (138000)	- -	28 140000	800 4,000000	200 1,000000	1120 (5,278000)
Ontario	- -	- -	- -	1500 7,500000	- -	1500 7,500000
Prairies	- -	- -	- -	100 500000	- -	100 (500000)
British Columbia	20 30000	3000 3,080000	5825 55,900000	115 700000	- -	8960 59,710000
Total	2,107 3,376500	4,907 6,806800	9,367 96,369000	2,748000 14,131000	211 1,067000	19,340 121,750300
% Quantity Value	10.9 2.8	25.4 5.6	48.4 79.2	15.3* 12.4* *trout in total		100 100

Aquaculture production 1989
Summary
preliminary estimations

	mt	value($ 000)
Newfoundland		
Mussels	70	
Rainbow trout	20	
Cod	59	
Nova Scotia		
Atlantic salmon	250	
Rainbow trout	450	
Mussels	400	
Oysters	140	
P.E.I.		
Rainbow trout	50	286
Mussels	2682	4425
Oysters	1895	3753
Bay Scallpos	20	120
New Brunswick		
Atlantic salmon	4500	50000
Mussels	(20)	
Oysters	(300)	
Trout	(15)	
Quebec no data received		
British Columbia		
Salmonids		
chinook	9049	
coho	2021	
Atlantic	1013	
trout	302	
total	12385	
Shellfish		
oyster	(3000)	

Denmark

by

Jasper Hørsted
The Danish Institute for Fisheries and Marine Research

Production:

Farming of rainbow trout *(Oncorhynchus mykiss)* has been carried out in freshwater in Denmark for nearly 100 years. The first farms were established in 1894 and the water was taken from nd led through earth ponds. From 1950, the production as increased rapidly. Today, the production is about 25,000 tonnes per year in freshwater. The production of European eel (Anguilla anguilla) in freshwater was about 480 tonnes in 1989.

The first Danish experiments raising rainbow trout in sea water were conducted in the fifties but the production did not increase until the late seventies. During the last decade, the expansion of marine fish farming has occurred rapidly in Denmark (Fig.1).

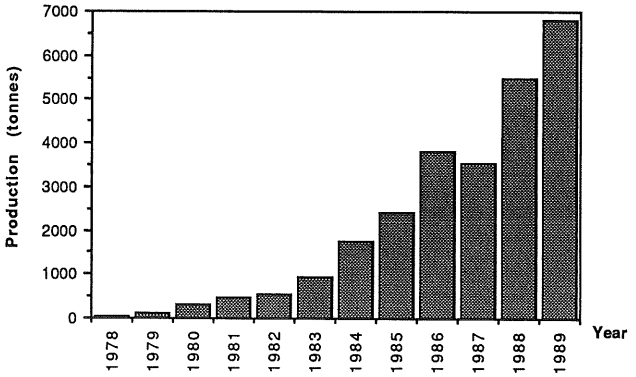

Fig.1: Development in gross fish production by Danish mariculture

The gross production of rainbow trout in Danish mariculture in 1989 was about 6690 tonnes (net production 4,805 tonnes) of which 90% was raised in in cage farms. The prduction of turbot *(Scophthalmus maximus)* and Atlantic salmon *(Salmo salar)* was 4 tonnes and 1 tonne, respectively. The total feed consumed was about 670 tonnes giving conversion coefficient of 1.4. The number of cage farms and land based farms was 31 and 11, respectively, and 3 of the land based farms utilized warm water.

Experiments with raising of sea bass *(Dicentrarchus labrax)* and gilthead bream *(Sparus auratus)* in warm water were conducted on one of the farms. Only ca. 500 kg were produced of these species.

The production of mussels *(Mytilus edulis)* and oysters *(Crassostrea gigas)* was 64 tonnes and 3 tonnes (about 37,000), respectively.

Since 1984, the development of feed quality has been rapid and food conversion coefficient has shown a pronounced decrease (see Table 1).

Table 1: Development of food conversion coefficient, feed quality and nutrient loadings in Danish mariculture from 1988-1989.

Year	1 Gross production t	2 Net production t	3 Food consumption t	4 Food conversion coefficient (III:II)	5 % Nitrogen content in food	6 % Phosphorus content in food	7 % Nitrogen content in fish	8 % Phosphorus content in fish	9 Nitrogen loading t (III*V-II*VII)	10 Phosphorus loading t (III*VI-II*VIII)	11 kg Nitrogen loading per tonnes net production (kg, IX:II)	12 Phosphorus loading per tonnes net production (kg, X:II) kg
1984	1729	1084	2157	1.99	8.0	1.2	3.0	0.4	140	22	129	20
1985	2386	1640	2886	1.76	7.8	1.1	3.0	0.4	176	25	107	15
1986	3732	2663	5006	1.88	7.5	1.0	3.0	0.4	296	39	111	15
1987	3500	2550	4500	1.76	7.2	1.0	3.0	0.4	248	35	97	14
1988	5500	4400	6600	1.50	6.9	0.9	3.0	0.4	323	42	73	10
1989	6690	4805	6720	1.40	6.7	0.9	3.0	0.4	306	41	64	9

Although the production in 1989 was 4 times higher than in 1984, the loading was only 2 times higher as a result of better handling of the fish and better food quality (i.e. lower food conversion coefficient). In other words, the loading per tonne fish produceds has decreased by 50%.

Mariculture production is limited by the environmental authorities. The national plan for mariculture development from the Ministry of Environment will probably be published in autum, 1990.

Cage farms in Denmark are controlled by the Danish countries by measuring the content of organic matter, nitrogen and phosphorous in the sediment around farms and by diving inspections 1-2 times per year. Land - based plants are controlled by measurements of organic matter, nitrogen, phosphorus and the microflora in the plant effluent 8-12 tmes per year.

Use of chemicals

The total use of therapeutic chemicals in Danish mariculture in 1989 was 977kg Oxolinic acid, 1 kg Enrofloxacin (quinoline derivate - experimental use), 98 kg Sulfamerazine: Trimethoprium (5:1, corresponding to tribrissen), 14 kg Sulfamerazine and 142 kg Oxytetracylin.

Oxolinic acid is commonly used for 7-10 days in concentrations of 12 mg*kg fish-1 * day-1, Encrofloxacin is used for 7 days in concentrations of 10 mg*kg fish-1 * day-1, Sulfamerazine is used for 5 days in concentrations of 30 mg*kg fish-1 . day-1 and Oxytetracyclin is used for 8 days in concentrations of 50 mg*kg fish-1 * day-1.

About 25%of the rainbow trout raised in mariculture in 1989 were vaccinated, while 50-60% will be vaccinated in 1990.

The use of non-nutritive food additives in 1989 was about 470 kg of which Astaxhanthin made up ca. 50%.

Different products were used as antifoulants but all contained copper oxide. Fihnally, carbon dioxide (before saughtering) and Chlorbutanol (before vacination was used as anesthetics.

Research

The research carried out in 1989 was a continuation of the 1988-programme. Calculations concerning the collected material and data from 1989 are not finalized but seem to confirm the conclusions drawn in the country report from Denmark in "Report of the Working Group on Environental Impacts of Mariculture - 1989".

The research in 1990 will be continuation of the University of Odense and the University of Copenhagen, resoectively, have contributed to the research programme in 1988-1989:

(I) Environmental impact of mariculture on sediment chemistry and microbial activity.

Sediments underlying marine fish farms generally receive a very high imput of particulate organic matter (food remains and faecal material). The knowledge of spatial and temporal impacts of thias organic load on microbial processes in sediments is very limited.

The present work on fish farm sediments in shallow Danish waters has revealed a highly elevated microbial activity under the cages. Bacterial sulfate reduction, oxygen uptake, carbon dioxide production and nutrient release are 10 to 25 times the rates of a nearby, unaffected sediment system. All rates are highest during summer and early fall. Only the sediment in the immediate vioncinity of cages is severely affected - 5 meters away from the cages microbial activity is only 3 times higher than at control sites.

Despite the limited spatial distribution of the affected area, the actual microbial activity rates (some of the highest ever recorded) imply a very serious impact on benthic communities underlying marine fish farms.

Questions fort the future: How does water depth influenc benthic activity under marine fish farms. What is the impact of antibiotics (added to protect

the fish stock from various infections) on the microbial communities surrounding the cages.

(II) The impact of antibiotics on the microflora on the sediments.

The pupose of this investigation was to study the impact of antibiotics on the naturally occuring microflora in the sdiments aroung a net cage mariculture. The antibiotic used for therapeutical treatment, during an outbreak of vibriosis, was oxolinic acid.

Monthly sediment samples were taken during the period April to November 1988 and extra samples were taken immediately after the conclusion of the 7 day therapeutic treatment. The popoulations of the total heterotrophic bacteria (total viable counts: TVC) and Vibrio anguillarum-like organisms (VLO) were registrated.VLO-populations were tested for resistance gainst sulfamerazine, trimethoprim and oxolinic acid.

Below the net cages there was a decrease in densities of heterotrophic bacteria, as a

France

by

Maurice Heral
IFREMER

and

Michel Merceron
IFREMER

1. Production estimation

Evaluation of the production

For Salmonid species the production in marine waters can be considered as stable. The overall production of 985 tonnes in 1989 is composed of:

Rainbow trout *(Oncorhynchus mykiss)*	850 t
Brown (Fario) trout *(Salmo trutta)*	5 t
Atlantic salmon *(Salmo salar)*	60 t
Coho salmon *(Oncorhnchus kisutch)*	70 t

A new operation began in 1989 with a large offshore salmon cultivation unit using large tankers. About 250 000 smolts have been stocked and are now ongrown for an anticipated production of 600t in 1990/1991.

With regard to other marine fish species a second hatchery for turbot cultivation has been constructed and is starting to operate during this year.

The cultivation of other marine fish species presently concentrates on the production of fry from hatcheries for the following species:

Sea bass *Dicentrarchus labrax*	5 770 000
Sea bream *Chrysophrys aurata*	1 445 000
Turbot *Scophthalmus maximus*	450 000

A large proportion of juveniles of these species were exported to Spain and Italy were these fish are grown to market size. The continued cultivation of these fish species in France to market size has slightly increased during the past years but remains relatively small compared to the production from other aqauculture activities. The overall production figures are:

For Sea bream and sea bass	250t
for Turbot	20t

The French production of shrimps *Penaeus japonicus* is usually obtained in tropical areas, however, a small quantity of the total production was also grown in France, reaching about 20 t.

2. The major research programmes related to the environmental impact of aquaculture can be summarized as follows:

1. Research on environmental causes of the summer mortality of sea farmed smolts of Atlantic salmon.

These mortalities concern smolts of *Salmo salar* during their first summer in the sea cages. The losses included between 15 to 80% of the stock. Each year, it appears about mid-June and ends with the end of July. Within this period, in two or three occasions, the daily mortality rate which is usually some parts per thousand increases shortly and can reach 4-5% of the stock per day. These periods of high mortalities last some days up to two weeks. They are connected with very calm and sunny weather.

The environmental conditions of two sites wer compared, one of high summer losses and the other with chronic summer losses. Temperature, salinity, turbidity, total bacteria, UV-B radiation, dissolved oxygen, and unionized ammonia were either similar on both sites, or more favorable in the site with chronic mortality. Effort is now focussed on the indirect effect of irradiance, because light-protected pens suffered similar mortalities as nonprotected ones.

This programme started in 1988. Reports on the results are anticipated by the end of 1992.

2. Guidelines of unionized and ionized concentrations of ammonia are being researched for farming salmonid species in sea water. Scientific literature about is toxicity in seawater is scarce. In freshwater, such data are very inhomogenous depending on the environmental conditions. The survey attempts to investigate the matter while controlling as many parameters as possible (temperature, salinity, dissolved oxygen, nitrite, turbidity, etc.)
The experiments were started in 1989. No date for achievement.

3. An industrial project of Atlantic salmon farming was develpoed in the Morla...? Bay (Brittany, France). It is managed in hulls of two ships moored at a site located 5 km offshore. The allowed production is 12 000 to year^{-1}. A very detailed environmental impact study was reviewed and accepted. It includes a mathematical model of currents and dispersion based on a two-dimensional model, integrating an average depth and the wind influences. Thus, the transport and mixing of disolved wastes from the farm could be predicted. It provided current fields at various tidal situations during neap and spring tides, and the

residual currents. These are directed outwards of the bay. The nitrogen excretion of the fish stock at the maximum biomass of the year was estimated and introduced into the model, the dispersion of nitrogen was computed (uptake by primary producers not included), and the additional concentrations of N were predicted by the model, according to the different tidal conditions. They were very low, approaching the natural concentration minimum (0.01µmol L^{-1} versus 1.0 µmol L^{-1}).

The lack of experience about the impact of such a large salmon farm led the French authoritries to an environmental survey of the zone during the period of increasing production, in order to control possible unexpected drawbacks.

The programme of this survey is as follows:

- self control of the farm
- each rearing volume to be checked daily (biomass, discharge, feeding pellets, veterinary treatment, mortality),
- quality of rearing water to be checked weekly (nitrogen compounds, phosphorus, turbidity, total organic matter, microbial content).
- survey on the environment:
- monthly bacteriological survey of water,
- sediment chemistry and benthos survey four times per year, in both the vincinity of the installation and a distant point,
- yearly checking of green algae proliferation along the closest part of the coastline (Ulva sp., Enteromorpha sp.),
- shape of the plume of nitrogen compounds around the farm at the most critical period (summer),
- physical, chemical and biological parameters of water quality near the farm at five stations, eight times per year (temperature, salinity, dissolved oxygen, NO3, NO2, NH4+, urea, PO4, Si, (OH)4, chlorophyll, particulate C and N, phytoplankton, zooplankton;
- veterinary survey of the stock.

4. Dichlorvos is used for controlling sea-lice infestation in salmonid farms. This product is very toxic for parasite crustaceans. Its high toxicity against other animals of the environment led to initiate a programme aiming at optimization of its use: dose, duration and techniques of treatment, ways of recycling the product, etc.

5. A research on industrial fish farming in offshore zones is planned (PRIMO). It concerns the mediterranean coastal zones with depth from 20 to 80 meters. The first application would be done on sea bass farming. The planned rearing structure would be a concrete tower set on sea bottom with several sattelite net cages able to be lifted up. The profitability of such an industrial farm will be assessed. Moreover, the automatization of the largest number of rearing functions would be looked for: feed poviding, treatment, sorting, net cleaning, etc. Funding decision now, 5 years for achievement.

5. A survey, presently in progress, is concerned with the optimization of the management of entirely closed rearing systems. Shrimp, prawns, scallops, and fish are involved in this project at various life stages according to species:

-larval stages for shrimps, prawns and fish;
-post larval stages of shrimps and fish;
-growing of juvenile shrimps;
-storage of reproduction stocks for scallops, shrimps, and fish;
-incubation of fish eggs.

The present aims are:

- to improve the sizing with regard to bio-technological results;
- to study the impact of veterinary treatments (antibacterial agents, antiparasites, etc.) upon the system operating;
- to design systems which are economical and practical for culture.

Presently in progress.

7. Determination of the carrying capacity for molluscs. The pilot studies on the Bay of Marennes-Oléron is continuing. The overall model clearly demonstrates an imbalance between the cultivated biomass and the trophic capacity of the area. This empirical model does not allow a spatial management and it mainly utilizes the hypothesis that the environmental variables are constant. For these reasons an analytical model is being proposed. In an numerical model the transport of the available food within the area and its limitation has been included. Advection and dispersion of food by transport is considered in different boxes where cultivated molluscs (oysters and mussels) and natural mollusc populations are present. An energetic model predicts the growth rate of oysters as a function of the temperature, the quantity and quality of the available food. A model of primary production has been built with derived variables such as nutrients and turbidity. It will be completed with the benthic model. Research now oriented towards a suspension and sedimentation model which could include resuspended biodeposits and the phytobenthos.

8. Determination of the impact of culture of oyster and mussel on suspension and accumulation of the organic matter on the bottom.

This work is in its first phase, it began in Thau Lagoon in the Mediterranaen where seasonal anaerobic conditions occurred in summer. The objective is to estimate the effect of mollusc culture on the oxygen consumption caused by respiration and by the deposit of faeces under the table over 15 years of cultivation.

Ireland

by
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1. Production trends

1.1 Salmonid production increased during the years despite serious losses of post smolts due to pancreas disease. Sea lice infestations were particularly severe due to protracted hot summer, necessitating repeat doses of dichlorvos.

1.2 Production of rope culture mussels further increased despite protracted closures due to the presence of Diarrhetic shellfish toxin (DSP) from June to September.

Production trends (tonnes)	1987	1988	1989
Atlantic salmon	2232	4700	6200
Rainbow trout marine	320	500	200
freshwater	600	680	645
Mussels (Mytilus edulis) rope	1500	2100	N/A
extensive	11870	10648	N/A
Oysters	264	575	860
others spp.	N/A	10	40

N/A - not yet available

2. Administrative measures

2.1 During the year the Department of the Marine gave legislative effect to the European Communities (Environmental Impact Assessmant) Regulations 1989 under which an En- vironmental Impact Statement (E.I.S) must be submitted for marine salmon and trout farms where the proposed annual harvest is to exceed 100 tonnes.

2.2 Mandatory monitoring programme has been expanded to inlude an annual measurement of sediment deposition, redox potential, and an assessement of the impact of solid waste on the benthos. The existing data base is currently being evaluated.

2.3 Mandatory codes of practice have been developed covering the use of drugs and chemicals, precise record keeping, disposal of dead fish, notifications of escapement and bleeding of fish at sea. These should come into force shortly and an inspection programme will be undertaken to establish compliance.

3. Research priorities

(1) Reduction of antibiotic inputs

(2) Efects of Dichlorous (NUVAN) on larval crustaceans and molluscs.

(3) Studies on the fate of antibiotics administered to fish in the environment.

4. Progress of existing projects

4.1 Trials are continuing with IVERMECTIN to establish the minimum effective dose for sea lice treatment. Residue levels and residence times in fish flesh are being examined using a more sensitive method which detects to a level of 2 p.p.b.

Laboratory trials have shown that the drug is not toxic to larval bivalves.
Contact: Dr. Peter Smith, Department of Microbiology, University College Galway (U.C.G.)

4.2 Efforts to develop a sensitive chemical method to detect very low levels of Dichlorvos in sea water were not successful.

4.3 Further studies at the Regional Technical College (RTC) Galway (Dr. B. Ottway) on sublethal effects of Dichlorvos showed that 50% *Gibbula lineata (monodonta)* failed to retract the foot when exposed to levels of 0.03 ppm Dichlorvos.

4.4 Trials on competitive exclusion of pathogens conducted at the Department of Microbiology University College Galway (Dr. P. Smith) were successful in vitro and attempts are now underway to apply these techniques under field conditions.

4.5 A project to examine the use of lysosomes to package antibiotics to reduce the leaching to the environment was postponed to April 1990 (Dr. P. Smith).

4.6 Trials on the use of Divosan Forte (Penacetic acid) as a sterilizing and decodlourizing agent for blood water arising from killing at sea have been concluded. The method is very effective, blood is disinfected, sterilized and bleached in 3 minutes. This is now commercially applied on a number of farms. (Dr.P. Smith)

4.7 A series of laboratory experiments to test the effects of NUVAN in the maximum concentrations likely to be found in the environment adjacent to treated cages was conducted at the Shellfish Research Laboratory Carna (Dr. David Jackson). Shore crabs (*Carcinus maenas*) were found to show no ill effects ofter exposore to 1ppm NUVAN for 24 hrs. The common prawn showed no ill efects after exposure to 1 ppm NUVAN for 1 hour but 6 hours exposure to 1 ppm NUVAN produced 100% mortality. Exposure to 1 ppm NUVAN for 24 hours had no detrimental effect on the survival or subsequent development to settlement of oyster larvae (*Crassostrea gigas*). Larvae of the clam (*Tapes semidecussatus*) were treated with 1 ppm NUVAN for 1 hour at a size of 170µ. The amimals were grown on through settlement for a period of three months. There was no significant effect on the growth of two species of marine microalgae (phytoplankton) *Chaetoceros calcitrans* and *Isochrysis galbana.*

Work undertaken at the Shellfish Laboratory during 1988 and 1989 included surveys of salmon cages and moorings and laboratory studies on toxicity in a variety of organisms.

Results of the survey work showed scallop, oyster and mussel spat to be plentiful on the moorings and floats of regularly treated salmon cages. Surveys beneath the cages showed adult scallop and prawns to be present.

The following were the list of therapeutics and other chemicals sold to the fish farming industry in 1989.

Product	Volume	
Nuvan	7713	L
Methasil (40% premix Sulphadiazine +Iramethoprim)	295	kg
Oxolinic acid	25	kg
Oxytetacycline pure HCl	1225	kg
MS 222 (anaesthetic)	1100	g
Chloramine T	398	kg
Chloramine B	9	kg
Malachite green (50% liquid)	725	L
Formalin	13415	L
Canthaxanthin	372	kg
Actomarc K 30 (1% Iodine)	170	L
Actomarc B 100 (10% Benzol)	725	L
Fish Farm Disinfectant (2% Iodine)	745	L

It must be emphasized that this data is preliminary and does not necessarily reflect the absolute usage on farms. For example in Ireland it has become mandatory for all farmers to keep a register of the usage of all chemicals on the farm but this was only introduced in mid 1989. The recorded usage of NUVAN for the six months ending December 1989 was 2004 litres. The assumption is made that usage was at least of the same order of magnitude for the first six month with a same allowance for small farms which may not have reported. So an estimate is made for total usage - whereas sale were recorded as 7713 litres. This may be due to end of year purchases or stockpiling. Final figures for farm usage will be in time for inclusion in the Technical Report.

Preliminary usage for 1989 in kgs/ tonne produced active ingredient ar estimated.

DICHLORVOS		0.390
Methasul	Sulphadiazine	0.014
	Irimethoprim	0.003
Oxolinic		0.004
Oxytetracycline		0.190
Canthaxanthin		0.058

The other chemical products listed are used mainly in freshwater.

Northern Ireland

by

Robert Rosell

Department of Agriculture for Northern Ireland

Aquaculture production

1) Salmon *(Salmo salar)* in sea cages

Initial production of salmon in sea cages has commenced at one site, due to produce 400 tonnes per annum from 1990 onwards.

2)Oysters

The following are tonnages of oysters have since 1984:

Year	Tonnes sold For human consumption	For ongrowing at other sites	Estimated value £ sterling
1984	124.400	163.000	273,000
1985	123.360	36.600	277,453
1986	126.400	78.500	284,253
1987	98.720	80.095	249,386
1988	125.650	33.146	342,827

3) Mussels *(Mytilus edulis)* - Cropping of natural beds.

Year	Tonnes	
1986	11	
1987	14	
1988	26	
1989-90	1 000	estimate
1991-92	4 000	projected estimate

4) Other species

Cultivation of Manila Clams *(Tapes semidecussata)* and Escallops *(Pecten maximus)* is comencing at one sheltered site. Commercial production levels have not yet been reached.

Research

The following projects are underway:

(1) Studies of nutrients, solids and BOD loading (from freshwater farms) in relation to feed formulation. (A/B)

(2) A study on sea survival, exploitation, migration routes and returns to source of experimentally released and microtagged S2 smolts of non-local genetic stock. Controls for comparison comprise similarily tagged wild native smolts and hatchery produced smolts of native origin. (A)

(3) An investigation of the spatial and temporal genetic differentiation of atlantic salmon stocks in relation to the process of gene flow, natural selection and genetic drift. The impact of stocking and farm escapement on genetic structure and fitness of natural populations will also be examined. (C)

(4) Multi- and single-locus hypervariable DNA probes are being developed for use in stock discrimination and in studies of fitness characteristics in wild and farmed stocks of atlantic salmon. (C)

Research organisations

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(B) Department of Agriculture for Northern Ireland, Freshwater Biological Investigation Unit, Greenmount Rd, Muckamore, Co. Antrim.

(C) The Queen's University of Belfast, Department of Biology, Belfast BT7 1NN.

Netherlands

by

Renger Dijkema
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1. Production trends

1.1 Molluscs

Mussel production in Dutch coastal waters remain variable, and the production capacity of the areas under cultivation is not reached in most years. This is often due to storm damage occurring in the Waddenzee area. In the fiscal year 1989 no storms were reported, but the results of the 1989-1990 (August to April) season and the following season will most likely be affected from the heavy storms experienced in the beginning of1990. Relocation of mussel cultivation plots to less riskfull areas in the eastern Wadden Sea is being considered, but such proposals are opposed by nature conservation groups, local authorities, and the shrimp fishing industry. Production of the Pacific oyster *(Crassostrea gigas)* is stable, but limited by varying and often low supply of oyster seed. This branch of the Dutch aquaculture industry will benefit from the forthcoming establishment of a mollusc hatchery and nursery. Production of the native flat oyster *(Ostrea edulis)* is beginning to suffer from the results of the outbreak of the

1.2 Fish culture

Production of cultivated eels in freshwater recirculation systems is increasing. No activities in sea water have been reported. The production of African catfish *(Clarias gariepinus)* in freshwater recirculation systems is increasing slightly. Attempts are made to attach a final phase in seawater to the cultivation, but this is only very short and is rather intended for flavouring the flesh. Farming of turbot in recirculation systems is in the experimental phase.

2. Research activities

2.1 Mussel culture

Mussel culture research in the Netherlands aimed, like in previous years, to determine primarily the effects of the flood barrier, which was constructed in the mouth of the Oosterschelde estuary in 1986. A study was made of mortality of mussels on a number of cultivation plots in the mouth of the estuary. This mortality occurred in the period April - June. The sediment on these plots became anoxic, resulting in mortality of the mussels on the plots. The phenomenon is attributed to the accumulation of sediment, rich in organic matter. This is originating from the dying-off of the yearly bloom of the phytoplankton species *Phaeocystis pouchetii*, which was particularly intensive in 1989. Biodeposition by the mussels themselves greatly increased the accumulation of sediment. Locally reduced current speeds must have caused the dead phytoplankton to concentrate in the area, its degradation causing an increased oxygen demand. In combination with increasing water temperatures and the usual post-spawning weakness of the mussels during that time of the year, the ensuing anoxic conditions are assumed to have caused the mortality, which also had been observed in 1987, when the bloom of *Phaeocystis* also was particularly intensive. Additionally, mortality was observed in the Waddenzee during the same period, which might have been caused by the same

combination of environmental factors. This could mean that the increasing eutrophication of the Dutch coastal waters, assumed to be the cause of the increasing intensity of the *Phaeocystis* bloom, is beginning to have a negative effect on mussel cultivation in the Netherlands.

Studies into growth, mortality and condition of mussels on about 40 experimental plots in the Oosterschelde, aimed at prospection for alternative locations for bottom culture of mussels are still under study. A first impression is that a number of plots, previously less appreciated by the mussel growers themselves, turns out to show the best production results.

A comparative study was made of the effects on the bottom and on the catch of three different types of fishing reas, in use for dredging mussel seed: a conventional mussel dredge, a hydraulic (non-suctional) cockle dredge used for seed fishery and a hydraulic suction dredge. The effects of the conventional dredge and the non-suctional hydraulic dredge appeared to be almost identical. The suction dredge caused high concentrations of suspended sediment.

2.2 Fish culture

Studies were carried out on first feeding of glass eels, using cod roe in combination with different types of commercially available dry feed. Also the effects of grading and stocking density on cultivated eels were studied. As yet, no significant effects could be demonstrated. Comparative research was started into the water quality in different commercial recirculating eel farms. In all farms, removal of suspended matter smaller than 80 micron appeared to be a problem, decreasing the performance of the water treatment system. The production of the farms appeared to be limited by the nitrite concentrations rather than by ammonia. A first impression is also that the skill of the farm manager in many cases has a greater influence on production performance than water quality, very good growth results being recorded in farms where high ammonia and nitrite levels were measured. First experiments with the cultivation of juvenile turbot in a flow-through system and a recirculating system revealed a substantially lower growth performance of the recirculating system, without measurable differences in the principal water quality parameters.

3. On-going research programmes.

Validation of the Oosterschelde ecosystem model SMOES.
To be completed in 1991

Improvements of the Waddenzee ecosystem model EMOWAD.

Research on experimental m ussel cultivation plots in the Oosterschelde, aimed at prospection for new culture sites.

Selection of areas for alternative mussel cultivation plots in the eastern part of the Waddenzee.

Measurements of in-situ production of nutrients and consumption of particulate food by cultivated and wild molluscs, experiments with intertidal tunnels and in raceways.

Research into mortality of cultivated mussels connected with biodeposition and increased sedimentation of organic matter in the Oosterschelde.

Comparative research into the influence of the use of different mollusc fishing gear on the sea bottom and on the catch.

Comparative research into the water quality in different recirculation systems for eels, removal of suspended solids and effluent quality.

Norway

by

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Production trends

The production from Norwegian Aquaculture is presented in table 1.

Table 1 Total aquaculture production in 1989. Compiled from various sources.

Atlantic salmon	114,844	Tonnes
Rainbow trout	3729	"
Arctic char	45	"
Blue mussel	143	"
Cod	19	"
Turbot	6	"
Cod fry	459,000	numbers
Turbot fry	341,000	"
Halibut fry	9,800	"
Oysters fry	12,000,000	"
Lobster fry	15,000	"
Manila clam fry	10,000,000	"

From 1988 to 1989 the production of Salmonids increased by 32.5% from 89,696 tonnes to 118,844 tonnes. The first hand value in 1989 was 3,694,459,000 NOK. The prognoses for 1990 are 150,000 tonnes.

A Norwegian license for fish farming allows you to use a certain water volume of the water body. The amount of fish enclosed is not predefined leading often to extensive stocking. A commity is evaluating the regulations to find alternatives that will decrease the stocking density and thereby improve the water quality and fish health.

Research programs

The majority of the research activity on environmental effects of mariculture in Norway is included in two research programs.

The "Frisk Fisk" program (frisk fisk means healthy fish) started in 1983. The aim

Sweden

by

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Introduction

The yield of Swedish aquaculture in 1988 was 7,456 metric tonnes(round fresh weight). The dominating species was the rainbowtrout (6,783 tons). Furthermore, there were 858 tons ofcultivated blue mussels harvested. The total value of the-aquaculture production amounted to 199 mill. SEK (approximately32 mill. US $). The compensatory program for releasing smolts ofsalmon and brown trout comprised 3.5 millions in 1988 and in1989.

Fishery management

For compensatory purposes 3.5 million smolts of salmon and browntrout were released in 1988 in Swedish rivers. The same amount ofsmolts were stocked as well in 1989.

Species	Number of released smolt (1000) in rivers leading to			
1988	Baltic	Lakes	Kattegat	Total
Salmon	2340	169	197	2706
Brown trout	629	145	11	785
1989				
Salmon	2388	207	172	2767
Brown trout	598	130	4	732

Commercial production

The commercial production of fish and shellfish in 1988 accordingto the official statistics (round weight in tons).

	Total production	Marine production
Rainbow trout	6783	4051
Salmon	363	363
Brown trout	-	-
Arctic charr	77	-
Eel	233	-
Total fish production	7456 (100%)	4414 (59.2%)
Blue mussel	858	858
Oyster	-	-
Freshwater crayfish	3	-

The fish production has thus increased by 57% compared to theprevious year. One the other hand the mussel production hasdecreased from 2556 tons in 1987 to 858 tons in 1988. The numberof enterprises engaged in aquaculture was 478, of which 297produced fish for consumption and 12 blue mussels. 173establishments cultivated juvenile fish for stocking. IThe numberof enterprises engaged in fish production, either for consumptionor for stocking purposes, of various species were as follows:

Species	Number of enterprises
Rainbow trout	272
Salmon	22
Eel	8
Arctic charr	28
Brown trout	9
Total	339

Diseases problems

In 1989 a new organisation "AB Fiskhaelsan" was established forcombat fish diseases and health control service. Some severediseases are especially noticed by the Swedish legislation andmust be reported. According to the Salmon Research Institute the-following diseases were reported in 1989.

Disease problem	Number of enterprises with reported outbreak of a specific disease
Viral Disease	
IPN	0
Bacterial Diseases	
Furunculosis	10
Bacterial Kidney Disease (BKD)	41
Enteric Redmouth Disease (ERM)	9
Infectious Dermatitis (ASA)	58
Parasitic infection	
Whirling Disease	0
Proliferic Kidney Disease (PKD)	5

Ongoing research

Salmonids:

1. The economic feasibility of public sea ranching of Atlantic salmon at the Swedish west coast (A).

2. The role and value of ecosystems for management and exploitation of renewable resources: the case of teh Baltic salmon (Salmo salar) (B).

3. The influence of the nuitritional status of fish on the formation of muscle proteins and maturation of the oocytes (D).

4. The growth and metabolism of salmonids in relation to feed and the structure and qualitative composition of muscles (E).

5. Fish migration and social functions (F).

6. Fish physiology. Environmental and comparative physiology and biochemistry. Chemoreception and orientation in chemical gradients (F).

7. Comparative studies on monoamine metabolism in lower vertebrates with emphasis on anoxia tolerance (F).

8. Carlonic anhydrase inhibition in vivo in rainbow trout acclimated to water of different ionic and gaseous compositions (F).

9. Lake water cage culture of arctic charr (G).

10. Analysis of the Arctic charr's basic properties for aquaculture (H).

11. Effects of alternative reproductive tactics on male spawning behaviour and migrational status in Baltic Salmon (H).

12. Sea-ranching with Baltic Salmon. Non-river based experiments with delayed releases (H).

13. Feeding behaviour of arctiv charr (H).

14. Genetic studies of arctic charr (H).

15. Sociobiological interactions in size and sex structure of Baltic salmon parr populations (H).

16. Disease resistence in stocks of cultivated fish (H9.

17. Population genetic studies of salmonid strains for cultivation and fishery management (K).

18. Breeding research on various strains of trout.

Cod:

1. A feasibility study on sea ranching of cod in the Bothnian Bay and the Swedish west coast (A).

2. Development of methods for the improvement of the recruitment of cod populations in the Baltic proper and the Bothnian Sea (B).

Freshwater crayfish:

1. Investigation on the reproduction and growth in Astacus astacus under intensive and extensive aquaculture (B).

2. The nutritional requirements of juvenile Astacus astacus with special reference to protein/energy ratios (C).

3. Social interactions between the species Astacus astacus and Pacifastacus leniusculus (C).

4. The growth rate of Astacus astacus under natural and experimental conditions (C).

5. Biochemical, molecular and molecular genetic studies of the immunoreactions of the freshwater crayfish (L).

Diseases problems:

1. The effects of vibriosis vaccination on the survival and antibody production of rainbow trout under various conditions (J).

2. Investigations on Aeromonas salmonicida infections (I).

Research bodies

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D. The Wenner-Green Institute, University of Stockholm, S-106 91 Stockholm

E. Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management, P.B. 7024, S-650 07 Uppsala

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J. National Veterinary Institute, S-750 07 Uppsala

K. Institute of Freshwater Research, S-170 11 Drottningholm

L. Department of Physiological Botany, University of Uppsala,
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Use of Chemicals in aquaculture

Although there exists no official statistics on the use of chemicals in Swedish aquaculture, some estimates have been made by various institutions. In 1989 about 394 kg of active substance have been used by aquaculturists corresponding to 0.044kg drug applied per tonne of fish produced. Additional about 147 L of vibriosis vaccine have been used, corresponding to 0.02L of vaccine applied per tonne of fish produced. A total of 20 to 25 tonnes of formaldehyde (30%) has been used in 1989 by the aquaculture industry in Sweden. The total amount of malachite green used has been estimated at 75 to 100kg.

Scotland

by

Ian M. Davies,
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and
John G. McHenery

The 1989 production figures for cultured marine organisms in Scottish waters are presented in the following table:

Species	Production (mt)		
	1988	1989	1990(est.)
Atlantic salmon	17,951	28,553	37,000
Rainbow trout	709	482	?
Turbot	?	?	?
Shellfish			
Mussles	463	440	
Oysters	134	139	
Scallops	13	11	
Queens	124	86	

At present Salmon farming is carried out in Scotland at 333 (244 in 1988) sea sites and in 12 (11 in 1988) land based farms. Some 26 million smolts (21 million in 1988) were placed in sea water from companies operating 68 freshwater sites (176 in 1988). The production of Atlantic salmon is continuing to increase as previously reported (55% over 1988). Due to disease, vaccine use has been recorded at 65 sites, compared with 11 in 1988.

In 1989, 223 shellfish farms were registered in Scotland, of which 181 (174 in 1988) were active. The size of units varies graeatly, and most of the mussel and oyster production came from less than 20 farms each.

Appendix 5: Suggested layout of the information sheets on "chemical usage in mariculture"

Common name: ..... (does not include trade names)	
Chemical name: ..... (includes structural formula)	
CAS No:..... RTECS No:..... (as far as possible) Other Monographes: ..... (original literature see below)	
Use:	Info on areas of application
Application Route:	includes info on preparation and dosage, concentrations and frequency of application effectiveness, etc.
Withholding:	Info from various countries, if available
Precautions:	Info on toxicity and side-effects
Environmental Implications:.....	Info on toxicity to other biota, ecological aspects, long-term effects, etc.
Relevant Literature:.....	A selection of references