

International Council for the
Exploration of the Sea

C.M.1984/F:1
Report of Activities

MARICULTURE COMMITTEE

by

D. Møller

1983

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Belgium

No report received.

Canada

No report received.

F: withdrawn: 5, 18, 13, 15
fehlen: ./.

DENMARK

(E. Hoffman & H.P. Bak)

The marine research in Denmark in 1983 covered the following species: Salmon (Salmo salar), Rainbow trout (S. gairdneri), Herring (Clupea harengus), Cod (Gadus morhua) and Turbot (Psetta maximus).

Salmonid fish.

A long term programme of restocking different rivers with salmon fish was continued. All the released fish were marked by tagging technique. Different groups of fish were released on selected places along a river system and marked individually.

Sea farming of rainbow trout has become a new growing area in Denmark. The farmers use cage culture to grow the trouts from 200-700 grams up to 2-3 kilos. Sea farming, however, faces a lot of problems, especially the often very high jump in both sea water temperature and salinity. Further more several diseases cause problems during the season.

To prevent high mortality following the transfer from fresh to sea water experiments are being conducted to secure a good smoltification before the transfer.

As the nutrition needs are different in sea water and in fresh water, experiments were carried out to develop a new and better feed for trouts in sea water.

Larvae recruitment.

To find the reason why recruitments of commercial important fish are oscillating, several experiments, concerning larval survival at different plankton food densities, were carried out. The herring is well fit to this kind of research, as it is relative easy to hatch in the laboratory.

The culture of turbot has yet to start in Denmark, however, feeding experiments using natural plankton and artificial micropellets, was carried out at a low scale.

North Sea Centre.

In the summer 1983, a new aquacultural laboratory was established in the North Sea Centre in Hirtshals, under the Danish Institute for Fisheries and Marine Research, which main office is in Charlottenlund near Copenhagen.

The new laboratory of Marine Aquaculture was started up - for the time - as a project to help the Danish aquaculture industry and to coordinate and develop the marine aquaculture research. The main headlines for the new laboratory will be nutrition studies, larval rearing and reproduction and genetics.

Statistics

Species	Tonnes	Approx.no in 100.000	Values in 1.000 US-dollars
Rainbow trout in enclosures	930		3500
Flat oyster (from culture beds)		0.15	10
Pacific oyster (Crassostrea gigas) from cage culture		1.00	60

FINLAND

(P. Tuunainen and K. Westman)

Mariculture in Finland is based on one hand on sea ranching of salmon (Salmo salar), sea-trout (Salmo trutta trutta) and migratory whitefish (Coregonus lavaretus) by introducing smolts of salmonids and 1-summer old whitefish young into the sea. On the other hand it is base on production of rainbow trout (Salmo gairdneri) in net cages and enclosures for human consumption. Mariculture production is continually increasing. This is caused by good domestic markets for rainbow trout and by efforts to increase the volume of sea ranching of the species mentioned above. As a new species for marine net cage culture the Baltic salmon (Salmo salar) is gaining more and more interest and experiments in this field are going on.

Restoration of salmon and sea-trout rivers is going on and remarkable increases in the numbers of parrs in the restored rapids have been reported. In two of the rivers, Simojoki and Tornionjoki, flowing into the Bothnian Bay constant monitoring programs are going on.

Study programs were also carried out to find out the production biological and economic results of the introductions for sea ranching, to improve the quality of reared fish young, to measure the quality by physiological tests and by tagging the fish. Work has also been done to improve the rearing methods and to decrease water pollution caused by larger fish farms.

For the UDN of the Baltic salmon stated in the middle of 1970s still limitations in transfers of fish between the sea and freshwater area as well as between the inland watercourses exist.

Especially in rainbow trout culture in the sea area the vibriosis disease still causes considerable harms and better vaccines against it are being developed.

For food fish production of salmon and rainbow trout in net cages and other marine farms comparative rearing experiments between different stocks have been carried out. These experiments include also rearing in warm effluents of nuclear power plants.

The quality of reared salmon and sea trout smolts has gained more and more interest and therefore physiological studies on the quality of wild and reared smolts as well as the criteria for reared smolts have become as an object of interest. These studies have been connected with tagging experiments with the Carlin tag as well as with the nose tagging with micro tags.

In connection with the COST 46 of the EC project on the factors increasing the survival rate of salmon smolts in the sea has been carried out in the area of the Bothnian Bay.

Because year after year a greater share of the input of salmon and sea trout smolts into the Baltic Sea is based on the reared smolts and because there are some indications of the influence of fishery, too, into the genetics of fish stocks also studies on the genetics of the wild and reared salmon and sea trout stocks have been intensified.

OUTLINE FOR STATISTICAL INFORMATION ON MARICULTURE PRODUCTION

Mariculture production 1982 (figures for 1983 not yet available)
Country: Finland

Species	in metric tons	approx. number in 100 000	value in 1 000 US \$
Rainbow trout in enclosures more than 0.5 kg each	3 226	-	11 000
Salmon smolts for introductions, 1 year and older	-	13.51	2 100
Other salmonids (specify): Sea-trout for introductions 1-summer old and older	-	8.56	1 100
Others (please specify): Migratory whitefish for introductions 1-summer old	-	78.26	560

FRANCE

(J. Guillaume and M. Grizel)

PARTIE CONCERNANT LA MARICULTURE AUTRE QUE
L'AQUACULTURE DE MOLLUSQUES

La production des diverses espèces peut se résumer ainsi :

Après une période de rapide augmentation de la production des élevages de salmonidés en mer, celle-ci reste stable depuis 1982. La production 1983 a atteint 430 tonnes environ, dont 350 tonnes de truites arc-en-ciel, 70 tonnes de saumon coho (Oncorhynchus kisutch) et 10 tonnes de truite fario (Salmo trutta).

La production de saumon coho s'est étendue à 8 exploitations en 1983. La reproduction en captivité de l'espèce reste mal maîtrisée.

En ce qui concerne la truite arc-en-ciel, les mortalités d'été se posent toujours avec autant d'acuité. Les essais réalisés avec de nombreuses souches différentes n'ont pas apporté d'améliorations.

Les essais de diversification des espèces de salmonidés élevables se poursuivent avec la truite fario et le saumon atlantique.

L'aquaculture d'autres espèces de poissons est restée au stade expérimental, bien que les efforts aient été intensifiés sur le turbot (Scophthalmus maximus).

Les recherches ont été poursuivies sur les salmonidés, les poissons plats et la crevette japonaise :

L'activité de la NaK ATP ase branchiale a été mesurée en même temps que les hormones thyroïdiennes plasmatiques et l'équilibre hydrominéral du milieu intérieur durant tout un cycle d'élevage chez le saumon atlantique (Salmo salar), ainsi que lors de transferts d'eau douce en eau de mer et d'eau de mer en eau douce chez la truite arc-en-ciel (Salmo gairdneri).

L'emploi de traceurs radioactifs (glutamate ^{14}C) a permis de mettre en évidence les effets de la smoltification et du transfert en eau de mer chez le saumon coho.

Des suivis physiologiques du transfert en eau de mer ont également été effectués pour la truite fario et divers autres salmonidés (truites arc-en-ciel, polyploïdes, hybrides, etc...).

Chez le turbot et la sole (*Solea solea*), des régimes synthétiques (à base de caséine et gélatine) permettant une croissance très rapide ont été élaborés. Grâce à ces aliments, le besoin protéique, très élevé dans ces deux espèces, a pu être évalué. On a également montré que le turbot et la sole avaient des aptitudes très différentes à utiliser les nutriments énergétiques (glucides et lipides). Les techniques d'élevage du turbot ont peu progressé par suite de problèmes d'origine bactérienne rencontrés dans la production des animaux proies (rotifères).

Chez la crevette japonaise (*Penaeus japonicus*), la nutrition phosphocalcique a fait l'objet de plusieurs expériences : le besoin en phosphore, nettement prépondérant, est élevé, et l'efficacité des différents sels de phosphore très inégale. Le rôle particulier de la farine de calmar a été explicité : un facteur d'appétence et un facteur de croissance ont été séparés.

Des essais à caractère pratique ont montré la possibilité de produire la crevette japonaise en conditions semi-extensive dans les marais de l'Île de Noirmoutier.

MOLLUSQUES

Pectinidés

Pecten maximus

Suite aux résultats très moyens du captage en Baie de Saint Brieuc, un programme de production de coquilles en éclosérie a été mis en place. En 83, ont été obtenus 250 000 juvéniles issus de l'éclosérie d'Argenton, puis prégressés à la nurserie du Tinduff et enfin mis en station d'élevage intermédiaire au C.O.B..

Les lots de jeunes coquilles importés d'Irlande courant 1982, ont subi une mortalité hivernale estimée à 60 %.

Pecten jacobaeus

Les premiers essais ont permis d'obtenir des pontes et de mener à bien l'élevage des larves. Des accidents dus aux développements des eaux colorées sont survenus lors du stade post-larvaire.

Chlamys varia

La première pêche sur le semis de juvéniles réalisé en 1982, a permis d'obtenir 13 tonnes de Chlamys après 2 jours de pêche effectué par 60 bateaux. Le taux de survie^{est} estimé à 18 %.

Un deuxième semis de $3,3 \cdot 10^6$ millions de bêtes a été réalisé.

Vénéridés

Les premiers résultats des semis expérimentaux à grande échelle (6 840 000 palourdes semées à la taille de 7 mm sur 26 sites à des densités variant de 180 à $300/m^2$) sont très encourageants sur le plan financier.

Les meilleurs résultats sont obtenus sur l'estran, pour des coefficients de marée compris entre 50 et 60. L'accroissement en poids est de 20 g en 19 mois. Ces données ont été confirmées sur le site pilote de Brenon, où les recaptures par engin mécanique ont été de 80 %, avec seulement 1 % de mortalités dues à la technique de récolte.

L'étude de l'incidence de la taille du semis en fonction de la période a montré que les gains de croissance sont maximaux pour le prégrossissement hors sol pour la période de mai à août, pour le grossissement dans le sol lorsque les semis sont réalisés tôt dans l'année (mars - avril).

La production de palourdes en 1983 est de l'ordre de 100 à 150 tonnes.

Ostréidés

Ostrea edulis

La production d'huitre plate est restée très basse en 1983 (1 500 à 2 000 tonnes) à cause des épizooties sévissant toujours en Bretagne.

Les résultats du plan de sauvegarde sont toutefois encourageants et devraient permettre de poursuivre la culture de cette espèce en accroissant progressivement les tonnages actuels.

Crassostrea gigas

La reproduction de cette espèce a été dans l'ensemble bonne. La surpopulation de certains bassins a entraîné des désordres physiologiques chez les huîtres très affaiblies et maigres aboutissant à des mortalités hivernales.

Des mortalités estivales ont également été observées. Elles semblent être en relation avec les températures très élevées survenant au moment de la période de frai.

Mytilidés

Mytilus edulis et M. galloprovincialis

La rentabilité de la culture sur moules en longues lignes n'a pu encore être démontrée.

Une recrudescence de *Mytilicola intestinalis* est notée dans certains bassins d'élevage. Des réductions d'implantations visant à rabaisser la densité de population ont été proposées. L'étude d'impact est en cours.

FEDERAL REPUBLIC OF GERMANY

(K. Tiews)

Crassostrea gigas:

Indoor experiments on the rearing of spat were continued as well as outdoor experiments on the fattening of spat to marketable sizes.

Container culture experiments on various places along the German North Sea and Baltic coasts were also continued by the Institut für Küsten- und Binnenfischerei.

Salmonid fish:

Studies on the development of techniques for marine intensive culture were continued at the Institut für Meereskunde, Kiel. Vaccination experiments were included. Comparative experiments on the behaviour of dense schools of herrings, of salmonids and of antarctic krills were carried out under special consideration of gas-physiological and behaviour biological parameters aboard the swimming laboratory of the Institut für Meereskunde, anchored in the Bay of Kiel.

Turbot:

Studies on the reproduction of turbot and on the rearing of the fry were continued at the Institut für Meereskunde. These studies included also feeding experiments to replace fishmeal in pellet feeds. For the automated assessment of the metabolic rates in growing turbot, computerized measuring techniques were developed.

Eel:

Research on eel farming in heated effluents of a conventional power station was continued at the experimental station Emden of the Institut für Küsten- und Binnenfischerei. Also scaling up experiments for the mass rearing of elvers in silos including the optimisation of feeds for these were continued by the same institute in its laboratories in Hamburg and Ahrensburg.

Recirculation sea water systems:

The Biologische Anstalt Helgoland concentrated its efforts also in 1983 on studies related to the performance of recirculation systems in brackish water. Of special interest was the study on the influence of the O_3 -concentration on the oxidation of ammonium, nitrite and BSB, and also the long-term stabilisation of water values in recirculation systems and the development of water purification systems using submersed cylindric filter reactors.

Fish pathology:

Work to develop methods with which to describe stress conditions for fish in intensive aquaculture systems was continued at the Institut für Hydrobiologie und Fischereiwissenschaft of the University of Hamburg. Immune biological studies on rainbow trouts were continued at the Institut für Meereskunde, Kiel.

Statistics: (Federal Republic of Germany)

	Tonnes	Approx. No. in 100 000	Value in 1,000 U.S. Dollar
Blue mussels (<u>Mytilus</u> <u>edulis</u>)	32,750	-	2947
Pacific oysters (<u>Crassostrea gigas</u>) from vertical cultures	1	-	5
Eel (<u>Anguilla anguilla</u>) not fresh water	15	-	88

GERMAN DEMOCRATIC REPUBLIC

No report received

ICELAND

(I.Johannesson & S.Tr Einarsson)

During the year 1983 about 800 000 salmon smolts, approximately 850 000 fingerlings were produced in Iceland. A little less than 400 000 smolts were released from ocean ranching stations with the intention of catching the returning salmon in traps. About 400 000 smolts and about 850 000 fingerlings were released into the river systems in order to increase catches. In the year 1983 11-12 000 salmon were caught in traps by the ocean ranching stations. Recapture of salmon smolts released by the ocean ranching stations seems to improve as people learn the right technique of producing and releasing the smolts.

The total production of farmed salmon is estimated 60 tons during the year 1983, but will reach approximately 200 tons in 1984. The total catches by anglers comes to approximately 200 tons yearly. However these figures can vary.

As production of farmed salmon and salmon produced through ocean ranching is relatively small, it has been possible to dispose of it to the inland market. It is evident, however, that if the production by ocean ranching increases marketing possibilities will have to be investigated, especially because the salmon produced by ocean ranching returns during a short period of 2-3 months in the summer. It is also evident that production of farmed salmon is increasing, thus that the production will have to be sold to foreign markets. The Icelandic Norwegian Fish Farming Company ISNO are planning to sell their next year's production of 120-140 tons to U.S.A. Generally speaking marketing possibilities have not been investigated to any extent over there.

Salmon is in fact the only species of fish being produced in rearing stations here. There has been very little effort made in cultivating trout, char and rainbow trout. Very limited experiments have taken place in culture of marine species.

It is clear that in Iceland environments are favourable in many places for producing salmon smolts in great quantities. It is not possible to produce salmon in cages except in very few places because the temperature of the sea is apt to drop below the danger mark during the winter. Therefore it is likely that farmed salmon in the sea will not be carried out in any measure unless the sea can be warmed by geothermal heat which is to be found in many places. Studies as to whether such operation is economical are now being carried out on Reykjanes by the ISNO Company, in co-operation with the Norwegian firm Norsk Hydro.

People here are mainly interested in ocean ranching. The State hatchery at Kollafjörður and the ocean ranching station at Lárós have obtained good results. The problem in connection with ocean ranching is mainly that recapture is always variable, because of different conditions in the sea. It also takes time to develop the suitable technique for production and release of smolts. Therefore it is evident that it is difficult to develop a business when it is uncertain what the end result will be, and it is not possible to control the quantity of the final production. However, the results obtained in ocean ranching experiments during the past years raise hopes that ocean ranching can be developed into a promising industry.

IRELAND

No report received.

NETHERLANDS

No report received.

NORWAY
(G. Nævdal)

INTRODUCTION

Research on problems related to mariculture is carried out by the following institutions in Norway:

1. Section of Aquaculture, Institute of Marine Research, Directorate of Fisheries, Bergen (including two research stations, Matre and Austevoll).
2. Institute of Nutrition, Directorate of Fisheries, Bergen.
3. The State Biological Station Flødevigen, Arendal.
4. Research Station for Salmonids, Sunndalsøra and Averøy, The Agricultural Research Council of Norway, Agricultural University of Norway, Ås.
5. University of Bergen
 - 5.1 Institute of Fisheries
 - 5.2 Zoological Museum and Institute of Microbiology and Plant Physiology.
 - 5.3 Institute of Biochemistry
6. Institute of Fisheries, University of Tromsø
7. Regional High School, Sogndal
8. National Veterinary Institute and Veterinary College, Oslo
9. Norwegian Herring Oil and Meal Industry Research Institute, Bergen
10. Norwegian Institute for Water Research (NIVA)
11. Nordland Research Foundation, Bodø

In the following report the institutions are referred to by number. The greater part of the institutions are concerned with short-time experiments on salmonids and on new potential species of aquaculture. Long time experiments are conducted at (1), (3), (4) and (6).

RESEARCH PROJECTS

Quantitative genetics

Experiments with selective breeding of Atlantic salmon and rainbow trout were continued, (1) and (4). The following sub-projects are included:

- a. Selection programmes to increase growth rate (1) and (4), reduce mortality (4), improve meat quality (4) and increase age at maturity, (1) and (4). At Sunndalsøra and Averøy about 300 families of Atlantic salmon and rainbow trout are tested in each year class in the selection programme.
- b. Study of phenotypic and genetic parameters in production traits including flesh pigmentation, (1) and (4).
- c. Study of inbreeding depression, (4).
- d. Study of heterosis effect, (4).
- e. Induce polyploidy to obtain a triploid fish which do not develop gonads. Production of all female triploids are under way, (4).
- f. Induce gynogenesis, (4).
- g. Study genetic variation in stress measured by cortisol level, (4).

At (6) a programme was initiated aimed at developing Arctic char, Salvelinus alpinus, as a salmonid for farming in northern regions. Progeny obtained by stripping wild fish from 11 different and widely separated populations in Northern Norway are being raised in order to establish base populations for later selective breeding programmes. Growth rates, age at maturity and osmoregulatory ability in seawater are the parameters of immediate interest.

Behaviour

Studies on antipredator behaviour in Atlantic salmon smolt were continued (1). The behaviour of cultivated smolt in relation to potential fish predators (cod, saithe, rainbow trout and others) was observed in a tank in order to reveal differences in smolt reacting to predators. Conditioning of smolt to avoid predators will be tried in an effort to improve recapture rate of released smolt.

Tracking of smolt migration in the sea was conducted with the aims of comparing wild and raised smolt, and study the migration of the fish in relation to the hydrography in the migration area. Fish behaviour studies in connection with fish farms in freshwater lakes are studied in a cooperation project between (1), (5.1) and (5.2). The behaviour of cod under influence of seawater polluted with crude oil was studied at (3).

Physiology and nutrition

Laboratory experiments on nutrition, digestion, growth, metabolism and energy budget of cod were continued (1).

Use of shrimp wasted for salmonid feeding was further tried out (1) and also experiments with comparison of different carotenoids were continued (4).

Feed treated with hydrochloric, formic or sulphuric acid were fed to rainbow trout to test the effects on protease activities, growth and feed utilization (2). Silage conservation of fish feed including long term effect, health and meat quality, was studied by (4).

Studies on protein, fat and carbohydrate level in fish food, digestibility, feed consumption at different temperatures and of varying fish size, and comparisons of wet and dry diets in salt water at low temperatures were carried out by (4) and (1). Also effects of different "new" feed ingredients were examined at (4).

Studies on factors responsible for varying egg quality of reared salmonids were continued by (1), (2) and (4).

Particularly, investigations concerning the effect of vitamin C supplementation to brood stock diets on reproduction in salmonids were carried out by (2).

Use of binders in salmon feeds (to increase feed efficiency and reduce water pollution) was studied by (2) and (4). Effect of dietary copper on rainbow trout was investigated by (2). In collaboration between (2) and (9) the following research activities on salmon nutrition were conducted in 1983:

- Influence of heat treatment in fish meal production on the protein quality in dry diets for salmon, effect on growth and feed utilization.
- The effect on growth and feed consumption in salmon using different fish meal qualities in the diets.
- Fish oil produced on capelin caught in winter or summer season as an energy source in diets for salmon.

Pathology

Work on vaccination and vaccines against vibriosis was continued by (1) and (6). Different disease problems at fish farms have been looked into. Special attention are still given to the cold-water vibriosis or Hitra-disease at (1). Studies on spreading of IPN-virus from known carriers in fish farms to the marine environment was continued (1).

At (8) the following projects were conducted:

- a. Vaccination experiments against vibriosis with special emphasis on comparison of commercially available vaccines.
- b. Registration of IPN in Norwegian Fish Farms and wild fish populations.
- c. Infection with Ichthyobodo necator in sea water.
- d. Methodology development for detection of residues of drugs in fish.
- e. Epidemiological, clinical, hematological and treatment studies in connection with hemorrhagic syndrom (Hitra disease).
- f. Cataract in fish.
- g. Uptake of drugs after intravenous injections.
- h. Methodological studies on lysozym in fish serum.
- i. Immunstimulating drugs and possible effect at vaccination.

Aquaculture technology

Experiments to assess the effectiveness of several antifouling impregnants for net pens were terminated in 1983 (1). Also experiments of storage of live saithe in net pens for subsequent delivering was continued in 1983 (1). Systems for resirculation of fresh water and treatment of acid water for smolt production were further studied and improved by (1). Oxygen consumption and effect of varying oxygen levels and supersaturation with nitrogen were studied at (4).

Experiments on raising of smolt in net pens in fresh water including ecological aspects were carried out in a joint programme by (1), (5.1) and (5.2). At (10) the following research programmes were continued:

- Development of advanced fishfarming plants with special attention to water quality, energy conservation and water demand.
- Research on aquaculture systems for waste water treatment including technical design, selection of species, inoculation, harvesting etc.
- Encouraging extensive fishfarming in the 3. world as part of the national development aid.
- Integrated research (social, natural and technological) on optimal localization of fishfarming plants. This project is part of a larger research programme on utilization of the coastal zone.

Rearing of marine fish larvae

The programme on mass-rearing of cod fry in an enclosed pond, initiated in 1980, was continued also in 1983 (1). The pond was treated with rotenon to exterminate predators on the cod

larvae and fry. The larvae were released at the yolk-sac stage and collected during summer and autumn. The tagging and release programme on cod fry was continued and considerably increased. Also the programme on rearing of cod fry in plastic bags in the sea was continued (1), and a programme for composing an artificial or semi-natural feed for cod larvae was continued (1). Ripe fish were caught with gill nets on the spawning grounds. A brood stock of halibut has been established.

Experiments with hatching and rearing marine fish larvae and fry was also continued by (3) in a land situated basin. A special experiment was carried out with eggs and larvae from mature cod which had been hatched and reared in the laboratory two and three years ago (3).

Other projects

Experiments on commercial culture of blue mussels were continued, (1) and (7). Similar experiments on culture of scallops were continued in a small scale; (1), (6) and (7).

Developmental studies of hatching system for increased production of oyster larvae were initiated (1).

Feeding experiments with newly hatched larvae of lobster were continued, and the effect of various food was investigated (3). Technology for raising lobsters in large scale is being tried out by a private firm.

STATISTICS

The main mariculture production in Norway is rainbow trout and Atlantic salmon. The public statistics give no breakdown on production in fresh and salt water, and the production in fresh water is not reported in the inland fisheries statistics. The total production therefore is given in the following table:

Species

In metric tons

Rainbow trout in enclosures	5 270
Salmon in enclosures	17 000

However, the quantities produced in fresh water are small, and less than 5% of the total production is indicated. Concerning other species, no statistics exist, but some quantities of blue mussel and oysters were produced.

POLAND

(J. Wiktor.)

Rainbow Trout

In the years 1982 and 1983, experiments were conducted with two goals in mind:

- the lowering of mortality due to such diseases as hemorrhagic septicemia in fish reared in cages,
- the lowering of migratory tendencies of trout stocked directly into the Baltic.

The results obtained so far show that the immunity from such diseases as hemorrhagic septicemia is high in fry reared from the eggs of spawners maturing in the sea as well as in fingerling whose acclimatization to brackish water conditions took place in water with a low temperature.

Preliminary observations indicate that the tendency to migrate from the place of stocking decreases if the fingerling is subjected for several months before stocking to the preliminary adaptation in cages with brackish water.

Statistics

In the years 1982 and 1983, no cage rearing on an industrial scale was carried out in Poland in the Baltic. On an experimental scale 1/4 of the technical/ the results were the following /in metric tons/

Species	1982	1983
Rainbow trout /0.5-1.5 kg per specimens,	10.0	6.8
Rainbow trout /spawners/ /2-4 kg per specimens,	0.5	0.5

Besides, the coastal waters of the Baltic were stocked with the fingerlings of rainbow trout /30-100 g per specimen - 400,000-600,000 specimens annually.

PORTUGAL

No report received.

SCOTLAND

(A.Munro)

Commercial Atlantic salmon culture produced 2,536 tonnes in 1983 an increase of 18% over the previous year. Smolt production increased by 72% over 1982. With increases in ova laid down, and increasing smolt production Atlantic salmon tonnage should reach 5,000 tonnes by 1985. Production of rainbow trout was 2,009 tonnes of which only 73 tonnes was produced in sea water. Eel production ceased in 1983, whereas significant expansion of juvenile sole and turbot production, mostly for export to Europe, began.

Research on aquaculture projects was conducted at the following Scottish Laboratories:

The Dunstaffnage Marine Research Laboratory, Oban, Argyll
The Heriot Watt University, Edinburgh
The Institute of Aquaculture, Stirling University
The Institute of Marine Biochemistry, Aberdeen
The Marine Laboratory, Aberdeen
The Zoology Department, University of Aberdeen, (Immunology of Fishes)
The Torry Research Station, Aberdeen
The Sea Fisheries Authority, Ardtoe

Their research programmes were much as reported last year and the following is a progress report from available information.

Dunstaffnage

Salmon nutrition - studies of the inclusion of fish silage in moist pellet diets included the need to use antioxidants, the loss of the essential amino acid tryptophan during silage storage and of the problems associated with ensiling bacteriologically spoiled fish.

Studies of egg composition and quality of rainbow trout and salmon were conducted using a range of biophysical and biochemical determinations on single eggs. The project concluded that although major differences were found between eggs from different females the major factor determining quality as measured by survival to first feeding, was ensuring stripping occurred within 7-10 days of ovulation.

A study of the ichthyotoxic factors passed by the dinoflagellate Gyrodinium aureolum was begun.

Institute of Marine Biochemistry

Work on the mechanism whereby vitamin E and a seleno-metallo enzyme (glutathione peroxidase) minimise the potentially toxic effects of peroxidized lipids in diets or generated by cell metabolism was completed using rainbow trout as experimental animals. The results suggest that the nutritional status of the fish for vitamin E could be reliably assessed by erythrocyte fragility tests and by the concentration of vitamin E in the liver and selenium in soft tissues such as liver and kidney.

Trials to establish the dietary requirement for typtophan established a minimum of 2.5g per kg of diet for rainbow trout.

The incorporation of chitin as a substitute for carbohydrate in trout diets gave depressed growth compared to controls and it was concluded little utilization occurred.

Torry Research Station

Work continued to establish a) the best methods for killing salmon to ensure subsequent carcass quality and b) to establish a more efficient method of ensuring efficient uptake of canthaxanthin for flesh coloration of salmon.

Marine Laboratory

Continuing studies of the effects of IPN virus infection on juvenile Atlantic salmon are in progress. Mortality may be high in alvins and first feeding fry but strain of virus is equally important.

Study of the toxins produced by different isolates of Aeromonas salmonicida indicate significant differences yet biochemical and serological comparisons between isolates indicate considerable uniformity.

Bacterial kidney disease has become firmly established in certain fresh-water trout farms in Scotland. It has been concluded that the occurrence of the disease as an economic problem is principally caused by the management system adopted by farmers. Prevention of lateral transmission between older infected stock and young uninfected fish adequately controls the economic consequence of this disease.

An ultrastructural study of exocrine pancreas cells of Atlantic salmon suffering from a pancreas disease of unknown aetiology has been conducted. In fish about to suffer onset of the disease a marked change in the acinar cellular endoplasmic reticulum from spherical to plate like formations is noted. Further work on this disease is in progress.

SPAIN

No report received.

SWEDEN

No report received.

U.S.A.

(J.H.Ryther & A.Longwell.)

Research and development on the commercial cultivation of marine, estuarine and anadromous species is now the exclusive responsibility of the U.S. Department of Commerce through its own programs in the National Marine Fisheries Service and through grants to universities and other non-government research organizations by the Office of Sea Grant.

Office of Sea Grant - sponsored Mariculture R and D Projects:

The Sea Grant Aquaculture Plan, 1983-1987 identified species of interest, indicated their approximate level of commercial development, and specified research needs as they relate to those species. Funding targets were established in the plan and priorities designated for both species (20) and subject areas (32).

Of the 640 identified areas, 93 (14%) are currently funded by the Office Sea Grant. Excluding freshwater cultivation and educational/advisory activities, the remaining 69 mariculture research projects are listed below.

Sea Grant Mariculture projects in progress in 1983:

I. Crustacea

1. Hatchability of the Brine Shrimp, Artemia salina Variation in Intracellular pH and its Effect
University of California
2. Particle Size Limitations in Osmotic Infiltration Techniques for Immunization of Shrimp
San Diego State University
3. Development of Procedures for Artificial Insemination and Sperm Storage in Lobsters
University of California
4. An Improved Filtering System for Production of Soft-Shell Blue Crabs
Louisiana State University
5. Improvement of Methods for Artificial Insemination of Penaeid Shrimp: Experimental and Ultrastructural Studies
South Carolina Marine Resources Center
6. Economic and Financial Evaluation of Shrimp Farming in Texas
Texas A & M University
7. Penaeid Pond Production: Nutrition Density and Immunoprophylactic Studies
Texas A & M University

8. Penaeid Shrimp Maturation and Reproduction: Nutrition and Culture Requirements
Texas A & M University
9. Microbial Diseases of Shrimp
Texas A & M University
10. Genetics of Domestication of Penaeid Shrimp
University of Houston

II. Molluscs

1. Biochemical Engineering for Improved Production of Commercially Valuable Marine Shellfish
University of California
2. Genetic Engineering: Modern Technology Applied to Improvements in Molluscan Aquaculture
University of California
3. Culture of Marine Bivalves: Nutritional Role of Dissolved Solutes
University of California
4. Nutrition of Crassostrea Virginica: Requirements of Spat and Larvae Fed on Artificial Diets.
University of Delaware
5. Lipids and Metamorphosis in Marine Bivalve Larvae
Woods Hole Oceanographic Institution
6. Oyster Quality on Delaware Bay Planted Grounds and its Relationship to Environmental Factors
Rutgers University
7. Demonstration of Commercial Clam and Oyster Mariculture: A Cooperative Study
State University of New York
8. Genetics and Aquaculture of the American Oyster
State University of New York
9. Significance to Shellfish Aquaculture of Resuspended Bottom Material
State University of New York
10. Molluscan Hatchery Technology
Oregon State University, Corvallis
11. Identification and Management of Mortalities and Specific Disease Problems in Mussel Aquaculture
University of Rhode Island
12. Nursery Culture of Juvenile Mollusks: Comparative Analysis of Experimental and Conventional Systems for Mercenaria mercenaria
South Carolina Marine Resources Center

13. Artificial Food for Oyster Larvae
Virginia Institute of Marine Science
14. Genetics of Growth and Reproduction in the Hard Clam, Mercenaria mercenaria
George Mason University
15. Molluscan Culture Studies
University of Washington
16. Oyster Hatchery and Genetic Study
University of Washington
17. Parasite Control of Paralytic Shellfish Poisoning
University of Washington
18. Chemical Induction of Setting in Crassostrea virginica: Emphasis on Melanin-Producing Autochthonous and Pathogenic Bacteria
University of Maryland
19. The Influence of Management Strategies and Regulatory Policies on the Production and Marketing of Long Island Sound Oysters
University of Connecticut
20. Advanced Mussel Seed Collection and Rafting System
University of Maine

III. Fin Fishes

1. Genetic Interaction of Auke Creek Hatchery Pink Salmon with Natural Spawning Stocks in Auke Creek.
University of Alaska
2. Potential for Genetic Improvement of Salmon
University of Alaska
3. OTEC Salmon Smoltification Investigations at the Natural Energy Laboratory of Hawaii
University of Hawaii
4. Acceptability of Efficacy of Cultured Euterpina acutifrons (Copepoda: Harpacticoida) as a First Food for Larval Marine Fishes
University of Hawaii
5. Computerized Forecasting in Salmon Hatcheries
University of Idaho
6. Etiology of Finrot Disease in Atlantic Salmon
University of Maine
7. Design and Fabrication of Microcapsules for Fish Larvae Feed
Massachusetts Institute of Technology

8. Development of Techniques to Increase Production of Striped Bass Hybrids
University of North Carolina
9. Survival and Nutritional Requirements of Salmonids in Transition from Fresh Water to Marine Environment
Oregon State University
10. Reproductive Physiology and Induced Maturation of Salmon Brood Stock
Oregon State University
11. Molecular Studies of Bacterial Fish Diseases
Oregon Health Science University
12. The Nutritional and Economic Consequences of Maillard Browning in Fish Feed
University of Rhode Island
13. Factors Important to Artemia Quality
University of Rhode Island
14. Immuno-Castration in Salmonids to Attain Maximal Production Efficiency
University of Rhode Island
15. Development and Demonstration of Finfish Mariculture in South Carolina
South Carolina Marine Resources Center
16. Red Drum Nutrition
Texas A & M University
17. Effects of Diet Size and Time Release on Salmon Return
Washington Sea Grant College Program
18. Salmon Broodstock Diet Development
University of Washington
19. Size-Dependent Mortality of Salmon
University of Washington
20. Salmon Stock Development for Pen Culture
University of Washington
21. Endocrine Control in Salmonids
University of Washington
22. Temperature Control in Salmon Culture
University of Washington
23. Induced Polyploidy and Gynogenesis in Pacific Salmon
University of Washington

24. Improving Coho Survival Through Exercise
University of Washington
25. Monoclonal Antibodies for Infectious Pancreatic Necrosis Virus (IPNV) and Infectious Hematopoietic Necrosis Virus (IHNV)
University of Maine
26. Fish Health Management through Disease Prevention and Control
Oregon State University
27. Incubation Technology
University of Alaska
28. Protein Chemistry and Genetic Engineering: Manipulation of Metallothionein Genes in Striped Bass and White Perch
John Hopkins University

IV. General Animal Culture

1. Aquatic Animal Production
University of California
2. The Population Dynamics of Infectious Diseases in Mariculture Systems
Woods Hole Oceanographic Institution
3. Recombinant DNA Technology In Aquaculture
Oregon State University

V. Plants

1. Vegetative Propagation of Commercially Important Benthic Algae
University of California
2. Spore Release in Two Species of Porphyra
Humboldt State University
3. Seaweed Mariculture for the Herring Eggs-on-Seaweed Fishery
University of California
4. Nutritional Evaluation of Halophytes and their Application in Food and Feed
Delaware Sea Grant College Program
5. Domestication and Improvement of Salt-Tolerant Angiosperms
University of Delaware
6. Experimental Manipulation of Sulfate in Agar-Producing Seaweed
University of New Hampshire
7. Seaweed Aquaculture
University of Washington
8. Physiological Aspects of Nitrogen Depletion in Fucus vesiculosus: Practical Applications for Seaweed Mariculture
State University of New York

National Marine Fisheries Service (NMFS) Mariculture Research.

NMFS research in mariculture is now largely restricted to work on pen culture and ocean ranching of salmon, at the Seattle/Manchester, Washington facilities, and bivalve mollusc culture at the Milford, Connecticut laboratory.

Salmon Culture:

U. S. production of salmonids of any type from floating sea-cages in 1982 was about 615 m.t., or 0.2% of all U.S. salmon production. The entire crop (with the exception of some minor production on both coasts that probably wouldn't total more than another 5 m.t.) comes from one farm in Puget Sound, Washington, and is all coho salmon between about 300-500g. By comparison, the cage culture of Salmo salar in Norway was about 9400 m.t., or 15 times the U.S. coho cage production. This is still only 3.4% of all U.S. salmon production, but is nevertheless an impressive figure.

There has been a heated interest in the commercial farming of Salmo salar in North America because of the apparent discovery of a latent demand for large fresh salmon during the winter months that cannot be supplied by U. S. Pacific salmon because of life cycles. Imports of cleaned, fresh Atlantic salmon of large size from Norwegian farms has jumped in 18 months from 0.75 m.t. to over 1500 m.t. As a result of this activity, Seafarms A/S of Norway, and at least one other Norwegian firm have begun operations in Puget Sound. The costs of feed, labor and materials in the U.S. are approximately the same as in Norway, but the companies would save \$2.20/kg on air freight costs alone.

The NMFS/NWAFRC field station at Manchester has been successfully culturing Salmo salar for at least six years. As a result of this success, the laboratory is currently engaged in a large scale production program to produce upwards of 5 million eggs per year of this species entirely from sea-cage cultured brood stocks. The purpose of this program is to replenish the depleted supplies of S. salar spawn from native fish in the northeastern United States. Each year, 10-20,000 eyed eggs of captured females from the Penobscot River, and the same number from the St. John's River are shipped to Manchester. These are cultured for one and two years in fresh water and two and three years in sea-cages, and one to two months before spawning the maturing fish are transferred to a fresh water hatchery for final maturation.

Bivalve Molluscs Culture:

Spawning and Rearing

Through experimental variation of phytoplankton density and measurement of food consumption rates, new information of practical importance is being collected on optimal feeding regimes for larval phases of the bay scallop, Argopecten irradians, and the hard clam, Mercenaria mercenaria.

The growth of 10 mm surf clams, Spisula solidissima, has been compared in passive and active upflow columns and in raceways. The latter system proved the better. Cage culture of the same shellfish in the natural waters of Long Island Sound and South Carolina has also been investigated. Information has been obtained on growth rate and mortality at different stocking densities and with clams of different initial size. Annual shellfish crops in different seasons in different U. S. regions remain an interesting consideration.

Experiments were continued on the production of bay scallops in Long Island Sound using three dimensional culture techniques. Studies this year focused on the influence of various density combinations in lantern nets on scallop growth and adductor muscle size.

Nutritional Requirements

Rather extensive studies have been made on the feeding behavior and growth responses of juvenile Crassostrea virginica oysters reared under rigorously controlled conditions and fed different algal diets. A specially designed growth chamber eliminates many of the variables inherent in conventional larger-scale rearing of shellfish larvae. Growth data obtained from such chamber experiments over a period of several years reveal that juvenile oysters so reared under a constant daily routine of feeding and seawater flow have a cyclic growth response with a period of five to seven weeks. Such a phenomenon seems not to have been reported previously.

The population growth and gross chemical composition of two Chlorophyte flagellates in different formulations of enriched seawater growth media have been determined. The flagellates were Dunaliella tertiolecta and Tetraselmis maculata. Growth media affected the chemical composition of the algae, and this alone could account for their differences in nutritive value to C. virginica.

Pathology

Throughout the year commercial hatcheries were advised on matters concerning disease control, and bacteria suspect of being disease factors in these hatcheries identified. Some formal instructions on disease control practices were also provided to hatchery operators. It was determined that seawater heated to 41°C had 5-fold fewer bacteria than seawater at 26°C. Surviving colonies were mostly resistant to ultraviolet irradiation but only a few of those from the 26°C water. This may have some practical application to hatchery sanitation.

As part of an effort to understand the mechanisms involved in bacterial pathogenicity in bivalve larval cultures, studies were continued on the nutritional requirements for production of toxin by pathogenic Vibrio sp.

In order to analyze disease resistance factors in molluscs by in vitro techniques, it has been necessary to modify a number of methods used to study immunity in mammals, and considerable effort has been expended doing this. Initial work on monolayers of cells taken from scallops exposed to 20 µg/l copper or cadmium indicated that ingestion of bacteria (phagocytosis)- was activated by these heavy metals. Scallop serum was found to contain a factor (opsonin) which helps cells ingest marine, but not

terrestrial bacteria, as well as other factors which cause clumping of both marine and terrestrial organisms.

Genetics

Holdings of special stocks include geographic hybrids of Long Island Sound oysters with other Crassostrea virginica; also 4 line generations with first, second and third generation full-sib inbred oysters of the same species. Oysters from a third selected generation of C. virginica with contemporaneously bred fast and slow growth populations are approaching the size where they might be successfully bred to produce fourth selected generations.

To provide additional data on selection responses in the American oyster, and to complement the first experiment which is now providing useful information, a second selection experiment was initiated in the spring of '84. The founding generation includes this time oysters from various east coast populations as well as those from Long Island Sound. Non-selected wild stock is being used to obtain better information on interactions between growth and gonad production than available in the published literature.

Techniques for inducing polyploidy are being used in conjunction with inter-species hybridization in a new effort to obtain the long-desired, but hitherto unsuccessful hybrid of American and Japanese (C. gigas) oysters. Potential use of gynogenetic techniques in oyster breeding continues to be of interest and exploration. Other yet newer techniques of cell biology, cytogenetics and molecular biology have been reviewed in regard to their likely applications to shellfish breeding and research in the not-so-distant future.

Publications of Note:

The National Aquaculture Development Plans, three years in preparation, was released in September, 1983. Produced by the Joint Subcommittee on Aquaculture, a committee of representatives of the 12 U. S. federal agencies involved in aquaculture, the report is in compliance with the National Aquaculture Act of 1980 as one of the key responsibilities of the USA.

Joint Subcommittee on Aquaculture. 1983. National Aquaculture Development Plan. Volumes I and II. Washington D. C. 67 and 196 pp.

A new international journal of abstracts of publications in aquaculture is now available from the producers of Aquatic Sciences and Fisheries Abstracts (ASFA). Designated ASFA Aquaculture Abstracts, the publication includes four quarterly issues, each containing author, subject, taxonomic and geographic indices and an annual cumulation of all indices.

ASFA Aquaculture Abstracts (ISSN 0739-814X)
Cambridge Scientific Abstracts
5161 River Rd.
Bethesda, Md. 20816

Aquaculture Productions:

Statistics on aquaculture production are no longer compiled by any single U. S. governmental agency or organization. Unofficial reports suggest little change in the production of most species in 1983 with the exception of channel catfish, which industry continued to boom with a yield of 137 million pounds (total live weight), up 37% from 1982.

U.S.S.R.

The Baltic Sea

Mariculture investigations in the Baltic Sea were devoted to two problems: commercial rearing of rainbow trout in sea water and the raising of the bioproductivity of coastal sea areas with the help of artificial reefs.

To solve the first problem efforts were directed towards the development of the trout rearing technic for geothermal mineralized water. The obtained results allowed us to define fish rearing standards for basins.

To raise the bioproductivity of coastal areas of the sea designs of artificial reefs and methods of their installation were worked out. The state of experimental reefs installed in the sea was under control.

The North Seas

With the view of increasing spawning efficiency of the White Sea herring the commercial test for utilizing artificial spawning grounds was continued. In the Chupa inlet (the Kandalakshskiy Bay) 36 artificial spawning grounds with total area of 1350 m² were placed. Eggs were found on 25 spawning grounds. Density of deposit averaged 0.74 million eggs/m². Total of 850 million eggs was clutched on the artificial spawning grounds. By the time of hatching the egg survival accounted for 89.2% (760 million spec.).

Underwater observations on natural spawning grounds were carried out in main inlets of the Kandalakshskiy Bay. It was revealed that in 1983 the majority of eggs was clutched in the littoral zone, where density of deposit averaged 1.4 million eggs/m². The loss of eggs was much greater than on artificial spawning grounds.

Hence, the artificial spawning grounds, when being numerous enough, may compensate for destruction of eggs on natural ones.

In the Far North region studies on the cultivation of Far East coho salmon applying ferment preparations were conducted. The weight of coho salmon increased by 8-30% while rearing at hatcheries, warm water of the nuclear power station and in cages in the White Sea.

In the Far North region (the warm water of the Kolskaya nuclear power station) selection investigations aimed at rearing trout parent stocks were conducted with three populations delivered from the south, west and central parts of the country. Females of the experimental group matured annually during three years. Size of eggs of the third generation varied from 4.1 to 5.2 mm (mean of 4.7 mm); weight varied from 51 to 82 mg (mean of 67 mg), percentage of fertilization 96-98%, that of hatching 93-97%.

In the Barents Sea (VNIRO, Murmansk marine biological institute) and the White Sea (Northern branch of PINRO, Arkhangelsk experimental algae plant) the first plantations of 1 hectare each for raising *Laminaria saccharina* were developed. Cultivation biotechnics was improved (raising of planting material, growth rates, planting density, etc.)