

International Council for the
Exploration of the SeaC.M. 1984/F:1
Report of Activities

DIO

MARICULTURE COMMITTEE

by

J. E. Stewart

for 1984

PUBLICATIONS OF INTEREST TO THE MARICULTURE COMMITTEE ARE INCLUDED AT THE END
OF THE REPORT.BELGIUM

(P. Sorgeloos)

Research at the Artemia Reference Center, Laboratory for Mariculture, State
University Ghent, was continued in the following fields:

- study of biometrical and production characteristics of various artemia strains;
- evaluation of the nutritional quality of artemia nauplii and decapsulated cysts for carp larvae;
- bioencapsulation techniques for nauplius and adult artemia aimed at improving their nutritional quality, especially with regard to the fatty acid profile;
- intensive culture techniques for controlled production of cysts and nauplii;
- techniques for mass production of artemia adults in a closed recirculation system.

CANADA

(J. E. Stewart)

Atlantic (R. E. Drinnan)Marine Plants

There is an active experimental Chondrus crispus (Irish moss) aquaculture operation in Nova Scotia. This facility is specializing in the production of a product with unique chemical properties not available from the wild stocks. Plans are to expand this facility to a pilot-scale operation within two years.

Shellfish

Blue mussel. The industry continues to show rapid growth both in participation and production. Markets, particularly in the U.S. are being expanded and growing and harvesting techniques adapted to local conditions.

European Flat Oyster. The availability of seedstock, all hatchery reared, limits expansion of production in the near future. To date seed has come from university and government facilities. A programme is underway to optimize the efficiency of production technology, to survey new potential hatchery sites and develop a privately operated facility.

Growth and survival of oyster, Ostrea edulis, larvae was improved when algal feeds, either Dunaliella tertiolecta or Tetraselmis suecica, were supplemented with micro encapsulated cod liver oil fed to the parent oysters.

Sea Scallop

In Newfoundland, seed collection and rearing of this species is continuing for both cooperative enhancement and private culture ventures. The production shown consisted of 2yr old animals exported to St. Pierre-Miquelon.

Lobster Nutrition

A reference diet based on casein and albumin developed in California and one based on crab protein developed in Nova Scotia are being tested by 21 scientists from 11 different countries in feeding trials with 22 different crustacean species in a study to consider the possible adoption of either diet as a Standard Reference Diet for crustacean nutrition research. Both diets are giving good growth and survival for a wide range of shrimp, lobster and crab species.

It has been shown that lobsters do not require a dietary source of vitamin C (ascorbic acid) and that this crustacean is able to synthesize this vitamin from C¹⁴ labelled glucose.

Based upon growth and survival data 22:6W3 appears to have greater essential fatty acid (EFA) for juvenile lobsters than either 18:2W6 or 18:3W3. There was no significant difference in growth or survival of juvenile lobsters fed 1% of 18:2W6 or 18:3W3.

Finfish

Furunculosis in Atlantic Salmon Smolts

In 1984 the supply of Atlantic salmon smolts destined for sea cages was severely limited due to furunculosis infection. In spite of restrictions on movement of infected fish, furunculosis outbreaks occurred at two cage sites in New Brunswick. These were quickly controlled through chemotherapy. Carrier fish have been heavily implicated in the transmission of the disease and steps have been taken this year to screen out carriers before smolts are moved to cages.

Bacterial Kidney Disease

Clinical bacterial kidney disease has posed a threat to the supply of Atlantic salmon eggs in New Brunswick. The disease, which is transmitted through the egg, was detected in broodstock supplying the majority of the eggs to the industry in 1985. A strategy was developed which involved treatment of broodstock with an antibiotic to reduce infections and subsequent monitoring of reproductive fluids by serological methods to screen out eggs from infected fish. The progeny from the eggs will be monitored to check the efficacy of the treatment.

Control of Bacterial Kidney Disease (BKD)

A long term experiment has been completed to determine whether a practical diet could be developed to control BKD at Margaree hatchery in Cape Breton, Nova Scotia. Control of dietary mineral intake by manipulation of feed components and supplementation of diet with 20 mg per kg of iodine showed complete protection against symptomatic and asymptomatic BKD infections.

Iron Requirement of Atlantic Salmon

A feeding experiment of 16 week duration on the iron requirement of Atlantic salmon indicated that a minimum iron level of 60 mg per kg of dry diet was required to maintain normal growth, hemoglobins, hematocrit, serum and body iron levels in Atlantic salmon.

Digestible energy

Digestible energy values of major feed components of Atlantic salmon feed were established for freshwater and seawater culture. Generally, protein digestibility and digestible energy values were 3-5% higher in seawater than in freshwater.

Atherosclerosis in Atlantic Salmon

Cultured and naturally produced Atlantic salmon were examined for presence of coronary arterial lesions. No differences were found in the incidence of lesions between artificially cultured males and females and between maturing and immature salmon reared in sea cages. There was no apparent relation between incidence or severity of lesions and hormone levels. In view of this, the possibility that lesions resulted from some aspect(s) of culture conditions or that lesions begin accumulating at earlier developmental stages was investigated. Naturally produced, sexually immature salmon from the sea of W. Greenland had a high incidence of lesions even though these fish would not have matured for at least another year. Cultured juvenile salmon at the parr stage (immature males and females and precociously mature males) had a high incidence of lesions; naturally produced mature and immature parr had few or no lesions. It appears that atherosclerotic lesions develop in Atlantic salmon well before the onset of sexual maturation and that some aspect of culture conditions can result in lesion development in such early stages as parr which are relatively free of the disease under natural conditions.

Dietary cholesterol resulted in increased incidence of atherosclerotic lesions in coronary arteries of Atlantic salmon. The incidence of lesions was higher in salmon held in fresh than in sea water. Blood cholesterol levels increased as a result of added dietary cholesterol.

Smolting and Hormone Activity

A significant correlation has been demonstrated between increased thyroid hormone levels and ATPase activity during smolting in Atlantic salmon. Increased thyroid activity has been previously reported during smolting of Pacific salmon species. ATPase activity is associated with the development of salinity tolerance during smolting.

Photoperiod and smolting

It has been demonstrated that juvenile Atlantic salmon grow faster following an increase in the daily light period from prevailing seasonal daylength in October (ca. 12-hr light) to continuous light. If continuous light is maintained, the fish grow well but do not smoltify and do not grow well following transfer to sea water in May. If normal photoperiod is resumed in December, the fish undergo smoltification and grow well in sea water. This system of photoperiod manipulation may be useful in producing larger proportions of 1+ smolts of larger size.

Dry vs Moist Diets

A trial is underway to determine comparative costs and growth in Atlantic salmon fed dry and moist diets, in sea cages. Results from the first summer of observation show that smolts averaging 19.4cm in May reached mean lengths of 39.2 and 38.5cms on moist and dry diets respectively. Similarly food costs of fish gain/kg were \$1.75 (moist) and \$1.61 (dry), based on purchase prices, on a dry weight basis, of \$1.50 (moist) and \$1.28 (dry)/kg. Results to date clearly indicate the superiority of the performance of the dry diet.

Commercial Smolt Supplies

The availability of smolts continues to be the major factor limiting the commercial production of Atlantic salmon. In New Brunswick a major facility with a planned annual production of 500,000 1 yr smolts is now in operation. In Newfoundland where there is presently no salmon hatchery a facility is planned using cooling water from an electrical generating facility on Bay d'Espoir with initial design capacity of 200,000 capable of expansion to 400,000.

Seals and Salmon Cages

The damaging attacks by seals on salmon cage rearing sites which were experienced in 1983 have not been repeated. This appeared to be largely due to preventive measures, essentially exclusion. A rigid metal mesh cage presently under field evaluation promises to provide complete security, has survived extreme conditions well and its fish load has shown excellent production performance.

Pacific (G. Hunter and N. Bourne)

Production information from the Pacific Coast is reported for 1983 only, since the statistical system does not provide final figures until after the reporting date for the ICES Activity Report.

Salmonids

The 1983 production of Pacific salmon came from 10 active farms; this number is increasing and is expected to reach 40 during 1985.

The Rainbow trout were produced on 106 separate sites. Until 1983, all farmed Rainbow trout were produced in freshwater; recently two mariculture enterprises began operations.

Studies have continued in a variety of areas related to finfish culture. New initiatives include:

- (1) development of induced spawning procedures for herring which will enable precise control of the production of spawn on kelp;
- (2) the development of induced spawning and incubation procedures for sablefish (Anoplopoma fimbria) to permit its culture;
- (3) the development of sex and growth control techniques for Pacific salmon;
- (4) the initiation of a stock selection and selective breeding program for chinook salmon.

Shellfish

The single commercial Crassostrea gigas hatchery in the Province continued to produce seed (juveniles) and eyed larvae which were used by several growers as their source of seed.

Limited production of the blue mussel, Mytilus edulis, from three culture operations occurred in 1983. Total landed production was about 10 tonnes. Methods continued to be developed to circumvent the disease problem and heavy predation by sea ducks.

Experimental clam culture continued in 1983, with all attempts being made with the manila clams, Tapes phillipinarum. Seed was imported from hatcheries and planted in experimental plots. Attempts were made by one company to operate a clam nursery. Clam seed, (0.5 to 2 mm shell length) was purchased from hatcheries and grown quickly to a planting size of 10 mm. Planting larger size juveniles will increase the rate of survival and decrease the length of time to commercial harvest.

Experimental work continued to investigate the feasibility of scallop culture. Most of the effort was devoted to attempts to breed several species of scallops to produce sufficient seed for grow-out trials along the coast. Most of the work was done with the Japanese scallop, Patinopecten yessoensis, but some work was also done with two native species, weathervane, Patinopecten caurinus, and rock scallops, Chlamys gigantea, and the Atlantic sea scallop, Placopecten magellanicus. Some juvenile Japanese and rock scallops were produced which will be used in grow-out trials.

MARICULTURE PRODUCTION* CANADAAtlantic Coast (1984)

<u>Species</u>	<u>Production</u> (tonne number)	<u>Value</u> (\$000 - US)
Native Oyster (<u>Crassostrea virginica</u>)	915	743
European Flat Oyster (<u>Ostrea edulis</u>)	3.3	20
Blue Mussel (<u>Mytilus edulis</u>)	876	802
Sea Scallop (<u>Placopecten magellanicus</u>)	2x10 ⁴	8
Rainbow Trout (<u>Salmo gairdneri</u>)	109	307
Atlantic Salmon Meat (<u>Salmo salar</u>) Eggs	163 <u>2,066.3</u>	1,410 108 <u>3,398</u>

Pacific Coast (1983)

Coho (<u>Oncorhynchus kisutch</u>)	70	300
Chinook (<u>O. tshawytscha</u>)	55	300
Other Pacific Salmon	4	
Rainbow Trout: (<u>S. gairdneri</u>) (mainly freshwater rearing)	84	400
Herring Spawn on Kelp (<u>Clupea harengus pallasii</u>)	192	5,000
Pacific Oysters (<u>Crassostrea gigas</u>)	2,977 <u>3,382</u>	+ 1.8x10 ⁶ (for halfshell trade) 1,200 <u>7,200</u>

* 1984 Statistics for Pacific unavailable until after ICES reporting date.

DENMARK

(Erik Hoffmann)

Production of marine organisms at a commercial level in Denmark is carried out only with Rainbow trout (Salmo gairdneri), Pacific oysters (Crassostrea gigas) and blue mussels (Mytilus edulis).

Rainbow trout

The production of rainbow trout in marine waters has increased rapidly. The total production in 1984 was about 1800 tonnes, expected to rise to about 3000 tonnes in 1985. Ninety percent of the production is in the 2000 to 3000 g. size group with a mean production size of about 2200 grammes. The trout are transferred from freshwater farms in April and the total production period is now six to eight months. Because of ice and bad weather conditions, production is not possible during the wintertime. The mean size of the transferred fish is 650 g. Normally a total growth to about three to five times the initial weight is expected. The food is standard dry pellets and the feeding is mostly done by hand. The food conversion rate has been measured and equals 1.5 and 3.0 with a mean of 1.97.

Oysters

The Pacific oyster (Crassostrea gigas) was introduced to Denmark in 1978. The growth rates have been good with a growth to about 8-10 cm. after a two-year period at which size the oyster can be marketed. A production of approximately 300,000 Crassostrea in cage culture was obtained in 1984. The European oyster was formerly produced in the Limfjord area. Today this production has been stopped mostly because of bad growth conditions for the oysters.

Blue mussel

Rope culture of blue mussel (Mytilus edulis) has developed in recent years. The production for these new units in 1984 was about 200 tonnes expected to rise to about 1000 tonnes in 1985.

Research and Development

In Danish mariculture, the biological research and development is coordinated and supported by the Ministry of Fisheries. In the spring of 1984, the Ministry founded a working group on aquaculture which has to prepare forecasts for the aquaculture production in Denmark and make a plan for research activities. The research was in 1984 carried out at the Danish Institute of Fisheries and Marine Research in Charlottenlund, at the North Sea Center in Hirtshals and at the Danish Aquaculture Institute in Horsholm and in Abenraa. Work has been carried out on the following species: Rainbow trout, turbot, plaice, eel, sea bass, whitefish, Black Sea bream, Pacific oyster and blue mussel.

Statistics

<u>Species</u>	<u>Tonnes</u>	<u>Approx. no. x 100,000</u>	<u>Values in 1000 US dollars</u>
Rainbow trout in enclosures	1800		7000
Pacific oyster from cage culture		3.0	120
Blue mussel rope culture	200		80

FINLAND

(P. Tuunainen and K. Westman)

Mariculture in Finland is based on the 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 one summer old whitefish young into the sea. On the other hand, it is based on production of rainbow trout (Salmo gairdneri) in net cages and enclosures for human consumption. Mariculture production is continually increasing. This is fostered 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 proceeding and remarkable increases in the numbers of parr in the restored rapids have been reported. In two of the rivers, Simojoki and Tornionjoki, flowing into the Bothnian Bay, one-year old salmon parr have been stocked into the rapids and constant monitoring programs are getting on. In Tornionjoki, the sea trout stock is declining alarmingly.

Study programs were also carried out to discover the biological and economic success of the introductions made 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 to decrease natural mortality rate of stocked salmon smolts by using release ponds, and to decrease water pollution caused by larger fish farms.

For the UDN of the Baltic salmon reported in the middle of the 1970's, limitations imposed on transfers of fish between the sea and freshwater area as well as between the inland watercourses exist. One observation of IPN in a Rainbow trout net culture in the Archipelago Sea area was reported. The disease, IPN, has not been reported in Finland before.

The vibriosis disease still causes considerable harm and better vaccines against it are being developed, especially for Rainbow trout culture in the sea area.

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 objects of interest. These studies have been connected with tagging experiments with the Carlin taggs as well as with micro taggs.

Studies on the genetics of the wild and reared salmon and sea trout stocks have been intensified, because year after year a greater share of the input salmon and sea trout smolts in the Baltic Sea is based on reared smolts and because there are some indications of the influence of fishery as well.

OUTLINE FOR STATISTICAL INFORMATION ON MARICULTURE PRODUCTION

Mariculture production 1983 (figures for 1984 not yet available)

Country: Finland

Species	in metric tons	approx.number in 100 000	value in 1 000 US \$ ¹⁾
Rainbow trout in enclosures more than 0.5 kg each	3 910	-	12 650
Salmon smolts for introductions, 1 year and older	-	17.42	2 300
Other salmonids (specify): Sea trout for introductions 1-summer old and older	-	11.22	1 200
Others (please specify): Migratory whitefish for introductions 1-summer old	-	96.38	690

1)

Rate 1 US \$ = 6.5 FMK

FRANCE

(H. Grizel and G. Guillaume)

Mollusques - CrustacésMollusques1. Pectinidés - Pecten maximus

Le programme de repeuplement des gisements de la rade de Brest s'est traduit par l'immersion de 800,000 coquilles St-Jacques de 3 cm. Cette production est obtenue à partir des écloséries d'Argenton et du Tinduff. Le prégrossissement est effectué sur casier en rade de Brest. La maîtrise des techniques de culture permet d'entrevoir l'élevage de cette espèce.

Chlamys varia

Les opérations de captage ont permis de collecter en rade de Brest 40 - 10⁶ juvéniles qui ont été semés début 85 en vue de "ranching".

2. Vénéridés

La culture de la palourde, R. philippinarum, progresse. La production a été de 300 tonnes au prix de 35 à 40 F/Kg soit un chiffre d'affaire d'au moins 10 millions de francs. Des programmes de transferts et de recherche sur des points de biotechniques sont en cours.

3. OstréidésOstrea edulis

Les épizooties à Marteilia refringens et Bonamia ostreae sont toujours présentes en Bretagne. Des résultats positifs ont néanmoins été obtenus dans le cadre du plan de sauvegarde avec une production de 500 tonnes d'huîtres de 2 ans à Cancale.

Des ensemencements de géniteurs sont opérés en Baie de Quiberon pour accroître les stocks. La production française a été d'environ 1500 tonnes vendues de 20 à 25 F le Kg.

Crassostrea gigas

La culture s'est généralisée le long du littoral français. La production actuelle se situe autour de 100,000 tonnes.

L'étude de modélisation des bassins progresse et des données intéressantes ont été obtenues sur les méthodes d'évaluation des stocks et sur les besoins énergétique des coquillages.

Des observations sont en cours sur une "souche" présentant des caractères possibles de résistance au TBT.

4. Mytilidé

Mytilus edulis

La production française est d'environ 50,000 tonnes. Une recrudescence de Mytilicola intestinalis a été noté dans quelques centres. Les essais d'élevage en mer ouverte sur longues lignes continuent.

Crustacés

Homarus gammarus

Le but des études entreprises est d'essayer de quantifier l'impact du repeuplement. A cet effet, 8500 juvéniles d'un an marqués magnétiquement ont été immergés sur un cantonnement près de l'île d'Houat et 5000 près de l'île d'Yeu. Par ailleurs 4500 juvéniles non marqués ont été immergés près de Sein.

Poisons Marins

Les recherches sur l'élevage de la sole solea solea ont été abandonnées et les efforts ont été concentrés sur le turbot scophthalmus maximus. Un syndrome de carence en acide ascorbique (granulomatosose renale avec hypertyrosinémie) a été mis en évidence chez cette espèce. La production totale de l'année a été voisine de 10 t mais les écloséries, expérimentales ou pilotes, ont enregistré, chez les larves, de graves mortalités dues à des causes non encore élucidées.

Salmonides

Plusieurs expériences ont été conduites dans une nouvelle station marine expérimentale en vue de comparer les aptitudes à l'élevage en période estivale de Salmo gairdneri, S. trutta, S. salar et Oncorhynchus kisutch. Seule S. trutta n'a pas subi de mortalité notable au dessus de 17 deg. C. Aucun aliment n'a permis de diminuer la mortalité chez S. gairdneri. Les populations monosexes ou triploïdes de la même espèce ne se sont pas non plus révélées plus résistantes que les populations normales. Une étude des causes de mortalité de S. gairdneri en période estivale a montré une étiologie plurifactorielle: hypermagnésémie, déséquilibre de la formule sanguine, baisse de la guconéogenèse, etc.

La production totale française a plafonné à 950 t de truite arc en ciel et saumon coho élevés en mer.

Crustacés

Des études sur le besoin qualitatif en phosphore ont été poursuivies sur la crevette japonais Penaeus japonicus. Ainsi que sur l'effet d'un facteur de croissance extrait du calmar Loligo vulgaris.

Des essais d'élevage extensif ou semi intensif de cette crevette ont été entrepris dans les marais de la côte atlantique. Les postlarves relâchées en mai ont bien survécu - parfois plus de 50% et ont atteint un poids de 15 à 20 g à l'automne.

GERMAN DEMOCRATIC REPUBLIC

No report received.

GERMANY, FEDERAL REPUBLIC OF

(K. Tiews)

Crassostrea gigas

Indoor experiments on the overwintering of spat and half grown oysters, as well as outdoor experiments on the fattening of spat to marketable sizes and container culture experiments on various places along the German North Sea and Baltic coast, were continued by the Institut für Küsten- und Binnenfischerei.

Eco-physiological studies on Crassostrea gigas under the conditions of the Flensburg fjord were started by the Institut für Meereskunde, Kiel.

Salmonid fish

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

Turbot

Studies on the reproduction of turbot, the rearing of the fry and the fattening of fingerlings were continued at the Institut für Meereskunde, Kiel. The studies included also the development of feeds.

Eel

Research on eel farming in heated effluents of conventional and nuclear power stations was continued by the Institut für Küsten- und Binnenfischerei. Also scaling up experiments for the mass rearing of elvers in silos including the optimization of feeds for these were continued by the same institutes in its laboratories in Hamburg and Ahrensburg.

Intensive Farming Systems

Work at the Biologische Anstalt Helgoland continued to focus on management problems in intensive farming systems. Studies were performed on the extent of daily water quality fluctuations under various culture conditions (i.e. flow-rates, stocking density, tank design, feeding regime). Experiments were carried out in brackish water and sea water. Long-term variations in three experimental recirculation systems were also monitored. Specific investigations concentrated: (a) on the performance of a rotating biofilter under various waste loads; (b) on the efficiency of an anaerobic denitrification unit (integrated into a recycling system for fish culture) in relation to substrate availability and carbon source; and (c) on behavioural aspects related to the influence of fish distribution in culture tanks on water mixing and exchange.

Species investigated in the experimental culture systems include mullet, turbot, eel and tilapia.

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

<u>Species</u>	<u>Tonnes</u>	<u>Approx. no. in 100,000</u>	<u>Values in 1000 US dollars</u>
Blue mussels (<u>Mytilus edulis</u>)	59,299		4,027
Pacific oysters (<u>Crassostrea gigas</u>) from vertical cultures	2		40
Eel (<u>Anguilla anguilla</u>) not freshwater	19		90
Rainbow trouts (<u>Salmo gairdneri</u>)	12		41

ICELAND

(Ingimar Johannesson and Solmundur Tr. Einarsson)

Eight hundred thousand smolts and one million fingerlings were produced in Iceland in 1984. One hundred fifty thousand smolts were exported to Norway for farming in cages. Approximately three hundred thousand smolts were released from ocean ranching stations coming mostly from four ocean ranching stations owned by Polarlax, Kollafjordur, Fjarfestingarfélagid on the south coast and by Isno on the north coast. Approximately two hundred thousand smolts and about one million fingerlings were released this year into rivers and lakes in order to improve catches for anglers. Approximately one hundred fifty thousand smolts were utilized for farming.

The production of farmed salmon reached approximately 120 tons in the year 1984.

Recapture at the ocean ranching stations came to about 30 tons and seems to be increasing.

Preparations are now underway for establishing new salmon farms and others are already being built on the Reykjanes. These will be pump ashore farms, but they are planning to warm the water by using geothermal heat in order to expedite growth of the fish. A big smolt hatchery with a production capacity of five hundred thousand smolts has now been built on Reykjanes by Islandslox Ltd., and they have put in hand preparations for a large pump ashore farm.

Salmon is the only species of fish used for significant fish farming in Iceland.

IRELAND

No report received.

NETHERLANDS

(R. Dijkema)

The year 1984 was marked by an increase of interest in aquaculture in the Netherlands. The Netherlands Society for Aquaculture was founded, aimed at bringing together professionals, scientists, administrators and other interested persons, active in the field of aquaculture.

An inventory of possibilities for mariculture around the large storm surge barrier complex, under construction in the mouth of the Oosterschelde estuary was completed. A number of locations suitable for fish culture in cages was indicated. Besides, possibilities were described for other mariculture activities, mainly in the field of shellfish culture.

Despite the increase in interest in mariculture, the number of firms engaged in fish farming in sea water decreased to two or three, situated in the delta region in the southwest of the country. The major constraints for sea culture of rainbow trout especially appeared to be occasional serious summer mortalities. These are thought to be a result of a combination of high water temperatures during periods of high temperatures in summer and the prevailing salinity of 28 - 30 g.l⁻¹. These affect the resistance of the fish, thus facilitating infection with bacterial diseases. An orientation survey was made in 1984 which in 1985 will be intensified in a coordinated research program into underlying environmental factors and occurrence of diseases. A trial with vaccination against vibriosis in Rainbow trout was carried out which will have to be repeated in the years to come.

A pilot-scale experiment took place with a combination of cage farming of rainbow trout and the suspended culture of oysters at a trout farm in the Oosterschelde. The growth of the oysters proved to be excellent, only exceeded by the growth of the oysters on a rearing plot on the bottom in salt water lake Grevelingen. The quality of the oysters proved to be very satisfactory. It is felt that off-bottom farming of oysters at cage-farms of salmonids can be a profitable supplementary activity, not interfering with labour peaks and helping to offset eventual effects of bad summers or winters, which until this moment have made sea fish farming a hazardous activity.

A number of individuals have started experimental projects with the cultivation of the ragworm (*Nereis viridis* M. Sars), a species commercially interesting as bait for sea anglers which commands high prices. A research project has been planned to give scientific support to the commercial projects and to take away biological and technical bottlenecks.

NORWAY

(T. Hansen)

INTRODUCTION

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

1. Selection 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, Flodevigen, Arendal;
4. Institute of Aquaculture Research, Sunndalsora and Averoy. The Agricultural Research Council of Norway, 1432 As-NLH;
5. University of Bergen
 - 5.1 Institute of Fisheries;
 - 5.2 Zoological Museum, Division of Ecology;
 - 5.3 Institute of Biochemistry;
 - 5.4 Department of Microbiology and Plant Physiology;
 - 5.5 Institute of Marine Biology;
6. Institute of Fisheries, University of Tromsø;
7. Regional College, 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, Bodo.

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), (2), (3), (4), (5) 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 (1) and (4) and reduce early maturation, (1) and (4). At Sunndalsora and Averoy 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 does not develop gonads. Production of all female triploids are underway, (4).
- (f) Induce gynogenesis, (4).
- (g) Study genetic variation in stress measured by cortisol level, (1) and (4).
- (h) Study the potential interaction between inheritance and environment on productive traits by stationing out 100 family groups of Atlantic salmon in 7 fish farms along the coast of Norway (1).

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

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 acting to predators (1). Conditioning of smolt to avoid predators was tried in an effort to improve recapture rate of hatchery smolts released for ocean ranching purposes.

Hydroacoustically tagged hatchery reared Atlantic salmon smolts were tracked in order to study the seaward 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), (5.2) and (5.4).

Physiology and Nutrition

Laboratory experiments on nutrition, digestion, growth, metabolism and energy budget of cod were continued (1) and (2). Use of shrimp wastes for salmonid feeding was further tried out (1) and also experiments comparing different carotenoids were continued (2), (4), (5.4) and (9).

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 of 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 broodstock diets on reproduction in salmonids were carried out by (1) and (2).

Use of binders in salmon feeds (to increase feed efficiency and reduce water pollution) was studied by (4). Effect of dietary copper in Rainbow trout was investigated by (2). In collaboration between (2) and (9) the following research activities on salmon nutrition were conducted in 1984:

- Influence of heat treatment in fish meal production on the protein quality in 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.

The environmental conditions of reared salmon and mussels were studied and related to stress in salmon and growth in Blue mussels and Iceland scallops (11).

Pathology

Work on vaccination and vaccines against vibriosis was continued both for salmonids and cod (1), (6) and (8). Special attention has been given to the cold-water vibriosis or Hitra-disease at (1), (6) and (8). Further the influence of poor environmental conditions on fish gills was started (1). The work on possible carrier states of *Aerococcus viridans* in local *Homarus gammarus* was finished (1). The investigations on pseudobranchial tumor in cod was continued (1). At (8) the following projects were continued. Registration of IPN in Norwegian Fish Farms and wild fish populations, infection with *Ichthyobodo necator* in sea water, methodology development for detection of residues of drugs in fish, cataract in fish, uptake of drugs after intravenous injections, methodological studies on lysozyme in fish serum, immunostimulating drugs and possible effect at vaccination.

Aquaculture Technology

Systems for recirculation of freshwater and treatment of acid water for smolt production were further studied and improved by (1).

Experiments on raising of smolt in net pens in freshwater stressing ecological aspects were carried out in a joint programme by (1), (5.1), (5.2) and (5.4).

Devices for scaring away eider ducks were tested in rearing plants for blue mussels (11).

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 third 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 juveniles in an enclosed pond, initiated in 1980, was continued also in 1984 (1). The pond was treated with rotenon to exterminate predators on the cod larvae and juveniles. The larvae were released at the yolk-sac stage and the surviving juveniles were collected during summer and autumn. The tagging and release programme on juvenile cod was continued and considerably increased. Also the programme on rearing of juvenile cod 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). A broodstock of halibut has been established and hatching and startfeeding experiments are carried out, (1) and (4).

Experiments with hatching and rearing marine fish larvae and juveniles was also continued by (3) in land-situated basins. Investigations on a polyspecies experiment in large outdoor basins were carried out with turbot, lobster and oyster (3). 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).

Environment

Studies of environmental influence on Atlantic salmon is carried out at (1). The connection between water quality and fish health and growth was investigated. So too was the accumulation of organic sediments and leakage of nutrition-salts from the sediments. A program at (1) and (5.5) is investigating the influence of fishfarming on the surrounding environment.

Other Projects

Experiments on commercial culture of blue mussels were continued, (1), (3) and (7). Similar experiments on culture of scallops were continued in a small scale, (1), (5.5), (6) and (7). Developmental studies of hatching system for increased production of oyster larvae were initiated (1). Experiments with culture of oysters were carried out at localities along the coast and in large outdoor basin (3).

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.

Production of microalgae for larval feed was studied at (5.4).

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 freshwater is not reported in the inland fisheries statistics. The total production therefore is given in the following table:

<u>Species</u>	<u>In Metric Tons</u>
Rainbow trout in enclosures	3,635
Salmon in enclosures	22,299
Arctic charr in enclosures	750
Rainbow trout eggs	2,148 kg

Concerning other species, no statistics exist, but some quantities of Blue mussel and oysters were produced.

POLAND

(J. Wiktor)

Production

In 1984, no commercial scale rearing was carried out; six tons of Rainbow trout were produced (whose individual weight was from 0.5 to 1 kg.) in experimental conditions.

Research and Experiments

Rearing of 2nd and 3rd generations of Rainbow trout in cages was continued; they were kept in brackish water up to the fry stage and included a stock of spawners from which eggs were produced.

Tagged young Rainbow trout, reared in the second generation from the fry stage in brackish water, were released into the Baltic; their migrations were observed. The survival rate of fish from inland centres to be released into the Baltic was tested.

New Facilities

In autumn 1984, a new centre for rearing and selection of spawners of salmonids, including migratory fish, was opened.

PORTUGAL

(M. T. Dinis and J. M. Saldanha Lopes)

Shrimp Culture

Attempts to induce artificial spawning of wild females (Penaeus Kerathurus) were made, using a recirculated sea water system, at different temperatures.

Assays of growth of wild juveniles, of Penaeus kerathurus, were carried out under laboratory conditions, using natural diets.

Fish Culture

Sparus aurata

Spawning induced by hormones applied to a wild broodstock kept in captivity produced some eggs and larvae for histological studies.

Studies on the ongoing of fingerlings captured in the "Ria de Faro" (Southeast of Portugal), were carried out in a closed sea water system using artificial diets with natural components.

Dicentrarchus labrax

Experimental work on the culture of this species has been carried out since 1983 using a closed sea water system. Some juveniles have been produced and assays using different types of natural food were undertaken.

Solea senegalensis

The broodstock was caught in 1982 and was progressively adapted to captivity. During the 1983 spawning season, the first viable eggs were obtained and the larval development was carried out successfully and juveniles obtained.

Experiments on weaning of the post metamorphosed larvae were performed using a moisture pellet obtained by extrusion.

Oyster Culture

Studies on the growth of a natural population of Ostrea edulis were carried out in a coastal lagoon, south of Lisbon. Assays of transplantation of Crassostrea angulata, and studies on its reproduction and growth were also done.

SPAIN

(G. Roman)

Crassostrea angulata

Collectors are being placed in Sanlucar de Barrameda (SW Atlantic), and the collected spat are being hung on floating devices, in order to study their growth and mortality.

Ostrea edulis

Different experimental activities are currently being performed on larval rearing in hatcheries and intermediate and final growing techniques on hanging cultures are being tested in La Coruna and Vilaxoan (NW Atlantic) and in Lepe and Cadiz (SW).

Pectinids

Larval and postlarval culture of Pecten maximus has been carried out in a hatchery in La Coruna. Irish scallop seed is being grown on suspended trays in Galician rias (NW). First experiments with collectors immersed in Alboran Sea resulted in good settlement of P. maximus, Chlamys varia and C. opercularis.

Venerupis decussata, V. pullastra

Experimental cultures are being performed in Lepe and Cadiz. Hatchery-produced seed of both species is being grown placed on hanging trays and eventually placed on intertidal beaches to determine useful techniques devoted to increasing clam production.

Venerupis semidecussata

This species is considered as potentially important commercially, so experiments on larval rearing and seed growing are being performed in La Coruna.

SWEDEN

(Hans Ackefors)

Sweden has an extensive program for the conservation of its fishery. Between two and three million smolts of salmon and sea trout are annually planted in Swedish rivers. Furthermore, a number of different species of trout such as lake trout, Rainbow trout, Arctic char, American brook trout, American lake trout, grayling and whitefish, are stocked to improve the sport fishing.

The commercial cultivation of fish for direct human consumption can be traced back to the eighteenth century, when people started to raise carp in ponds. By the end of the following century, Rainbow trout, tench, carp and some other

species were being cultivated on a small scale. Cultivated carp and tench were exported at the beginning of this century to Germany. However, not until the early 1970's did the commercial production rapidly increase through the introduction of net cages for cultivation of Rainbow trout and rope cultivation of blue mussels. According to the official statistics, the production for human consumption consisted of 1567 tons of Rainbow trout, 1498 tons of blue mussel, 27 tons of salmon and 50 tons of eel. It is thus evident that Rainbow trout and blue mussel dominated the production. About half of the production of rainbow trout took place in brackish or marine waters, as well as the whole production of salmon and blue mussels. The production of salmon smolts for compensatory purposes in 1984 was 4.35 million. The production in 1985 may be in the order of 4000 tons of Rainbow trout and about the same amount of blue mussel. However, in reality the amounts may be higher.

A few years ago, the experiments with cultivation of salmon and Arctic char started in net cages, the former in brackish water where there is very little risk of supercooled waters in winter. The overwintering experiments have been successful. Arctic char have been raised successfully both in freshwater and brackish water up to 4 °/00.

At present, there is also a trend toward raising eels in connection with waste heated waters in flow-through systems or heated waters in recirculation systems. The glass eel is imported from France or England. This import is heavily regulated by Swedish authorities. The glass eel must be kept in quarantine for some time before it is released to the weaning tanks. About 10 companies are now in operation. The aim is to produce eel for export to Germany, Belgium and France.

Even a flatfish such as turbot is being considered for some experiments in Sweden. It is likely that this species will also be cultivated in Sweden in connection with waste heat water.

Cultivation of Blue Mussel and Oyster

The cultivation of blue mussel is expanding currently. Although about 2000 tons were produced in 1984, according to our recent estimates licences to farm 11,000 tons of blue mussel have been issued for the coming year. The rope cultivation method has been improved in Sweden, and a modern factory for processing the mussels was instituted in 1984.

However, this branch of industry was struck by the appearance of a microalgal species in the west coast waters. In October 1984, analyses of the mussels showed that they had accumulated a toxin from the dinoflagellate, *Dinophysis acuminata* (D. acuta), which causes DSP (Diarrhetic Shellfish Poisoning). Still in effect in April 1985, when this was written, was a ban to harvest blue mussels on the Swedish west coast. The industry now has serious financial problems and the brand new factory has gone into bankruptcy. This will seriously hurt the mussel industry and probably the future willingness to invest in mussel cultivation.

The interest in growing oysters on the Swedish west coast is increasing. The natural oyster beds are restricted because of low winter temperatures including ice conditions and the summer temperatures for breeding are normally too low. This fact and good prospects for selling oysters have induced the interest in cultivating oysters on the Swedish west coast. Special techniques of farming oysters in areas without tidal waters must be applied. Special nursery areas with warm waters must be created, e.g. sheltered lagoons. A long line method with lantern nets is now being applied by three commercial farmers. Hitherto, oyster seed have been imported from Norway. The native species Ostrea edulis, is cultivated. Crassostrea gigas have been tested in experiments and grows very well, but there is no market for this species.

UNITED KINGDOM

SCOTLAND (A. L. S. Munro)

Commercial Atlantic salmon culture produced 3,912 tonnes in 1984 compared to 2,536 tonnes in 1983. Smolt numbers placed in sea water were 3.6 million compared to 2.9 million in 1983. Numbers of new farms continue to increase as does the production of existing farms. The industry employed over 500 people mostly in the remoter areas of Scotland.

Commercial Rainbow trout culture produced 2,082 tonnes of which only 86 tonnes were produced in sea water. Total gross production has been maintained at this level for the past four years indicating trout culture has reached a stage of maturity where production and consumer demand are in balance.

The commercial culture of mussels, oysters and turbot was also in progress at lesser levels of production.

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

- The Dunstaffnage Marine Laboratory, Oban, Argyll;
- The Departments of Biology and Chemical Engineering, Heriot-Watt University, Edinburgh;
- The Institute of Aquaculture of the Department of Biology, Stirling University;
- The Institute of Marine Biochemistry, Aberdeen;
- The Marine Laboratory, Aberdeen;
- The Zoology Department, Aberdeen University;
- The Torry Research Station, Aberdeen;
- The Sea Fisheries Authority, Ardtoe.

ENGLAND AND WALES (C. Purdom)

Aquaculture in England and Wales continues to be dominated by Rainbow trout farming in freshwater with production in 1984 of about 12,500 tonnes (value \$25,000,000). Some salt water cultivation of salmon and trout has begun and production of salmon smolts is also reaching significant levels. No further progress has been made in marine flatfish farming with only one existing farm providing a modest output. Eel cultivation has declined, but there are signs of re-emergence. Carp farming is making slow steady progress but is well short of fulfilling modest national needs.

Shellfish farming output is confounded to some extent with natural harvesting but produces about 1,000 tonnes/year principally of mussels and native oysters. Increased production of Japanese oysters and of native and introduced clams seems likely to increase, partly in response to localized outbreaks of bonamia disease and the movement restrictions imposed to control it.

Lobster cultivation is restricted to juvenile production for use in stock enhancement exercises; the one small commercial undertaking is probably premature.

Research on trout covers genetics/endocrinology and disease diagnosis and control measures. Sex-ratio control and induced triploidy (sterility) are now implemented on many commercial farms and research is directed largely towards final refinement of techniques. More advanced genetic engineering, the production of fully homozygous individuals and, eventually, clones from them, is progressing well. Haploid cell lines in tissue culture have been produced for biotechnology studies.

Refined techniques for the diagnosis of a variety of notifiable diseases are now available and, in particular, more reliable tests have been developed for Bacterial Kidney Disease. The major non-notifiable disease in trout is still Proliferative Kidney Disease for which an epidemiological study is nearing completion. New problems have arisen with Enteric Redmouth Disease but diagnosis, therapeutic and prophylactic measures seem to be adequate for the control of the disease at present. A major new commitment is the examination of a variety of different Rainbow trout strains for resistance to diseases endemic or widespread in the United Kingdom.

Work on intensive marine fish cultivation has been suspended in favour of stock enhancement studies with sole. Responses of hatchery-reared sole to release will be assessed and preliminary population studies in selected release areas will be conducted with tagged sole.

Main objectives with shellfish cultivation include the establishment of the dynamics of food availability, lipid reserves and survival of bivalve larvae and assessment of the commercial potential of upwelling nursery systems and on-growing tactics. Quarantined imports of Crassostrea virginica and Venerupis semidecussata have been completed and trials under commercial conditions are planned.

Lobster stock enhancement experiments are being conducted off East Yorkshire, and other areas of the United Kingdom Coast, using tagged juvenile lobsters of hatchery origin, released by diver-monitored methods.

UNITED STATES

(J. H. Ryther and A. C. Longwell)

I. Academic Research in Mariculture

The National Sea Grant College Program (National Oceanographic and Atmospheric Administration, U.S. Department of Commerce) nominally has the lead role in the development of aquaculture for marine, estuarine and Great Lakes species as mandated by the National Aquaculture Act of 1980. In 1984, 98 aquaculture projects were partially supported by that organization, which has a requirement for matching funds by the recipient. The number of projects funded and the total funds available for that purpose (\$3-4 million) have remained relatively constant over the past six years.

Sea Grant projects funded in 1984 included 45 in the area of finfish culture (26 of which were salmon projects), 23 in crustacean culture (9 each in *Macrobrachium* and *penaeid* culture), and 28 in mollusc culture (16 oysters, 7 clams, 3 mussels and 2 abalone). Twenty-five of the projects involved research in aquaculture systems, 25 dealt with genetics and selective breeding, 13 were in the field of nutrition, and 19 were in the areas of disease and parasites.

Level funding by Sea Grant during a period of economic inflation and of increased interest and activity in U.S. mariculture has resulted in a diminishing role in the development of the field by that agency and one that other branches of the federal government have not assumed. Increasingly, private organizations and individual states have begun to undertake and support research programs in mariculture. Several states (Hawaii, California, Texas, South Carolina, Florida) have developed aquaculture plans of their own and some have created major research facilities.

New developments in mariculture during 1984 include the use of chemical mediators to induce both spawning and setting of molluscs. Serotonin, a neurotransmitter used in human medicine, has now been successfully employed for the stimulation of spawning, by injection into the adductor muscle, of 19 species of molluscs. Another neurotransmitter, aminobutyric acid (GABA), causes the larvae of abalone and other molluscs to settle and metamorphose. There has been increasing activity in clam culture on both coasts, that of the hard clam (*Mercenaria mercenaria*) along the entire East Coast and *Venerupis* spp and other species on the West Coast. Several new hatcheries have been built and upwelling nursery systems developed in England have become increasingly popular in the United States, as have grow-out systems in protected beds, covered with plastic netting, to curtail predation. Research on *Mercenaria* has included genetic selection of fast growing strains and induction of polyploidy.

Several new mollusc species have been brought close to commercialization with large-scale hatchery production of seed and their subsequent grow-out to marketable size. These include the surf clam (National Marine Fisheries Service, Milford, Connecticut), the angel wing clam (Harbor Branch Foundation, Florida), the geoduck (State of Washington Dept. of Fisheries) and the rock hinged scallop (San Diego State and Humboldt State Colleges, U. California).

Recent advances in oyster culture include the practice of "remote setting", developed at the University of Washington, whereby advanced larvae may be transported long distances, for extended periods of time, out of water and remain viable with high incidence of setting when re-immersed at their destination. Other studies on the nutrition of oysters have involved use of low-cost supplemental feeds (yeast, starch, whey, blood meal, powdered shrimp and fish meals, clay particles, microgels, and various microencapsulated diets), in addition to their usual microalgae. Other research has provided new evidence of the importance of dissolved organic compounds in the nutrition of bivalves.

In the field of crustacean mariculture, major developments have also been in the area of reproductive physiology. Twelve species of penaeid shrimp have now been matured and spawned in captivity, though the resulting post larvae are still inferior in quality to those resulting from naturally matured females, for reasons not yet understood. One of the more popular mariculture species P. stylirostris, has now been carried through their second (F₂) generation in culture. U.S. shrimp culture is, however, constrained by the inability to utilize the more rapidly growing exotic (Pacific) species in Gulf of Mexico operations because of restrictions on their production.

Recent accomplishments of artificial insemination of both penaeid shrimp and northern lobsters (Homarus) have opened the possibility of genetic improvements of their stocks.

New developments in finfish mariculture include the near commercialization of the red drum (Sciaenops ocellata) in Texas and the striped bass, Morone saxatilis, the latter often hybridized with the white bass, M. chrysops. The common snook, Centropomus undecimalis, and the sheepshead, Archosargus probatocephalus, were both successfully spawned and reared in Florida. Most of these marine fishes have been reared for natural stock enhancement purposes, but their potential as mariculture species for food is also being simultaneously investigated.

A recent trend in the cultivation of several marine species with small eggs and larvae is the extensive cultivation of the very young larvae (1 - 7 days) in fertilized ponds, sometimes inoculated with cultures of copepods, rotifers, or other food organisms.

II. Government Research in Mariculture

Government research in mariculture is restricted to mollusc studies at the Northeast Fisheries Center, Milford Laboratory (National Marine Fisheries Service, National Oceanic and Atmospheric Administration). What research continues into the next fiscal year is intended to be focused more on experimental biology and away from commercial aquaculture.

As previously, research at the Milford Laboratory this past year was conducted in four programs - hatchery systems, algology, pathology and genetics. There has been continued success in developing commercially attractive grow-out procedures for juvenile clams (Spisula solidissima and Mercenaria mercenaria).

A reduced-nutrient sea water medium has been formulated for growth of algal species used as food for juvenile oysters. A computer program has been developed which uses biochemical similarity levels to sort bacteria and can match an unknown bacterium with its nearest relative. A third generation of American oysters (Crassostrea virginica) simultaneously selected for fast and slow growth seems to be showing less response to selection than did the prior two generations. Major research thrusts in genetics this year are: (1) in the broader aspects of chromosome engineering in molluscs; (2) and in the development, for fish and shellfish alike, of a technique not dependent on chromosome manipulation which will completely eliminate gametogenesis.

Estimated U.S. Private Aquaculture Production^{1/} for 1983^{2/}

Data provided by National Marine Fisheries Service, Washington, D. C.

Species Groups	Value	Weight	
	(1000 dollars)	(metric tons)	(1000 pounds)
Baitfish	100,000	15,000	33,000
Catfish	132,000	100,000	220,000
Clams	9,500	4,300	15,000 (2,700) ^{3/}
Crawfish	30,000	27,300	60,000
Freshwater Prawns	1,500	125	275
Mussels	1,500	1,680	3,700 (775) ^{3/}
Oysters	31,500	125,000	275,000 (23,300) ^{3/}
Pacific Salmon	6,800 ^{4/5/}	9,400	20,600 ^{5/}
Trout	50,000	22,000	50,000
Other species ^{6/}	<u>7,000</u>	<u>3,200</u>	<u>7,000</u>
TOTAL	369,800	308,005	684,575

^{1/} Data shown are live weight harvests including mollusks. Excluded are eggs, fingerlings, etc., which are an intermediate product level.

^{2/} Data are preliminary

^{3/} Meat weight

^{4/} Excludes the value of returning fish which were used for broodstock and were not sold.

^{5/} Includes pen-reared and ocean ranched salmon

^{6/} Includes such species as sturgeon, paddlefish, carp, tilapia, mullet, abalone, etc.

Separate production figures for wild catch and hatchery product are compiled only every few years, as proportions have not changed substantially from year to year. For such a breakdown see prior Administrative Reports.

USSR

(V. P. Bykov)

In 1984, investigations aimed at the development of commercial rearing of salmon were continued. The Polar Research Institute of Marine Fisheries and Oceanography developed the growth acceleration method for rearing salmon by adding the fermentation preparation protosubtilin G3X. The obtained results allowed us to recommend the dose of 0.5%. Stocking material for rearing salmon in sea water was obtained.

Rainbow trout parent stock was reared in the warm water of the Kolskaya nuclear power station. The abundance of the stock is sufficient to meet industrial requirements for planting material.

In the Baltic, the technique of rearing in subsoil mineralized water was developed. The obtained results allowed us to define standards for the stocking material and market fish. Various artificial foods for trout raised in mineralized water were tested. The use of aspirin to stimulate the growth of the young Baltic salmon gave good results. Dietilstilbestrol was also tested; experimental runs were not successful.