International Council for the Exploration of the Sea

Mariculture Committee
C.M. 1989/F:1

Activity Report 1988
Mariculture Committee

by

Harald Rosenthal

Belgium

by

(**Patrick Sorgeloos**, Ghent)

State University of Ghent, **Artemia Reference Center**

Ongoing research with regard to the following topics:

- manipulation of yeasts with regard to their potential use as algal substitutes in aquaculture
- use of Artemia biomass as a feed source in aquaculture
- larviculture of Macrobrachium: effect of HUFA enrichment of the Artemia-diet
- larviculture of Penaeus monodon: evaluation of new diets
- development of new culture and/or enrichment diets for Brachionus and Artemia
- Artemia quality control, strain evaluation, cyst production and diapause inhibition

Organization of special Artemia training course for participants from Spain, Brazil, PR China, Ecuador, Jamaica, Singapore and Egypt.

Cooperation projects for Artemia production and use in local aquaculture in Egypt (EEC), Philippines, Thailand and Ecuador (through the Belgian Administration for Development Cooperation, and the Flemish Association for Educational Programmes Abroad).

Publications: Artemia Newsletters nr. 7, 8, 9 and 10.

Artemia Systems NV/SA

Development (contract research with the ARC) and marketing of new diets for use in larviculture of marine fish and shrimp.

Catholic University of Leuven, Laboratory for Ecology and Aquaculture

Ongoing research with regard to the following studies with sea bass:

- experimental production of 9,000 larvae; main topics of research were the influence of dietary highly unsaturated fatty acids and light intensity on growth, survival and morphological development (malformations such as shorted operculae and lordosis); larval survival rates varied between 12% and 29%.

- the influence of various physical and chemical variables on growth of sea bass fingerlings

- the effect of protein and fat content in the diet on growth and body composition (fat, proteins, dry weight) of sea bass fingerlings.

Nuclear Power Plant at Doel

More than 300 kg of sea bass have been produced at the pilot plant for fish farming at the nuclear power plant. Experiments were also performed on the influence of protein and fat content in the diet on growth and body composition of sea bass fingerlings.

Canada

by

(**B. Cook**, St. Andrews)

Atlantic Canada

New Brunswick

DEPARTMENT OF FISHERIES AND OCEANS
Salmonids

Physiology

At the St. Andrews Biological Station, a preliminary experiment compared growth of Atlantic salmon parr at late-summer thermal ranges (18°-12°C). There was no difference in growth between groups held in water at normal oxygen levels (75-85% of air saturation) and high levels (125%). Further studies will be conducted at temperatures which usually inhibit feeding and growth (20°-24°C).

Researchers at the St. Andrews Biological Station are investigating the development of salinity tolerance in Atlantic salmon parr in early winter to learn if it is indicative of smolt status and long-term survival following transfer of these fish to sea water during autumn-early winter. Preliminary studies suggest that, although large parr may survive abrupt transfer to sea water in autumn, smolting is not complete until the following spring.

The incidence and severity of coronary arteriosclerosis was studied in Atlantic salmon during the various stages of recovery after spawning. All recently spawned fish had high incidences of lesions of moderate to extreme severity. Observations on Atlantic salmon from various sources gave no evidence of lesion regression. Coronary arteriosclerosis in *Salmo salar* appears to be a progressive condition, which continues during recovery of bodily condition and growth after spawning.

Disease

A program operating in New Brunswick since 1985 to monitor Atlantic salmon broodstocks for Bacterial Kidney Disease (BKD) by fluorescent antibody testing of reproductive fluids and screening out eggs from infected matings was effective in reducing vertical transmission to progeny. Last year, monitoring was relaxed somewhat, resulting in egg transmission of BKD to one major smolt producer in New Brunswick this year, resulting in the destruction of 500,000 smolts. Plans are in motion to increase monitoring this year.

No clinical outbreaks of furunculosis have occurred in marine cage sites traced to smolt movements since 1985. This is due primarily to a successful program of corticosteroid carrier testing of all smolts going to sea cages in the province.

A new, highly virulent strain of *Vibrio ordali* was responsible for losses in many marine caged salmon facilities in the Bay of Fundy area of New Brunswick in 1988. The agent can kill salmon at low temperatures down to 1°C. To date, available vibrio vaccines do not adequately protect salmon from this new strain. A new commercial vaccine is currently available and in use on smolts going to cages this year.

Salmonid Demonstration and Development Farm

The trials at the experimental farm continued to focus on the nutritional requirements of Atlantic salmon and the assessment of the relative growth rates of 1+ and 2+ smolts under commercial scale sea cage conditions. The performance of moist feed was contrasted with a moist silage-based feed, as well as dry pelleted and extruded feeds. The performance of various feeding strategies were also evaluated such as feeding only six days a week, feeding a sequence of dry-moist dry during an annual cycle, and time of feeding. The results of these trials are made available to the local industry and serve as a benchmark for the expanding Bay of Fundy salmon aquaculture industry.

The Salmonid Demonstration and Development Farm also served as a research site for experiments on environmental impacts, the testing of antifoulants, and participates in the broodstock development porogram of the Salmon Genetics Research Program.

Environmental Impacts

Ongoing research in the Letang inlet system is examining the capacity of this system for finfish aquaculture development. An ecosystem model will be built using the physical, chemical and biological information being collected. The model will be developed through a series of multidisciplinary, interactive workshops beginning in June 1989.

Other Finfish

A research program on halibut culture was initiated at St. Andrews Biological Station. Initial acitivities included the collection of broodstock for egg production and juveniles for grow-out experiments. The latter were used in a tidal enclosure (modified herring weir).

Invertebrates

Studies on lobster culture are continuing at the St. Andrews Biological Station. A study was completed on four grow-out methods for the culture of giant scallops in the Bay of Fundy. The mechanism of oyster larval dispersal and retention were studied last year to better understand the self-sustaining mechanisms of the long term resident population of American oysters *(Crassostrea virginica)* in Caraquet Bay, N.B.

HUNTSMAN MARINE SCIENCE CENTRE (HMSC)

HMSC is evaluating various strains of Arctic char for freshwater and seawater aquaculture at its research facilities in St. Andrews, New Brunswick. A breeding program is seeking to improve seawater tolerance in these strains. Under a license agreement, 200,000 eggs were provided to the aquaculture industry in Eastern Canada; under this agreement, HMSC also provides rearing and marketing advice. HMSC is assisting in the devleopment of two new hatcheries for Arctic char, one in Quebec and one in Newfoundland.

ATLANTIC SALMON FEDERATION

A controlled selection experiment for increased size in Atlantic salmon has demonstrated an increase of 1.84 cm in the fork length (length from the nose to the fork in the tail), where a selection differential of 6.70 cm was applied in the parents, yielding a realized heritability of 0.27 (Proc. Third Intl. Symp. in Aquacult., Trondheim, Norway, June 20-24, 1988 - In Press). Other studies in the program indicate that generic correlations between growth in fresh water, during the first 18 months of life, and subsequent growth in sea water, after smoltificaiton, are weak (Aquaculture 88, Vancouver, Aug., 1988 - In Press). Consequently, selection for aquacultural stocks is now making use of indexes, involving both freshwater and saltwater traits.

The New Brunswick Salmon Growers Association is now employing gene pools, from the Salmon Genetics Research Program, as primary breeding stock.

PRODUCTION

Salmon cage culture industry: 2,600 tonnes ($36,900,000)

Nova Scotia

DEPARTMENT OF FISHERIES AND OCEANS

Salmonids

Physiology

In a study at the Halifax Fisheries Research Laboratory, differences in a number of physiological responses were observed in juvenile Atlantic salmon held at pH 4.6, compared to those held at pH 5.0 or 5.5. These included: lower plasma osmolarity, higher urine osmolarity, apparently lower plasma volume, lower condition factor, lower moisture content, and lower survival at pH 4.6.

A mortality of 8.6% of the juvenile Atlantic salmon at the Mersey Fish Culture Station during August 1988 was attributed to the release of ferrous and manganous bicarbonates

from the headpond bottom sediments. Subsequent aeration of the water resulted in the formation of ferric and manganic hydroxides precipitates. Accumulation of ferric and possibly manganic hydroxide on the gill filaments of the salmon parr appeared to cause an impairment of respiratory function which resulted in mortality. Concentrations of hydrogen sulphide in the water supply may also have contributed to the mortality of parr which occurred.

Nutrition

A study was conducted at the Halifax Fisheries Research Laboratory to determine the effects of vitamin C deficiency and excess on growth, pathology, immunity, and disease resistance in Atlantic salmon *(Salmo salar)*. The supplemental vitamin C level of 500 mg/Kg was sufficient for normal growth and prevention of deficiency signs including lethargy, scoliosis, lordosis, broken back and anemia. Liver and spleen iron levels increased with increasing dietary ascorbic acid level in the diet.

For all diets, no effect on the non-specific resistance of Atlantic salmon to vibriosis and furunculosis was observed. Groups of fish fed 0 to 2000 mg of vitamin C were also immunized with *A. salmonicida* and *V. anquillarum* vaccines. One month after vaccination, both the humoral response and the complement system were not affected by these dietary levels of vitamin C and protection was observed in all vaccinated groups following a live challenge.

Broodstock Development

A strategy for evaluating strain performance and for developing broodstock for the Nova Scotia salmon aquaculture industry has been initiated, involving the production of three different strains in each of four years. Approximately 2,500 smolts of each strain are being provided to each of four marine farm operators by the Mersey hatchery in southwestern Nova Scotia. The program is a cooperative venture between industry and government.

Invertebrates - Phytoplankton Toxicity

The Bedford Institute of Oceanography is sampling five coastal sites at regular intervals for the purpose of developing methods to monitor and predict the occurrence of significant concentrations of shellfish toxins. The project will also be of use to coastal mariculture development in general by adding to our understanding of the dynamics and composition of phytoplankton communities and their interaction with aquaculture developments. There are similar studies being conducted by the St. Andrews Biological Station, the Gulf, Quebec and Newfoundland Regions. The studies are being coordinated by the Habitat Ecology Division at the Bedford Institute.

NOVA SCOTIA DEPARTMENT OF FISHERIES

Finfish

Work in 1988 included: application of submersible finfish rearing cages for the avoidance of super-chill problems; technological development of an automatic grading system for use inside a finfish rearing cage; broodstock enhancement work with industry; and provision of fish to members of the academic community.

Molluscs

Hatchery technology enhancement was conducted with the following species: *Crassostrea virginica* (native oyster), *Ostrea edulis* (European Belon oyster), *Mya arenaria* (soft-shelled clam), *Mercenaria mercenaria* (quahogs), *Spisula solidissima* (bar clam), *Aropectan irradians* (baby scallop), and *Esnis directus* (razor clam). Aminobutyric acid (gaba) was experimented with for enhanced metamorphic characteristics and found to have marginal effect. Various shell chips (clam, oyster, mussel) were evaluated as cultch. Cultivated mussel shells were found to be best suited, due to their thin shell. Inexpensive stacked screens were developed and tested for size grading of larvae.

PRODUCTION 1988

Atlantic salmon:	27 tonnes	($ 229,000)
Rainbow trout:	184 tonnes	($1,193,000)
Speckled trout:	11 tonnes	($ 67,000)
Oysters:	130 tonnes	($ 208,000)
Mussels:	306 tonnes	($ 455,000)

Algal Culture

Varying amounts of silicate were added to diatom cultures. The fastest growing cultures were obtained with the addition of 60 g/L $Na_2 SiO_3.9H_20$, as recommended in Guillard's f/2 formulation. An automatic algal delivery system for shellfish feeding was designed and built.

Industry Activities

Activities in 1988 included: information services; water sampling; technology transfer, training private industry hatchery staff; grow-out cultivation methods; equipment development; hatchery and site demonstrations; and mediating coastal zone conflicts.

Prince Edward Island

DEPARTMENT OF FISHERIES AND OCEANS

Mussels and Oysters

In the Gulf Region, research continues (year 2 of 3) on examining the environmental factors influencing growth, survival and productivity and modelling of carrying capacity of longline cultured blue mussels, *Mytilus edulis* (in the Cardigan River estuary, P.E.I., Canada). Preliminary results show that food availability via water currents may be a limiting factor. In situ measurements of clearance rates will be estimated and used to calibrate the model being developed for estimating carrying capacity.

ATLANTIC VETERINARY COLLEGE

Studies are investigating fresh and frozen storage of salmonid spermatozoa. Another study is examining aspects of fish health for the culture of Atlantic halibut and other marine finfish. This includes the examination of bacterial flora in halibut, vaccine trials on

marine flatfish, and an inventory of finfish diseases. The college is also a participant in a study evaluating the efficiency of a new antibacterial agent in the control of three economically important gram negative fish pathogens.

In conjunction with the Department of Fisheries and Oceans, investigations were made of the domoic acid - blue mussel toxicity incident.

Studies on mussels indicated an approximate doubling of ammonia excretion and oxygen consumption for every 2°C increase in temperature, over the range of 2°-10°C.

Another study evaluated the flow dynamics in a fibreglass tank holding 225 kg of mussels.

In collaboration with the Nova Scotia Department of Fisheries, a study determined the lethal effect of dichlorovos on phytoplankton, zooplankton, larval lobster, adult lobster, mussels, and periwinkles.

PRODUCTION

The mussel industry rebounded following the December 1987 domoic acid incident.

Oysters:	1 464 tonnes	($2 899 000)
Mussels:	1 444 tonnes	($2 383 000)
Trout (mostly freshwater):	14 tonnes	($ 68 000)

Newfoundland

DEPARTMENT OF FISHERIES AND OCEANS

Atlantic salmon

In Newfoundland, a request for proposal has been developed for a contractual study to design a broodstock selection program that addresses the needs of the industry as well as recognizing DFO concerns regarding fish health and genetics. It is expected that this study will be implemented and completed this year.

NEWFOUNDLAND AND LABRADOR DEPARTMENT OF FISHERIES

Salmonids

Research is ongoing to provide technology to increase overwinter survival of Atlantic salmond during ice conditions. Work continues to identify culture potential of Artic char in estuarine conditions: initial data indicates good survival and growth.

Molluscs

Scallops research continues on the practicality of culturing Giant Scallops *(Placopecten magellanicus).* Hatchery technology for spat production has been developed as well as

refinement of wild spat collection techniques to increase production. Grow-out technology utilizing net culture, ear-hanging and bottom culture are also being investigated.

PRODUCTION

Atlantic salmon:	10 tonnes
Rainbow trout:	20 tonnes
Blue mussels:	225 tonnes

Quebec

MINISTERE DU LOISIR, DE LA CHASSE ET DE LA PECHE

Salmon

Three moist diets for salmon parr have been produced in collaboration with a private fish farm. Two diets were silage-based and the other one was produced with cod flesh. These three diets have been compared to a commercial dry food.

Growth rates observed were quite low, due to a bad adaptation of the parrs to their new tanks and also to some external stresses. The cod flesh-based diet gave the better mean growth rate. The higher specific growth rate was observed with one of the silage-based diets.

Mussels

Work on the estimation of the carrying capacity of the Magdalen Islands lagoons for mussel culture has been continued in cooperation with the Institut National pour la Recherche Scientifique en Océanologie. Work has been pursued on the development of mussel culture in open waters using a long-line technique. Preliminary work was done to investigate the possibility of using the Swedish mussel culture technique in our area.

A second year study on the rate of intoxication of wild and culture blue mussels by the toxic dinoflagellate *Gonyaulax tammarescens* was conducted in the Baie de Gaspé. Wild mussels were less toxic than cultured mussels. Samples placed at the bottom of the water column were more toxic than those near the surface; both were more toxic than mussels immersed near shore. It was concluded that the production of culture mussels would be possible by harvesting in the autumn in open waters or in the winter under the ice cover.

Scallops

Approximately 20,000 young scallops were placed in culture on the Lower North Shore. Most of these scallops come from two experimental hatcheries. The hatchery production option was initiated to overcome the low spat collection success of the last six years. Due to the small size (less than 7 mm) of the scallops and the time (late autumn) of the transfer, mortality during the first winter was high (greater than 70%).

Four hatchery production trials in 1988 resulted in the production of 500,000 post-larvae (≥250 microns). The post-larvae from one trial suffered high mortality after metamorphosis, due to water quality problems.

In an experimental nursery trial, post-larvae grew from an an average of 1.35 to 6.1 mm in 60 days, with 65% survival. In 1989, it is expected that more than 100,000 juveniles (5-10 mm) will be produced. Also in 1989, the feasibility of suspended culture in coastal waters of les Iles-de-la-Madeleine will be studied.

PRODUCTION

Salmon : 28 tonnes
Mussel : 92 tonnes

British Columbia

DEPARTMENT OF FISHERIES AND OCEANS

Salmonids and Other Finfish

Aquaculture Biotechnology

Studies were conducted on the oral administration of recombinant growth hormones to accelerate the growth of juvenile coho salmon and on treatment of adult chinook salmon in seawater netpens with recombinant growth hormones. A program was undertaken to purify salmon pituitary growth hormone in order to develop an homologous radioimmunoassay for use in studies of growth physiology.

Reproduction Biotechnology

Experiments were conducted to improve the yield of triploid rainbow trout from heat shocking treatments, to induce ovulation of captive sablefish broodstock, and to optimize sterilization procedures for salmon. Work continued on the development of all-female stocks of coho salmon for the farming industry.

Nutrition

Experiments were conducted to determine the quality of the flesh of farmed salmon, to assess the nutritive value of alternate protein sources for fish feeds, and to determine the digestibility of feedstuffs.

Salmon Genetics

A strain comparison study evaluating the performance of six stocks of coho salmon in netpen culture was completed. A selective breeding program for coho salmon was initiated with 130 families transferred to netpens as zero-age smolts. The genetic variation in resistance of coho salmon to bacterial kidney disease was evaluated in laboratory experiments.

Salmonid Mariculture

A laboratory experiment was conducted to determine the genetic control of photoperiod sensitivity in juvenile chinook salmon. Laboratory studies or photoperiod control of early growth and smolting were conducted with coho and Atlantic salmon.

Chinook Strain Comparison

A four-year study comparing the performance of six river stocks of chinook salmon reared on four commercial salmon farms and in the Experimental Fish Farm in Nanaimo was completed with the spawning of 5.5 million eggs.

Incubation Research

Laboratory experiments were conducted to examine development of chinook salmon eggs in moist air incubation at 12-15°C. A conical upwelling incubator was developed for incubation of sablefish eggs.

Disease Control Research

Work continued on development of diagnostic and treatment procedures for bacterial kidney disease, vibriosis and furunculosis. Investigations were initiated with newly reported disease problems such as liver disease, eye tapeworm and marine anemia.

Disease Control

Carried out inspections required to ensure compliance with the Canadian Fish Health Protection Regulations, acted as a reference laboratory for private sector personnel, monitored quarantine facilities for imported Atlantic salmon eggs, and offered workshops for fish culturists.

Sablefish Culture

Larval rearing studies were conducted to determine optimum temperature conditions for growth and survival of yolk-sac larvae, best food organisms, and causes of edema in post yolk-sac larvae.

Molluscs

Research focused on developing methods to produce large quantities of juvenile scallops, mainly Japanese scallops, *Patinopecten yessoensis* and rock scallops, *Crassadoma gigantea* and on studies of the summer mortality in blue mussels, *Mytilus edulis.* Only minor work was done on clams, mostly manila clams, *Tapes philippinarum* and Pacific oysters, *Crassostrea gigas.*

Research on scallops focused on producing large numbers of juvenile Japanese scallops, improving technology of the nursery stage of scallop culture and completing a grow-out study with Japanese scallops at seven sites along the British Columbia coast. Over 100,000 juvenile Japanese scallops were produced that measured 1-4 cm shell height by the end of 1988. This production was achieved through improved breeding and hatchery techniques. The grow-out data are being analyzed and will be published later in 1989.

Studies of the blue mussel summer mortality problem were designed to determine if it is caused by environmental or genetic factors. Data are still being analyzed.

One private company was awarded an IRAP grant to build a scallop hatchery and begin scallop culture operations in British Columbia. Construction will begin in 1989.

Minor commercial operation continued for manila clams culture.

PRODUCTION

Official statistics are not yet available for 1988. The B.C. Salmon Farmers' Association estimates total salmon production at 6,040 tonnes worth approximately $56,600,000. This was comprised of 4,040 tonnes of chinook salmon, 1,750 tonnes of coho salmon and 250 tonnes other (Atlantic salmon, rainbow trout).

The Pacific oyster continued to provide the largest landings of any culture invertebrate in British Columbia. Production in 1987 totaled 3,751 tonnes (whole weight), about 80% of these landings came from culture operations. Total landings were comprised of 380,873 dozen single oysters for the half shell trade and the remainder was shucked. Total landed value was $3,851,000. Preliminary data indicate that 1988 landings will be similar to those in 1987. About 350 oyster leases were held by about 200 growers, total area under lease was about 1,600 hectares. Two oyster hatcheries operated in British Columbia to produce seed (juveniles) and eyed-larvae for sale. Most growers now rely on setting eyed-larvae at their facilities for their seed source.

Commercial blue mussel farms operated in 1987 but production was low; estimates indicate it will be under 20 tonnes (whole weight), with a value of less than $30,000. The major obstacle ot development of a large mussel culture industry in British Columbia continues to be the summer mortality problem.

Thirteen companies are licensed to culture manila clams, but production is only experimental (less than 1 tonne in 1988).

One commercial operation for northern abalone continued in 1988 and minor production was realized (less than 1 tonne whole weight). The company ceased to operate in 1988.

Denmark

(no report received)

Finland

by

(K. Westman and P. Tuunainen)

Finnish Game and Fisheries Reasearch Institute,
Fisheries Division, P.O. Box 202, SF-00151 Helsinki

Production of Fish for Human Consumption

Rainbow trout *(Salmo gairdneri)* is practically the only fish species cultured in Finland for human consumption. 99% of the production is rainbow trout. The cultivation of

salmon as a food fish has been tried in a dozen of brackish water cage farms in Finlands. There have been problems with cultivation techniques, however, and this type of fish farming is still in the experimental stage. At present, only 1% of the total production, i.e. about 100 t, is other species than rainbow trout, mainly salmon and brown trout.

Farming of rainbow trout increased considerable in the 1980's, especially in net cages and enclosures in the sea. By 1987, marine fish farms produced 69% of all the rainbow trout raised in Finland.

Table 1. Number of fish farms and production of fish for human consumption in Finland in 1980-1987 on statistics from the Finnish Game and Fisheries Research Institute. Production 1,000 kg (ungutted fish).

	Marine Fish Farms		Fresh Water Fish Farms		Total		Est. Value of Prod.
Year	Number	Prod.	Number	Prod.	Number	Prod.	Mill. FIM
1980	78	1,958	108	2,712	186	4,670	95,7
1981	85	2,221	157	3,175	242	5,383	116,8
1982	98	3,226	195	3,099	293	6,325	128,4
1983	105	3,910	173	3,601	278	7,511	158,0
1984	151	5,381	184	4,112	335	9,493	204,0
1985	176	6,647	159	3,427	335	10,074	227,0
1986	177	7,140	184	3,773	361	10,913	246,0
1987	177	8,784	204	3,894	381	12,678	304,0

Production of Fish for Stocking

The stockings required by law of power companies and similar compulsory stocking and state stocking have sharply risen in the 1980's in regard to salmon *(Salmo salar),* sea trout *(Salmo trutta m. trutta)* and migratory whitefish *(Coregonus lavaretus)* in marine waters. In 1987, a total of 5.0 million salmon, 6.8 million migratory whitefish and 1.6 million sea trout, one-summer-old and older juveniles were produced in Finland for stocking purposes.

Especially the rearing and stocking of salmon has rapidly increased in Finland in the last few years. According to the satistics of the Finnish Game and Fisheries Research Institute, in 1980, a total of 672,000 salmon juveniles, aged one-summer and older, were stocked in the Baltic or in rivers flowing into the Baltic. In 1982, the number of stocked salmon exceeded 1 million (1,430,000); in 1984, the number exceeded 2 million (2,196,000); and in 1988, ca. 5 million salmon were stocked. The value of the salmon juveniles stocked in 1988 exceeded FIM 20 million (ca. USD 5 million).

The total number of Baltic salmon stocked in Finland between 1980 and the present (1988) now exceeds 20 million individuals. About half of these were stocked by the Finnish Game and Fisheries Research Institute, and the other half were stocked by the power companies.

In the Simojoki and Tornionjoki Rivers, which flow into the Gulf of Bothnia, stocking of one-year-old salmon parr has continued in the rapids to maintain the sharply declining stocks. In the Simojoki River in 1988, 67.000 salmon parr were stocked; and in the

Tornionjoki River, 68,000 parr. In addition, 2,600 and 17,200 smolkts were stocked into the rivers, respectively. Extensive monitoring programs are being run in both rivers. Genetic studies of the salmon and sea trout stocks continued. The sea trout stock in the Tornionjoki River is particulary threatened. In 1988, 11,200 sea trout smolts were stocked.

Salmon and sea trout smolts are produced principally by conventional, intensive-cultivation methods at fish farms; whitefish are produced in large natural-food ponds. As a result of the drastic weakening of wild salmon and sea trout stocks, the acquisition of eggs from wild spawners has been insufficient to meet the rapidly increasing needs. Hence, the volume of eggs required for the cultivation of salmon and sea trout juveniles for stocking purposes has been ensured by establishing brood fish stocks at state fish farms. For example, in 1986, the amount of salmon brood fish at state fish farms was ca. 14,000 kg.

Salmon eggs have been hatched in the state fish farms from 1980 to 1988 in volumes of 5.1-10.6 million eggs annually. The number of hatched sea trout eggs has varied from 1.6 to 4.0 million respectively.

Today more and more often fish farms in Finland are using warm water in some phase of rearing in order to speed up the growth of juveniles. New techniques, including water circulation and heat exchange have been adapted in the rearing of salmonid juveniles, particularly at the incubation and fry stage. Due to the usage of warm water the stocking volumes of one-year salmon smolts are rapidly increasing.

Research

Research studies were carried out to investigate the results of stockings made for sea ranching. These studies included extensive tagging both Carlin- and micro tags. Other research included studies aimed at improving the quality of reared fish young by investigating food and feeding, improved rearing methods, and the use of ADP in fish culture monitoring and management. Effective control of parasites and disease was studied, and fish quality was measured using the physiological testing methods developed.

Studies have also been continued to the end of improving stocking results by decreasing the mortality rate and stock salmon smolts, e.g., by the use of release ponds and delayed release, and by developing better transport methods and equipment. Extensive research continued into methods to decrease the water pollution caused by fish farms. The phosphorus content of the feeds has been reduced, self-cleaning tanks have been taken into use, and the collection of sludge has been more efficient.

Studies of one-year-old salmon smolts in the warm water effluents of nuclear power plants, and comparative studies on the genetics of wild and reared salmon and sea trout stocks are also being continued.

Fish Diseases

In Finland, Furunculosis (*Aeromonas salmonicida* var. *salmonicida)* was first observed in 1986 in a few marine fish farms and in ine fresh water farm. In 1987, the first marine fish farm was infected with IPN and four new observations were made in 1988. All IPN cases were located on a restricted southwestern sea area. To prevent the spread of the diseases, limitations on transfers of fish were set, and other preventive measures taken. No signs or cases of VHS or any other major, communicable fish diseases were found in Finland in 1986-1988.

Vibriosis disease still causes considerable damage in rainbow trout cultivation in the sea; better vaccines are now being developed.

Outline for Statistical Information on Mariculture Production 1987

Species	In Metric Tons	Approx number in 100,000	Value in 1,000 U.S.$ [1]
Rainbow trout in enclosures more than 0.5 kg each	8,784	-	49,000
Salmon smolts for introduction one-year-old and older	-	48.6	5,000
Other salmonids: sea trout for introductions, one summer and older	-	15.8	1,800
Other: migratory whitefish for introduction, one summer old	-	61.8	, 900

[1] Rate $ U.S. = 4.3 FIM

CONDENSED FROM FAO FORM REPORTING STATISTICS ON AQUACULTURE

From Sheet No. 1

Method of Culture	Freshwater culture		Brackishwater Culture	
	No. of Units	Hectares	No. of Units	Hectares
Fishes				
Tanks	3,656	4.8	-	-
Enclosures) Cages)	192	4.4	1,460	30.6
Raceways (earth ponds)	1,641	86.8	-	-
Others: natural food rearing ponds	931	9495.0	-	-

HATCHERY OUTPUT

- see attached statistics "Fish culture in Finland 1987"
  produciton ot stockings

From Sheet 2

Species Cultured	Freshwater Culture		Brackishwater culture	
	Metric Tons	Price Kg	Metric Tons	Price Kg
Fishes (live weight)				
Ponds:				
99% (rainbow trout, *(Salmo gairdneri)* 1% (Atlantic salmon, *Salmo salar* and (brown trout, *Salmo trutta)*	3,894	23.9 FIM		
Cages:				
99% (rainbow trout, *Salmo gairdneri)* 1% (Atlantic salmon, *Salmo salar* and (brown trout, *Salmo trutta)*			8,784	23.9 FIM

FISH CULTURE IN FINLAND IN 1987

Number of Fish Farms and Hatcheries	Brackish Water Cage Farms	Fresh Water Farms and Hatcheries	Natural Rearing Pond Breeders	TOTAL
	181	318	248	747

PRODUCTION CAPASITY OF FARMS AND HATCHERIES	Incubation Capasity		Rearing Space				
					Net Cages and Enclosures		
	Glass Incubation	Tray Incubation	Artificial Tanks	Earth Ponds	Sea Area	Freshwater Area	Natural Rearing Food Pond
	Egg Liter		Number		1 000 m^2		ha
	15 680	23 000	3 656	1 608	1 460	192	931
			48	868	306	44	9 495
Farms and Hatcheries	68	87	98	201	177	32	248

Food Fish Production of Fish Farm [1]	Brackish Water Cage Farms	Fresh Water Farms	Total	Value of Production M FIM
	Production - 1 000 kg [2]			
	8 784	3 894	12 678	304
Farms	177	204	381	

1) 99% of production rainbow trout. The rest salmon and brown trout.
2) Production in kg ungutted fish.

FRANCE,

by

(J. Guillaume and M. Héral)

a) Elevage des poissons et crustacés

L'élevage des salmonidés en mer a connu un développement soutenu en France, portant sur les trois espèces suivantes: truite arc-en-ciel (légère progression de la production), truite fario, et saumon atlantique (démarrage d'une production commerciale). La production du saumon coho a progressé elle aussi.

Les statistiques sont les suivantes:

truite arc-en-ciel *(Salmo gairdneri)*	800 tonnes
truite fario *(Salmo trutta)*	50 tonnes
saumon atlantique *(Salmo salar)*	60 tonnes
saumon coho *(Oncorhynchus kisutch)*	200 tonnes

La recherche a surtout porté sur les points suivants:

En génétique des populations de saumons atlantiques monosexes triploides (stériles) ont été obtenues et ont pu supporter sans problème un passage en mer.

En physiologie il a été montré que le smolt de saumon atlantique est réfractaire à tout traitement hormonal susceptible de modifier sa croissance ou son adaptation à l'eau de mer avant ou après smoltification.

La relation entre hormones thyroidiennes et migration a pu etre précisée par l'étude des niveaux circulants de différentes hormones chez des saumoneaux de rivières très longues (Loire - Allier); les processus physiologiques sont très différents de ceux que l'on connait chez les populations de rivières courtes.

b) Elevage des poissons marins

L'élevage du turbot s'implante progressivement sur le littoral atlantique; la production francaise n'a été que de 20 tonnes environ, mais plus de 200,000 juvéniles ont été commercialisés à partir de la seule écloserie commerciale existant. Plusieurs entreprises (écloseries ou élevage) sont en train de s'implanter.

Le bar, provenant d'écloseries de la région méditerranéene, a fait l'object d'essais d'élevage en conditions semi-intensives dans les anciens marais salants. Les résultats obtenus sont très encourageants: la taille commerciale peut etre obtenue en une saison d'élevage à partir d'animaux d'un an; le taux de transformation de l'aliment est alors excellent.

Au laboratorie les recherches ont surtout porté sur les techniques d'élevage des larves de turbot: augmentation de la fiabilité par un meilleur controle de l'environnement bactérien; pour le bar les efforts ont été tournés vers le sevrage précoce à l'aide de microparticules; mais l'amélioraton des aliments destinés aux juvéniles a également été poursuivie.

c) Elevage des crevettes japonaise

La production de crevettes japonaises dans les marais de la Cote Atlantique a connu un léger accroissement, mais au total elle n'a pas dépassé 15 tonnes.

Germany, Democratic Republic

no report received

Germany, Federal Republic of

by

(K. Tiews)

Crassostrea gigas

The development of the newly initiated commercial oyster farming along the German North Sea coast and in the Flensburg fjord area was closely followed by the Institut für Küsten- und Binnenfischerei der Bundesforschungsanstalt für Fischerei. Four different farming activities produced a total of 800,000 oysters using the methodology developed by the said institute at its former Langballigau field station located on the fjord of Flensburg and which was closed in April 1985, after the task to develop a culture system for the Pacific oyster applicable under the conditions of the German coasts had been more or less completed.

Salmonid fish

Some 15 tonnes of rainbow trouts were grown in 1987 by a private company in cages in the Kiel and Neustadt Bight on a commercial basis in continuation of former experiments carried out by the Institut für Meereskunde an der Universität Kiel and at the Institut für Küsten- und Binnenfischerei der Bundesforschungsanstalt für Fischerei, Hamburg.

Turbot

At Kiel-Bülk, a new purpose-built turbot hatchery started its work in 1987. The facilities include light-controlled brood-stock tanks, egg incubation, live food production and rearing tanks, planned for a production of 150.000 fingerlings/year. The research work focused on the development of improved live and dry larval feeds.

Artemia enrichment techniques were adapted to the conditions at Kiel-Bülk and resulted in reliable results and good nutritional value of the Artemia.

Experiments on the water quality control led to the establishment of a continuous NH_4 measurement device, using a gas-sensitive electrode.

Intensive farming

Experimental investigations on the influence of dissolved gasses on fishes under intensive farming conditions were continued at the Institut für Küsten- und Binnenfischerei.

Fish pathology

Studies to develop methods with which to describe stress conditions for fish in intensive aquaculture systems were intensified at the Institut für Hydrobiologie und Fischereiwissenschaft der Universität Hamburg.

Statistics for 1988	Tonnes	Value in 1000 US $
Blue mussels *(Mytilus edulis)*	29 700	9 180
Pacific oysters *(Crassostrea gigas)* from vertical cultures	64	560
Eel *(Anguilla anguilla)* not fresh water	17	225
Rainbow trout *(Salmo gairdneri)* (1987)	15	94
Turbot fingerlings	20,000 fingerlings	36

Ireland

by

(Jacqueline Doyle, Dublin)

Species		**Tonnes**
Finfish	**1988**	
Salmon *(Salmo salar)*		4 000
Rainbow trout *(S. gairdneri)*		
Marine		500
Freshwater		680
Molluscs	**1987**	
Mussels		
Rope culture		1 500
Bolton culture		13 393
Oysters		
O. edulis		477
C. gigas		104
Escallops *(Pecten maximus)*		227

Finfish

Production expanded rapidly in 1988 but major losses aere still being encountered due to pancreas disease. Losses due to this disease were in the region of 300,000 mortalities in post smolts. The cause of the disease remains uncertain. To date no infectious agent has been isolated in Ireland.

Sea lice also cause significant problems leading to a heavy dependence on treatment with Nuvan (Dichlorvos) and giving rise to environmental concerns. Furunculosis also caused significant losses in farmed salmon in the sea and antibiotic resistance is a growing phenomenon especially to the drug Oxolinic Acid and to a lesser estent Oxytetracycline.

Shellfish farming

In relation to diseases of shellfish *Bonamia* disease of oysters continued to be the most important. No new infected sites were found in 1988.

Harvesting of mussels was again curtailed in the southwest region due to the presence of Diarrhetic Shellfish Toxin (DSP) caused by *Dinophysis acuminata* and *D. acuta*. Toxicity was detected in early June and persisted in some areas until late October. No human illnesses were recorded due to early detection and closure.

Mandatory monitoring programmes are required for all salmon farms under the Aquaculture License. Nevertheless there is considerable concern at the impact of aquaculture on the environment particularly of chemicals such as Nuvan on larval stages of commercially exploitable molluscs and crustaceans.

Research priorities are as follows:

(1) The replacement of Dichlorvos (Nuvan) with an alternative drug such as Ivermectin which has been tested experimentally under field conditions. The drug is orally administered. At levels tested the numbers of lice present and associated lesions were significantly lower than those of control fish. Human toxicological studies are now being undertaken.

(2) A number of field studies have been completed to establish the sublethal effects of Dichlorvos which indicated that for crustacean species tested, mortality was both rapid and high at the recommended Nuvan working strength for salmon cages. Changes in behaviour of mollusc species were also noted.

(3) The development of sensitive chemical methods for the detection of very low levels of Dichlorvos in seawater.

(4) The reduction of antibiotic loading from marine cages using liposomes to package antibiotics and render them insoluble and unavailable in the marine environment.

(5) The use of competitive exclusion to control pathogens on the surface of fish.

(6) The use of biodegradable chemicals to sterilise and decolorise blood water arising from harvesting at sea.

(7) The use of alternative techniques for monitoring the environmental effects of fallout from fish cages and mussel rafts. A sediment profile imaging technique REMOTS (Remote Ecological Monitoring of the Sea Floor) is being used to examine effects and recovery rates of sites which have been soured.

Norway

by

(A.Mangor-Jensen)

This report gives a summarized view over the main research activities concerning aquaculture in Norway. The institutions that have contributed will here be presented separdately. Only the main research insitutions in Norway will be presented here. Further details about minor acitvites are available in the 1988 report of activites.

The institutions that are included in this report are:

1. Institute of Marine Research, with three research stations: Flødevigen Biological Station, Austevoll Marine Aquaculture Station and Matre Aquaculture Station.

2. Institute of Fishery Technology Research

3. Norwegian Herring oil and meal industry research institute

4. University of Bergen

5. University of Tromsø

6. Institute of Aquaculture Research (Akvaforsk)

1. INSTITUTE OF MARINE RESEARCH, DIRECTORATE OF FISHERIES

Flødevigen Biological Station

a) Shellfish:

* Growth rates in oysters in natural biotops. 1985-1988.

* Collection of natural produced larvae of the blue mussel. The planktonic larvae were collected by pumping. Settlement on tapes was also registered. 1984-1988.

* Release of lobster in orderto increase local catches

b) Marine fish:

* Production of turbot and sole fry from eggs stripped of broodstock.

* Growth experiments on sole and turbot on several experimental diets.

* Domesticaiton of Wolfish including first feeding of larvae, and optimizing of food quality for fish in culture. 1987-1990.

Dept. of Aquaculture, Austevoll

Marine Fish:

* Domestication of Atlantic halibut *(Hippoglossus hippoglossus)* . The project was started in 1986 and includes all aspects of halibut fry production in intensive system. The work aims at optimizing the production methodical and technical. Also broodstock management is iincluded in the project.

  In addition to the intensive systems, semi-extensive systems based on natural production of food organisms in large out-door tanks were tested. The food organisms that are being cultivated are several species of algae, rotifers *(Brachionus sp.)* and brine shrimp *(Artemia salinas).*

* Induced spawning in marine fishes. The aim is to induce maturation and ovulation in marine fishes both with hormone injection or by manipulation of the photoperiods. Also the investigation aims at finding methods for displacing spawning periods. The species involved are halibut, turbot and plaice.

* Extensive production of lobester, including studies of behavior.

* Extensive and intensive production of clams *(Pecten maximus).*

Dept. of Aquaculture, Matre

* Effects of photoperiods on smoltification and growth of salmon fry.

* Effects of oxygenation on presmolt stages of salmon. Various degrees of supersaturation are used to find effects on stress, sea water tolerance and blood parameters. Effects of population density related to behavior are also included.

* Hatching/fry quality of salmonids. Fry quality is determined by survival, growth and biochemical parameters like RNA/DNA ratio. Experimental conditions are temperature and different egg/fry substrate.

* Closed cage culture. Aims at giving a biological evaluation of the closed cage system based on growth parameters and physiology.

* Effect studies of prolonged light cycles on growth and grilsing on salmon on the postsmolt stage.

* Timing of sexual maturity on salmon by manipulated light cycles.

Dept. of Aquaculture, Bergen

* A research program on characterization, diagnostization and controlled transfer of infectious pancreatic disease (IPN). Also diseases caused by fish pathogens such as *Vibrio sp.* were studied both in cultures and wild fish.

* Effects of self-pollution and environmental conditions on fish culturing. Natural environmental limitaitons for fish farming was also studied.

* Mitochondrial DNA as a tool for determination of populations of wild salmon. Mitochondrial DNA was found convenient for this purpose due to its special frequency of mutation.

* Effects of polycultures of salmon, rainbow trout and Arctic char on growth, aggression, predation and mortality. Also effects of stocking densities on growth and mortality was studied.

* Effects of environmental conditions as photoperiods and temperature on smolification in salmon. A joint project between Department of Aquaculture, BP Norge a/s and University of Bergen, department of Fisheries Biology.

* Large scale pond production of cod fry, and releasing of cod fry in natural biotops.

2. INSTITUTE OF FISHERY TECHNOLOGY RESEARCH (FTFI)

* Behavior of salmon in net cages is studied to identify important negative stressors from enviornmental parameters and operational procedures - a joint project between SINTEF, IMR and UiB.

* Development of automated feeding systems based on hydroacoustic monitoring of feed waste and fish behavior.

* Development of PV-based echo-integrator systems for monitoring vertical fish distribution in net cages.

* Cleaning behavior between wrasses and salmon is studied. The results indicate that this might be an alternative method for de-lousing.

* Arctic char. The project includes studies on the effect of natural and artificial photoperiods on seawater adaptation during spring season, potential in sea ranching, growth potential at low temperatures, quality assessments by sensory and chemical analyses.

* Fish feed investigations including feeding trials with floating dry feed, alkaline conservation of fish waste for use in fish feed, fish wasste as ingredient in feed for farmed cod and lactic acid bacteria in the gut flora of farmed and wild cod.

3. NORWEGIAN HERRING OIL AND MEAL INDUSTRY RESEARCH INSTITUTE (SSF)

Food quality:

* Optimalization of relative content of protein, fats and carbohydrates in salmonide feed.

* Effects of fish meal protein quality on growth rates and assimilation efficiency in salmonides.

* Effects of various fish oils in feed on the meat quality of salmonides.

* Comparative experiments with pellets and extruded fish feed. The effect of extrusion on the protein quality of fish meal.

Feeding of marine larvae:

* Development of dry feed for sole, turbot and halibut. A joint project between SSF and Flødevigen Biological Station.

* Hydrolysed and fermented fish proteins for fish fry.

* Acceptability and nutritional "value" of feed produced of fish meal from fish conserved by organic acids.

* Effects of food quality on the growth rate of halibut juveniles with special reference to carbohydrates.

4. UNIVERSITY OF BERGEN

Several aquaculture projects are carried out at the University of Bergen. However, most of them are in cooperation with the Insittute of Marine Research, dept. of aquaculture and are therefore listed elsewhere.

* Research on environmental condition in smolt production. The aims of this project are to increase the yield in smolt production, reduce mortality and to increase amount of smolt with high quality.

* The research activity of the department of fisheries are joint programs together with IMR and the Agriculture Research Council of Norway, Ås, where a large part of the projects include graduate student programs.

5. UNIVERSITY OF TROMSØ, DEPT. OF FISHERY BIOLOGY

Department of aquatic biology

* Egg quality problems in marine fish. The aim of the project is to develop objective criteria for determination of egg quality, to study the influence of varying egg quality on condition and survival of the fish larvae, and to investigate egg quality during the spawning period of naturally spawning fish.

* Development of the digestive system in marine fish larvae. Microscopic methods are used in order to elucidate the functional digestive development of fish larvae. Effects of different diets on the intestinal epithelium are also studied.

* Development biology and ecology of Atlantic halibut. The project includes field studies of the planktonic egg and larval stages, egg development and spawning seasons. Growth, feeding rhythms, food intake and digestion, and oxygen consumption is investigated for juvenile halibut in captivity.

* Feeding biology and ecology of larval cod. Survival growth, and behavior of cod larvae feeding on phytoplankton, and copepod nauplii is studied in intensive culture system.

* Production of selected zooplankton species as first feed for fish larvae. Continuous culture of harpacticoid copepod (*Tispe* sp.) has recently been established, and the potential for this species as food for cod larvae is investigated under controlled experimental conditions.

Dept. of Fishery Biology

* Physiological ecology and energetics. Several studies are concerned with the investigation of food consumption and energy partitioning both at the individual and population level. Investigations are carried out on fish held under culture conditions in order to describe the effects of feeding regimes, food compositon and environment on feed utilization, growth and body consumption, with the aim of optimizing production. Field studies are directed towards quantitative assessment of predator - prey intereactions within marine systems.

* Arctic Char *(Salvinus fontalis)* . Several investigaitons have been carried out in order to elucidate the potential of Arctic char as species for cultivation. These include studies of hatching, start-feeding, growth in different cultivating densities, stress factors, nutrition, pigmentation and sea water tolerance. Several populations are being investigated.

* Ecology and growth of cod. The main aim of the project is to examine the growth requirements of juvenile cod in the coastal waters of northern Norway, in an attempt to describe the processes of determining recruitment and to predict possible effects of sea ranching programmes. Field studies of feeding habits, growth and population dynamics are carried out, and these are coupled with laboratory studies of larval rearing, food requirements and growth.

Dept. of Marine Biochemistry

* Bacterial flora in the gut of fish and disease prophylaxis. Bacteria belonging to the genus *Vibrionaceae* have been demonstrated to live in close association with the intestinal wall of seawater fish (herring, cod and saithe) and salmon in sea water. In addition, studies on possible competition between this flora and pathogenic species and how this many ge affected by feed and environmental facts are carried out.

6. TROMSØ MUSEUM

Dept. of Marine Biotechnology

* Fish immunology and development of diagnostic methods and vaccines: studies of the immune system of fish in order to produce effective vaccines against fish diseases; isolation and characterization of bacteria causing cold.-water vibriosis, classic vibriosis and furunculosis in salmonids; studies of viral diseases of farmed fish; monitoring changes in levels of specific serum components as function of bacterial infections; development of monoclonal antibodies against bacterial antigens.

* Digestion and feeding of marine fish larvae. The project includes studies on the digestive enzymes in fish larvae, develop methods for monitoring digestive capacity of marine larvae, and development of formulated dry feed for marine larvae.

7. INSTITUTE OF AQUACULTURE RESEARCH (AKVAFORSK)

* **Breeding and selection.** Based on the results from several years of research a selection program for salmon and rainbow trout have been developed. Together with Norwegian Fish Farmers Breeding Center this selection scheme is carried out as a national selection program.

* **Breeding and genetics.** Genetic gain of salmon and rainbow trout; study of body composition of salmon by computertomography; study of genetic resistance in salmon and rainbow trout; immune response in salmonid fishes, development of methodology and study of inheritance; correlation between growth and age at maturation; correlation between feed intake, feed utilization and growth; selection for growth rate in Tilapia; selection and return frequency of sea ranched Atlantic salmon; gene technology - isolation of gene for transferin.

* **Nutrition:** nutritional requirement in fish, metabolical and physiological studies of salmonid fishes; effect of nutrition on reproduction; possibilities of reducing pollution by changing feeding regimes; cereals, soya and legumes as feed sources for salmonid fishes; conservation of fish and fish byproducts; health of fish in relation to nutrition, breeding and enironment; effects of nutrition on meat quality; undigested fat in the stomach; new indicators in nutritional experiments; production of 0 year + smolts; studies on fatty acids in cell membranes of salmonids and halibut; sources of carotenoids for coloring fish meat; effect of light regimes in fish farming.

* **Health:** effect of n-3 PUFAs on cell membrane structure and function in Atkantic salmon and rainbow trout; DIC, a basic pathologic process in Atlantic salmon; presentation of chemotherapeutics to fish; methods of parasite control in farmed fish; vaccine testing; untoward effects of formaline; blood coagulation in Atlantic salmon and rainbow trout; in vitro model for studying endothelial degeneration in Atlantic salmon; shortening of the opercula in farmed salmonides; health control measurements in farmed halibut; optimalization in the use of fish anestethics; disease control in pumped sea water sites; morphology of the liver and the gut wall in farmed salmonides.

POLAND

by

(Krysztof Groyczko, Zukowa)

Note: *This is a section of the activity report originally prepared for the Genetics Working Group*

1. The family selection commenced, based on five strains of spring spawning rainbow trout at the Inland Fisheries Institute Salmonid Research Laboratory.

The present part of this programme has two purposes: first, to build up the outbred broodstock characterized by fairly high genetic variability and second, to determine if any heterosis effect can be observed between tested strains.

2. Sex control in rainbow trout

Proved functional phenotipic males / XX genotype / were distributed to several fish farms for the whole female market fish production.

3. Polyploidization.

3.1. The experiment airmed to compare "normal", whole female and sterile /triploidized females /rainbow trout was continued / second season /.

3.2. Effects of polyploidization on survival and growth rate of hybrids among book, sea and rainbow trout involving reciprocal crosses were tested during the first year of experimental fish life.

4. Gynogenesis
The experiments aimed on improving the methods of sperm sterilization were continued as well as those for UV radiation and for artificial gynogenesis.

Portugal

by

(Jaime Menezes, Lisboa)

Introduction

The mariculture activities have been pursued through extensive and semi-intensive cultures, the former including the economically significant artisanal fishermen skilled to exploite finfish also in polyculture in backwaters. This consists of the utilization of tidal movements in estuary or lagunar branches which are bound by a dike and where the sluices are opened during the appropriate nursery season for commercially- important fish species.

The assessibility of funds, mainly from the EEC, permitted the increase and improvement of mariculture, mainly of extensive and semi-intensive culture systems for finfish and shellfish.

Finfish

During 1988, the most significant extensive and semi-intensive fish cultures are the poly- and monoculture of gilthead sea bream, sea bass, sole and mullets, according to the coastal localization. Additionally, three intensive fish cultures are in the process of being established, two for Atlantic salmon and one for turbot.

On the south coast, two hatcheries are under construction and are almost ready for starting the operation, each of the hatcheries will work with gilthead sea bream, sea bass and Japanese shrimp.

At the INIP aquaculture unit in Lisbon, the continuous spawning of gilthead sea bream and sea bass has been controlled through the handling of environmental parameters in addition to the successful inducement of spawning through the hormone injection (HGC). The increase in the survival rate of juveniles has been improved in the INIP units in Lisbon and the Algarve (Olhao).

A new pilot station is under construction and has almost been completed in the center part of the Portugesian coast (Figuerira da Foz), and this is undertaken under the supervision of the INIP. The sea bass has been selected as the prime species for the culture experiments, with the main emphasis placed on studies on the genetic selection of parental fish (brood stock improvement).

Shellfish

Concerning *crustacea,* culture trials are centered around the Japanese paeneid shrimp, using extensive and semi-intensive systems. Culture techniques are timed to allow at least two to three months grow-out time. In 1987, shrimp culture production was small, reaching approximately one tonne, but this loww production was followed by five tonne output in 1988; the projected production for 1989 is estimated at 15 tonnes.

These results were achieved through INIP research and development which began as early as 1985, first in small-scale, laboratory experiments. These were followed by field trials through cooperative work with shellfish culturists, and this approach is still being pursued.

Two shellfish hatcheries are under construction and have almost reached completion, with two more units projected for operation. This will be constructed in the near future.

With regard to molluscs, in particular the clams and Portuguese oysters, seed production and its adaptation in the field and delivery for culturists is being carried out in the Algarve by the INIP Regional Center.

Experimental cultivation of the sea scallop, *Pecten maximus,* is being conducted on the south coast.

Diseases

Health surveys on wild populations and sanitation support for aquaculturists continues, facilitating the identification of fish pathogens important in culture conditions and supporting and guiding the implementation of prophylactic measures.

The main pathogens identified were protozoans in molluscs, protozoan bacteria and fungus in crustacea, and protozoans, bacteria and worms (monogenea) in commercially grown finfish.

Live Food

Various microalgae and planktonic herbivorous species are employed in research work on mass production of feed for finfish and shellfish larvae and juveniles and these studies are encouraged.

Scotland

by

(**A.L.S. Munro,** Aberdeen)

Commercial Atlantic salmon culture produced 17,951 tonnes in 1988, compared to 12,721 tonnes in 1987. Numbers of sea sites were 258 (196 in 1987) of which 14 were tank-based, producing 3% of the total. The returns showed that 11,866 tonnes (av. wt. 2.3 kg) were from the 1987 smolt intake and 6,084 tonnes (av. wt. 3.5 kg) were from the 1986 smolt intake. Survival trends in both groups were the lowest recorded suggesting that only two out of three smolts placed in sea water survive to harvest compared to survivals of four out of five in previous years. The additional mortality (about 14%) is considered to be largely due to two diseases, furunculosis and pancreas disease.

Numbers of smolts placed in sea water in 1988 were 20,921,000 (13,106,000 in 1987). Estimated production in 1989 is about 31,000 tonnes. The sea operaitons of salmon farming directly employed 1,320 people and some 329 on a part-time basis.

Commercial rainbow trout culture produced 709 tonnes from 11 sites in sea water compared to a gross of 3,556 tonnes (641 and 3,207 tonnes, respectively, in 1987). In addition, there were 189 shellfish farms of which 136 grew mussels, 84 Pacific oysters, 38 native oysters, 46 scallops, 36 queen scallops and 4 clams.

In each of the last three years, in excess of 0.5 million triploid salmon have been produced in several commercial premises by post-fertilization pressure shock treatment of all female ova. Triploidy has been near 100% and survival to eyeing stage with 5-10% of all female controls. Subsequent survival has been comparable to all female and normal diploid stocks and growth has been comparable to the salmon component of normal diploid stocks.

In studies involving dietary vitamin E supplementation over and above the normal commercial ration content, no protection against pancreas disease has been found.

Significant programmes of work are in progress to evaluate the possible ecological impact of salmon farm wastes and use of chemicals on the coastal environment as well as the possibility that fish farm escapes may affect the fitness of wild populations.

Spain

by

(J. Iglesias and G. Roman)

During 1988, the expansion of the Marine Aquaculture industry in Spain continued, particularly on the Galician coast (NW) and Andalucia (S and SE). In the first region, the new main species cultivated was the turbot *(Scophthalmus maximus)* ; in the Mediterranean area, shrimp, sea bass, sea bream and clams were the dominant species in the new culture industry.

In most of the research institutions along the Spanish coast, the investigations focus on improvement of the hatchery techniques: reproductive management and analysis, plus development of enriched diets for the prey of zooplankton.

The first convention of the National Program on Marine Resources and Aquaculture took place in Madrid on 23 May 1988. The Interministerial Commission of Science and Technology gives aid in these areas of research and technological development by financing cooperative projects among the official centers of research and industries.

There is no current published statistical production data for Aquaculture in Spain, but the statistics will be slightly higher than the 1987 official production data of the Spanish General Subsecretary of Fisheries, outlined in the following Table:

1987. Aquaculture Production in Spain. Spanish General Subsecretary of Fisheries

Species	Production (Metric Tonnes)
Marine Finfish	
Turbot *(Scophthalmus maximus)*	50.0
Sea bass *(Dicentrarchus labrax)*	37.5
Sea bream *(Sparus aurata)*	109.2
Mugilidae *(Mugil sps.)*	89.8
Geat amberjack *(Seriola dumerilii)*	20.0
Sole (*Solea sp.)*	5.8
Thunnidae	99.0
Anguila *(Anguilla anguilla)*	29.4
Salmon *(Salmo salar)*	150.0
Crustaceans	
Shrimp *(Panaeus japonicus)*	19.7
Prawn *(Palaemon serratus)*	40.0
Molluscs	
Clams *(Truditapes/Venerupis)*	423.1
Oysters *(Ostrea/Crasostrea)*	3 155.1
Mussels *(Mytilus sp.)*	245 455.0
Venus verrusosa	1.5
Pecten maximus	150.0

Sweden

by

(Hans Ackefors, Stockholm)

Introduction

The aquacuture production for the market is growing and the official yield in 1987 was 4,743 tons. It is still dominated by rainbow trout; however, eel and salmon farming is increasing. The farmers on the Swedish west coast were hit by the exceptional blooms of the toxin-producing prymnesiophycean flagellate *Chrysochromulina polylepsis*, which occurred in the Kattegat and Skagerrak areas in May-June 1988. The farmers lost about 100 tons of rainbow trout. In 1987, the mussel harvest increased again after a very problematic year in 1986. The compensatory program for releasing smolts of salmon and brown trout comprised 3.4 million specimens in 1987, and 3.6 million in 1988.

Fishery management

For compensatory purposes, 3.4 million smolts of salmon and brown trout were released in Swedish rivers in 1987, and 3.6 million smolts in 1988.

Species	Number of released smolts (1,000) in rivers leading to:			
	1987			
	Baltic	Lakes	Kattegat Skagerrak	Total
Salmon	2 620	88	123	2 831
Brown trout	490	96	17	603
	1988			
	Baltic	Lakes	Kattegat Skagerak	Total
Salmon	2 340	169	198	2 707
Brown trout	629	145	114	888

Commercial production

The commercial production of fish and shellfish in 1987, according to the official statistics (round weight in tons):

	Total production	Marine production
Rainbow trout	4 388	2 834
Salmon	224	224
Brown trout	-	-
Arctic char	27	27
Eel	104	
Total fish production	4 743 (100%)	3 058 (64.5%)
Blue mussel	2 556 (100%)	2 556 (100%)
Oyster	3 090 (number)	3 090 (100%)

In total, there were 295 aquaculture operations aimed at production of food fish. 133 of these were located in brackish and marine waters; they produced about 65% of the harvested fish. The total production value of trout, salmon and mussels amounted to 128.9 million SEK, excluding the value of Artic char, eel and oysters.

Ongoing research

Salmonids:

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

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

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

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

5. Fish migration and social functions (F).

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

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

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

9. Lake water cage culture of Arctic char (G).

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

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

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

13. Feeding behaviour of Arctic char (H).

14. Genetic studies of Arctic char (H).

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

16. Disease resistance in stocks of cultivated fish (H).

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

18. Breeding research on various strains of trout.

Cod:

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

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

Freshwater crayfish:

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

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

3. Social interaction between species *Astacus astacus* and *Pacifastacus leniusculus* (C).

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

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

Disease problems:

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

2. Investigations on *Aeromonas salmonicida* infections (I).

Research bodies

A. Institute of Marine Research, P.B. 4, S-453 00 Lysekil

B. Askö Laboratory, University of Stockholm, S-106 91 Stockholm

C. Department of Zoology, University of Stockholm, S-106 91 Stockholm

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

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

F. Department of oophysiology, Uppsala University, Box 560, S-751 22 Uppsala

G. Länsstyrelsen i Norrbottens län, S-951 86 Lulea

H. Department of Aquaculture, Swedish University of Agricultural Sciences, Box 1457, S-901 24 Umea, Sweden

I. Swedish Salmon Research Institute, S-810 70 Älvkarleby

J. National Veterinary Institute, S-750 07 Uppsala

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

L. Department of Physiological Botany, University of Uppsala, Box 540, S-751 21 Uppsala

The Netherlands

by

(Renger Dijkema, Yerseke)

General

The situation in mariculture has remained rather stable since 1987. No drastic changes in production, numbers of enterprises or new developments occurred, exept the start of research activities into fattening of turbot.

Eels

Research into acceptation of dry feed by elvers *(Anguilla anguilla*) was continued. The effectiveness of different attractants was tested at different concentrations and at different feeding levels. At low feeding levels, high doses of attractants appeared to increase feed uptake considerably. At high feeding levels, no effects were found. Grain size appeared important as well: feed with a small grain diameter gave significantly better results.

A number of experiments were carried out at semi-commercial scale, aimed at assessing effects on the fish of grading and of the number of feeding places. The experiments into grading were not conclusive yet. The number of feeding places appeared not to influence growth differentiation significantly.

Under supervision of the RIVO and in close cooperation with the eel farming industry and other research institutes, a number of experiments were carried out to find means to combat the swim bladder parasite of the eel, Anguillicola crassa, in eel farms. The only effective vermicide appeared to be L-Levamisole, immobilising all adult and pre-adult parasites after an immersion treatment of the eels of 1 - 2 days. Dimilin proved effective in reducing densities of host copepods in the systems. Treatment through the feed appeared to give similar results, but took more time. Preventive measures are possible combating the intermediate host of the parasite and to avoid accumulation of organic matter in the cultivation system.

The diversity of systems, used for fattening of eels is steadily increasing. Differences between systems are being investigated in a project, subsidized by the European Community, aimed at a zootechnical and economical comparison of commercial eel farming systems, with the aim to evaluate the results of FEOGA subsidies, which have made possible a great deal of the development of eel farming in the Netherlands.

Turbot

A pilot-scale seawater recirculation system was built in the sea aquarium of the Netherlands Institute for Fishery Investigations in IJmuiden. The water treatment section of this system consists of two lamellae separators and a trickling filter and is dimensioned at a daily feeding rate of 3 kg dry feed .As the temperature extremes in summer and winter in the Dutch coastal waters are too large to allow year-round fattening in natural sea-water, water, cultivation in (semi)recirculated systems seems to be the only solution. The research program will focus on system development, in particular of the water treatment section, and nutrition and water temperatures in relation with production and water quality . In 1988 a first batch of 3 - 4 gram turbot juveniles were stocked The experiments will be continued.

Rainbow trout

The only Dutch project for sea-cage cultivation of rainbow trout again had encountered severe mortality problems due to high water temperatures and salinity. Following the French example, a trial was done, stocking with relatively large fish in september and harvesting in june. This proved successful.

Ragworms

Research into cultivation of larval stages of the ragworm Nereis virens at different temperatures were concluded. Increasing of the water temperature appeared to have a positive influence on growth rate of the larvae. The sharp decline in the number of ragworm farms and the fact that most of the exisiting farms are part-time operations or are alreay carrying out research of their own, prompted a lower research effort in this field. Further research will be aimed at rearing at increased temperatures in recirculated sea-water.

Molluscs

Cultivation of mussels, oysters and cockles is dealt with in the activity report of the Shellfish Committee.

Production data

Species	Production in tons x 103	Value in US$ x 106	Number of firms
Anguilla anguilla	0.2	1.6	10
Salmo gairdneri (marine waters)	0.015	0.08	1
Salmo gairdneri (freshwater)	0.25		10
Clarias gariepinus	0.4	1.2	40
Nereis virens	0.002	0.03	2?
Mytilus edulis	70.5	38.5	79
Ostrea edulis	1.0	8.9	16
Crassostrea gigas	0.7	1.8	14
Cerastoderma edule	0.3	01	3

USSR

by

(S.A. Studenetsky)

Studies proceeded in 1988 for the improvement of technology of cage rearing of rainbow trout in the White Sea inshore area in addition to the experimental work for the development of technology of cage rearing of Atlantic salmon in the coast of the Barents Sea.

Rainbow trout. Research was undertaken with cages in the White Sea inlets. Initial weight of stocking material, density of planted fish for cage rearing were studied, and methods of fish transportation and feeding were evaluated and improved. Planting material of rainbow trout (mean weight: 79.6 g) was obtained from cconventional fish farms. Losses of rainbow trout transported for cage culture reached up to 3.9% and growth of fish during the cultivation period (in principle during summer) - reached 487%. In the experimental cages a yield of 41.3 kg/m^2 were obtained when the initial density of the planted trout was 15.5 kg/m^2. Food conversion coefficient did not exceed the factor 2 when using pelleted food. About 35 tonnes of trout were cultivated in this unit.

Atlantic salmon. The best size of smolts to be transplanted to sea water was determined to be not less than 50 g wet weight. In June, the mean weight of smolts ready for transplanting to cages reached 50 g, and by the end of October the growth of trout was fast enough to reach an average weight of about 300 g.

No particular changes were observed in the results considering different variables tested in salmon feeding in cages. Atlantic salmon specimens reaching up to 250-300 g in the previous fall, spent the winter safely in cages under the environmental conditions typical for the West Murman region. From November onward until May the following year, mortality was relatively low and fish losses did not exceed 10%. The highest mortality was observed during the winter in salmon weighing less than 100 g wet weight.

A possibility of cultivating Atlantic salmon (up to a size of 2.5 kg in weight and over) during a two year culture period in sea cages has been demonstrated as feasible.

Initial data on the general development of the technology adapted to the local conditions and on standards for acceptance in marketability of Atlantic salmon under marine culture conditions were identified.