

Mariculture Committee

by
Harald Rosenthal

Belgium

by
(Patrick Sorgeloos)
and
(F. Pauwels)

Further experimental work was conducted at the laboratory of Prof. Dr. F. Ollevier (Catholic University of Leuven) on the following topics:

- Larval culture of seabass (*Dicentrarchus labrax*)
 - effect of light intensity and HUFA-content of live prey on morphological development, growth and survival (in cooperation with the Artemia Reference Center)
 - factors influencing first feeding of the larvae
 - study of the whirling syndrome
- Growout of seabass and seabream in thermal effluents of the nuclear power plant Doel near Antwerp
- Distribution of leptocephali larvae in the North Atlantic and influx of elvers in the Belgian estuaries,
- Study of the parasites of marine fish: life cycles of parasitic trematodes and nematodes.

State University of Ghent, Artemia Reference Center (Dr. Patrick Sorgeloos and co-workers):

further research was conducted on the following topics:

- selection of Single Cell Proteins for use as food for *Artemia* and *Penaeus monodon*.
- comparative study of *Artemia* strains: characteristics of cysts, nauplii and adults
- diapause regulation in *Artemia* cysts from different geographical origin
- effect of various diet components on the qualitative and quantitative reproduction characteristics of *Mysidopsis bahia* shrimp
- set-up of new test system for hatchery and nursery rearing of *Penaeus* larvae (evaluation of new experimental diets)
- development of SELCO-type enrichment diets for *Brachionus* and *Artemia*: extra HUFA-levels, pigments, sex-hormones, antibiotics (contract research for Artemia Systems SA)

-joint testing of larval diets developed at the Artemia Reference Center for different species of marine fish and shrimp (SEAFDEC-Philippines, ESPOL-Ecuador, Piscimeuze-Belgium, Kasetsart University-Thailand, ect.)

-Publication of three volumes of conference proceedings "Artemia and its research applications" (2nd International Artemia Symposium, Antwerpen, Belgium September 1985)

-organisation on the 5th International Artemia Training Course (August 16-October 1, 1987) attended by 39 participants from 22 countries

Canada

(communicated by J. E. Stewart)

Atlantic (R. Drinnan, Halifax)

Substantial growth in commercial aquaculture activity in Atlantic Canada has continued in 1987. Production of all species has increased according to projections, though a ban on marketing of blue mussels for several weeks due to a toxic incident reduced the harvest. The number of active enterprises is still increasing rapidly suggesting that the expansion will continue for some years.

Quebec (Y. Bastien)

Production of Giant Scallop (*Placopecten magellanicus*) seed.

A research programme was begun in 1987 to develop an efficient method for artificial production of Giant Scallop seed on a large scale. During the first year, a total of 80,000 spat of 1 mm in size were produced. Next year, effort will focus on hatchery production and the nursery growth of spat in 10 mm size.

Mussels

Preliminary work was done to estimate the carrying capacity for mussel culture of the lagoons in the Magdalen Islands. Research is also underway on the development of mussel culture in open waters using a longline technique.

In 1987, PSP was reported for the first time ever in Magdalen Islands mussels. Two samples were slightly toxic (between 80 and 130 µg toxin/100 g meat) in late November, but no toxicity was found in the 200 samples taken thereafter. As Quebec mussel culture is practiced mainly in this archipelago, PSP will now have to be monitored closely to guarantee consumer's safety.

Work has begun on the comparative PSP intoxication/detoxification pattern of wild and off-bottom cultured mussels in the Bay of Gaspé.

There are now nine mussel producers operating in Magdalen Islands lagoons and three in the open waters of the Baie des Chaleurs. A large increase in production is forecast in 1988 if the market recovers after the recent toxicity problem.

Salmon farm

The first salmon farm is now well established at St-Omer in Baie des Chaleurs. It is an integrated land Base operation composed of a 400,000 smolt hatchery and a 100 metric ton growing unit. Water is pumped from three sources to give the fish the best salinity and temperature all year round (fresh water from deep wells, low salinity water from deep wells and salt water from a surface well on the beach). All stages of fish are raised in Grain silos: 3 m and 7 m (diameter) for smolt production and 10 m (diameter) for adults.

Lobster

A new technology for holding lobster through the molting period, out of the fishing season, has been developed on a pilot scale by a private firm in the Magdalen Islands. Some complementary research aimed at forecasting molt probability in these holding units has been undertaken.

Aquaculture Technology Unit,
Canadian Institute of Fisheries Technology, Halifax, Nova Scotia
(C. Marr).

This unit has been operating for the past two years primarily in development and refinement of techniques and equipment utilized by the aquaculture industry of Atlantic Canada. In the past, the ATU has been involved in subsurface cultivation strategies for marine salmonid farming in coastal Nova Scotia, development of automatic/demand feeding systems for use in salmonid cultivation under harsh environmental conditions, and site evaluations and feasibility studies for private sector aquacultural operations. More recent studies have included the development of holding systems for onboard holding of Stimpson surf clams and land-based lobster hatchery and grow-out facilities. The Unit has also designed, constructed and employed a successful polyethylene ring cage for the surface cultivation of salmonids on the southwest coast of Nova Scotia. This technology is presently being adapted for subsurface cultivation in avoidance of severe winter surface temperatures prevalent throughout Canada's eastern coastline.

Amongst the ongoing projects is a program to enhance the Arctic char broodstock potential of the Maritime provinces. Arctic charr eggs, received from the Freshwater Institute, DFO, Winnipeg, are being dispersed through a program of careful monitoring to several aquaculture operations in both Nova Scotia and Prince Edward Island.

Salmonid Demonstration and Development Farm.

Moist vs Dry Feed.

Comparative studies on 1+ and 2+ 1986 smolts fed moist and dry diets were continued in 1987. The enhanced growth on the moist feed noted early in the winter of 1986/87 continued through 1987. 2+ smolts on moist and dry diets showed mean growth rates (% weight gain/day) of 0.82 and 0.79, respectively over the 18 month period reaching mean weights of 4.9 and 3.8 kg in October. 1+ smolts showed comparable growth rates of 0.97 and 0.95 and weights of 4.3 and 3.5 kg. A full analysis of the study data, including economic comparisons of the feeding regimes, will be carried out on the completion of the harvest which is presently underway.

Fish Density in Cages

It has been a common industry practice in the Bay of Fundy to stock 12 metre cages with 2500 smolts and carry that number through to market. A comparative study has shown that this number can be doubled in the first year with no significant loss in growth or survival, but the number should be reduced early in the second year.

Sexual maturation

To date, using Saint John River stock, grilse rates have been generally low (5% or less) in commercial operations in the Bay of Fundy. In 1987, preliminary data on some groups, e.g. 2+ smolts fed on moist feed, suggest rates as high as 15-20%.

Nutrition (S. Lall).

Ascorbic acid requirement and effect on disease resistance.

A study was conducted to determine the requirement for ascorbic acid and its effect on immunity and disease resistance in Atlantic salmon (*Salmo salar*). A practical diet was supplemented with 0, 50, 100, 200, 500, 1000 and 2000 mg of ascorbic acid per kg of diet and fed to Atlantic

salmon fingerlings for 22 weeks. Growth rate was improved by supplementation with vitamin C; increasing vitamin C above the lowest level did not affect the growth rate. There was no significant difference in food conversion nor mortality rate between all dietary treatments. Fish fed no ascorbic acid supplement showed significant low tissue ascorbic acid levels in liver and kidney. Ascorbic acid deficient fish showed lordosis, depigmentation and external hemorrhages.

The following immune responses were also investigated: antibody production, bactericidal activity of serum (complement system) and non-specific resistance to *Vibrio anguillarum*, *Yersinia ruckeri* and *Aeromonas salmonicida*. Results do not support the disease protecting role of ascorbic acid against these disease causing organisms.

Atlantic salmon grower diets (moist and dry) were developed and tested under laboratory and experimental fish farm conditions. Lipid is more effectively utilized and deposited in salmon fed moist diets. Attempts are now being made to develop finisher diets to reduce excessive fat deposition.

Shellfish Toxin (D. Scarratt).

Following the occurrence of an unusual and hitherto unknown toxin in mussels in Eastern Prince Edward Island, a number of toxic mussels were sectioned and examined by light and electron microscopy. This revealed an unusual and extremely heavy concentration of lysosomes in the cells of the digestive gland. The toxin, which was confined to the digestive gland, was subsequently shown to be Domoic acid (Wright, NRC pers. comm.). There was clear correlation between the presence of the toxin and the unusual lysosome condition. A detoxification experiment commenced in mid December 1987 and by late January 1988, mussels on the original toxic sites, and transplanted to the laboratory, were domoic acid free. Circumstantial evidence suggests the source of domoic acid may be the diatom *Nitzschia seriata* but this is not confirmed.

Lobsters fed toxic mussels avoided the digestive gland unless starved, when they would eat it. After 6 weeks, lobsters had accumulated up to 7mg/100 g of domoic acid in the hepatopancreas. Tail meat was domoic acid free.

Diseases (J. Conick).

Bacterial Kidney Disease.

Bacterial kidney disease (BKD) continues to be the disease of greatest concern in cultured Atlantic salmon brookstock in the Maritime provinces. Although it occurs chronically in salmon in seawater cages in this region, the greatest threat is through vertical transmission via the egg. Control strategies since 1984 involving non-lethal monitoring of brood fish reproductive fluids by fluorescent antibody techniques (FAT) and exclusion of eggs from positive parents, appear to have been effective in controlling the spread of this disease. Unfortunately, normal culturing techniques are too slow for routine use and the correlation of the more rapid FAT tests with the potential for clinical diseases has not been clearly established.

Furunculosis

This disease impacts most heavily on fish in freshwater culture sites in the Maritime Provinces where it can be transmitted in the clinical or carrier states to marine cages sites at the time of smolt transfer. Testing for clinical disease has been in effect for some time and carrier testing by corticosteroid treatment was initiated in 1985 for all smolts going to cages. Since inception of the carrier testing program, no furunculosis has occurred at cage sites related to movements under the program.

Gaffkemia

Gaffkemia, a bacterial blood disease, continues to be the most important disease causing losses in commercial lobster holding facilities in the Maritime Provinces. At present, no regulations or policies exist to control the spread of this disease via live lobster movements. Current control procedures involve monitoring for the disease and initiation of salvage strategies when appropriate. The antibiotic, oxytetracycline, has recently been licensed for use as a food additive to control this disease and is becoming more commonly used. An injectable vaccine is available commercially, but has not to date received widespread acceptance. Two of the largest lobster producers in the Maritimes now have in-house diagnostic capability and the number is growing, largely through the assistance and encouragement of the DFO, Fish Health Service Unit in Halifax which carried out most of the diagnostic work in the past.

Atlantic Salmon (R. Saunders)

Photostimulation and growth

Photostimulation of postsmolt Atlantic salmon growth under laboratory (artificial light) conditions were very effective. Groups of fish exposed to various photoperiod regimes (16, 18, 20 h light/day) between September and December grew significantly faster than controls under natural photoperiod. These fish were moved to a sea cage and grown under natural light conditions. There was no effect of prior photoperiod treatment on incidence of maturity.

Studies on photostimulation of juvenile (presmolt) growth of *Salmo salar* emphasize the importance of restoring natural photoperiod by the end of November. A regime of extended daylength between August and November stimulated growth and was compatible with completion of smoltification the following spring.

Environmental effects on maturation

Atlantic salmon from Western Arm Brook, Newfoundland, which mature in nature exclusively as grilse (one-sea-winter), were artificially spawned near the river. Fertilized eggs from four single pair (family) matings were incubated and reared to the smolt stage at the St. Andrews, N.B. Biological Station. Fourteen-month-old (1+ yr) smolt were identified as to family and grown in a sea cage in S.W. Bay of Fundy. After 18 months, only 67.5% of males and 47.6% of females (<57% os sexes combined) were mature as grilse. In September, both mature and immature individuals took on spawning colors. In other stocks of salmon reared at the same farm, immature fish were bright and silvery. Levels of three sex hormones in late November were similar to those usually found in sexually mature and immature salmon at spawning time. There were significant differences between families in respect to incidence of sexual maturity and size. Mature males and females were consistently larger than immature fish of the same sex in respective families.

Bay Scallop (K. Freeman).

Following its introduction to the Maritimes in 1979, the bay scallop (*Argopecten irradians*) is now being considered by some aquaculturists as the bivalve most likely to follow culture application behind mussels and oysters. Initial outplantings of *Argopecten* were made to several sites around Nova Scotia in August, 1986, as part of a contractual arrangement between the Provincial Fisheries Department and a private research concern. The study has shown that this species can grow well with good survivorship in some Nova Scotian inshore areas.

Blue Mussel (K. Freeman)

Winter Growth

Although studies of growth in the blue mussel (*Mytilus edulis*) have consistently reported diminished growth in winter months, there are persistent reports from some producers that this is not always the case. Eleven mussel stocks were outplanted at the Nova Scotian sites beginning late 1985 and monitored in the spring of 1986. Stock and site differences were important determiners of shell growth but site alone accounted for most of the tissue growth variation. Ice cover appeared correlated with a reduction in average tissue growth among all stocks and was likely related to delayed phytoplankton blooms whereas shell growth appeared uniform among all sites.

Genetics

Inheritance of various characters in bivalves has historically been performed on few families and limited to larval and juvenile characters. A study using thirty replicated families produced in a hatchery provided strong evidence of moderate to large growth heritabilities with a significant dam component.

Carrying Capacity

The development of mussel farming in Maritime Canada has resulted in a proliferation of leases in some inshore areas. This has led to a realization that there are no guidelines for some aquaculturists who wish to know when stock density begins to affect production. A first try at assessing carrying capacity was made at a mussel lease in a semi-enclosed embayment in Whitehaven Harbour, Nova Scotia. On-site grazing experiments with local mussels combined with tidal exchange information formed the basis for estimations of upper limits on stocking density.

Lobster (S. Waddy)

Egg Production

Under culture conditions, mature American lobsters are usually held individually and the unobserved molt of a preovigerous female means the loss of that mating opportunity and the production of infertile eggs. This problem has been eliminated by the discovery that intermolt insemination occurs routinely if unmated preovigerous females are held communally with males. Egg attachment and incubation success are normal in these females mated just prior to spawning.

Growth enhancement

Bilateral eyestalk ablation is unsatisfactory for promoting growth in American lobsters because of high mortality, low meat yield and abnormal body proportions. However, unilaterally eyestalk ablated lobsters survive as well as intact lobsters but grow significantly faster. A preliminary study suggested that unilaterally ablated lobsters would reach market size 7 months sooner than intact lobsters.

Marine Fish (K. Waiwood)

A marine finfish aquaculture program was initiated during 1987. Halibut was chosen as the initial focus for the program. Broodstock were collected in July and their growth, feeding and food conversion efficiency have been followed subsequently.

Pacific (N. Bourne)

Chinook Brookstock Strain Comparison.

Six river stocks of chinook salmon were reared on 4 commercial farms and in the Experimental Fish Farm in Nanaimo. The purpose of the study was to evaluate genetic and environmental influences on growth, survival and age at maturity as well as to provide eggs for the mariculture industry. In 1987, the first eggs were obtained from 3-year-old spawners.

Salmonid Mariculture

Atlantic salmon reared in the Experimental Fish Farm were shown to be much more susceptible to mortality from blooms of the diatom *Chaetoceros convolutus* than are chinook and coho salmon. Atlantic salmon grilse were spawned successfully. Sterile and triploid coho salmon exhibited similar growth to normal coho in the Experimental Fish Farm.

Sex Control Biotechnology

A five-month study examined the use of slow release devices for delivery of recombinant growth hormones in chinook salmon in sea water. A production-scale test of hormonal sterilization procedures was conducted in 17 private hatcheries. Female milt from chinook salmon was provided to 15 private hatcheries in 2442 aliquots of 5 ml.

Salmon Genetics

A sperm competition study with chinook salmon indicated that the order of sequential application of milt to eggs can affect the level of fertilization achieved by individual males and thus the overall level of genetic variation in the progeny. Over 200 purebred and hybrid families of coho salmon were created using gametes from 3 river stocks; these crosses will be used to estimate heritability of performance traits and form a baseline population for development of an improved coho stock for aquaculture.

Fish Nutrition

An experiment was undertaken with juvenile chinook salmon to determine the influence of the quality of dietary ingredients on resistance to bacterial kidney disease. Ten stocks of juvenile chinook salmon were tested for their ability to utilize digestible carbohydrate. The nutritional value of hake byproduct meals was assessed in chinook salmon held in sea water. The dietary lipid requirements for chinook salmon broodstock were studied in the Experimental Fish Farm.

Scallop Culture

Most scallop culture research was focused on two species, the exotic Japanese scallop, *Patinopecten yessoensis* and the native rock scallops, *Crassadoma gigantea*. Fewer spawnings were attempted with both species in 1987 than in previous years but because of improved hatchery techniques, higher numbers of mature larvae were produced in 1987. Over 40,000 juvenile Japanese and 10,000 juvenile rock scallops were produced in 1987. Experimental work focused on studies of the nutritional requirements of scallop larvae and juveniles. A major development in 1987 was that Japanese scallop broodstock used during the year had been produced in our hatchery in 1985 showing that *P. yessoensis* can undergo gametogenesis and produce mature gametes in British Columbia waters. Initial grow-out studies indicated that *P. yessoensis* can grow to 10 cm shell height within two years in southern British Columbia waters. More extensive grow-out studies were initiated along the coast in 1987.

Mariculture Production

Atlantic (Based in part on incomplete returns)

	Production (Tonnes)	Values (\$000's)	
		Can \$	US\$
Atlantic Salmon (<i>Salmo salar</i>)	1 008	13 589	10 871
Rainbow Trout (<i>Salmo gairdneri</i>)	251	1 464	1 171
Brook Trout (<i>Salvelinus fontinalis</i>)	7	40	32
Blue Mussel (<i>Mytilus edulis</i>)	1 789	3 407	2 725
European Flat Oyster (<i>Ostrea edulis</i>)	10	111	89

Pacific (Official statistics for 1987 are not yet available. The B.C. Salmon Farmers Association estimates 1987 sales of coho and chinook salmon at 1,500 tonnes. Oyster production is estimated to be similar to 1986 values).

1986 Production (tonnes) and Value (Can\$)

Rainbow Trout*	109	641	- - -
Chinook Salmon	89	657	- - -
Coho Salmon	299	1 972	- - -
Oysters	2 864	2 515	- - -

*Rainbow trout production 92% from freshwater farms.
Under 5 tonnes of blue mussels were landed

Mussel culture

Mussel culture research continued with work focused on analysing results of 1986 work and studying growth and survival characteristics of resident and transplanted mussels at 5 selected sites in southern British Columbia.

Sablefish Culture

Studies focused on the biological requirements necessary for demonstrating the feasibility of sablefish culture. To date, success has been achieved in a number of areas. In particular, developing techniques for the capture and transport of all life history stages of sablefish, including procurement of gametes from the field; developing techniques for induced ovulation and spermiation of sablefish using hormonal treatments; developing fertilization and incubation

techniques for both wild and induced gametes; determining optimal salinity and temperature conditions for incubation of eggs and yolk-sac larvae; and determining acceptable food organisms, their particle sizes and densities, and their presentation in time, that are required to bring larvae through successfully to the postlarval stage. In addition, studies have also focused on optimum growth conditions for postlarval and juvenile sablefish; determining nutritional requirements and development of diets of juvenile and adult sablefish; and determining baseline fish health data from wild stocks to assist in the recognition of future disease problems that could occur during rearing.

Denmark

by

(Hans Peter Bak)

Sea farming in Denmark consists still mainly of cage culture of large rainbow trout - so called rainbow salmon (*Salmo gairdneri*). There has however been a progress in research and development of other marine species, especially turbot. The year 1986 was a catastrophic year for Danish sea farms due to the low price level. During 1987, the situation gradually changed into a more normal stage and there is again optimism in Danish marine aquaculture.

Sea Farming of Rainbow "Salmon"

Cage culture of rainbow salmon is still the most important and most common production method in Denmark. Due to low prices in 1986 some farmers decided to cut down the production level or even stop the production. Therefore, the annual production in 1987 dropped to near 3000 tonnes or a little more.

At the pilot farm situated inside the power plant "Enstedværket" at Aabenraa the experiments concerning production planning and production strategy in a full scale land based sea farm using heated waste water was carried on, and the annual production has reached a stable level of 50 tonnes.

Besides the full scale production unit the pilot farm includes two systems (50 m³ and 5 m³) of recirculating heated sea water in which experiments with marine species are conducted.

A genetic programme run by the Danish Institute for Fisheries and Marine Research has gradually taken form and the preliminary results are showing a remarkable difference in growth potential between different groups (strains?) of rainbow trout.

Diseases

The year was rather cold with low summer temperatures in the sea and partly because of this fact very few outbreaks of diseases were reported. A local breakout of VHS caused severe mortality.

Marine Species

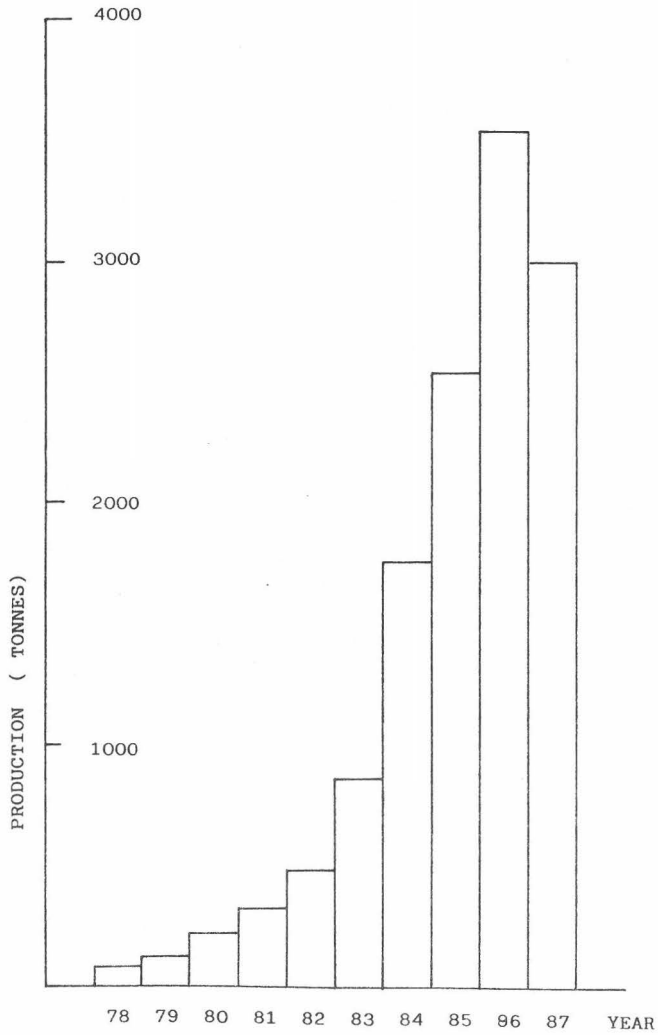
Turbot

In Denmark there has been an interest in turbot culture over the past decade. Two lines are followed in the research and development activities to find the right production methods for larvae:

- Intensive rearing of larvae
- Extensive rearing of larvae

Both methods are followed by an intensive culture for the on-growing stages until market size.

PRODUCTION OF RAINBOW SALMON IN SEA WATER IN DENMARK



The intensive method consists of experiments trying to control every step of the life cycle from hatching to metamorphosed post larvae. This includes feeding the newly hatched larvae with either live food or artificial feed (micro pellets) or a combination of these. Micro pellets have been produced, however, the improvement through the use of this feeding technique in the intensive rearing method so far was small.

By using the extensive method a good part of the problematic first feeding complex is taken care of by mother nature. The rearing of larvae takes place in large tanks or ponds with filtered sea water inoculated with wild caught plankton before introducing the newly hatched larvae. The method had proven to produce well, and experiments are carried on to optimize the system.

Other Fish Species

Initial experiments in warm recirculated sea water have shown some improvement in the culture technique for Sea bass and Sea bream. Some growth experiments were made with Grass shrimp (*Penaeus monodon*), and a growing interest in culture of crustaceans resulted in an Association of interested persons and firms.

Mussel and Oyster Farming

Mussel and oyster farming has still along way to go before it will reach high production figures in Denmark.

Only one commercial company is culturing blue mussels using rope culture and the production was some 150 tonnes. However, the expected production for 1988 is 1500 tonnes. The high numbers of blue mussels used in the canning industry are still delivered by fishermen using a small beam trawl.

A research programme has been set up trying to use the dutch method of culturing blue mussels on growing banks. In the Limfjord an area of 70 000 m² are being stocked with blue mussels at different densities ranging from 1 to 9 kg/m². The programme continues until 1990.

Oyster farming is also at a low level, though probably increasing in the coming years. The annual production is 50-60 000 pieces, which all are consumed in Denmark.

Finland

by

(K. Westman and P. Tuunainen)

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 Finland. 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 obtained from other species than rainbow trout, mainly salmon and brown trout.

Farming of rainbow trout increased considerably in the 1980s, especially in net cages and enclosures in the sea. By 1986, marine fish farms produced 65% of all the rainbow trouts raised in Finland.

Table 1. Number of fish farms and production of fish for human consumption in Finland in 1980-1986 on statistics from the Finnish Game and Fisheries Research Institute. Production 1000 kg (ungutted fish).

Year	Marine Fish Farms		Freshwater Fish Farms		Total Estimated value		
	Number	Production	Number	Production	Number	Production	of Production (Mio FIM)
1980	78	1958	108	2712	186	4670	95.7
1981	85	2211	157	3175	242	5383	116.8
1982	98	3226	195	3226	293	6325	128.4
1983	105	3910	173	3601	278	7511	158.0
1984	151	5381	184	4112	335	9493	204.0
1985	176	6647	159	3427	335	10074	227.0
1986	177	7140	184	3773	361	10913	246.0

Production 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 1986 a total of 3.2 million salmon, 14.7 million migratory whitefish and 1.6 million sea trout, 1-summer old or 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 statistics of the Finnish Game and Fisheries Research Institute, a total of 672,000 salmon juveniles, aged 1 summer or older, were stocked in the Baltic or in rivers flowing into the Baltic in 1980. 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 1987 over 3.6 million salmon were stocked. The value of the salmon juveniles stocked in 1987 exceeded FIM 14 million (c. US\$ 3.2 million).

The total number of Baltic salmon stocked in Finland between 1980 and the present (1987) now exceeds 16 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 has continued of 1-year old salmon parr in the rapids to maintain the sharply declining stocks. In the Simojoki River in 1987, 35,000 salmon parr were stocked; and in the Tornionjoki River, 138,000 parr. 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 particularly threatened.

Salmon and sea trout smolts are produced principally by conventional, intensive cultivation methods at fish farms and whitefish 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, the amount of salmon brood fish at State fish farms in 1986 was c. 14 000 kg.

Salmon eggs have been hatched in the State fish farms from 1980 to 1987 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.

More and more often fish farms in Finland are today 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 adopted in the rearing of salmonid juveniles, particularly at the incu-

bation and fry stage. Due to the usage of warm water the stocking volumes of 1-year old salmon smolts are increasing rapidly.

Research

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

Studies have also continued to improve stocking results by decreasing the mortality rate of stocked salmon smolts (e.g. the use of release ponds and delayed release). Improved survival has also been achieved through the development of better transport methods and equipment. Extensive research continued into methods to decrease water pollution caused by fish farms. The phosphorus content of feeds has been reduced, self-cleaning tanks have been taken into use, and the collection methods for the removal of sludge and suspended solids from fish farm effluents has been made more efficient.

Studies continue on rearing of 1-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.

Fish Diseases

Furunculosis (*Aeromonas salmonicida* var. *salmonicida*) was first observed in Finland in 1986 in a few marine fish farms, and in one fresh water farm. To prevent the spread of the disease, limitation on transfers of fish from the sea to inland waters were set, and other preventive measures taken. No signs or cases of IPN, VHS, or any other major, communicable fish diseases were found in Finland in 1986.

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

For the prevention of furunculosis and other fish diseases, the Official Fish Health Control service which is carried out by the National Veterinary Institute, is being intensified. Research activities into the understanding and control of fish diseases has also recently increased considerably in Finland.

Outline of Statistical Information on mariculture Production in Finland - 1986

Species	Metric Tonnes	Approx number in 100,000	Value in 1000 US\$*
Rainbow trout in enclosures (more than 0.5 kg each)	7 140	- -	36,511
Salmon smolts for introduction 1-year old and older	- - - -	31,17	3,106
Other salmonids: Sea trout for introductions, 1-summer old +	- - - -	15,55	1,818
Other: Migratory whitefish for introduction, 1-summer old	- - - -	146,69	2,000

CONDENSED FROM FAO FORM FOR REPORTING STATISTICS ON AQUACULTURE

From Sheet No. 1

<u>Method of Culture</u>	<u>Freshwater Culture</u>		<u>Brackishwater Culture</u>	
	<u>No. of Units</u>	<u>Hectares</u>	<u>No. of Units</u>	<u>Hectares</u>
<u>Fishes</u>				
Ponds	4 197	5.1		
Enclosures) Cages)	230	14.0	1 510	38.2
Raceways (earth ponds)	1 608	81.4		
Others: natural food rearing ponds	840	9 768		

HATCHERY OUTPUT

- see attached statistics "Fish culture in Finland 1986",
production to stockings

From Sheet 2

<u>Species Cultured</u>	<u>Freshwater Culture</u>		<u>Brackishwater Culture</u>	
	<u>Metric Tons</u>	<u>Price/ Kg</u>	<u>Metric Tons</u>	<u>Price/ Kg</u>
<u>Fishes (live weight)</u>				
Ponds:				
99% kirjolohi, <u>Salmo gairdneri</u>)				
1% (lohi, <u>Salmo salar</u> and)	3 773	22.5		
(taimen <u>Salmo trutta</u>)		FIM		
Cages:				
99% kirjolohi, <u>Salmo gairdneri</u>)				
1% (lohi <u>Salmo salar</u> and)			7 140	22.5
(taimen <u>Salmo trutta</u>)				FIM

FISH CULTURE IN FINLAND IN 1986

Number of Fish Farms and Hatcheries	Brackish Water Cage Farms	Fresh Water Farms and Hatcheries	Natural Rearing Pond Breeders	TOTAL
	179	339	248	766

PRODUCTION CAPACITY OF FARMS AND HATCHERIES	Incubation Capacity		Rearing Space					
			Net Cages and Enclosures		N R			
	G l a s s	I n t a c u b a t i o n	T r a c u b a t i o n	I n t a c u b a t i o n	A r t i f i c i a l	E a r t h	P o n d	a t u r i n g
								F P o n d
		Egg Liter		Number				
				4 197 1 608		1 510	230	840
				1 000 m ²				ha
	14 830	25 730		51	814	382	140	9 768
Farms and Hatcheries	69	90		101	218	177	18	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⁾			
	7 140	3 773	10 913	246
Farms	177	184	361	

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

France: Rapport CIEM 1987

Conchyliculture
par

(H. Grizel)

En France, les recherches conchyloles portent sur différents aspects dont:

1. la modélisation des productions pour chaque bassin:

Le bassin de Marennes-Oléron sert d'atelier. Un modèle empirique basé sur l'analyse de séries historiques est disponible pour Marennes-Oléron, Bouin et Arcachon. Son utilisation nécessite l'acquisition de données de croissance, de mortalités et une estimation de la biomasse. Le modèle analytique est en cours d'élaboration.

2. L'impact et le rôle des apports des rivières sur les élevages conchyloles:

Le programme se propose de caractériser les apports terrestres provenant du drainage, des rejets agricoles et d'en étudier la cinétique dans le cours d'eau, l'estuaire et au niveau du bassin. Des études physiologiques complémentaires permettent d'apprécier le rôle de certains paramètres.

3. L'étude d'agents polluants tel le cadmium et l'étain et leurs actions sur les phases larvaires et adultes des coquillages.

4. Les maladies de l'huître plate:

Un immunodiagnostic spécifique de *Bonamia ostreae* devrait être commercialisé au cours de 1988. Un modèle expérimental *in vitro* a été mis au point, permettant de comparer les mécanismes de phagocytose et d'élimination de *Bonamia ostreae* chez *Ostrea edulis* et *Crassostrea gigas*. Chez *Crassostrea gigas* un enzyme de type sérine-estérase neutralisant l'action des bactériophages a été mis en évidence.

5. La mise au point d'une thérapie contre *Mytilicola intestinalis*:

La posologie définie au laboratoire a été transposée sur le terrain.

6. Les conditions d'élevage de la palourde sont bien définies et un manuel pratique est en cours d'élaboration.

Des mortalités anormales ont été notées dans un centre d'élevage. Dans la majorité des cas les palourdes présentaient un anneau brun sur les valves et autour des siphons. L'étiologie n'a pas été établie.

7. Le programme de repeuplement des gisements naturels de coquilles St Jacques se poursuit. Des mortalités hivernales ont été notées. Des infections rickettsiennees notoires ont été observées dans les cellules branchiales. Une étude de cet agent pathogène est en cours.

PRODUCTION DE MOLLUSQUES D'ELEVAGE EN FRANCE EN 1987

Huîtres creuses-	<i>Crassostrea gigas</i>	120,000 tonnes
Huîtres plates -	<i>Ostrea edulis</i>	2,500 tonnes
Moules -	<i>Mytilus edulis</i>	50,000 tonnes
Palourdes -	<i>Ruditapes philippinarum</i>	600 tonnes

Poissons et Crustacés
by

(J. Guillaume)

Production annuelle en France en 1987:

- Truite arc-en-ciel (<i>Salmo gairdneri</i>) eau de mer	700 T
- Saumon Coho (<i>Oncorhynchus kisutch</i>)	85 T
- Truite Fario (<i>Salmon trutta</i>)	4 T
- Saumon atlantique (<i>Salmo salar</i>)	6 T
- Bar (<i>Dicentrarchus labrax</i>)	120 T
- Daurade (<i>Chrysophrys aurata</i>)	20 T
- Turbot (<i>Psetta maxima</i>)	20 T
- Crevette japonaise (<i>Peneaus japonicus</i>)	15 T

Principales recherches

- **Salmonidés:** Chez le saumon atlantique, le déterminisme du biomodalisme des parrs (apparition de deux classes de taille) a été étudié en relation avec la smoltification.

Chez cette même espèce, le rôle de l'hormone de croissance (GH) et des hormones thyroïdiennes dans les phénomènes d'osmorégulation et de croissance a été précisé. De même le métabolisme des poissons a été suivi pendant la smoltification et après le passage en mer (rôle des hormones thyroïdiennes) tandis que des études du flux des ions et des cellules à chlorure permettaient de mieux caractériser l'osmorégulation des parrs et des smolts (contrôle enzymatique et endocrinien).

Des études ont également été conduites sur des poissons triploïdes (truite arc-en-ciel et saumons atlantiques): croissance en eau douce- smoltification passage en mer et survie estivale.

Une étude de nutrition conduite avec trois espèces (*Salmo gairdneri*, *Salmo trutta* et *Oncorhynchus kisutch*) nourries avec quatre aliments (2 taux protéiques cotribués à 2 taux lipides) a permis de mettre en évidence une interaction aliment x espèce au niveau de la croissance mais non de la digestibilité, de l'utilisation des protéines ou de la composition corporelle.

- **Poissons marins:** Une étude des phénomènes digestifs chez le bar a permis de préciser les techniques les plus appropriées pour la mesure des bilans; le transit digestif et l'absorption des nutriments (en particulier acides aminés) ont été précisés avec plusieurs sources de protéines.

Lors d'une étude du besoin du turbot en acide ascorbique aucun signe de ralentissement de la synthèse de l'acide ascorbique n'a pu être observé. Ce poisson, incapable de synthétiser l'acide ascorbique, paraît réfractaire au scorbut; toutefois la carence entraîne une forme mortalité par la granulomatose rénale (due à l'hypertyrosinémie) et perte d'appétit.

Chez le bar, des microparticules d'un type nouveau ont été élaborées et employées avec succès pour l'élevage expérimental des larves à partir du 20ème jour: la survie a été comparable à celle de larves nourries de proies vivantes (*Artemia*) mais la croissance a été légèrement ralentie. Ces microparticules permettent d'envisager une réduction très importante du coût de production des juvéniles.

- **Crevettes:** Les recherches conduites en France visent surtout l'amélioration des aliments destinés aux élevages semi-intensifs pratiqués sur les côtes françaises dans les anciens marais salants.

Des recherches sont toujours conduites dans le but de caractériser le "facteur de croissance" contenu dans le calmar (*Loligo* sp.). D'autres travaux sont poursuivis sur la nutrition minérale de la crevette (besoin en phosphore - rôle de l'acide phytique) et sur son besoin en inositol.

German Democratic Republic

No report received

Germany, Federal Republic of

by

(K.Tiews)

Crustaceans

Crangon crangon

By-catch research in the German brown shrimp fishery to determine indices for and crustaceans of commercial and non-commercial importance occurring on the shrimp fishing grounds was continued at the Institut für Küsten- und Binnenfischerei der Bundesforschungsanstalt für Fischerei. A total of 359 samples of 2836 kg were analysed.

Studies on the occurrence and cause of the black spot disease of *Crangon* which were started in 1986, were continued.

As part of a cooperative program agreed upon with The Netherlands and Belgium German coastal waters along the coasts of Niedersachsen and Schleswig-Holstein were surveyed to study the abundance of young fish and brown shrimp populations by the Institut für Binnenfischerei der Bundesforschungsanstalt für Fischerei.

Molluscs

Mytilus edulus

Monitoring of blue mussel beds along the German North Sea coast and in the Flensburg Fjord has been continued by the Institut für Küsten- und Binnenfischerei. Management advice has been formulated regarding the optimal utilization of the mussel resources in the Flensburg Fjord. There was no new occurrence of DSP in 1987 on the German coasts after January 1987, when from October 1986 to January 1987 the selling of blue mussels harvested at the Niedersachsen coast had to be prohibited because of several cases of DSP.

Cerastoderma edule

Cockle beds in the Wadden Sea along the coasts off Niedersachsen and Schleswig-Holstein were monitored for management purposes at the Institut für Küsten- und Binnenfischerei.

Research at the Biologische Anstalt Helgoland.

The aquaculture research programme at the Biologische Anstalt Helgoland continued to focus on water quality aspects as they relate to modern highly intensive farming system. The following studies were undertaken:

- Behaviour of various fish species in circular tanks at different stocking densities and operational conditions;

- Toxicity studies with ammonia using juvenile rainbow trout. The study attempted to keep all other parameters (pH, O₂, Ammonia, Nitrite, BOD load) constant despite the variation in activity patterns of the fish (e.g. compensatory hyperventilation).
- Continuation of the studies on long-term variation of water quality parameters in recycling systems;
- Rearing of mullet fry in brakish water recirculation systems;
- Investigations on protein requirements and nitrogen excretion rate in *Mugil cephalus* and *Mugil brasiliensis*;
- Studies on the effectiveness of various tank structures on the reduction of canibalism in juveniles of *Macrobrachium rosenbergii*.
- Long-term live preservation of fish food organisms.

Iceland by

(B. Björnson)

Aquaculture production

The commercial aquaculture production in Iceland 1987 was limited to that of salmonids. By the end of the year there were 113 salmon farming sites registered in the country. Most of them were not in full operation. The production figures for the years 1986 and 1987 are:

Type	1986	1987
	(x 1000)	(x 1000)
Parr	1528	2963
Salmon smolts	1910	4581
Juvine trout/char	1100	615
	tonnes	tonnes
Salmon from sea cages	106	266
Salmon from land based units	17	223
Salmon from ocean ranching	65	40
Adult trout/char	150	152

The prognosis for the year 1988 is 12 million salmon and about 1800 tons of salmonids.

Research

The following governmental institutions and private firms participate in aquaculture research activities in Iceland:

1. Institute of Freshwater Fisheries, P.O. Box 5252, Hverfisgata 116, 125 Reykjavik
 - production of juvenile salmonides
 - ocean ranching
 - cage-culturing
 - selective breeding

2. Marine research Institute, P.O. Box 390, Skulagata 4, 121 Reykjavik.
 - ongrowing of halibut
 - culturing of blue mussels
 - environmental monitoring
3. Icelandic Fisheries Laboratories, P.O. Box 1390, Skulagata 4, 121 Reykjavik.
 - development of fish feed
4. National Center for Hygiene, Food Control, and Environmental Protection, P.O. Box 5276, Sidumuli 13, 125 Reykjavik
 - pollution caused by aquaculture
5. Institute for Experimental Pathology, Keldur v. Vesturlandsveg, P.O. Box 8540, 110 Reykjavik
 - fish disease
6. Agriculture Institute, Keldnaholt, 112 Reykjavik
 - selective breeding
7. National Energy Authority, Grensasvegur 9, 108 Reykjavik
 - water supply and chemistry: freshwater, seawater and geothermal water
8. Fisheries Association of Iceland, Höfn Ingólfsstraeti, P.O. Box 820, 121 Reykjavik
 - production of adult salmon in fresh water
 - transportation of live smolts
9. University of Iceland, Grensasvegur 12, 108 Reykjavik
 - fish physiology, smoltification of salmon
10. National Research Council, Laugavegur 13, 101 Reykjavik
 - allocation of research funds
 - future development in aquaculture in Iceland
11. Fiskeldi Eyjafjardar hf., Glerargata 30, 600 Akureyri
 - culturing of halibut

Ireland

by
(Jaqueline Doyle)

Introduction: Status of the Industry

Commercial farming of salmonids, and molluscs continued to expand in 1987 and production figures available for the period are as follows:

Species		Tonnes
Finfish (1987)		
Salmon (<i>Salmo salar</i>)		2,232
Rainbow trout (<i>Salmo gairdneri</i>)		
	marine	206
	freshwater	500
Molluscs (1986)		
Mussel (<i>Mytilus edulis</i>)		
	Rope culture	1,407
	Bottom culture	9,572
Native oyster (<i>Ostrea edulis</i>)		
	intensive	113
	extensive	168
Japanese oyster (<i>Crassostrea gigas</i>)		120
Escallops (<i>Pecten maximus</i>)	extensive	533

Finfish

Salmonids

Following disastrous losses in 1983 and 1984 when sea temperatures were in excess of 20°C for prolonged periods in shallow inshore sites and environmental conditions deteriorated, there has been a major expansion in the development of off-shore fish farming using very large enclosures in exposed areas. Production of salmon is projected to reach 10,000 tonnes by 1990. Production of rainbow trout in sea cages and freshwater remains static due to low demand. A number of trout farmers have converted to salmon smolt production and output for 1987/88 has increased to 4.9 million. Six new hatcheries are under construction with further capacity of 2 million smolts. Domestic supply is now expected to meet demand. To avoid the introduction of disease further imports of live parr or smolt have been banned since July 1987. Imports of ova are permitted subject to health certification.

Disease

Pancreas disease - caused serious losses at virtually all salmon farms. These losses varied from slight loss in production due to poor feeding and loss of condition to significant mortalities and/or failure to recover. Vitamin supplementation made no appreciable difference to the course of the disease and nutritional analysis of diets showed no evidence of deficiency of macro or micro constituents.

Furunculosis - only two outbreaks were observed in marine cage sites in contrast to the previous year. Smolts from hatcheries with a known history of the disease were given intraperitoneal injections with antibiotics just prior to transfer. Oral treatment prior to and following transfer of smolts is also routinely used.

Vibriosis - not detected.

Sea lice - regular treatment with Dichlovos now largely controls this condition but use of this compound is causing increased concern as to its toxic effects on humans and marine organisms. Guidelines on its continued use are being prepared and alternative strategies for sea lice control are being examined.

Algal Blooms - Losses of up to 60% of stock were recorded at one inshore site due to a bloom of Flagellate "X". The flagellate was persistent from May through October. As this was the third loss since 1984 the site has been abandoned as unsuitable.

Environment - As part of the conditions of the Aquaculture Licence issued by the Department of the Marine, the physical chemical and biological characteristics of salmon farms and control sites are monitored to assess the environmental impact of cage farms. The data are used to calculate biological loadings and to estimate carrying capacities of embayment systems.

Following an extensive survey for the presence of Tri-Butyl-Tin (TBT) residues, using the TBT induced "imposex" condition of the dogwhelk, the further use of TBT net-dips and TBT antifouling paints on boats under 25m, was banned.

Molluscs

Oysters- A moderate settlement of *Ostrea edulis* occurred on natural beds. A new complex of three oyster breeding ponds for the production of *O. edulis* and a green house hatchery for *C. gigas* were established by a new company in Co. Clare. Cultivation of *C. gigas* continued to expand.

Bonamia - was detected from oysters in Cork Harbour early in 1987. As reported by other workers mortalities were highest in market size 4 year old oysters estimated to be about 90%. A survey of other important sites was initiated yielding negative results, but early in 1988 the disease was detected in the West coast but no mortalities reported. The transfer of molluscan shellfish from one area to another is prohibited except under licence.

Scallops (*P. maximus*)

Following years of poor and failed settlements of scallops during 1982-1985 in Mulroy Bay, a moderate settlement took place in 1986 and again in 1987. Approximately one million spat were collected during 1987. The return of settlements follows the discontinuation during 1985 of tributyltin net dips by fish farms. Approximately 20,000 scallops, of the 1986 Mulroy Bay settlement, of about 40 mm were sown in two West of Ireland bays during November 1987.

Mussels (*Mytilus edulis*)

The expansion of rope culture of mussels continues. In the south west coast where growth and condition of mussel meat is particularly good. However, some slow down in growth has been reported, the causes for which are not clear. The markets for mussels were seriously disrupted by the detection of DSP toxin which persisted from late July to early December. *Dinophysis acuta* and *D. acuminata* were the species detected. No sales were permitted.

PSP toxin was detected in low levels (maximum 420 mouse units per 100g of mussel meat) following a bloom of *G. spinifera* and *G. tamarensis* in Cork Harbour. Other areas were tested but no PSP toxin was detected. This fishery was closed for five weeks to the end of July.

Research

Eight organisations are now engaged in on-going research projects on mariculture related topics and the main areas of activity are summarised below:

(1) Fisheries Research Center, (FRCO, Dublin)

- Research on diseases diagnosis and control;
- Mollusc culture techniques, predator control studies;
- Environmental effects of salmonid cage culture;
- Investigations of incidence and effects of unusual marine algal blooms on mariculture activities.
- Effects of antifoulants and chemicals on mollusc and crustacea.

(2) Taighe Mhara Teo, Galway

- Development of mollusc hatchery techniques, raft and cage engineering design;
- Pilot studies of Buchot method of mussel culture;
- Shellfish stock enhancement programmes.

(3) Shellfish Research Laboratory, Carna, Co. Galway

Resource Management

The Kilkeiran and Bertraghuoy embayment system in Co. Galway on the West Coast of Ireland supports mixed capture fisheries (finfish, crustacea and mollusca), a rapidly increasing number of Aquaculture operations (both finfish and shellfish) seaweed and limited Lithothamnion harvesting. In addition re-development pans are in operation for extensive natural beds of flat oysters and scallops.

Investigations commenced in 1980 towards the development of an integrated management plan for effective multi-purpose utilization of these resources. These studies were completed during the year and the reports will include an environmental/hydrographic atlas of the system, case histories of various intensive and extensive aquaculture developments of various intensive and extensive aquaculture developments (e.g. salmon, oyster, scallops, clam, mussel cultivation, evaluation of new species such as abalone etc.), fishing and related activities and management implications and strategies.

Oysters

Ostrea edulis : Investigations were undertaken of larval concentrations, settlement patterns, growth, predator control and general stock assessment.

Crassostrea gigas : Preliminary investigations to compare performance of triploid animals with normal diploids.

Scallops

Pecten maximus : Ongoing investigations on reproductive biology in natural populations, recruitment, spat collector programme and commencement of ranching trials with 30 mm spat.

Chlamys varia : Identification of locations for pilot scale spat collector trials.

Clams:

Stock assessment of *Venus verrucosa* fishery and preliminary gear trials for *Laevicardium crassum* and *Glycymeris glycymeris*. Growth rates and stocking density trials for *Tapes semidecussatus* in intensive cultivation.

Abalone:

Haliotis tuberculata : Trials continued with grow-out systems, the most promising of which appear to be deep water long lines. Various innovations have been made to hatchery and nursery systems to upscale spat production to pilot commercial levels over the next four years.

H. discus hannai. Initial attempts to produce and F1 generation from brood stock were unsuccessful. The holding systems are being modified for 1988.

Sea Lice: Investigations continued into the biology and reproductive cycles of *Lepeophtheirus salmonis* and *Caligus elongatus* within the environment of salmon farms. Preliminary tests were undertaken to evaluate the effects of dichlorovos on selected marine organisms under laboratory conditions.

Water monitoring:

Physical, chemical and biological characteristics of salmon farms and control sites were carried out bimonthly as part of a cooperative industry programme.

4. University College Galway

Zoology Department: Genetic studies of molluscs and salmonids

Microbiology Department:

- Continued studies on incidence and control of furunculosis
- Immunological studies of *Aeromonas salmonicida*
- Drug resistance problems in furunculosis
- Studies on the use of Ivermectin for lice control
- Pancreas disease

5. University College Cork

- Zoology Department
- Fish Diseases
- Study of renal diseases in farmed salmonids with particular emphasis on Proliferative Kidney Disease (PKD); transmission experiments and role of vectors, natural hosts and prevention;
- Ectoparasitic protozoans on salmonids in freshwater and marine culture;
- Identification and control of two species of sea lice infesting salmon in a Bridgestone cage farm;
- Immunological assessment of the effectiveness of vaccination against furunculosis;
- *Bonamia* in Cork harbour: improved detection methods, possible control measures and investigations of relative resistance of stocks.

Genetics:

- Genetic variation in salmon throughout the range of the species
- Genetic effects of hatchery rearing in salmon and trout

Physiology:

- The early detection of grilse maturity using morphological and hormonal indicators;
- T- hormone and smoltification in salmon;
- Studies on the immune mechanisms of fish;
- The effect of pre-slaughter starvation on flesh quality in farmed salmon.

Molluscs:

- The spawning patterns of mussels in Bantry Bay and their relationships to environmental and handling factors (Ph. D. in progress);
- The efficiency of U.V. treatment for the depuration of bottom dredged mussels;
- The revitalisation of a derelict oyster bed;
- The effect of exposure and site on growth in the Pacific oyster;
- The Pacific oyster as a bio-filter in a land-based seawater salmon farm effluent.

Re-seeding trials with scallops;

6. Salmon Research Trust, Newport, Co. Mayo;

- Biochemical genetics, nutrition and disease control of salmonids.

7. Electricity Supply Board

- Research and development of salmon and eel farming, investigation of methods of control of sexual maturation in salmon.

8. Regional Technical College Galway

- Dichlorvos toxicity in Crustacea;
- analytical techniques for examining Dichlorvos in fish and water.

Education and training:

In response to increased demand from the rapidly expanding Aquaculture Industry additional specialised courses (Higher diploma in Applied Science (Aquaculture) (and M.Sc. Aquaculture) were offered in 1985/86 and were fully subscribed during 1987.

Eleven organisations are involved in training for Aquaculture ranging from degree courses for management staff through to practically oriented courses for farm operatives.

Organisation	Course
RTC Galway	National Certificate in Aquaculture Diploma in Aquatic Biology B.Sc. in Aquaculture
RTC Letterkenny	Certificate in Technology (Fish Farming)
RTC Tralee	Certificate in Technology (Fish Farming)
U.C.G.	M.Sc. in Aquaculture Higher Diploma in Applied Science (Aquaculture)
U.C.C.	M.Sc. in Aquaculture
B.I.M.	Industrial Training Course (NFTC) Training Grants
Udaras	Industrial and Community Education
Y.E.A.	Community and Group Training

V.E.C.'s

Community and Group Training

Private

Individual and Group Training

Netherlands

by

(Renger Dijkema)

General

Views on the prospects of aquaculture, especially in heated recirculated systems have become somewhat more sober in the past year. A variety of systems for intensive farming of eel and catfish has been installed, in salt as well as in fresh water, and gradually the technical and economical feasibility of the different systems followed: for water treatment or holding facilities, the question whether to depart from elvers or from wild-captured eel fingerlings etc. Also more information could be gathered from the industry than before. The estimation of the quantity of eels produced in 1986 appeared to have been somewhat optimistic, rather around 125 tons than the 180 given in last year's report

Eels

Apart from about 12 firms cultivating eel for consumption, 3 enterprises have started producing fingerlings (10-20 g) for the market. The use of wild-captured eel for stocking eelfarms appears to be more and more abandoned in the Netherlands, principally due to the increasing incidence of the parasite *Anguillicola* all over the Dutch waters. A combined research program into infection of eels with *Anguillicola*, combatment of the parasite and immunisation is being carried out by various laboratories in The Netherlands and Belgium. Other research is aimed at early feeding of elvers and eels, as well as a technical and economical evaluation of farming systems for eels, flat- and catfish.

Salmonids

Cage farming of salmonids in sea water has practically been abandoned after experiments in 1987 failed to demonstrate feasibility. Despite a relatively cool summer, massive mortalities occurred among experimentally reared rainbow trout, even of selected strains from Denmark and France. Research into blood parameters showed low blood protein levels. In fresh water research is being done to develop on-shore rearing of rainbow trout using the ecosystem of small lakes as water supply. Only one small firm, cultivating rainbow trout in cages in brackish water as a sideline remains. The reduced market prices for rainbow trout (red meat seems hardly to be an advantage anymore) also have reduced interest in salmonid farming in the Netherlands.

Sea Bass (*Dicentrarchus labrax*)

In combination with an on-growing experiment in a recirculated system, sea bass was reared during summer and autumn in cages in the sea. Apart from troubles with lordosis, presumably caused by nutritional problems, outdoor growth proved satisfactory. Heated-water facilities will, however, be necessary to bridge the winter period. This means that the economic feasibility has still to be proven.

Ragworms (*Nereis virens*)

Sobering up certainly applies to this branch, in which in 1987 several projects ran into problems or even disappeared from the scene. The causes of this decline are initial over-optimism as to prices and marketing, over-investment and precipitatedly and ill-designed systems, resulting in a lower production than expected. Especially the larger projects, with more employees and higher bank loans, appeared to be vulnerable and were often not able to cope with the problems, generally arising in starting aquaculture operations. A selection has set in towards smaller and/or less capital-intensive projects or recirculated systems which are not longer dependent on the climate.

Statistical Data on Aquaculture Production in The Netherlands in 1987.

Species	Production (tonnes)	Numbers (x1000)	Value in US March '88 (x 1000)	Number of Firms
Rainbow trout (marine waters)	15	15	80	2
Rainbow trout (freshwater)	250	2,000	1,250	10
Eels (for consumption)	200	1,111	1,729	9
Eels (Fingerlings)	8	- - -	- - -	3
African Catfish	300	1,667	1,135	40
Ragworms	4	800	86	4

Norway
by

(S. Tølseth)

Introduction

This report gives a summarized overview on the research activities concerning aquaculture in Norway. The institutions that have contributed will be presented separately. Some research institutions have not replied to the request of information and for further information about research programs, this is available in the 1987 report by. I. Opstad.

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, Bergen (FTFI)
3. Norwegian Herring oil and meal industry research institute.

4. University of Bergen
 - 4.1 Department of Marine Biology
 - 4.2 Department of Microbiology and Plant Physiology
 - 4.3 Department of Biochemistry
 - 4.4 Department of Fishery Biology
5. University of Tromsø, department of Fishery Biology
6. Nordland Research Foundation

1. INSTITUTE OF MARINE RESEARCH, DIRECTORATE OF FISHERIES

Flødevigen Biological Station

a) Shellfish:

- * Growth rates in oysters in natural biotops. 1985-1988
- * Special plant arrangements for protecting clams in culture against poisonous algae. Effects of poisonous algae were detected at different depths. 1986-1987.
- * Collection of natural produced larvae of the blue mussel. The planktonic larvae were collected by pumping. Settlement on tapes was also registered. 1984-1988.

b) Marine fish:

- * Observations on rainbow trout in sea cages during the winter season. 1986-1987.
- * Production of turbot and sole fry from eggs stripped of broodstock.
- * Growth experiments on sole and turbot. Started 1985 and terminated in 1987 when the fish reached sexual maturity
- * Domestication of Wolfish including first feeding of larvae, and optimizing of food quality for fish in culture. 1987-1990.

Austevoll Marine Aquaculture Station

Marine Fish

- * Domestication of Atlantic halibut (*Hippoglossus hippoglossus*). A joint project between IMR and BP a/s. The project was started in 1986 and includes all aspects of halibut fry production in intensive systems. The work aims at optimizing the production methodical and technical. Also broodstock management is a large part of the project.

In addition to this project, semi-extensive systems based on submerged enclosures were used for similar production experiments. The domestication project was extended in 1987 to include production of live feed for marine fish larvae. The food organisms that are being cultivated are several species of algae, rotifers (*Brachionus sp.*) and brine shrimp (*Artemia salinas*).

- * Pond production of cod fry. Two ponds of different size have been used for extensive production of cod fry. The ponds are closed to the sea, and top-predators were removed by poisoning before newly hatched larvae were released. The natural production of plankton in these ponds served as a sufficient supply of start food for the larvae.

- * Effects of physical stress on growth and development of halibut larvae. The stress was applied as various rates of air bubbling through the incubation units. A significant correlation between rates of air bubbling and developmental failure was found.
- * Fish larvae behaviour in the pre-feeding stages and in the start-feeding stage have been monitored. These studies have been performed on cod, halibut and turbot. Changes in activity is correlated to developmental events.
- * Studies of biochemical changes in the gonad during oocyte maturation of marine fish. The significance of small organic molecules as osmotic effectors has been established.
- * 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 photoperiod. Also the investigation aims at finding methods for displacing spawning periods. The species involved are halibut, turbot and plaice.
- * Composition and optimization of synthetic start feed for marine fish larvae. A joint project between IMR, the Marine Aquaculture Station Austevoll and UiB, Dept. of Biochemistry. The aim of the project is to compose, test and optimize artificial start-feed for marine fish larvae, and also gain knowledge of how selection of basis feed, preparation and feeding methods influence the feed and the larvae offered this feed. 1986-1988.
- * Ultrasonography. Development of techniques for early detection and separation of maturing salmon by use of ultrasonography.

Matre Aquaculture Station

- * Broodstock management vs. egg quality of salmon. The investigation was started in 1985 and aims at finding effects of environmental conditions on physiological parameters in brooders and the effects on egg quality. Egg quality is determined by fertilization, survival and growth of fry. The project also includes investigation on the effect of LHRH treatment.
- * 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.

2. INSTITUTE OF FISHERY TECHNOLOGY RESEARCH (FTFI), BERGEN

- * Behavior of salmon in net cages is studied to identify important negative stressors from environmental 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 PC-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.

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

Food quality:

- * Optimisation of relative content of protein, fats and carbohydrates in salmonid feed.
- * Effects of fish meal protein quality on growth rates and assimilation efficiency in salmonids.
- * Effects of various fish oils in feeds on the meat quality of salmonids.
- * 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 protein for fish fry
- * Acceptability and nutritional "value" of feed produced of fish meal from fish conserved by organic acids.

4. UNIVERSITY OF BERGEN

4.1. DEPARTMENT OF MARINE BIOLOGY

- * "King scallop - spat production and Cultivation"
Various aspects of spat production and cultivation of king scallop (*Pecten maximus*) have been investigated. The aspects concerning methodology and technology for spat production was terminated in 1987. Basic routines for production of spat up to 3 mm size has been established, and during 1986 about 40.000 spat of this size were produced. Artificially induced spawning has been possible between May and December, but the process involved in production and maturation of eggs in the gonad are not fully understood.

Growth and survival experiments of scallop spat in test systems were carried out in 1987. The different systems included plastic cylinders in the sea enriched with artificial fertilizers, tanks on shore with different temperatures and food regimes, and in different types of equipment at various depths at natural sea localities.

4.2. Department of Microbiology and Plant Physiology

- * Genotypical and phenotypical studies of fish pathogen bacteria, including the lobster pathogen bacteria *Aerococcus viridans*.
- * Studies on survival of *Vibrio anguillarum* and *V. salmonicidae* in sea water. The project aims at finding technology for detection of low concentrations in marine environment.
- * Fish pathogen bacteria in the marine environment-survival in water and on surfaces.

- * Microbial activity and halibut farming. This project is carried out at the Marine Aquaculture Station Austevoll, and aims at finding procedures for controlling bacterial populations in rearing units by bacterial grazers.
- * The role of bacteria in fertilization, hatching and larval development of marine fishes.
- * Bacterial resistance against antibiotics. Development and exchange of resistance among fish pathogen bacteria.
- * Fungus infections on cultivated fish species with special reference to *Exophiala* - infection on salmon.
- * Spat production of oysters. The project aims at optimizing the production and nutritional composition of algae as food for oysters.

4.3. Dept. of Biochemistry

- * Studies of the biochemical mechanisms in the transport processes in the gills. The project will try to study the physico-chemical parameters of the Mg-dependent proton translocation ATPase in fish gills to gain a better understanding of the mechanism of pH-regulation in teleosts.
- * Metabolism of branched amino acids in rainbow trout muscle.
- * The chemical structure of the fish egg shell at fertilization, hardening and hatching.
- * Exopeptidase from marine fish waste. Exopeptidase from the pyloric caeca of the Atlantic cod is isolated and characterized by biochemical means. The aim of the project is to elucidate the mechanisms underlying the activation of the digestive enzymes.
- * Lipases from marine fish waste. Pancreatic lipases from cod pyloric caeca are isolated and characterized in order to gain a better understanding of digestion of fat by teleosts.
- * Nucleases from Atlantic cod. Pancreatic type nucleases from the cod intestine is isolated and characterized by biochemical means. A better understanding of the physiological role of enzyme in nucleic acid metabolism is part of the project.
- * Pituitary hormones from marine fish. The project aims to get a molecular understanding of fish endocrinology with special emphasis on growth hormone (GH), prolactin (PRL) and gonadotropic hormones (GTH). Most work has been done on GH and PRL from cod (*Gadus morhua* L.), and these hormones have been purified from alkaline pituitary extracts by gel filtration and reversed phase HPLC. Extensive biological and physicochemical characterization. It is of interest to gain a better understanding of hormone action, and collaborative projects will try to establish the role of GH in protein synthesis and the role of GH and PRL in sexual maturation. Assays for measurement of plasma hormone levels can be affected by changing environmental conditions.

4.4. Department of Fishery Biology

- * Research on environmental condition in smolt production. The aim 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, As, where a large part of the projects include graduate student programs.

5. UNIVERSITY OF TROMSØ, DEPARTMENT OF FISHERY BIOLOGY

- * Development of artificial feed for marine fish larvae. On the basis of a newly developed start-feed for salmonids a start-feed for marine fish larvae are being developed. The feed has proved to give earlier growth and lower mortalities in salmon fry.
- * Larval uptake of bacteria. Possible interactions of endocytotic processes by digestion of bacteria, and also the significance of a microflora of bacteria in the larval gut for nutritional and digestive purposes and resistance against certain diseases. Started 1983.
- * Cultivating of cod and other marine species. Development of technology for mass production of marine fish fry, with special emphasis on cod. Started 1983.
- * Cultivation of clam *Chlamys islandica*. The project aims at developing methods for mass production of spat, both by artificial cultivating and by collection of natural occurring populations. The project also includes test cultivation at several localities along the Norwegian coast.
- * Arctic Char (*Salvinus fontalis*). Several investigations have been carried out in order to elucidate the potential of arctic char as species for cultivation. These includes studies of hatching, start-feeding, growth in different cultivating densities, stress factors, nutrition, pigmentation and sea water tolerance. Several populations are being investigated.

6. NORLAND RESEARCH FOUNDATION

- * Transport of fry and smolt of salmonids. Transport experiments where fish handling, stock density, water quality, transport equipment are carried out.
- * Investigations on environmental pollution in intensive aquaculture with special emphasis on organic molecules.
- * Blue mussel in culture. Optimalization of growth by semicontinuous cultivation of microalgae by fertilization of deep water.
- * Cultivation of shell. The action of forced convection of primary production for cultivation of shell.

Poland

by

(J. Wiktor and K.Goryczko)

Breeding and rearing of brood stocks of rainbow trout adapted to brackish water conditions continued in 1987. The programme is a long-term one and has produced the third generation. Fish produced from hatchery operation will be released into coastal waters. Breeding of salmon which were received from Latvia (USSR), continued. This work is carried out in sea-water pens. The aim is to produce a stock of spawners under controlled artificial conditions. The first spawning of this fish is expected to take place in 1988. There was no commercial mariculture production in Poland in 1987.

The present report represents the genetic studies carried out in Poland:

Sex control in rainbow trout.

Masculinized females (300 fish) were produced by treatment with methyltestosterone applied to the progeny of functional males (genetic females) obtained as a result of experiments completed in 1986. These fish will be distributed in 1988 to enable the whole female market fish production in Northern Poland.

Gynogenesis.

Experiments aimed to induce artificially gynogenesis in sea trout and rainbow trout. The work was started in autumn 1986 (s.t.) and continued in spring 1987 (s.t.). Sea trout ova were inseminated with brook trout sperm previously sterilized by UV light, and then treated with heat shock (28°C). Survival rate at the beginning of feeding was 14%. It is supposed that the applied method was effective because in autumn 1987 treated population consisted of sea trout only - not one "tiger" fish was found. Similar results were obtained with rainbow trout. Ova of xantoric (yellow) female were inseminated with previously UV irradiated sperm obtained from the "wild" coloured male. Inseminated eggs were heat shocked. Survival rate up to swim up stage was 8%. All fish are xantoric (yellow). This may suggest that they are of maternal genotype only. Control group (eggs and milt of the same experimental fish, normally fertilized) consisted of "wild" coloured fish only.

Induced polyploidy

The experiments on induced polyploidization in rainbow trout were continued in 1987 in cooperation with the Academy of Agriculture in Warsaw. To induce polyploidy, the thermal shock method was applied to the two groups of ova. The first group consisted of eggs fertilized by normal sperm, the second one of eggs fertilized by sperm obtained from masculinized females. The ratio of polyploidy in experimental groups was 80% (amount of DNA in erythrocyte nuclei as well as nuclei diameter was measured). No significant differences in growth rates of experimental and control fish was observed during the first season.

Portugal

by

(Tereza Diniz; Jaime Menezes)

Research concerning mariculture which is related to INIP was carried out through laboratory and field works as follows:

Finfish:

Successful spawning induction by environment manipulation and by hormone injection on sea bream and sea bass. For the former species, by temperature control, a daily regular egg production is pursuing since early November. Complementary studies related to larval survival are being implemented.

Sanitary support of the transfer and maintenance of wild breeders is being applied improving its management and of the wild juveniles utilisation.

Field activities were carried out through cooperative arrangement between INIP and aquaculturists, mainly to improve extensive polyculture in the Sado estuary and the Faro-Olhão lagunar system.

Shellfish:

Crustacea (shrimp) and molluscs (clams and oysters) are considered. With regard to shrimp culture research was implemented by cooperation of INIP with aquaculturists in three estuarine areas along the northern (Mondego estuary), central (Sado estuary) and southern (Faro-Olhão lagunar system) coasts of the country, following extensive production with promising results.

Concerning experimental work on molluscs (namely clam, *Ruditapes decussatus* an portuguese oyster, *Crassostrea angulata*), artificial reproduction and mass production of seed was achieved under laboratory conditions. Field trials using that seed are now pursuing.

Disease diagnosis and prophylactic measures were implemented in shellfish culture.

Experimental work was carried out at the Aquaculture Facilities of the National Institute of Fisheries, located in Olhão (South Portugal) with the cooperation of the University of Algarve, on the subjects following:

- larval culture of *Sparus aurata* juveniles: food conversion efficiency, food conversion rate using commercial pellets, incorporated with fish byproducts;
- effect of food enrichment on fatty acids, on the survival and growth of postmetamorphosed *Solea senegalensis* kaup.

Some private companies had been set-up in the area including the start-up of a commercial hatchery for sea bream and sea bass; the latter project is with the support of EEC through the FEOGA funds.

Experiments on extensive on-growing of *Peneaus japonicaus* have also been conducted in Algarve, and the results (average production of 600 kg/ha/crop) appear to be promising.

Spain

by

(M. Torre and C. Roman)

Research on aquaculture was continued with the following species: *R. philippinarum*, *Venerupis decussata* and *V. pullastra*. In most of the research institutes along the Spanish coast these studies are intensified with the aim to develop commercial clam farms which use the most modern cultivation methods.

Intensive research activities are also taking place with the Pacific oyster (*Crassostrea gigas*), in particular with the "pochon" method in northern and southwestern Spain.

Studies on the methodology to advance the controlled spawning of two shrimp species (*Peneaus japonicus* and *P. kerathurus*) are also under way.

Investigations are undertaken to improve larval cultivation of the Red Sea Bream (*Pagellus spec.*).

Commercial production of marine fish fry has started in Spain, mainly producing species such as turbot (*Scophthalmus maximus*), sea bass (*Dicentrarchus labrax*) and gilthead bream (*Sparus auratus*).

The overall production figures for aquaculture in Spain are outlined in the following Table.

Table 1: Aquaculture Production in Spain in 1987. Statistical data provided are not yet official and may need adjustment

Molluscs	Production (Metric Tonnes)	Finfish	Production (Metric Tonnes)
Flat oyster	300 *	Marine Fishes	
Pacific oyster	33	Turbot	47
Clams**	400	Sea Bass	40
Cockles	800	Gillthead Bream	160-170
Subtotal	1533	Great amberjack	20
		(<i>Seriola dumerilii</i>)	
Crustaceans		Gray Mullet (Mugil spec)	???
<i>Penaeus japonicus</i>	33.6	Dover sole (<i>Solea solea</i>)	10.5
Subtotal	1566.6	Salmon	150
		Rainbow trout	10
		Subtotal	00437.5
		Freshwater Fish	
* = Production of flat oyster through "semi-culture" yielded additional 1,800 to.		Rainbow trout	15600
** = includes production of all three species: <i>V. decussata</i> , <i>V. semidecussata</i> , <i>V. pullastra</i>		Brown trout	400
		Carp	012
		Tench	400
		Eel	52
Total shellfish	2,366.6	Total finfish	16901.5

Sweden

by

(Hans Ackefors)

Introduction

The aquaculture production for the market is still rather small in Sweden. It is dominated by rainbow trout. However, the eel and salmon farming is increasing, especially the former species. The mussel harvest was small in 1986 due to frequent occurrence of algal toxins in the mussels for a long period. In 1987, however, the conditions have improved and probably more than 2000 tons were harvested in 1987. The compensatory program for releasing smolts of salmon and brown trout comprised 2.6 million specimens.

Fishery management

For compensatory purposes 2.6 million smolts of salmon and brown trout were released in 1986 in Swedish rivers.

Species	Number of released smolts (x 1000) in rivers leading to:			Total
	Baltic	Lakes	Kattegat Skagerrak	
Salmon	1,977	46	86	2,109
Brown trout	447	48	6	501

Commercial production

the production of fish and shellfish in 1986 according to the official statistics:

Rainbow trout	2,668	3,785
Salmon	160	160
Brown trout		2
Arctic char		22
Eel		59
Total fish production		4,028
Freshwater crayfish		1
Blue mussel	325	325
Oyster	6,250 (number)	6,250 (number)

In total there were 277 aquaculture operations for production of fish of which 118 were located in marine or brackish water areas. The number of producing mussel operations were only 5 and the number of oyster units only 4. The production of salmon and rainbow trout in marine areas were located in the following areas:

Sea area	Tons
Bothnian Bay	442
Bothnian Sea	205
Baltic proper	1,940
Kattegat	000
Skagerrak	289
Total	2,876

In commercial operations the following diseases have been recognized last year, viz., vibriosis, furunculosis, infectious dermatitis, enteric redmouth disease (ERM), bacterial kidney disease (BKD) and parasitic kidney disease (PKD). Vibriosis is the most common disease in Swedish aquaculture. Antibiotic treatment is common and the amount of active substances increased from 150 kg in 1986 to 325 kg in 1987. The main part of the antibiotic substances were used for treatment of *Vibrio anguillarum* (VA-A and VA-2). A minor part was also used to treat *Aeromonas salmonicida* (ASA and ASS).

The parasitic nematod *Anguillicola* sp. is not yet found in those Swedish aquaculture operations which produce eel. The parasite has, however, been detected in eels imported from Poland to Sweden. It has also been identified in a single specimen of eel from the east coast of Sweden in the Baltic.

Safety regulations for mussel harvest

The Swedish Food Administration has now given directions for a comprehensive control of algal toxins in blue mussel harvest. The High Performance liquid Chromatography technique with Fluorometric Determination of DSP content is used. If the DSP toxin is indicated according to the NMKL method (Nordic Committee of Methods for Provisions) daily sampling for analyses must be taken. In practise every mussel harvest is now investigated according to an agreement among the farmers. For consumption in Sweden the following values are given:

DSP	Maximum 60µg expressed as Ocadaic acid equivalents/ 100g mussel flesh.
PSP	Maximum 80µg expressed as saxitoxin equivalents/ 100g mussel flesh.

Even if HPLC-technique is the routine method, the mouse test is also used for screening of other toxins. According to Dr. Yasumoto 10 Mu (mouse units) correspond to 34 µg *Dinophysis* toxin I resp. 40 µg Ocadaic in HPLC-method.

For export to the continent no mussels are exported where the concentration of mussel toxins exceeds half of that which is accepted for the Swedish market. This is a special agreement among the Swedish mussel farmers.

United Kingdom

Scotland
by
(A.L.S. Munro)

Commercial Atlantic salmon culture produced 12,721 tonnes in 1987, of which 7,200 tonnes comprising 3.285 million fish (av weight 2.193 kg) were from the 1986 smolt intake and 5,521 tonnes comprising 1.522 million fish (av weight 3.627 kg) were from the 1985 smolt intake. There were 185 sea cage sites and 11 pump ashore sites. Some 13 million smolts were placed in sea water from companies operating 131 fresh water sites. Numbers of ova laid down in 1986-7 were 60 million. The industry directly employed 1,142 people in the cultivation only aspect, 25% in a part time capacity.

Rainbow trout culture produced in fresh and sea water 3,207 tonnes of which 1,088 tonnes were fish greater than 1 lb in weight. A total of 28 million ova were laid down in 1987. The industry directly employed 216 people, 14% in a part time capacity.

Commercial mussel, oyster and scallop culture continue to develop but production figures are still not available. Turbot culture produced 100 tonnes.

Research continues on pancreas disease with much evidence pointing to a primary infectious cause. Much effort also continues to research for a better furunculosis vaccine, for safer methods in the use of dechlorvos containing chemicals used to control sea lice, and in trials to establish if triploid (ie sterile) salmon can contain the grilising factor. New programmes to study the effects of fish farm wastes on the waters and sediments of sea lochs and on fish and cage performance in more exposed off-shore waters are also in progress.

England and Wales
by

(C. Purdom)

MAFF: A principle development has been the creation of a register of fish farms in Great Britain. Separate registers exist for fin fish, marine shellfish and freshwater shellfish. These are designed to provide for effective action in the case of disease and although documentation includes production levels these are not currently used as official statistics.

No formal statistics are available on production but moderate activity continues in shellfish cultivation with some recovery from the *Bonamia* situation and new developments with

Manila clams and blue point oysters. Most finfish production is in freshwater but on-shore marine farming units have been developed for trout, salmon and turbot.

Research continues on stock enhancement with lobsters and sole. No research is performed on intensive marine fish farming but stocks on extensive production derive from the enhancement work. Fish disease and pathology continue to receive attention in connection with fish husbandry and with pollution.

United States

No report received

USSR

by
(L.A. Dushkina)

The mariculture in the European Part of the USSR was developing in different ways. Research on artificial reefs was intensified in the Black Sea, the Azov Sea, and the Baltic Sea. These constructions serve as spawning grounds and coverings and for the increasing of hydrobionts productivity. The reports on the projects were introduced at the All-Union Conferences "Artificial reefs for fish culture" and were published in 1987. The research and practical works on mussel cultivation are continuing in the Black Sea focusing on the use of storm-resistance constructions allowing to get the yield of about 50-100 tonnes per ha. The first thousands of oyster spat have been obtained with the use of artificially rearing techniques for microalgae in plants depending on solar energy.

In the Azov Sea a breeding stock of *Mugil soluy* which was introduced from the Far East of the Soviet Union has been established. The first of the two-year old introduced specimens have now appeared in the sea. The biotechnology of rearing the flatfish *Platichthys f. flesus* in the Black Sea area has been practiced.

In Baltic Sea mineralized hydrothermal water is widely used for rearing of rainbow trout fingerlings.

Near the northern Polar Circle fry of the rainbow trout are reared with the use of warm-water systems and thereafter juveniles are transferred to cages in the White Sea for growing to market size. Fry rearing for this purpose is undertaken by PINRO. The average weight of fry increases by about 459% during 170 days of rearing. The yield is 42kg per m² with range 30-58 kg in average. Better results have been obtained when using juveniles of 60g weight as stocking material. A farm guide for trout rearing in cages in the White Sea has been prepared.

The most favourable conditions for rearing of Atlantic salmon fry includes to operate a safe system with a changeable temperature regime: this method has permitted to rear salmon to a weight of 50 to 80g within 17 months.

