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International Council for the
Exploration of the Sea

Mariculture Committee
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Activity Report 1989/90 Mariculture Committee

by

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THÜNEN

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BELGIUM

by

(Patrick Sorgeloos, Ghent)

State University of Ghent,
Laboratory of Aquaculture & Artemia Reference Center

R & D achievements:

- successful substitution up to 80% of the microalgal diet by amanipulated yeast product in the early nursery culture of the clam *Tapes semidecussata*.
- improved larvaculture outputs of *Macrobrachium rosenbergii* by the use of HUFA-enriched Artemia.

- improved larviculture outputs of the Asian sea bass *Lates calcarifer* and the mahi-mahi *Coryphaena hippurus* by the use of HUFA-enriched *Artemia*.
- successful use of a new microparticulate diet as a zoea/mysis diet for *Penaeus* spp.
- successful use of decapsulated *Artemia* cysts as a post-larval diet for *Penaeus* spp.
- development of dry enrichment diets for *Brachionus* and *Artemia*.
- development of super-HUFA rich enrichment diets for *Brachionus* and *Artemia*.
- successful substitution of *Artemia* nauplii by ongrown *Artemia* in the PL-culture of *Penaeus monodon*.
- processing and use of *Artemia* biomass as a dietary ingredient for postlarval shrimp.

Organization of the "6th International *Artemia* Training Course" with 35 participants from Italy, Spain, Greece, Cyprus, Morocco, Algeria, Tunisia, Egypt, Thailand, Indonesia, PR China, Malaysia, Vietnam, Philippines, USSR, Ecuador, Brazil, Chili, Cuba, Haiti, Panama and Costa Rica.

Organization of workshops and training sessions on fish/crustacean larviculture and *Artemia* culture in Australia, Philippines, and the Dominican Republic.

Consultancy missions for the international agencies UNDP, UNIDO, UN-Mekong, FAO, and the EEC regarding *Artemia* production and use.

***Artemia* systems NV/SA**

Development (contract research with the Laboratory of Aquaculture of the State University of Ghent) and marketing of new diets for use in larviculture of marine fish and shrimp.

**Catholic University of Leuven,
Laboratory of Ecology and Aquaculture**

- Marine ecological research on the impact of bacterial and parasitological infections of fish populations.
- Monitoring and prevention of biofouling in industrial cooling systems, especially the species *Balanus improvisus* and *Cordylophora caspia*.
- Study of the immune response in fish larvae
- Biochemical characterisation of fish *Aeromonas* strains
- Sea bass *Dicentrarchus labrax*:
 - zootechnical aspects of growout in nuclear power effluents,
 - synthesis and secretion of thyroid hormones,
 - sex-differentiation and sex-ratio in farmed populations,
- Eel *Anguilla anguilla*:
 - zootechnical aspects of growout in nuclear power effluents,
 - development of recirculation system for intensive culture,
 - study of parameters responsible for the reduction innatural ,
- eel-stocks in Belgium
 - genetic study of sex-differentiation.

Nuclear power station, Doel--Antwerpen

Production of 900 kg sea bass *Dicentrarchus labrax* and 200 kg eels *Anguilla anguilla*. Intentions exists for up-scaling to culture of sea-bass on a commercial basis.

CANADA

by

(R.H. Cook)
St. Andrews, New Brunswick

This report summarizes mariculture research activities in Canada, concentrating on research by government institutions. For the most part, university and private sector research has not been included, except in joint projects with government agencies.

Newfoundland and Labrador

Salmonids

The Canadian Department of Fisheries and Oceans (DFO, St. John's) has a project to determine salmonid stocks in North America that have desirable characteristics for farming in Newfoundland and to design a program of selection breeding and performance evaluation. A private hatchery is comparing the performance of introduced Saint John River multi-sea winter salmon stock to Grand Codroy River stock from western Newfoundland, and also has projects on arctic char (*Salvelinus alpinus*) incubation and development of female triploid rainbow trout (*Oncorhynchus mykiss*).

The Ocean Science Centre of Memorial University is inducing past-spawned Atlantic salmon (*Salmo salar*) kelt to repeat breed without skipping a year of reproduction; this involves both kelt reconditioning and reactivation of the reproductive system.

Several industry-led projects have studied overwintering problems in salmon cage culture, including: a study of the causes of, and mitigative measures to prevent, winter mortality of salmonids in Roti Bay (more specifically, prevention of swim bladder disfunction which results in abnormal mortality rates); determining the environmental and economic viability of farming salmon on the Northeast Coast of Newfoundland by utilizing wood heat to regulate winter temperatures in sea cages; research into various types of pump configurations and other technologies to maintain access for cage cultured salmonids to open water in winter when an area freezes over (Bay D'Espoir).

Marine Finfish

Experimental cage culture of cod (*Gadus morhua*) is ongoing at Bay Bulls, sponsored by a private company and the Institute of Fisheries and Marine Technology; research activities include husbandry practices and feed development.

Memorial University is assisting in the establishment of an experimental hatchery for marine finfish at Wesleyville. Activities in 1989 were directed towards the culture of ocean pout (*Macrozoarces americanus*) and lumpfish (*Cyclopterus lumpus*). Research on broodstock holding, egg incubation, and feed development are ongoing. The biological feasibility of rearing wolffish (*Anarhichas lupus*) is being assessed. Molluscs

Scallops

DFO studies on giant scallop (*Placopecten magellanicus*) include growth and survival in suspended culture and toxin accumulation in relation to the occurrence of *Alexandrium* and *Nitzschia* sp. Industry-led projects include assessment of bottom culture and ear-hanging culture techniques, including predator control for crabs at the bottom culture site, and broodstock development.

Mussels

DFO studies on blue mussels (*Mytilus edulis*) are determining growth and production parameters, determining factors which influence spatfall density on artificial collectors (spatfall densities in 1989 ranged from 2-100 per square cm on Vexar and polypropylene rope), and evaluating the potential of using a single piece of gear for spat collection and growout, versus the currently used method of separate rope collectors and socking for growout. Industry-led research includes: studies on depuration systems; assessment of the effectiveness of rope and cable barriers to prevent ice from damaging equipment and gear in longline culture sites; and the design of a vessel for use in longline culture.

Production Statistics (1989 estimates)

Blue Mussels	70 t
Rainbow Trout	20 t
Cod	59 t

Nova Scotia, Prince Edward Island, and New Brunswick

Salmonids

Culture and Physiology

Research by DFO (St. Andrews) has shown that Atlantic salmon grew best during first feeding at 16-20°C; water content of 80% in swim-up fry was a suitable index of when to start feeding. It was also found that potential 2+ Atlantic salmon smolts are capable of direct transfer to seawater in late autumn; prior exposure to extended daylengths (LD 16:8 hr) enhances survival and growth in seawater. Accelerated spawning, incubation, and rearing through elevated temperature has resulted in production of smolt-sized

fish in November (age 10-11 mo.); those fish reared under a photoperiod with summer solstice in November or December satisfied smolt criteria and are surviving in seawater.

Other culture research includes the use of insulated/heated rearing cages for avoidance of superchill problems (Nova Scotia Department of Fisheries) and the assessment of arctic char as a culture species (Prince Edward Island Department of Fisheries and Aquaculture).

Broodstock Development

River Philip, LeHave, and Saint John River 1+ smolts produced at DFO's Mersey Hatchery will be provided to four Nova Scotia farms each year for a four year period. Performance of the stocks while in the cages will be compared and the stock exhibiting the best performance traits will be selected for broodstock purposes. Thirty thousand 1+ smolts will be produced from eggs selected from 50 matings of Saint John River salmon performed in 1989 at DFO's Mactaquac Hatchery. These fish will be supplied to the New Brunswick aquaculture industry in 1991 for broodstock development purposes.

The Atlantic Veterinary College is investigating the long and short term storage of salmonid spermatozoa using cryopreservation and fluid extenders, including in vitro assessment of sperm viability after storage.

Genetics

A summary of data collected over three years by the Salmon Genetics Research Program (SGRP) has revealed that an improvement of about 5% in the incidence of smolts in Atlantic salmon was realized when parr were reared in fibreglass as opposed to concrete tanks; a study involving low amplitude sound waves indicated that concrete tanks were noisier. A SGRP study comparing pairs of families reared together, in contrast to single families in individual tanks, indicated that families which grow fastest in the non-competitive environment are not the same as those which excel in the competitive rearing regime. Hence, the mixing of families in selection programs is required to meet the requirements of most environments in which Atlantic salmon perform.

The potential genetic interactions of wild and cultured stocks of Atlantic salmon has become a real concern. The SGRP has begun

cooperative research with the University of New Brunswick on sterility through triploidy and with Dalhousie University on DNA fingerprinting.

Nutrition

In studies by DFO (Halifax), the vitamin B6 requirement of Atlantic salmon fingerlings was found to be 5 mg per Kg of diet. Vitamin B6 deficiency signs included: growth depression, low hematocrit level, disintegration of haematopoietic tissue, and histopathological changes in gills and liver. Increases in the levels of dietary vitamins C and E caused gradual increases in the tissue concentrations of these vitamins, but were found to have no beneficial effect in protection from *Aeromonas salmonicida* and *Vibrio anguillarum*. Preliminary observations from pathological examinations showed signs of microcytic anemia in fish fed diets deficient in vitamins C and E.

DFO (Halifax) analyzed and evaluated various commercial feeds for Atlantic salmon. Modifications were made to existing feed formulas (starter, grower, and broodstock), based on new information obtained on digestible energy values of feedstuffs and nutrient requirements.

Also at DFO (Halifax), a study was completed to determine the differences in chemical composition of eggs and milt from wild and cultured fish.

Research at the Atlantic Veterinary College included: a histopathological investigation of the chronic effects of diets deficient in Vitamins C and E on the health of Atlantic salmon parr; an evaluation of six experimental diet formulations as potential commercial feeds for salmon parr; and a study on amino acidbioavailability in fish meals used in commercial fish feeds.

Disease

Bacterial Kidney Disease (BKD) continued to limit Atlantic salmon smolt production in the Maritime Provinces. In spite of extensive screening of broodstock reproductive fluids to eliminate infected eggs, one major smolt producer experienced clinical BKD traced to infected eggs, resulting in a shortage of smolts this year. The Atlantic Veterinary College is studying the occurrence and distribution of BKD in wild and cultured salmonids in Nova Scotia, the

development of a rapid ELISA assay for the detection of BKD in salmonids, and characterization of monoclonal antibodies directed against *Renibacterium salmoninarum*.

A new species of vibrio was identified at one marine cage site at low temperature in the Bay of Fundy. The agent was confirmed biochemically and serologically at DFO's Halifax Research Laboratory as a strain of *Vibrio salmonicida* causing Hitra disease; this is the first reported identification of this species in North America, although it is common in Norway. The distribution and prevalence of the disease is under investigation. The Atlantic Veterinary College is evaluating commercial vaccines used in the prevention of vibriosis in Atlantic salmon post-smolts and six antimicrobial agents (Tetracycline, Oxolinic Acid, Erythromycin, Streptomycin, Romet, and a new Arylfluoroquinolone) against strains of *Vibrio anguillarum*, *V. ordalii*, and *Aeromonas salmonicida*.

Immunosuppression tests for the carrier state of furunculosis were carried out by DFO on all salmon smolts going to sea cages in New Brunswick. Fish from 18 sources were screened under the program and disease was detected in two facilities. Furunculosis was introduced to two freshwater hatcheries in New Brunswick and subsequently to three marine cage sites via the use of a contaminated commercial furunculosis vaccine. Eradication was successful at the freshwater sites; at the marine sites, the disease persists, but is under control.

Other activities at the Atlantic Veterinary College include: monitoring for oxytetracycline in muscle tissue in commercially reared Atlantic salmon from New Brunswick; blood protein electrophoresis for use in diagnostic clinical pathology; standardization and normal range determinations of clinical pathology indices for salmonids; development, testing, and standardization of bacterial challenge systems and systems for efficacy evaluation of fish health drugs and biologicals; production of anti-sera to help identify bacterial finfish pathogens by diagnostic laboratories; development of liposomal delivery systems for drugs and biologicals; disease diagnostic and consulting services for the mariculture industries of Atlantic Canada.

The Nova Scotia Department of Fisheries is studying the effects of using Dichlorovos-Nuvan as a delousing agent.

Marine Finfish

Research on halibut (*Hippoglossus hippoglossus*) culture by DFO (St. Andrews) focussed on broodstock development and on-growing of wild-caught juveniles. Numerous refinements were made to the methods used to capture and transport juvenile (bottom trawled) and adult (longlined) fish. Excellent growth and survival were obtained in juvenile halibut stocked in a modified herring weir in Passamaquoddy Bay. Research by DFO (St. Andrews) on striped bass (*Morone saxatilis*) included behavioral studies, induction of spawning, collection and rearing of eggs; some juveniles were raised to ca. 10 cm, but larval mortality was high. Other studies at DFO (St. Andrews) were spawning and rearing to juvenile stage of lumpfish (*Cyclopterus lumpus*) and rearing at different temperatures and preliminary feeding behavior studies of glass eels (*Anguilla rostrata*).

Body composition and vitamin and amino acid concentration studies have been done for marine finfish (halibut, cod, bluefin tuna, and mackerel) by DFO (Halifax).

The Atlantic Veterinary College has undertaken a survey and characterization of bacterial diseases of cultured marine flatfish.

Shellfish

Mussels

DFO (Moncton) has been studying the limiting environmental factors influencing growth, survival, and productivity of cultured mussel (*Mytilus edulis*) populations in relation to natural food supply. In cooperation with researchers from Acadia University, this data was used to develop a predictive simulation model of cultured mussel growth and production, which has the potential for use in delineation of the controlling factors for aquaculture site selection. At DFO (Halifax), short-term shell growth was monitored, using a laser diffraction technique, in experimental mussel populations exposed to an average concentration of 224.75 mg/L particulate inorganic material; in 5 continuous days of exposure, a marginal, but not significant, decrease in shell growth was noted compared to controls. Atlantic Veterinary College studies include: the uptake, tissue distribution, and depuration of domoic acid from commercially-reared blue mussels maintained under different temperature, salinity, and dietary regimes; analytical procedures

for measuring domoic acid in biological matrices; methodologies for effectively depurating mussels contaminated by domoic acid; and setting-up a shellfish bacterial depuration testing service.

Scallops

A semipurified microparticulate diet has been tested in growth studies with juvenile scallops (*Placopecten magellanicus* and *Aequipecten irradians*) by DFO (Halifax). A private company has developed the encapsulation technology and has agreed to prepare the test formulations; preliminary results indicate that the diet will support growth and survival. DFO (Moncton) and the Atlantic Veterinary College have studied parasites in bay scallop (*A. irradians*). Following the discovery of a previously undescribed protozoan parasite in bay scallop, which were imported to Canada in the last 10 years for aquaculture, intensive studies have been carried out to establish its identity and disease potential. Laboratory experiments at DFO (St. Andrews) examined the environmental factors that influence maturation, vitellogenesis, and spawning in sea scallop.

Oysters

DFO (Moncton) has conducted intensive field studies on oysters (*Crassostrea virginica*) in Caraquet Bay (New Brunswick) and Dunk River (Prince Edward Island), including determining the optimal locations for the collection of spat for local enhancement projects. The Nova Scotia Dept. of Fisheries is studying hatchery production and field grow-out techniques for native oyster, as well as bar clam, razor clam, soft-shell clam, Icelandic scallop, and moon snail. Studies include: innovative hatchery and nursery methods, testing a variety of species under winter conditions, researching new candidate aquaculture species, and broodstock management.

Lobsters

DFO (St. Andrews) has studied the effect of winter temperature and photoperiod on control of the vitellogenic cycle and induction of spawning in American lobster (*Homarus americanus*) and is collaborating with researchers in the United States to determine the role of the mandibular organ in the control of spawning. DFO (Halifax) is participating in studies evaluating the nutritional and

physiological factors involved in the molt death syndrome in lobster culture.

Aquaculture Ecology

DFO (Halifax) has begun a project on the influence and involvement of bacteria in the production of marine toxins, coupled with work on the biodegradation of marine toxins (domoic acid and members of the saxitoxin/neosaxitoxin family) and is enlarging a program (in conjunction with DFO St. Andrews) studying the impacts of salmonid aquaculture on pelagic and benthic habitat in the L'Etang Inlet of New Brunswick; a preliminary impact assessment simulation model has been developed using the BSIM modelling software package. DFO (St. Andrews) has been collecting sediment and gas samples near salmon net pen sites and is continuing research and monitoring studies on phytoplankton species that are harmful (or potentially harmful) to commercially valuable molluscs and finfish in southwestern New Brunswick.

Production Statistics (1989 estimates)

Nova Scotia:	Atlantic salmon	250 t
	Trout	450 t
	Mussels	400 t
	Oysters	140 t
Prince Edward Island:		
	Mussels	2 682 t
	Oysters	1 895 t
	Rainbow trout	0 050 t
	Bay scallops	0 020 t
New Brunswick:	Atlantic salmon	4 500 t
	Trout	<100 t
	Mussels	226 t
	Oysters	not available

Quebec

Marine Finfish

DFO (Mont-Joli), in collaboration with Université du Québec at Rimouski and Institut National pour la Recherche Scientifique (INRS) en Océanologie, is evaluating the adaptation of cod (*Gadus*

morhua) to culture conditions. It was found that cod could easily tolerate salinities lower than isotonicity of its blood ($<14\text{‰}$); this could be advantageous for culture in sheltered brackish waters. Physiological stress indicators, such as cortisol and glucose are being tested for their potential use as monitoring tools of culture condition suitability. Oxygen requirements are investigated under stressful conditions in individual cod held in a respirometer; in vivo blood sampling techniques are used to study the dynamics of physiological adaptation to low oxygen. Another study examines the metabolism of cod under different temperatures and food rations; the objective is to identify enzymes that are correlated with growth success; ultimately, these could be used to rapidly assess the suitability of culture conditions in terms of growth potential.

Cod and American plaice (*Hippoglossoides platessoides*) sampled at sea and after a long period in captivity were tested for normal (at sea) and adapted (captivity) viral and bacterial flora; potential pathogens are particularly being looked for. Fish with clinical signs of disease were found both at sea and in captivity. At least one viral disease (Lymphocystis) was identified in the American plaice at sea. *Vibrio* sp. (*V. anguillarum*, *V. salmonicida*), *Aeromonas* sp. (*V. salmonicida*), *Pseudomonas* sp., and *Acinetobacter* sp. were found in cod held in captivity.

Molluscs

Mussels

Intensive sampling by DFO (Mont-Joli) of navigation buoys was used to investigate the distribution and productivity of blue mussel (*Mytilus edulis*) in the marine regions of Quebec; these results will be used to evaluate the potential for culture expansion. Mussel filter-feeding behavior was tested under experimental conditions to evaluate the capacity to segregate between different types of food particles, such as toxic dinoflagellates. Preliminary results show that mussels can distinguish between types of particles and has preferences, but will reduce selectivity under low densities of food particles. In collaboration with INRS-Océanologie at Rimouski and le Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPA), the carrying capacity and limitations of the Magdalen Islands lagoon for mussel culture are being investigated.

Scallops

Spat collection data of DFO (Mont-Joli) in the Magdalen Islands suggest the existence of waves, both in time and space, in the spawning and settling of giant scallop (*Placopecten magellanicus*). A stocking program for extensive mariculture in the Magdalen Islands has been developed by DFO, MAPA, and local industry; young scallops will be obtained from wild spat and hatcheries.

Toxic dinoflagellates

The ecology and spatio-temporal distribution of *Protogonyaulax tamarensis* in the Gaspé current and in the Bay of Gaspé are being studied; the results will be used to understand the different rates of toxicity observed in mussels, both wild and cultivated, in this area.

British Columbia

Salmonids

Salmon Culture Research (DFO Nanaimo)

A laboratory experiment investigated the feasibility of administering 17a-methyltestosterone to accelerated underyearling coho salmon (*Oncorhynchus kisutch*), so as to produce sterile zero-age smolts. A photoperiod experiment was conducted with chinook (*O. tshawytscha*) and coho salmon in seawater pens to determine the feasibility of delaying the season of sexual maturation so as to lengthen the harvest season.

Disease Research (DFO Nanaimo)

Bacterial Kidney Disease (BKD) - studies have resulted in the development of an improved method for growing the responsible bacterium (the nurse culture technique). It was showed that vertical transmission is accomplished with eggs that acquire their infections from ovarian tissue prior to ovulation, as well as from ovarian fluid following ovulation. The egg mediated transmission of the disease can be prevented or substantially reduced using the broodstock injection technique.

Vibriosis - studies revealed the presence of a *Vibrio anguillarum* serotype (0-2) in British Columbia coastal waters, previously unrecognized in the region. This serotype will have to be incorporated into the anti-vibrio vaccines being used in B.C. if maximum protection is to be ensured. A strain of *V. anguillarum* (serotype (0-2) that could easily be mistaken for *Aeromonas salmonicida*, a causative agent of furunculosis, was also isolated. The isolate produces a brown diffusing pigment on NaCl-supplemented Tryptic Soy Agar indistinguishable from that of *A. salmonicida*.

Toxicopathic Liver Disease - this disease, primarily a problem in Atlantic salmon, but also affecting chinook salmon and steelhead trout, has been found at several sites in B.C., but thus far it has occurred only in mild form. It is thought to be caused by a water-borne toxin, possibly of algal origin. Work to verify this and to identify the source of the toxin is underway.

Marine Anemia - this is a new and pressing problem in B.C. chinook salmon, because of the losses it causes and because it appears to be untreatable. The condition has been shown to be infectious and a viral etiology is suspected.

Sea Lice - two species, *Caligus clemensi* and *Lepeophtheirus salmonis* are problems in B.C. In general, Atlantic salmon and rainbow trout are more heavily affected than chinook or coho salmon raised at the same site. Studies on *L. salmonis* have resulted in: identification and description of its developmental stages; determination of development rates at several temperatures; determination of the survival of the infectious stage under different temperature and salinity regimes. Work to determine the comparative susceptibility and histopathology of coho, chinook, and Atlantic salmon to infection with *L. salmonis* is underway; preliminary results suggest that Atlantic salmon are more susceptible than coho or chinook.

Other - a new infection, associated with mortalities of pen-reared chinook salmon was recognized. The infection is due to the plerocercoid stage of a trypanorhynch cestode (*Gilquinia squali*) that infects the eye of the salmon. The source is almost certainly the dogfish, the host of the adult cestode. The infection of chinook salmon is evidence that pen-reared chinook eat planktonic crustacea which carry the infective stage of the parasite.

Nutrition Research (DFO West Vancouver)

A study is comparing the organoleptic qualities (color, taste, texture) and chemical compositions of market-size farmed and wild Pacific salmon (collaborative study with University of British Columbia). It was found that the flesh of farmed salmon generally had increased lipid (%) and absolute amounts of $\omega 6$ fatty acids and decreased moisture content (%) than wild salmon. The absolute amounts of $\omega 3$ highly unsaturated fatty acids in the flesh of farmed salmon were found to be either equivalent or lower than in wild salmon.

An evaluation of alternative protein sources to West Coast herring meal for inclusion in chinook salmon diets in seawater has found that there is good potential to replace 75% of the herring meal (collaborative study with U.S. National Marine Fisheries Service, Seattle, and University of B.C.). A study is assessing the influence of freshness of raw herring and processing temperatures during meal production on the quality of fish meal protein (collaborative study with University of B.C.).

Research is determining the nutrient and energy availability in conventional and novel feedstuffs for chinook salmon (with University of B.C.). A modified Guelph system of fecal collection was found to be suitable for feedstuff digestibility assessment of chinook salmon in seawater. A table of digestibility coefficients for various fish meals, poultry by-product meals, other animal sources, and plant protein sources is presently under preparation. This will facilitate least cost diet formulation, formulation of diets to minimize water pollution, and nutrient requirement research. Research has been initiated on the influence of dietary protein:lipid ratio on the performance and flesh quality of chinook salmon in seawater (with Simon Fraser University).

Aquaculture Biotechnology (DFO West Vancouver)

Peptide and Protein Transport - recently completed studies have determined that oral administration of various biologically active peptides and proteins to commercially cultured teleosts is feasible. Oral delivery of recombinant somatotropin to coho salmon markedly accelerated growth compared to sham-treated controls. Similar studies with sablefish indicate that it is possible to induce ovulation in this species following oral delivery of a potent analogue of LH1RH; while experiments upon controlled administration of bioactive material, using sustained drug delivery devices, indicate that such

approaches to therapy offer realistic alternatives to the current injection and immersion procedures.

Monosex Salmon Production - the production of all female chinook enables aquaculturists to produce larger and therefore more valuable salmon without being constrained to a particular marketing window by the onset of sexual maturation and the deterioration in external appearance and flesh quality that accompanies it. The production of monosex female chinook was achieved by producing phenotypic male salmon which have a female genotype. These fish produce milt which contains only female spermatozoa. When this milt is used to fertilize normal eggs, all the offspring are female. The original work took two chinook generations to accomplish, owing to the fact that the original embryos were of mixed sex, however, now that all female stocks have been produced, the aquaculturist needs only to sex reverse all female embryos into phenotypic males at the time of hatching, following the two hour immersion technique, in order to obtain his own phenotypic male genotypic female salmon which will produce monosex female sperm. Over the last 4 years, the West Vancouver Laboratory has provided thousands of 5 mL bags of monosex milt to the industry. There are now many millions of all-female chinook being grown and marketed by the aquaculture industry.

The same approach has not yet resulted in the isolation of all female progenies in coho salmon. A significant step toward this goal has been recently achieved using an alternative technique: diploid gynogenesis. Flow cytometric and histological analysis of samples from groups of coho salmon produced by fertilization of ova with irradiated sperm followed by heat or pressure shock showed that several diploid monosex female groups had been produced. One each of two replicates were masculinized and are currently being reared. Progeny testing of these fish will be done at maturity. Similar procedures were carried out in the fall of 1989 on Atlantic salmon eggs using irradiated sperm from rainbow trout. The technique is also very promising for the generation of new genetic sources of monosex sperm from chinook salmon.

Induction of Triploidy and Reproductive Physiology of Triploids - research into chromosome manipulation of salmonids, as a means of inducing sterility, continued with studies on the induction of triploidy in steelhead trout (*O. mykiss*), coho salmon, all-female chinook salmon, and triploid hybridization of coho and chinook, and coho and sockeye salmon. Heat and pressure shocks were tested to produce large numbers of triploid coho salmon for evaluation of performance under commercial aquaculture conditions. Reproduc-

tive physiology of triploid rainbow trout (*O. mykiss*) and coho salmon was studied, and compared to that of normal diploids, through measurement of several reproductive parameters.

Salmon Genetics (DFO Nanaimo)

Quantitative genetic research on three strains of coho salmon has revealed that growth, smoltification as underyearling fish, and resistance to BKD differ among strains, and are strongly heritable within strains. Genetics correlations among the traits are low or absent. A small selective breeding program to improve growth, smoltification, and BKD resistance has been undertaken in cooperation with industry. A DNA probe isolated from chinook salmon appears to have "fingerprinting" capabilities. Further work is underway to establish the utility of the probe for identifying siblings, determining lineages, and estimating effective population sizes in cultured salmonid populations.

Genetic Engineering (DFO West Vancouver)

A research program has begun aimed at the improvement of salmonid stocks for aquaculture through the use of genetic engineering and other molecular genetic methodologies. The focus is to understand and control growth, reproduction, and disease in commercially important species. The gene encoding growth hormone from sockeye salmon (*O. nerka*) has been cloned, and a study has begun to study its structure and function in preparation for the production of transgenic salmonids containing altered forms of this gene. To aid in the analysis of natural variation at the growth hormone loci, the polymerase chain reaction (PCR) has been used to amplify coding and intronic regions from these genes. It is hoped to correlate structural variation at these genes with differences in growth performance in natural and domestic stocks. A study has begun to examine insulin-like growth factor genes (somatomedins) in Pacific salmon as an alternative approach to controlling growth.

Marine Finfish

Sablefish or Alaska blackcod (*Anoplopoma fimbria*) and Pacific halibut (*Hippoglossus stenolepis*) have been identified as good prospects for commercial mariculture on the Pacific Coast of Canada. Artificial culture of these species requires the development of

reliable techniques for maturation and spawning of adult broodstock and the incubation and rearing of larvae in captivity. Since ovulation trials started in 1985, sixty sablefish (close to 60% of treated fish) have been successfully spawned following injections, pellet implantation, or oral intubation of different LHRH analogues. In 1989, one female and three male halibut were induced to ovulate and spermiate following LHRHa injection (DFO West Vancouver).

Molluscs

In studies by DFO (Nanaimo) on molluscan diseases, bacteria (*Nocardia* sp. and *Cytophaga* sp.), the microcell protozoan (*Mikrocytos mackini*), and an Ostracoblabe-like fungus were identified as pathogens for oysters (*Crassostrea gigas* and *C. virginica*). Mortalities among larval and juvenile Japanese scallops (*Patinopecten yessoensis*) were associated with increases of bacteria (especially *Vibrio*) and were thought to signify inadequate culture conditions, rather than the presence of a specific pathogen. The etiology of the disease conditions observed in adult scallops of all species (*P. yessoensis*, *Crassedoma giganteum*, *Chlamys* spp.) and geoduck (*Panopea abrupta*) remains unknown. Mortalities among Manila clams (*Tapes philippinarum*) were attributed to freezing during low tides in early 1989.

Production (1989 estimates):

chinook salmon	09 049 t
coho salmon	02 021 t
Atlantic salmon	01 013 t
trout	00 302 t
total salmonids	12 385 t

shellfish statistics not available for 1988/89.

DENMARK

by

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Finfish production (tonnes):

	portion size trout	large trout	eel
Production 1988	22.500	5.200	235
Est. production 1989	25.000	4.500	250
Forecast 1990	22.000	5.000	>500

Trout:

Production of portion sized trout has been regulated in order to reduce pollution problems. The production is therefore not expected to increase in the coming years. As a consequence research interest has focused on development of feed products giving a lower N and P excretion.

Trout production in sea-water has suffered from a temporary ban to establish or increase production. This ban has been replaced by strict regulations, which now permits a limited increase in production. Research has, therefore, focused on evaluation of the release of nutrients and particulate matter from cages, and development of better feed products.

Eel:

There has been a significant increase in number and size of Danish eel farms. Many of the problems in the production has been reduced, and a significant increase in production is expected.

Research interest has focused on the technical optimization of recirculation systems. There has also been research on the problems relating to parasite infestations, esp. the spreading of the parasite *Anquillicola*.

Turbot:

Two commercial turbot hatcheries based on the extensive rearing technology has been established. Two on-growing plants based on waste heat and partial recirculation has also been established.

Development of production methods for turbot larvae, cultivation of copepods, and a growth model for turbot, has continued.

Restocking programme:

A restocking programme based on both fisheries and government contribution has been established with a total annual budget of approx. 10 mio. DKr. The main activities are presently restocking with Salmonids and eel, and transplantation of plaice. There will be increased activity on rearing of marine species (turbot, cod, plaice, dover sole etc.) for restocking.

Based on local initiatives, two hatcheries for turbot and cod have been established, and a larger rearing programme has started at a power plant.

As a consequence investigations on carrying in potential restocking areas will be performed.

FINLAND

by

Timo Mäkinen

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SF-00151 Helsinki

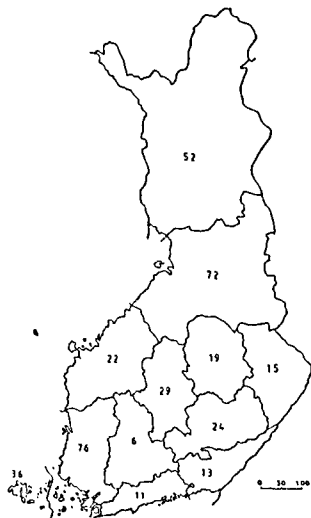
Production of Fish for Human Consumption

Rainbow trout (*Oncorhynchus mykiss*) is practically the only fish species cultured in Finland for human consumption. 99% of the aquaculture production consists of 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 and with growth rate; consequently, farming of this species is still in an experimental stage. At present only 131 tonnes (117 tonnes salmon and 14 tonnes others, mainly brown trout) of species other than rainbow trout are produced.

Farming of rainbow trout increased considerably in the 1980's, especially in cages in the sea. By 1988, marine fish farms produced 79% of all the rainbow trout raised in Finland (See Figure 1).

The amount produced in 1988 (tonnes/a) in different areas:

1. County of Lapland	1,000
2. Koillismaa-area	800
3. Kuivaniemi-area (Bothnian bay)	700
4. Selkämeri-area	1,300
5. Southern Finland	1,700
6. Southwestern Archipelago	4,800
7. County of Åland	5,100
8. Gulf of Finland	1,000



KIRJOLOHEN
RUOKAKALANTUOTANTOLAITOKSET
LÄÄNEITTÄIN VUONNA 1987

— 375 kpl (vt. RKTL 381)

(Luvut on laskettu Kalatalouden Keskusliiton
monisteesta 4/1988: Kalanviljelylaitokset 1987).

MATFISKODLINGARNA LÄNSVIS
ÅR 1987
- 375 st (inf. VFFI 381 st)



KIRJOLOHEN RUOKAKALANTUOTANTO
ALUEITTAIN VUONNA 1988, 1000 KG

MATFISKPRODUKTIONEN
OM RÅDESVIS ÅR 1988, 1000 kg

1. Lapin lääni, Lapland	1000
2. Koillismaa	800
3. Kuivaniemi	700
4. Selkämeri, Bottenhavet	1300
5. Etelä-Suomi, Södra Finland	1700
6. Saaristomeri, Skagårdsh	4800
7. Ålännsmaa, Åland	5100
8. Suomenlahti, Finska viken	1000

Figure 1. The main production areas for rainbow trout in Finland.

Table 1. Number of fish farms and production of fish for human consumption in Finland in 1980-1989 according to 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
1988	172	12,875	167	3,493	339	16,367	392,0
1989*						21,000	420,0

*estimated

Production of Fish for Stocking Natural Waters

The stockings required by law of power companies and similar compulsory stocking and state stocking have sharply increased 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 1988 a total of 5.7 million salmon, several million migratory whitefish and 3.4 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 statistics of the Finnish Game and Fisheries Research Institute, in 1980, a total of 672,000 salmon juveniles were stocked in the Baltic or in rivers flowing into the Baltic. In 1988, 5.7 million were stocked. The value of stocked salmon exceeded FIM 24 million (ca. US\$ 6 million).

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 smolts were stocked into the rivers, respectively. Extensive monitoring

programs are being run in both rivers. The sea trout stock in the Tornionjoki River is particularly threatened. In 1988, 11,200 sea trout smolts were stocked.

Research

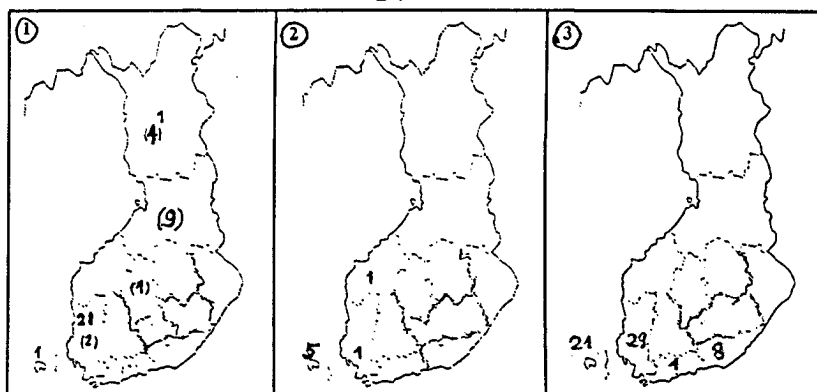
Research studies were carried out to investigate the results of stockings for sea ranching purposes. These studies included extensive tagging programmes with both Carlin- and micro-tags. Other research work included studies aimed at improving the quality of reared young fish by investigating the effect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

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

Studies on the environmental impacts of mariculture (nordic co-operation project) have been continued and finalized during the interseasonal period and reports will be available during this year in Swedish. A report in English compiling the main results of this international study will be ready for publication in 1991. Some papers from the research project concerning algae as an indicator for environmental changes caused by fish farming in brackish water have already been published and some additional papers regarding the use of model ecosystems to describe the eutrophic effect from fish farming will be published in the very near future. (see bibliography in the Literature list of interest to the Mariculture Committee, 1990).

Fish Diseases

In Finland, furunculosis (*Aeromonas salmonicida* var. *salmonicida*) was first observed in 1986 in a few marine fish farms and in one fresh water farm. In 1987, the first marine fish farm was infected with IPN and six new cases have been observed during 1988-1989. All IPN cases have been located in the southwestern area (Figure 2). To prevent the spread of the diseases, limitations on transfers of fish were set, and other preventive measures have also been taken. No signs or cases of VHS or any other major infectious fish diseases were found in Finland during the period 1986 to 1989.



Furunkuloosi Suomessa
1988—1989 vuonna 1989 uudet laitokset ja edellisen vuoden laitokset ().

IPN Suomessa vuosina
1988—1989.

Vibrioosi Suomessa 1989. Laitoksia/lääni.

Fig. 2: The number of reported cases of furunculosis (1988 numbers in parenthesis (1), and IPN (2) in 1988 and 1989 as well as known cases of vibriosis (3) in 1989 in Finland.

Outline for Statistical Information on Mariculture Production 1988:

Species	in metric Tons	Approx. number in 100,000	Value in 1,000 USD ¹
rainbow trout in net-cages (mean weight over 0.5 kg each)		12,749	70,081
Salmon smolts for stocking one-year-old and older		57,890	5,905
Other salmonids: sea trout for stocking, one-summer and older		34,290	3,906
Other: migratory whitefish for stocking, one-summer-old		?	?

Rate 1 USD = 4.0 FIM

FRANCE

by

(Jean Guillaume)

Salmonidés

Dans le domaine de la recherche

En physiologie - A l'IFREMER (Centre de Brest et en relation avec l'INRA Rennes), les thèmes principaux sont les suivants: adaptation des salmonidés au milieu - répercussions sur la croissance: mécanismes enzymatiques (ATPase) et endocriniens (prolactine, hormones thyroïdiennes, hormone de croissance). Ces expériences sont surtout conduites chez le saumon atlantique. Les techniques de transfert en mer précoce par recours aux implants hormonaux ou à l'accélération de la smoltification par manipulation de la photopériode et de la thermopériode sont également étudiées.

En nutrition - Une expérience a été conduite par l'IFREMER en vue de poursuivre l'étude des particularités nutritionnelles des diverses espèces de salmonidés utilisées en aquaculture marine; et ceci par le recours à des expériences de nutrition comparée. Dans l'étude 1989, l'accent a été mis sur le saumon atlantique. La truite fario (*Salmo trutta*) qui donne pendant la phase marine une croissance similaire à celle du saumon atlantique, a été étudiée pendant la phase eau douce: ses besoins de même que l'effet des lipides ont été cernés.

A l'INRA (Rennes) des travaux sont en cours sur l'ontogenèse des fibres musculaires (myosine) chez le saumon atlantique et l'anguille.

Dans le domaine de la production

Le fait marquant a été la mise en place sur les côtes de la Manche d'un élevage de saumon atlantique dans un navire minéralier transformé. Le nombre d'alevins mis en élevage est de 250 000 et la production attendue, à partir de ce seul stock, est de 600 tonnes.

Dans l'ensemble du pays on a constaté une certaine stagnation de la production et les statistiques globales sont les suivantes:

Production de poisson de consommation

truite arc-en-ciel(<i>Oncorhynchus mykiss</i>)	850 t
truite fario(<i>Salmo trutta</i>)	5 t
saumon atlantique(<i>Salmo salar</i>)	60 t
saumon coho(<i>Oncorhynchus kisutch</i>)	70 t

Poissons marins

Dans le domaine de la recherche - A l'IFREMER l'effort a été orienté surtout sur les larves de poisson: de nombreuses expériences ont porté sur l'environnement bactérien des proies vivantes (rotifères surtout) et des larves de turbot; l'intérêt de limiter la prolifération des bactéries pour augmenter la fiabilité des élevages dans les écloseries commerciales, soit par mesure sanitaire, soit par addition de probiotiques a été vérifié.

Des tentatives de remplacement de la nourriture vivante (rotifères et surtout artémies) ont été pour suivies, surtout sur la larve de bar (*Dicentrarchus labrax*); elles ont porté soit sur la phase larvaire (à partir du 25e jour), soit sur la phase post-larvaire.

Sur les juveniles l'intérêt des probiotiques comme stimulants de la croissance a été testé chez le bar; la valeur nutritionnelle de diverses matières premières a fait l'objet des premières études systématiques: valeur nutritive globale estimée par des essais de croissance, digestibilité des protéines et de l'énergie, etc.... Ce travail doit se poursuivre pendant plusieurs années.

Des recherches sont également en cours sur l'origine des différences d'efficacité de diverses protéines chez la larve ou le petit juvénile de bar, différences qui ne s'expliquent pas par la composition en acides aminés essentiels.

Des recherches appliquées ont également été pour suivies sur la mise au point de techniques d'élevage extensif de poissons (bars) dans des marais (anciens marais salants) de la côte atlantique.

Dans le domaine de la production - L'année 1989 a été surtout été marquée par l'entrée en production d'une seconde écloserie commerciale de turbot.

Pour l'ensemble de la France, les statistiques sont les suivantes:

Production d'alevins d'écloserie:

bar	(<i>Dicentrarchus labrax</i>)	5 770 000
daurade	(<i>Chrysophrys aurata</i>)	1 445 000
turbot	(<i>Scophthalmus maximus</i>)	0 450 000

Poissons de consommation:

bar + daurade	250 t
turbot	020 t

Crevettes pénéides

Les recherches conduites à l'IFREMER visent essentiellement la production de crevettes pénéides (espèces tropicales).

Les recherches sur les espèces susceptibles d'être produites en France métropolitaine ont été limitées à des expériences visant à fiabiliser les techniques d'élevage semi-intensives dans les marais de la côte atlantique (où les rendements peuvent atteindre 1,5 tonnes par ha en 5 mois).

La production globale de *Penaeus japonicus* a été de 20 tonnes. Presently in progress.

Shellfish

by

Maurice Héral
IFREMER

Determination of the carrying capacity for molluscs. The pilot studies in the case of Marennes-Oléron is going on. In the global model an imbalance between the cultivated biomass and the trophic capacity of the area was clearly demonstrated. This empirical model does not allow a spatial management and it mainly utilizes the hypothesis that the environmental variables are constants. For these reasons an analytical model is in creation. A numerical model transports the available food which has been injected at the limits. Advection and dispersion transports the food in different boxes where cultivated molluscs (oysters and mussels) and natural mollusc populations are present. An energetic predicts the growth rate of oysters as a function of the temperature, the quantity and quality of the available food. A model of primary production has been built with deriving variable as nutrients and

turbidity. It will be completed with the benthic model. Research now oriented towards a suspension and sedimentation model which could include resuspended biodeposits and the phytobenthos.

Determination of the impact of culture of oyster and mussel on suspension and accumulation of the organic matter on the bottom. This work is in its first phase, it began in Thau Lagoon in the mediterranean where seasonal anaerobic conditions occurred in summer. The objective is to estimate the effect of the mollusc culture on the oxygen consumption caused by respiration and by the deposit of faeces under the table since 15 years of cultivation.

GERMANY, Democratic Republic

by

(Wolfgang Jansen)

Institut für Hochseefischerei und Fischverarbeitung Rostock

During the past years marine aquaculture in the DDR has contributed only a relatively small proportion to the total aquaculture production of the country. In 1988, finfish farming in well protected brackish back waters of the DDR (called "Bodden" or "Haff") reached a total of 813 tonnes. All of these fish were produced in net cages which were particularly designed for use in these waters. The species cultured is rainbow trout. In 1989 production fell to a level of 536 tonnes, reflecting the decline in production of stocking material. The coastal fin fish farming activity can be divided into two branches, representing a recent development: pen-sized trout production (250-300g) reached 494 tonnes while larger fish were produced at more exposed sites (quasi "offshore"-farming; about 42 tonnes of 2.5 kg fish).

A special problem in the further development of coastal aquaculture in the DDR relates to the continued production of stocking material. This has been hampered in recent years due to a lack of investment to meet the rising demand of the grow-out units. In order to partly overcome this problem, stocking sized fish were taken from freshwater production, which follow a biannual supply cycle.

Research activities

Studies on improved reproduction in brackish water using rainbow trout continue. The goals center around development of adaptation strategies over generations (the programme has been initiated since

1976), changes om timing of maturation (aimed to obtain early maturing fish), sex reversal, and production of polypoids. The last two subject items are intensively studied; sofar results obtained are not consistent, although positiv test results have also been obtained. The early induction of maturation and synchronization of the timing in spawning was successful and satisfactory.

Research activities also focus on diseases of fish in marine habitats with main emphasis on bacterial diseases. Work centers on diagnostic and therapeutic studies.

A new programme has been initiated since 1986 in the Darß-Zingster Bodden-chain, which can be considered as a sea ranching programme with freshwater fish adapted to brackish conditions. About 100,000 juvenile common carp (*Cyprinus carpio*) are released annually into the Saaler Bodden. The fish are approximately 300 g in weight. This stocking size was chosen because of their capability to escape larger predators. As a first measure to promote growth and survival after stocking, fishing for carp was not permitted in 1987. As a second measure, the minimum size at catch was changed from 35 cm to 40 cm TL (1988). Thereafter, the normal fishery was opened for this fish. The results so far show that the stocking programme initiated in 1986 yielded about 60 tonnes market size fish in 1989. The fish was of high meat quality.

Several biotechnological developments have taken place over the last years. In 1989, activities concentrated around the following aspects:

- Development of effective oxygenation devices for use in small-scale hatcheries; studies on maximization of oxygen transfer when using liwuid oxygen.
- development of a new oxygen generator supplied with ambient air, particularly suited to serve in places with little access to infrastructure.

Another branch of the developing aquaculture industry along the coast of the DDR is presently engaged in trials on mussel growing. Basic studies in this field have been performed in the Mecklenburger Bucht. Several techniques commonly used in mussel farming elsewhere were tried first in these areas. Data were collected on (a) dynamics of settlement, (b) growth rates, and (c) contaminant body burden. First results obtained with adapted techniques for longline culture (similar to the french system, which has also been used in the Sowjet Union and Bulgaria) indicate that

this technology has potential under local conditions along the western Baltic coast. The experimental unit produced about 1.5 tonnes (harvest = end 1988, early 1989).

GERMANY, Federal Republic of

By

(Harald Rosenthal)
Institut für Meereskunde
Universität Kiel

Introduction

In the Federal Republic of Germany marine aquaculture is limited to a few coastal enterprises along the coasts of Schleswig-Holstein and Lower Saxony. These include eel farming in heated effluents from a coastal power station using brackish water, rainbow trout grow-out in net cages in the Kiel fjord, partly utilizing the heated effluent plume of the local power station, a turbot hatchery and a pilot-scale turbot ongrowing unit with an intended annual production of market size fish of about 10 tonnes, and extensive mussel farming on licenced plots in several parts of the German Wadden Sea.

Commercial production

Although official statistics on marine fish and shellfish farming are not available for 1989, a few estimates can be made based on information provided by individual farmers. Total amount of rainbow trout produced in net cages in seawater was about 18 tonnes in 1988 and 20 tonnes in 1989.

A total of about 30,000 juvenile turbot were produced from about 200,000 feeding larvae. Most of these fish were exported to Spain for stocking. Near the hatchery at Kiel a pilot-scale grow-out facility has been installed in 1988 and started its operation in 1989. The anticipated annual production will reach between 8 and 10 tonnes of market size turbot. The purpose of this pilot-scale unit is to provide empirical data for an realistic evaluation of operational costs of commercial grow-out units under given local conditions.

Mussel farming

Mussel production in 1989 was less than in previous years and this had various reasons. About 18,556 tonnes were landed, representing a value of about 8,243, 000 Marks. One reason for the low production figure was the high yields in The Netherlands.

Pacific oyster production. Two oyster farmers have expanded their production along the Schleswig-Holstein North Sea coast. Sales have doubled annually and numbers produced have well surpassed the 1 million mark in 1989 with about 85 tonnes of landed weight. Local production now ranks third in the German oyster market compared with imports from France and The Netherlands. The German oyster aquaculture is based on imported seed which ranges from a few grams in size to almost market size according to import statistics.

Ongoing Research Activities

Institut für Meereskunde Kiel (Department of Fisheries Biology)

Research activities centered around metabolic and physiological investigations related to larval rearing of turbot. Studies were performed to analyse the protein and amino acid composition of feed and feed organisms and the transformation of proteins into body tissue of early feeding larvae. The study describes the trend in total amino acid content in starved and fed larvae and in ongrowing larvae over a period of about 1 month.

Further studies focussed on behavioural aspects of larval and juvenile turbot in relation to various operational conditions in circular tank systems designed for mass rearing. The investigation included observations on distribution of fish larvae and their life food items in circular fish tanks under different light and feeding regimes.

Within the German-Canadian Cooperation programme tests were performed with the global Kiel cage to study its performance under conditions prevailing along the coast of eastern Canada. Under the same agreement, cooperative research work on the behaviour of sturgeons in circular tank systems were carried out, identifying rhythmic phenomena under various culture conditions.

A joint project with the Dunstaffnage laboratory is underway to study the effects of gas ebullition under cages by simulating various

stages of hydrogensulfite exposure in laboratory tanks. The study has started during the spring of 1990.

Another programme on the environmental impact of cage farming is presently underway in cooperation with the Israel National Center for Mariculture, Eilat. The study focus on sea bass cage farming in the Gulf of Aqaba. Nutrient fluxes as well as the effects of suspended solids on the sediment and benthic macrofauna are being investigated. Measurements under the cages and on transects show a strong gradient of organic enrichment and provide some insight of the fate of the exported material under tropical conditions and a hydrographic regime quite different from the tidally controlled northern European coastal sites suitable for mariculture.

Biologische Anstalt Helgoland (Department of Experimental Ecology)

At this institute the following investigations were undertaken:

- studies on feed conversion and excretion in juvenile turbot
- studies on behaviour of *Macrobrachium rosenbergii* larvae and postlarvae, their adaptation from sea to freshwater, and methods to reduce cannibalisms
- mass rearing of larval *Macrobrachium rosenbergii* at high densities in stagnant seawater tanks
- growth and feed conversion efficiency of juvenile mullets (*Mugil cephalus*, *Liza ramada*, *Liza brasiliensis*) in highly intensive recirculation systems
- biofilter performance in brackish water systems, and
- studies on the use of ion exchangers for nitrate removal in brackishwater recirculation systems.

THE NETHERLANDS

By

Renger Dijkema
(Netherlands Institute for Fishery Research)

Production figures:

African catfish (fresh water)	600 t
Eels: <i>Anguilla anguilla</i> : (Fresh water):	200 t
Rainbow trout:	015 t

Eel culture

During two experiments start-feeding of glass-eels was studied, comparing five commercial starter-feeds. The difference in specific growth rate between the best and the worst group was 1.3 % per day maximally and was mainly caused by differences in sensoric attractivity of the feeds. Additional feeding with cod roe as well as longer feeding cod roe before changing to dry feed can positively influence growth in glass-eel.

Adult eels were tagged with a "bar-code" on the skin which lasted at least for four months. On semi-commercial scale, the effect of grading on growth and variation in growth of eels were studied. In another experiment the effect was studied of stocking density on growth and variation in growth. In this stage, neither grading nor stocking density appeared to have any significant effect on growth and growth differences.

A series of measurements were performed of water composition in commercial eel farms. The obtained data made estimates possible of the rate of production of solid and dissolved waste products by eels in recirculation systems. Notably the removal of particles smaller than 80 micron appeared to form an obstacle in water treatment of the systems/farms. The systems studied showed that nitrite rather than ammonia is a limiting factor for production. In general, the recirculation flow appeared to be too low to guarantee the design-capacity of the plants. In the framework of this program, a research project was started in cooperation with the Institute for Agronomic Economics and two Danish research institutions, partially subsidized by the European Community. Aim of this project is to evaluate biological, technical and economical characteristics of commercial

projects, subsidized by the FEOGA of the EC . A questionnaire was designed and distributed and visits were made to commercial plants. The results will be worked out in 1990.

Turbot cultivation in recirculation systems

Orientating experiments were performed into the development of recirculation system for the cultivation of turbot. This is necessary, because in the Netherlands the sea-water temperature regime does not permit cultivation of turbot in unheated water. A maximal growth rate of 2.7% per day and a feed conversion rate of 0.86 was reached for juvenile turbot, using regular pelletized eel feed. A comparison was made between growth results in recirculation and a flow-through system. Although no differences in water quality between the two systems could be measured, growth performance in recirculation water appeared to be significantly lower than in the flow-through system. An extensive experiment into the effect of food composition in growth and feed conversion showed that a higher protein level in the food can lead to considerable improvements compared with the food previously used .

NORWAY

by

(Snorre Tilseth, Bergen)

The report summarizes the mariculture research activities contributed by the main aquaculture research institutions in Norway.

INSTITUTE OF MARINE RESEARCH (BERGEN)

Atlantic Salmon

Genetics

Genetic variation in growth rate of Atlantic salmon (*Salmo salar*) was observed by using trypsin-like isozyme patterns of the pyloric caeca as an indirect trait. With the use of biopsy-technique and isoelectric focusing on agarose gel, the fish were individually biologically marked with the isozyme pattern. The fish possess the isozyme variante TRP-2(92) had significantly higher growth than the group without the variant. The growth was followed from smolt

until maturation in the second sea-year. The specific growth rate of the variant group was found to be significantly higher in the first sea-year during winter while the temperature was low. The fish with the variant TRP-2(92) may have better digestion and utilization of feed protein at low temperature. If the fish are selected bysed on the isozyme pattern, higher production of at least 30% of food could be possible at the slaughtering time during the second sea-year.

Physiology

Atlantic salmon pre-smolt was exposed to different oxygen levels, water exchange rates and fish densities for 7 months. Survival, growth, hematology, behaviour and smoltification was followed. Growth and survival os smolts from different freshwater quality regimes were thereafter followed for 6 months in sea water.

The effect of photoperiod and temperature regime on seawater performance in 0+ and 1+ smolts were studied. The effect of photoperiod on incidence of grilse and on time of ovulation has been studied.

Growth rate studies of salmon post-smolts in closed cages have also been performed. To obtain different temperature regimes during the winter the cages were supplied with water from sources about 25 m (warm) and 5 m (cold) water depth. The effect of different winter temperatures on maturation had been examined.

Nutrition

Atlantic salmon has been fed 9 diets supplemented with different-concentrations of astaxanthin. The concentration of astaxanthin has been measured in different tissues by analytical methods and the color of the flesh by colorimetric measurements.

The biological function of astaxanthin is studied in all stages of Atlantic salmon. Eggs without carotenoids have been produced by feeding salmon a diet without astaxanthin.

Maturation

Early detection and manipulation of sexual maturation in Atlantic salmon have been regarded as important topics for research. In

1989, a three year early detection project has been completed. A method to non-invasively determination of sex and gonad size employing ultrasonography has been developed. Gonad diameter can be estimated; the correlation coefficient between ultrasonography and ruler derived measurements were 0.926 for female and 0.754 for males.

Arctic charr

Genetics

Genetic difference in trypsin-like isozyme pattern of two strains, an anadromous and a non-anadromous strains, of Arctic char (*Salvelinus alpinus*) was observed. The anadromous fast growing strain has the isozyme pattern similar to the fast growing group of Atlantic salmon which possess the trypsin-like isozyme TRP-2(92) allele, an allele which does not exist in the non-anadromous strain.

Juvenile studies

The impact of different light regimes on growth rate was studied on three different Arctic charr strains.

Physiology

Studies on smoltification related to light regimes and growth rates has been carried out on three different Arctic charr strains.

Brackish water survival and growth rate studies has been carried out on five Arctic charr strains.

Nutrition

Deposition of carotenoids related to growth rate has been studied in three Arctic charr strains.

Marine species

Atlantic cod

A successful development of a spawning enclosure for cod has been carried out. During a three week period of 831 L good quality egg were produced with two pens, giving a mean daily egg production per kg female of 0.0326 L and 0.0367 L. In the im-

proved system, the egg collector is located outside the pen and a 160 mm flexible hose drains the pen 30 cm below the water surface. All water flowing through the pen is forced to pass through the egg collector.

Nutrition

Several startfeeding experiments have been conducted on halibut larvae. Different cultured live prey organisms (*Artemia*, *Brachionus*, *Tisbe*) have been tested together with different enrichments of the live prey. In addition to the cultured live prey, zooplankton collected from highly productive lagoons has been used as start feeding diets with air success. A study has also been carried out to evaluate the possibility to culture local species of copepods and cladocerans for the purpose of start-feeding marine fish larvae.

Some startfeeding experiments have also been conducted on turbot in semi-extensive systems. Natural zooplankton has been offered to larvae in large submerged bags. These experiments have been carried out in order to transfer know-how to commercial producers.

An experiment on on-growing of cod has been conducted in 1989. In this experiment one studies the relationship between feeding regime, the realized growth potential, slaughter weight and maturation among individually tagged and intensively cultured cod.

Behaviour

Several behavioural studies have been conducted on larvae of cod, turbot, halibut and plaice. The studies have mapped their responses to light, stress (turbulence) and prey organisms.

Technology

Several halibut projects have been engaged in the development of relevant technology for the incubation of yolk sac larvae of halibut. The problems of keeping the larvae through the yolk sac stage, have to a large extent been solved.

Invertebrates

The development rate of the eggs of *Sclerocrangon boreas* were investigated in a temperature experiment. Preliminary results indicate a depressed development for embryos exposed to relatively

high temperatures. *Scloreocrangon boreas* embryos hatch as a benthic juvenile quite similar to the noble crayfish. This arctic crangonid are easy to startfeed, show no cannibalistic behavior if decently fed, grow to an economically interesting adult size and are therefore judged as a possible candidate for crustacean culture in ambient temperatures in Norway.

Nutrition

Studies have been conducted to verify the possibility to utilize fertilized ponds and lagoons for ongrowing of the scallop *Pecten maximus*.

Behaviour

In order to study the possible effects of releasing juvenile lobsters, observations have been made on the behaviour of lobster after time of release. Different manipulations have also been made prior to time of release.

Environmental impact from mariculture

The research activity has been concentrated on interactions between environment and health and on environmental effects of antibiotics in fish feed.

In 1989 a project investigating the influence of heritage and environmental conditions on fish growth and health has been terminated. The experiment was carried out in commercial fish farms making a gradient with regard to water exchange. For two years individuals belonging to different family groups of salmon (marked by fin-clipping and cold branding) were placed at same farms. At regular intervals environmental parameters and fish growth was recorded. Pathological changes were detected and the frequency varied with fish farm and time.

The results shows distinct differences with regard to environmental conditions and fish growth between the fish farms. However, there are no clear connection between environment and growth, and management seems to be the most important factor controlling growth. Of special interest is the observation that at each fish farm some superior families did not perform equally well at the other farms. This might suggest that some families are specially adapted for certain environmental conditions.

The environmental effects of antibiotics is being investigated in a joint project between the University of Bergen and the Institut of Marine Research. In this integrated project the duration of the antibiotics in the sediment is measured, the antibiotics' influence on the bacterial flora and the effects of changed microbiological community on the remineralisation of organic material.

The results so far shows that oxytetracycline and oxolinic acid remains long in the sediments, while furazolidone disappear quickly. Sediment with the first two drugs showed antimicrobial activity, which is not found in sediment treated with furazolidone. All sediments treated with antibiotics showed a small reduction in bacteria numbers. Measurements of sulfat reduction shows that the activity is twice as high in unexposed sediments compared with sediment exposed with antibiotics.

Disease

Infectious Pancreatic Necrosis Virus has been isolated from moribound, farmed Norwegian turbot (*Scophthalmus maximus*) and halibut (*Hippoglossus hippoglossus*) fry. All isolates are serotyped N1. Histological examinations revealed pancreatic necrosis indicating that IPNV was the probable causative agent of the mortalities. In 1988 IPNV (N1) was isolated from moribund Norwegian scallops (*Pecten maximus*). IPNV might become a growing problem in the farming of marine fish species and it is possible that serotype N1 is particularly adapted to the marine environment.

Infectious Anemia of Salmon (IAS) is spreading and has been responsible for great losses in Norwegian fish farming 1989. The disease can be transmitted by injection of erythrocytes from diseased fish. IAS is primarily affecting Atlantic salmon (*Salmo salar*) and other salmonids like the Arctic char (*Salvelinus alpinus*) appears to be far more resistant.

Vaccination of fish has become an important part of the fish health management. However, new species will require new vaccines and new vaccination strategies. Characterization of isolates from cod (*Gadus morhua*) and turbot has made it possible to produce pilot vaccines. The results of laboratory testing are promising. Arctic char is highly susceptible to vibriosis and the gross-pathology is similar to vibriosis in rainbow trout. Through vaccination this species develops a high resistance against vibriosis.

The Norwegian shellfish industry is now in the process of increasing the export. This will require more knowledge about the health status of the Norwegian shellfish population. A shellfish screening program including virology and parasitology have been started.

Parasites

Experiments on alternative treatment against salmon lice have developed a new administrative principle for fat-soluble chemotherapeutics. A natural compound pyrethrum, extracted from ground flower (*Chrysanthemum cinerariaefolium*), approved in the food industry, produced in a developing country, has been found to be promising and effective when added to cage surface in a thin layer with synergist and antioxidant. The tests carried out indicate that this method is far more effective and to be preferred compared to the synthetic nerve poisons that are used today.

INSTITUTE OF NUTRITION, DIRECTORATE OF FISHERIES (BERGEN)

Salmonid Nutrition

Nutrition and protein metabolism in fish. The aim of the project is to estimate the amino acid and protein requirement in Atlantic salmon, and to study the amino acid metabolism in fish fed different diets, different feeding regimes and at different swimming activity.

An experiment was carried out to study whether the degree of fish silage hydrolysis affected growth of Atlantic salmon. Atlantic salmon weighing about 300 g were fed diets with 20% of the total protein from fish silage with different degrees of hydrolysis. The rest of the protein source was fish meal. The fish silages, 5 in all, had been stored for different periods and were used as moist feed. The growth experiment lasted for 2.5 months.

Studies have been carried out to evaluate the bioactivity of derivatives of ascorbic acid as vitamin C sources for Atlantic salmon. The compounds tested were ascorbate-2-sulfate, ascorbate-2-monophosphate and ascorbate polyphosphate. These results will be published in 1990.

A large scale feeding experiment have been running since March 1988, feeding Atlantic salmon different levels of dietary (n-3) highly unsaturated fatty acids and vitamin E. Growth, lipid

metabolism as well as fish health have been investigated during 1989. Parts of the results will be published in 1990.

We are running a project with the aim of finding the dietary requirements of trace elements in Atlantic salmon. We are also studying interactions between trace elements and other dietary factors.

Zinc requirement in young salmon

A three months experiment was performed with young salmon (start weight 40g) to find the zinc requirements. Important test parameters were growth, zinc concentration in liver, vertebrae and kidneys as well as serum alkaline phosphatase activity.

Iron requirement in young salmon

A three months experiment was also performed with young salmon (start weight 30 g) to find the dietary iron requirements. Important test parameters were growth, hematological values and iron concentration in liver, head kidney, kidney and vertebrae.

Influence of different dietary lipids and vitamin E levels on trace elements status. The influence of three different dietary lipid sources and two different dietary vitamin E levels on trace element status was investigated.

Marine species

Protein sources in feed to Atlantic cod. The aim of the studies is to find and evaluate other protein sources than fish meal to be used in commercial feeds to cod, and to estimate the first limiting amino acid in such protein sources.

Growth in Atlantic cod. The aim of the study is to establish growth data and to collect data on the energy flow and organ growth in cod fed natural diets and feed organisms, and at different temperatures. The data are intended to support cod growth models for use in sea ranching studies.

The utilization of carbohydrates by cod:

Cod given four experimental diets varying in carbohydrate and fat energy composition has been run. In this experiment hormonal regulation of carbohydrate metabolism has been investigated together with weight gain and feed utilization.

Purified diets, cod:

So far a problem of running requirement studies on n-6 and n-3 fatty acids has been limited by a lack of good fat-free protein sources. An experiment comparing 5 types of "new" fat-free protein sources has been run with good results.

The effect of n-3 fatty acids in feed to cod:

Three diets with increasing levels of n-3 fatty acids were fed to cod from 30 g until fertilization. The aim of this trial was to investigate the incorporation of long chain fatty acid into membranes of different organs, and the effect on fertilization and egg-quality.

Feeding experiments with different levels and derivatives and ascorbic acid for marine species as cod (*Gadus morhua*) and plaice (*Pleuronectes platessa* L.) have been performed.

Halibut:

In cooperation with Institute of Marine Research two feeding experiments with halibut have been carried out. Experiment 1 was related to the surrounding temperature and experiment 2 was related to diet composition.

Eel:

This was a comparison of fat and glycogen levels in liver and muscle of wild and two size of cultured eel.

UNIVERSITY OF BERGEN, INSTITUT OF FISHERIES BIOLOGY

Salmonids

The studies of photoperiod and temperature effects on growth and smoltification in Atlantic salmon have resulted in improved methods for rearing of salmonids in freshwater, as well as better understanding of the mechanisms governing the smolting process.

Experiments have documented that Atlantic salmon also has a large potential for the production of under-yearling smolts.

Photoperiod manipulation of broodfish of Atlantic salmon has resulted in significant alteration of the time of ovulation. Photoperiod treatment during the spring and autumn may advance or delay ovulation time as well as the proportion of maturing fish. Additional light on sea cages holds promise as an effective way of improving growth and affecting the maturation of Atlantic salmon.

Marine species

Halibut

The early life stages of halibut have been studied for the effects of temperature on development and growth, biochemistry and the accompanying bacteria (in cooperation with the Institute of Marine Research).

Cod

Studies on extensive rearing of cod in seawater enclosures with emphasis on growth, mortality factors including cannibalism and predation by jellyfish have been carried out.

Environmental impact

Marine Salmon Farms

Six fish farms and a control station have been studied on a seasonal basis for over a year and analysed for nutrient salts, oxygen flux, sedimentation rates and the spread and impact of the waste food (in cooperation with the Institute of Marine Research).

NORWEGIAN HERRING OIL AND MEAL INDUSTRY RESEARCH INSTITUTE (SSF)(BERGEN)

SSF does continuous research on optimizing fish feed related to 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 salmonids.

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

Comparative experiments with pellets and extruded fish feed. The effect of extrusion of 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 Floedevigen 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.

THE UNIVERSITY OF TROMSØE

Salmonids

Nutritional energetics of salmonids

Studies are concerned with the investigation of food consumption and energy partitioning both at the individual and population level, with the aim of optimizing growth and production.

- feeding behaviour and food intake of Arctic charr and Atlantic salmon
- influence of exercise training and food intake, metabolism and growth
- manipulation of feeding regimes and influences upon growth.

Ecology of Arctic charr is studied with the aims of investigating the fishery potential of natural population and with special reference to the problem of stunted growth. Aspects include population structure, growth, food consumption, zooplankton selection and parasitology.

Marine species

Cod enhancement

The project involves production of cod juveniles for release. The broodstock was caught from a local fjord population, and spawn in a spawning tank at temperatures from 1.5-5°C. Yolk sac larvae are hatched in a hatchery. The enclosure method for juvenile production is used, and factors affecting the production potential of the enclosure are studied. This involves:

- effect of abiotic factors on larval mortality
- production of zooplankton
- feeding ecology of cod larvae
- weaning from zooplankton to dry feed.

Methods for feed-marking of juveniles are investigated, and factors affecting mortality and catch yield of released juvenile sand carrying capacity of the fjords are investigated.

Cod

Pilot field trials are conducted in order to investigate the effects of different dietary formulations and feeding regimes on growth and patterns of energy disposition in cod.

Wolffish

The reproductive cycle, egg and larval ecology are studied in north Norwegian waters. Studies of embryonic and larval development from naturally spawned egg-batches have been initiated. Organogenesis and bacteriological investigations of eggs and larvae are included. In cooperation with others a broodstock of wolffish is established.

Egg quality

The aim of the project is to develop objective criteria for 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.

Larval fish

Several studies are concerned with the investigation of the morphological development of fish larvae. Both light and electron microscopy is used to elucidate the functional digestive development of these larvae. Effects of starvation and various feeding conditions are studied, as well as digestive patterns in the larval gut of larvae fed live and artificial start-feed. Ultrastructural immuno-cytochemical techniques are developed for morphological identification and localization of digestive enzymes.

Halibut

Aspects include field studies of the planktonic egg and larval stages, egg development and spawning season. Growth, feeding rhythms, food intake and digestion, and oxygen consumption is investigated for immature halibut in captivity.

Cod

Survival, growth, and behaviour of cod larvae feeding on phytoplankton, and copepod nauplii is studied in intensive systems.

Zooplankton

Production of selected zooplankton species as first feed for fish-larvae. Continuous culture of a 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.

Shrimp

The potential of cultivating the shrimp *Sclerocrangon boreas* was investigated. The distribution of the shrimp *Sclerocrangon boreas* is circumpolar, and it inhabits regions of cold water. The study concentrated on larval survival, growth and moulting, suitable feed and on general behaviour of the species, its biology and ecology.

Diseases (Parasites)

The expanding commercial fish cage culture may affect the distribution of aquatic parasites in wild host populations, both in a broader zoogeographical scale, and locally near a single fish farm. One aim of the project is to record the abundance of model parasite species in wild host populations close to the farms, and in farmed fish. The hypothesis that fish farms may function as focal points for the life cycle of parasites is also investigated.

TROMSOE MUSEUM

Marine species

Field studies of Atlantic halibut, with special emphasis on parameters of relevance to domestication, including:

- migration and stock identity
- reproduction (sexual maturity, gonadal development, spawning)
- planktonic stages
- growth (in nature and captivity)
- proximate composition of tissues and egg
- general life history traits
- ectoparasites.

Blooming of ectoparasites on halibut in captivity and experiments with potential treatments.

Studies of food intake and turnover and oxygen consumption of immature Atlantic halibut in captivity.

FOUNDATION OF APPLIED RESEARCH AT THE UNIVERSITY OF TROMSOE(FORUT)

Diseases

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.

Marine species

Digestion and feeding of marine fish larvae

- studies of digestive enzymes in fish larvae
- development of assay techniques for monitoring of digestive capacity of marine larvae
- development of formulated dry feed for marine larvae.

INSTITUTE OF FISHERY TECHNOLOGY RESEARCH (TROMSOE)

The following aquaculture research projects were carried out in-1989:

Salmonids

Ecophysiology of Arctic charr (*Salvelinus alpinus*). Physiological aspects of different life history strategies are studied with the aim of optimizing production in fish farming. Aspects include environmental influences on seawater tolerance, growth and food intake in different salinities and factors leading to maturation.

Marine species

Reproductive behaviour and physiology of the spotted wolffish (*Anarhichas minor*) and the striped wolffish (*Anarhichas lupus*). The aim of the project is to monitor and describe the reproductive behaviour of the species. Further, to estimate the antibacterial effect from wolffish mucus during the period of brood protection. Finally, to monitor sex steroids during sexual maturation.

Marine lectins

- Structure and function of lectin from marine invertebrates (shellfish)
- Role of lectins in invertebrate defense.

Diseases

Microbial ecology and fish farming

- Lectins in adhesion of bacteria to mucous surfaces of fish
 - The indigenous microflora on farmed and wild captured marine fish
 - fish diet and gut microflora
 - Typical characteristics of the indigenous microflora of farmed versus wild fish
- Lactic acid bacteria from fish intestine - use as probiotics.

INSTITUTE OF FISHERY TECHNOLOGY RESEARCH (BERGEN)

Aquaculture research is related to:

Effect of feeding regime (no. of meals, intensity, starvation periods) on behaviour, growth, food intake, feed conversion and nutritional status of adult salmon in sea cages.

Development of methods to automatically feed salmon in sea cages in accordance with their fluctuating appetite based on change in vertical distribution of the population during feeding or hydro-acoustic detection of food waste.

Behaviour of adult salmon escaped from sea cages with consideration to methods of recapture.

Individual behaviour of salmon in sea cages.

Sea lice infection is a major problem in intensive cage culture of Atlantic salmon, and the current chemical treatment has several negative aspects. Promising results from full scale trials indicate that two or three different wrass species might be used as cleaner fish for effective parasite control in commercial salmon farming.

FOUNDATION FOR SCIENTIFIC AND INDUSTRIAL RESEARCH AT THE-NORWEGIAN INSTITUTE OF TECHNOLOGY (SINTEF) TRONDHEIM

The aquaculture research at the SINTEF-Group is mainly related to technology and industrial processes within the following topics:

Intensive fish farming, flatfish

- Time of spawning. Egg quality.
- Initial feeding of larvae. Live feed.

Feed

- Nutritional value. Contamination.
- Feed production quality.

Chemical/physical environment in fish farming units (Facilities)

- Current environment, water exchange.
- Water quality, water treatment.
- Regulation of water temperature.

Structural strength of sea cages

- Model tests.
- Calculation programmes.
- Anchoring.

New concepts in fish farming

- Closed plants
- Ocean cages
- Extensive fish farming.

Development of instruments

- Biomass registration
- Fish telemetry
- Computerized monitoring and control.

INSTITUTE OF AQUACULTURE RESEARCH (AKVAFORSK)

The research activities within AKVAFORSK is relected to nutrition, breeding and preventive health problems. The present notes give a short review of the most important issues covered.

Salmonids

Nutrition

Feeding dependent factors on product quality:

- Flesh colour
- Fat content
- Fat quality.

Balancing feed composition and feeding techniques.

Feeding techniques and waste production.

Use of vegetable feedstuff in the diet.

Breeding

Evaluation of breeding values of potential parent of next generation of fish for the breeding system of Norway.

Analysis of slaughter quality as a trait included in the selection criteria in the breeding program.

Immune response, methodology and inheritance.

Genetic resistance.

Evaluation of breeding program for tilapia applied on Philippines.

Study on breeding in sea ranching.

Marine species (Halibut)

Nutrition

Evaluation of start-feeding system.

Feeding ration for growth.

Reproduction

Artificial fertilization and handling of eggs until start-feeding period.

Extension of reproduction season by using light.

Diseases

Interaction between heart-disease and different nutrients in the diet.

Interaction between cell membrane integrity in poikilotherms and fatty acid composition of the diet and physical exercise of the fish.

Pharmacokinety of antibacterial agent in salmonids.

Reduced amount of antibiotics due to optimization of dosage regimes.

On an individual basis, 8000 1+ cod were monitored through a feeding experiment, providing two different feed types and two different feeding regimes to the fish. Fish are interchanged between

treatments. The experiment carries on to 1991, giving a total of 22 different treated fish groups. Individual growth rate were monitored in 1989, in addition to indirect determination of sex, and gonad and liver weight measurements based on ultrasonography.

POLAND

by

(J. Wiktor and Krzysztof Goryczko)

Inland Fisheries Institute
Salmonid Research Laboratory
Rutki, 83-330 Zukowo Poland

The mariculture of salmon (*Salmo salar*) in cages has been continued during 1989 and aim was to obtain the eggs for further production of the stocking material. The fish were reared from smolts and after obtaining the proper maturity they spawned twice/in 1988 and 1989/. The quality and number of eggs were satisfactory. The mariculture is being continued at present. Some of cages were stocked with fish representing the next year-class. The reintroduction of artificially reared young fish to the rivers in which the natural stocks of salmon have disappeared, is planned for the nearest future.

Report on the fish genetics research in Poland for the year 1989.

1. The family selection based on 5 strains of spring spawning rainbow trout has been continued (second year). About 5000 fish was tagged and placed in two farms. The current data on growth and mortality are analyzed.

This programme is realized by Inland Fisheries Institute Salmonid Research Laboratory Rutki 83-330 Zukowo, Academy of Agriculture - Department of Applied Animal Genetics 05-840 Brwinow and Inland Fisheries Institute - Berlin Friedrichshagen 1162 GDR.

2. Sex control in rainbow trout.

Six hundred functional phenotypic males of xx genotype (gynogenomes treated with Mt) were distributed to several fish farms to enable the whole female market fish production. This

programme is realized by JFI Salmonid Research Laboratory Rutki and Academy of Agriculture - Department of Ichthyobiology and Fisheries 30-149 Krakow.

3. Polyploidization

3.1. The experimental part of programme aimed at evaluation of practical value of "normal", whole female and sterile (triploidized females) rainbow trout terminated in November. Results are being analyzed.

3.2. The programme of interspecific hybridization among brook, sea, rainbow trout and salmon with and without polyploidization (diploids, triploids and tetraploids) is being realized. The survival, growth rate, kariology and enzyme markers of hybrids are analyzed. These programmes are realized by J.F. I. Salmonid Research Laboratory Rutki, Academy of Agriculture - Department of Applied Animal Genetics 05-840 Brwinow and Academy of Agriculture and Technology - Department of Basic Fishery Research 10-957 Olsztyn.

4. Gynogenesis

The simple and practical method for inducing gynogenesis in rainbow trout has been elaborated in salmonid Research Laboratory in Rutki in cooperation with Academy of Agriculture Institut of Ichthyology 71-550 Szczecin and Finnish Game and Fisheries Research Institute - Aquaculture Division SF-001151 Helsinki.

5. Coregoniae stock identification

5.1. Six spawning populations of whitefish from Mazurian Lakes were analyzed (morphology and enzymes) as well as "reference" lines of *Coregonus Lavaretus* and *Coregonus peled*, to assess the degree of its hybridization.

5.2 The genetic analysis (morphology and enzyme markers) of two stocks of *Coregonus lavaretus* and four stocks of *Coregonus albula* were realized to compare its with related taxons.

This programme was realized by the Academy of Agriculture and Technology, Department of Basic Fishery Sciences 10-957 Olsztyn.

The research no.1 and 2 were realized with support of UNDP/FAO and Polish Government progrmaee No Pol. 86/004/A/01/12.

PORTUGAL

by

(Jaime Menezes and Francisco Ruano)

This report summarizes the research activities concerning mariculture in Portugal. The contributions of different institutions will be presented separately, however, several others contacted have not replied to our request.

The following institutions have responded and have been included in this report:

1. INIP (National Fisheries Research Institute)
 - 1.1. Aquaculture Department
 - 1.2. CRIPAlgarve (Algarve Regional Research Center)
2. Instituto de Zoologia "Dr. Augusto Nobre" - Faculty of Science of Porto
3. Centro de Parasitologia - Faculty of Veterinary Medicine

1. INIP

- 1.1. Aquaculture Department

- a) Finfish:

Being sea bass, *Dicentrarchus labrax*, gilthead sea bream, *Sparus aurata* and sole, *Solea senegalensis* and *S. vulgaris*, the target species, research was carried out through laboratory and field works. Studies on physiology of reproduction were continued, fish behaviour and improvement of juvenile survival rates.

Field work included sole monoculture in semi-intensive systems using different food and feeding techniques.

Fish diseases survey was pursued in wild fish and in fish farming.

b) Shellfish:

Penaeus japonicus adaptation in controlled conditions to achieve continuous spawning and post larvae production. Cooperation with fish farmers was intensified for extensive and semi-intensive culture.

Molluscs: Field adaptation and survival rate studies of Portuguese oyster, *Crassostrea angulata*. Oyster seed artificial production. Improvement of oyster quality and growth rate collected from natural beds.

A continuous health survey was carried out to establish the epizootology and diseases control.

Sea scallop, *Pecten maximus*, culture by long-line system was settled by a private enterprise funded on EEC/FEAGA and Portuguese Administration. This attempt was followed by INIP since the introduction of seed.

c) Plankton:

The study of local *Artemia* species, rotifers and *Artemia* mass production fed by different diets in different environmental conditions.

Microalgae mass production on the basis of organic effluents from pig raising industry and breweries.

1.2. CRIPAlgarve

a) Finfish:

Research concerning massive juvenile production of sea bream and sea bass, field adaptation and extensive and semi-intensive culture.

b) Shellfish:

Reproduction, condition index determination and field adaptation of Portuguese oyster and clam, *Ruditapes decussatus*.

2. Instituto de Zoologia "Dr. Augusto Nobre"

a) Finfish:

Settlement of an experimental hatchery

- b) Shellfish:
Studies on the eco-physiology of clam, *Tapes decussatus*, fed by several algal associations.
- c) Plankton:
Growth study of rotifer, *Brachionus plicatilis*, and *Artemia* sp.-fed different diets. Concerning *Artemia* mass cyst production.

3. Centro de Parasitologia

It was pursued the identification of marine fish parasites and parasitosis.

SPAIN

by

(J. Iglesias)

This report gives a summarized overview on the research activities concerning mariculture in Spain. Some research institutions are not presented because they have not replied to the request of information, but those will be included in the next year report.

The institutions that are included in this annual report of activities can be grouped in four main organizations:

- a. Instituto Espanol de Oceanografía (I.E.O.). Ministry of Agriculture and Fisheries.
- b. Consejo Superior de Investigaciones Científicas (C.S.I.C.). Ministry of Science and Education.
- c. Universities.
- d. Local research centers from autonomic governments.

1. INSTITUTO ESPANOL DE OCEANOGRAFIA (I.E.O.)

Centro Oceanográfico de Santander

- Hatchery and ongrowing techniques on turbot (*Scophthalmus maximus*) and *Pagellus bogaraveo*.

- Biological research and production (indoor and outdoor) of macroalgae: *Gelidium sesquipedale*, *Gracilaria verrucosa* and *Gracilaria folifera*.
- Tele-detection systems for drift seaweeds.

Centro Oceanográfico de La Coruna

- Nutritional studies in bivalve Molluscs. Dosing of live and artificial diets for *Ostrea edulis*, *Venerupis decussata* and *V. semidecussata*.
- Biochemical composition of Ciroficea, Diatomea and Dinoflagellates
- Studies on "Red Tides" and their effects on mussel culture in the Gallician areas.
- Incubation and larval development of *Necora puber*.

Centro Oceanográfico de Vigo

- Hatchery research on turbot (*Scophthalmus maximus*): The effect of light and temperature on reproduction, enrichment larval diets, oxygen consumption and ongrowing in sea cages.
- Studies on "Red Tides" and their effects on mussel culture.
- Parasitism in mussel (*Mytilus edulis*).

Centro Oceanográfico del Mar Menor

- Hatchery and ongrowing of Sea bass (*Dicentrarchus labrax*) and Sea bream (*Sparus aurata*).
- Natural stock assessment on *Ostrea edulis* in Mar Menor (Murcia).

Centro Oceanográfico de Tenerife

- Hatchery and ongrowing of Sea bream (*Sparus aurata*)

2. CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS (C.S.I.C.)

Instituto de Acuicultura de Torre de la Sal. Castellón

- Research activities on Sea bass (*Dicentrarchus labrax*): oxygen consumption on eggs and larvae, reproduction and sex control, ongrowing diets and pathology.

- Quality control of *Artemia salina* from different sources.
- Culture of *Penaeus kerathurus* and *P. japonicus*.
- Biochemical composition of *Tetraselmis suecica*, *Thalassiosira minima*, *Pecten jacobaeus* and *Ostrea edulis*.

Instituto de Ciencias Marinas de Andalucía, Puerto Real, Cádiz

- Ecophysiology of clams (*Venerupis secussata* and *V. semidecussata*)
- Culture of Sea bream (*Sparus aurata*)
- Reproduction control of sole (*Solea senegalensis*)
- Metabolism of organic P and growth physiology of microalgae.

Instituto de Investigaciones Marinas de Vigo

- Larval nutrition in bivalve molluscs: Biochemical composition of *Ostrea edulis* and *Mytilus galloprovincialis* larvae.
- Nutrition of turbot (*Scophthalmus maximus*)
- Biology and pathology of bivalves molluscs: *Ostrea edulis* and *Mytilus galloprovincialis*.

Centro de Documentación en Acuicultura, Madrid

- National bank of aquaculture data
- Spanish directory of aquaculture activities.

3. UNIVERSITIES

Universidad de Santiago de Compostela

- Laboratorio de Microbiología
 - Culture of marine microalgae, Biochemical variability
 - Culture of *Artemia* with microalgae and inert diets.
 - Computer prediction of the culture of microalgae, molluscs and turbot
 - Utilization of the pigment orixinantina in fishes.
- Biochemistry department
 - Biochemical composition of molluscs larvae.

Universidad de Barcelona

- Botanic Department
 - Biological capacity (potential) of macroalgae and their application in aquaculture: *Gelidium sesquipedale* and *Pterocladia capillacea*
 - Structural and biochemical characteristics of microalgae: *Thalassiosira minima*, *T. stellaris* and *Skeletonema costatum*
- Biology cellular-physiology department
 - Natural feeding of sole (*Solea vulgaris*)
 - Aerobic metabolism of mussel
 - Stress in marine fishes.

Universidad de Granada

- Department of animal biology, ecology and genetic.
 - Chromosomic manipulation, sexual maturation and hybrids in Salmonidae, Sea bass and Sea bream

Universidad de Murcia

- Animal physiology department
 - Nutrition of Sea bream (*Sparus aurata*) and Sea bass (*Dicentrarchus labrax*)
 - Nutrition and metabolism of rainbow trout (*Salmo gairdneri iridens*).

4. LOCAL RESEARCH CENTERS

Centro de Cultivos Marinos, Robadeo, Punta de Galicia

- Culture of bivalve molluscs: *Ostrea edulis*, *Venerupis decussata*, *B. pullastra* and *Donax trunculus*

Centro Experimental de Villajuán, Villagarcía, Punta de Galicia

- Culture of salmonidae and turbot
- Natural stock assessment of bivalve molluscs.

Centro Experimentación Pesquera, Principado de Asturias

- Biology and culture of clams: *Ruditapes decussata* and *R. philippinarum*
- Hatchery research on bivalve molluscs: *Ostrea edulis*, *Crasostrea gigas* and *Ruditapes philippinarum*

Planta de Experimentación de Cultivos Marinos, Consejo Murciano, Murcia

- Hatchery research on Sea bass (*Dicentrarchus labrax*) and Sea bream (*Sparus aurata*).

Estación de Acuicultura del Port d'Andrade, Govern Balear, Islas-Baleares

- Hatchery production and ongrowing in sea cages of Sea bream (*Sparus aurata*), Sea bass (*Dicentrarchus labrax*)
- *Diplodus puntazzo*, *Dentex dentex*, and *Seriola dumerili*
- Design of different structures for sea cages and their effects on the natural environment.

5. PRODUCTION

The Ministry of Agriculture and Fisheries has still not published the official production data for 1989.

SWEDEN

by

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Introduction

The yield of Swedish aquaculture in 1988 was 7,456 metric tonnes (round fresh weight). The species dominating in culture was the rainbow trout (6,783 tons). Furthermore, there were 858 tonnes of cultivated blue mussels (*Mytilus edulis*) harvested. The total value of the aquaculture production in Sweden in 1989 amounted to about 199 million SEK (approximately 32 million US \$). The compensatory programme for releasing smolts of salmon and brown trout comprised 3.5 millions in numbers in both, 1988 and 1989.

Fishery management

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

Species	Number of released smolt (1000) in rivers leading to			
	1988			
	Baltic	Lakes	Kattegat	Total
Salmon	2340	169	197	2706
Brown trout	0629	145	011	0785
	1989			
Salmon	2388	207	172	2767
Brown trout	598	130	004	0732

Commercial production

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

	Total production	Marine production
Rainbow trout	6783	4051
Salmon	0363	0363
Brown trout	-	-
Arctic charr	0077	-
Eel	0233	-
Total fish production	7456 (100%)	4414 (59.2%)
Blue mussel	0858	0858
Oyster	-	-
Freshwater crayfish	0003	-

The fish production has thus increased by 57% compared to the previous year. On the other hand the mussel production has decreased from 2,556 tonnes in 1987 to 858 tonnes in 1988. The number of enterprises engaged in aquaculture was 478, of which

297 produced fish for consumption and 12 blue mussels. 173 establishments cultivated juvenile fish for stocking. The number of enterprises engaged in fish production, either for consumption or for stocking purposes, of various species were as follows:

Species	Number of enterprises
Rainbow trout	272
Salmon	022
Eel	008
Arctic charr	028
Brown trout	009
Total	339

Diseases problems

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

Disease problem	Number of enterprises with reported outbreak of a specific disease
Biral Disease IPN	00
Bacterial Diseases	
Furunculosis	10
Bacterial Kidney Disease (BKD)	41
Enteric Redmouth Disease (ERM)	09
Infectious Dermatitis (ASA)	58
Parasitic infection	
Whirling Disease	00
Proliferic Kidney Disease (PKD)	05

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 muscle proteins and maturation of the oocytes (D).
4. The growth and metabolism of salmonids in relation to feed and the structure and qualitative composition of muscles (E).
5. Fish migration and social functions (F).
6. Fish physiology. Environmental and comparative physiology and biochemistry. Chemoreception and orientation in chemical gradients (F).
7. Comparative studies on monoamine metabolism in lower vertebrates with emphasis on anoxia tolerance (F).
8. Carbonic anhydrase inhibition in vivo in rainbow trout acclimated to water of different ionic and gaseous compositions (F).
9. Lake water cage culture of arctic charr (G).
10. Analysis of the Arctic charr's basic properties for aquaculture (H).
11. Effects of alternative reproductive tactics on male spawning behaviour and migrational status in Baltic Salmon (II).
12. Sea-ranching with Baltic Salmon. Non-river based experiments with delayed releases (II).
13. Feeding behaviour of arctic charr (II).
14. Genetic studies of arctic charr (II).
15. Sociobiological interactions in size and sex structure of Baltic salmon parr populations (II).
16. Disease resistance in stocks of cultivated fish (II).
17. Population genetic studies of salmonid strains for

cultivation and fishery management (K).

18. Breeding research on various strains of trout.

Cod:

1. A feasibility study on sea ranching of cod in the Bothnian Bay and the Swedish west coast (A).
2. Development of methods for the improvement of the recruitment of cod populations in the Baltic proper and the Bothnian Sea (B).

Freshwater crayfish:

1. Investigation on the reproduction and growth in *Astacus astacus* under intensive and extensive aquaculture (B).
2. The nutritional requirements of juvenile *Astacus astacus* with special reference to protein/energy ratios (C).
3. Social interactions between the species *Astacus astacus* and *Pacifastacus leniusculus* (C).
4. The growth rate of *Astacus astacus* under natural and experimental conditions (C).
5. Biochemical, molecular and molecular genetic studies of the immunoreactions of the freshwater crayfish (L).

Diseases problems:

1. The effects of vibriosis vaccination on the survival and antibody production of rainbow trout under various conditions (J).
2. Investigations on *Aeromonas salmonicida* infections (I).

Research bodies

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- B. Askoe 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
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UNITED KINGDOM

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Commercial salmon farming increased production by 59% to 28,553 tonnes in 1989 and estimates for 1990 indicate a further increase to 37,000 tonnes. However, based on numbers of smolts and ova in farms production between 1991 and 1994 is likely to level at about 40,000 tonnes per annum. Survival of fish in sea water for the 1987 smolt intake harvested in 1988 and 1989 was 65,5%. Survivals of 85% should be anticipated. The additional 20% loss was due to disease, largely furunculosis assisted by lice infestation and pancreas disease. The mean weight of the two sea winter fish was down for the fourth successive year to 3,156 kg a drop of 0,324 kg on the 1988 figure. This drop was also attributed to disease.

Research continues at several institutes to develop better methods of control of furunculosis (vaccines, new antibacterials) and sea lice (new insecticides, vaccines and use of cleaner fish) as well as research on the cause of pancreas disease.

Work also continues to develop a commercial process for halibut culture, the ranching of lobsters and improving methods of scallop culture.

United States

Regional and National Developments

The rapid growth and increasing importance of the aquaculture industry in the United States to both agriculture and natural resources was recently recognized in a joint agreement between the Department of Agriculture (USDA) and the Department of the Interior's Fish and Wildlife Service (USFWS). The agreement establishes policies and organisational arrangements to provide for and foster interagency coordination and cooperative programs in support of commercial aquaculture development. The agreement also directs the formation of interagency work groups to address such issues as (1) aquatic animal health management; (2) protective federal status; (3) research and technology transfer.

The executive committee of the USDA's Northeastern Regional Aquaculture Center (NRAC), located on the campus of Southeastern Massachusetts University (SMU), North Dartmouth, Massachusetts, has approved several projects for funding in 1990. The NRAC will provide grants totalling about \$180 K/year. Last year most grants were directed toward raising shellfish and freshwater finfish.

Among the continuing projects are:

"Increasing Aquaculture Production in the Northeast Through Nutrition",
with objectives to:

- estimate the nutrient requirements of natural hybrid striped bass;
- develop nutritious and cost-effective foods for salmonids and striped bass;
- develop commercial feed-production processes while maintaining nutrient availability, and
- transfer technology and management methods to industry.

Institutions participating include:
Cornell University

Monell Chemical Senses Center
 National Fisheries Research Center
 New England Fisheries Development Association
 University of Maine
 University of Maryland
 University of Massachusetts
 University of Rhode Island

"Genetic Manipulation of Oysters Through Hybridization and Polyploidy"

Objectives include improving interspecific diploid and polyploid oysters by:

- developing and refining methods for producing diploid and polyploid hybrids of the genus *Cassostrea*, and
- using these methods in a small quarantine hatchery system.

The participating institutions include:

University of Delaware
 Rutgers University
 University of Maryland

In addition, an Aquaculture Innovation Center has been set up at the University of Maine.

Approxiamtely 95% of salmon production in the region is located in the East Lubec area of Cobscook Bay, Maine, on the southwesterly shores of Passamaquoddy Bay. Pen-rearing operations have been expanded dramatically in the past five years. There are currently 17 farms varying in size from a single, four-pen operation with a total annual production of 80,000 pounds to farms with over 300 pens and a potential annual production of 20 million pounds.

Approximately 33 million dollars was invested in Maine's salmon aquaculture industry in 1989. In that same year, aquaculture for shellfish and finfish totalled \$11 million. Presently, Maine has permitted 36 lease sites for finfish and 32 leases for shellfish. Maine anticipates that by 1992, total production of Atlantic salmon will be 11,000 tons. In New Brunswick, Canada, just across the border, 50 million pounds of Atlantic salmon were marketed in 1989. They expect to increase that production to 125 million pounds by 1992. Presently, Maine is expanding its aquaculture industry. The Maine Department of Marine Resources has taken an

active role in helping the industry by providing site location advice and monitoring for adverse impacts to the surrounding area.

While most of the production in the U.S. is of Atlantic salmon, some operators are also raising rainbow trout. One of the farms is planning to raise codfish and is currently doing research to determine the feasibility of raising halibut in a pen. Another farm has a grant from the National Science Foundation to raise haddock. The principle investigators, however, found it difficult to locate 100 live haddock to begin the effort. The State of Maryland is considering raising striped bass in pens in the Chesapeake Bay region.

The following is a list of all private finfish aquaculture operations (fresh and saltwater) in the northeast region as of 31 December 1989:

State	Number	State	Number
Maine	27	Maryland	1
New Hampshire	14	Virginia	9
Vermont	8	West Virginia	4
Massachusetts	37	Ohio	77
Rhode Island	7	Indiana	27
Connecticut	80	Illinois	24
New York	39	Michigan	44
Pennsylvania	140	Wisconsin	47
Minnesota	36		

Environmental Issues

The environmental impact of salmon farming is a controversial issue facing the industry. As a result, permits and/or lease issuances or denials are delayed. The issue is pressed by groups

worried about potential adverse effects and by those concerned with protecting their economic and/or aesthetic interests.

Often, environmental issues are used as a lever to stop projects when the real concerns are aesthetics or alternative uses. Water quality, pollution and diseases, as well as the introduction of non-native species, remain major concerns of several state and environmental agencies.

Other environmental concerns are:

- effects on water circulation and suspended sedimentation;
- organic sedimentation and impacts on benthic organisms;
- increased phytoplankton growth and PSP;
- use of antibiotics and hormones;
- use of toxic substances;
- conflicts with marine birds and mammals (many seal attacks have occurred on these farms causing losses up to \$160,000), and
- impacts from associated hatchery and processing operations.

To respond to these concerns, and to the increase in permit applications from the ACOE, guidelines by NOAA have been developed in conjunctions with the ACOE, EPA and USFWS. These guidelines have been implemented by the ACOE. When all guidelines are met, the aquaculture venture is generally approved without delays. If the guidelines are not met, the applicant must monitor his operation for sedimentation, organic loading and other effects of the program. Monitoring must continue until such a time that it can be shown that there will be no adverse impacts. The EPA, however, may require the fishfarmer to be consistent with its Northwest Region to obtain a NPDES permit.

Industry Concerns

The aquaculture industry is concerned that government is becoming too invasive, restrictive, and overly regulatory. It wants assistance from the federal government in the form of research and would like answers to the concerns raised above. Presently, the University of Maine at Orono and the Maine Department of Marine

Fisheries are performing a small part of this function and are also monitoring aquaculture sites in the State of Maine.

During a recent hurricane, the Waddell Mariculture facility in South Carolina was severely damaged. The effects of a major storm on experimental and production facilities will be of interest to operators, managers and scientists. Periodic reports on such events will be useful.

Introductions of Atlantic salmon to Pacific pen culture systems have been made have been made and are being studied. Fish are reported to have a better rate of survival and to grow more rapidly. The members of the Mariculture Committee should keep abreast of the Working Group reports forthcoming from various ICES sponsored meetings on introductions.

Future Projects

In Massachusetts, there is a proposal by an American multinational company to place two strings of nine fish-pens each, each measuring 90 x 90 x 90 feet, 32 miles off the Massachusetts coast. Their goal is a total of 9 strings of 9 pens each for a total annual production of 48 million pounds of Atlantic salmon.

In comparison, raising shellfish has generally been without controversies, and the growth of the industry has been stabilized. Leasing of estuarine bottomlands for shellfish and finfish culture occurs in several states: Maryland (1050 acres), Virginia (110,000 acres). The majority of these leases is for shellfish production. It is interesting to note, however, that in Maine there are 530 acres devoted to shellfish, 393 acres devoted to finfish, and 87 acres for both resources, but the value of finfish is slightly higher than that for shellfish.

On Cape Cod, recent proposals to rear scallops and other shellfish in float-suspended containers in the near-offshore have been criticized and met with objections from the community. The prejudice against salmon aquaculture and its effects on habitats is often directed erroneously to shellfish endeavors.