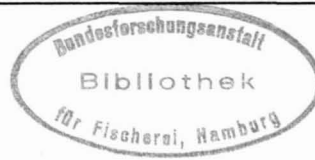


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International Council for the
Exploration of the Sea

Mariculture Committee
C.M. 1991/F:1



Activity Report 1990/91

Mariculture Committee

by

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BELGIUM

by

(Patrick Sorgeloos)
State University of Ghent

Further developments and dietary testing of live (*Brachionus* and *Artemia*) and formulated (enrichment and substitution) diets for use in the larviculture of freshwater and marine fish, marine shrimp and freshwater prawn, and molluscs (in cooperation with different research laboratories and private hatcheries in Belgium, France, Greece, Japan, Norway, Philippines, Singapore, Spain, Thailand, UL, USA and Yugoslavia).

Evaluation of coating techniques to improve the water stability of microparticulate diets.

Biochemical characterization and dietary testing of chemically preserved *Artemia* biomass for penaeid shrimp larvae.

Intensive production, processing and quality control of *Artemia* biomass and cysts.

Quantitative study of the bacterial flora of the live food department of commercial hatcheries of European sea bass and sea bream (in cooperation with the Laboratory of Microbiology, State University of Ghent).

Development of a bioencapsulation technique for the incorporation of high doses of antibiotics in *Brachionus* and *Artemia* (in cooperation with the Laboratory of Medical Biochemistry and Analytical Chemistry, State University of Ghent, and the Thessaloniki University, Greece).

Possibility to use *Artemia* for oral vaccination of fish larvae (in cooperation with the University of Stirling, Scotland, UK).

Fatty acid composition of turbot larvae reared in different culture systems (in cooperation with the Danish Institute for Marine Research and the Instituto Oceanografico, Vigo, Spain).
Organization of workshops and/or training sessions on fish/crustacean larviculture and *Artemia* culture in Belgium, Canada and Taiwan.

Consultancy missions regarding *Artemia* and/or larviculture applications for different official organizations and private companies to Brazil, Ecuador, Egypt, Honduras, Malaysia, PR China, Peru, Tunisia, USA.

ARTEMIA SYSTEMS NU/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 FOR ECOLOGY AND
AQUACULTURE NUCLEAR POWER STATION, DOEL-ANTWERPEN

In 1990 more than 2 tons of sea bass *Dicentrarchus labrax* was produced at the pilot plant of the nuclear power station at Doel.

Experiments were performed on the influence of different dietary fish meals on the growth and body composition (fat, dry weight, proteins) of sea bass fingerlings.

Toxicity studies on sea bass were carried out as well as studies on water quality of effluents from fish tanks.

Preliminary experiments started with sturgeon *Acipenser baeri* to study the possibilities of culturing these species in the thermal effluents of this power station.

A monitoring method for biological fouling has been developed.

CANADA

by

(R.H. Cook)

St. Andrews, New Brunswick

This report is a partial summary of the mariculture research activities in Canada concentrating on research in government institutions but also including some university and private research activities. The research is identified according to the Canadian province in which the activity is carried out. There will be a continuing emphasis to broaden the number of reports received from mariculture scientists in Canada.

Newfoundland and Labrador

Finfish:

The Ocean Sciences Centre (OSC) of Memorial University carried out research on a number of finfish species. In January, 1990, Atlantic halibut were successfully spawned. Egg quality was good and we had surviving larvae up to metamorphosis (greater than 90 days post-hatch). Information was collected on: steroid levels in mature and spawning females and males, sperm quality and the survival of halibut under ambient seawater conditions in Newfoundland.

Research on larval rearing and survival of lumpfish and ocean pout continues. Food quality and loading density experiments were carried out on both lumpfish and ocean pout. Initial rearing experiments were conducted on wolffish. Sex steroid profiles are being collected on these species as a first step towards efficient broodstock management techniques. This work continued in cooperation with the Wesleyville Marine Finfish Hatchery on improving the rearing and hatchery management of these species.

Studies have been initiated on farmed cod with the aim of improving the growth and survival of cod held in sea pens. With the use of video, information is being collected on: the feeding of cod on different food types, the daily activity and distribution of cod in pens and the behaviour of cod held at different loading densities. In addition, cod larvae were reared at the OSC and preliminary information on the culture and feeding of this species collected.

Studies comparing egg quality over the spawning season were carried out on arctic char. In addition, egg quality studies were also carried out comparing wild and cultured Atlantic salmon eggs. Sex steroid analysis of spawning Atlantic salmon were performed over the year to determine why some individuals skip a reproductive season.

Shellfish:

In 1990, the hatchery located at the Ocean Sciences Centre continued the experimental production of spat of the giant scallop for transfer to grow-out sites to assess feasibility for aquaculture. Over 0.5 million spat were transferred to three bays in Newfoundland and grown in pearl nets. Results indicate excellent survival. Test marketing with real product of cultured scallop has commenced in Newfoundland from two farm sites.

Research by the Canada Department of Fisheries and Oceans (DFO) (Newfoundland) has completed the second year of a three-year project to provide data on growth, survival, and other production parameters related to culture of the giant scallop, *Placopecten magellanicus*. These data will be used to conduct a bio-economic analysis of aquaculture production of whole, juvenile scallops. Results have been very successful to date, with about 80-90% survival in pearl net culture with harvestable size (50-70 mm shell height) attained in 24-28 months from spat settlement.

Seasonal fluctuations in phytoplankton species, particularly those associated with production of shellfish toxins, and the occurrence of toxins and heavy metals in scallop tissues, were studied at two commercial shellfish culture sites.

A two-year project was initiated to determine relationships between spat settlement, seasonal variation in spawning, and depth distribution of pediveliger stage larvae for the blue mussel, *Mytilus edulis*, at a commercial shellfish culture site in Newfoundland.

DFO (Moncton) completed a two-year study of the effects of density and environmental factors on the growth and productivity of giant scallops (*Placopecten magellanicus*) in suspended (pearl net) culture in Port-au-Port, Newfoundland. The resulting data is being used to evaluate the economic viability of different culture scenarios. A multi-year study was initiated on the spatfall prediction and recruitment mechanisms of giant scallops in Port-au-Port, Newfoundland in relation to physical and chemical, environmental and biological factors. The study will help to explain why this particular site is consistently an excellent area for spat collection and the quantities collected far exceed any other known area in Atlantic Canada.

Nova Scotia

In 1989-90, the Province of Nova Scotia received 44 new applications (20 shellfish 24 finfish) for aquaculture leases, licenses and experimental permits. Shellfish seed stock was provided to commercial growers which consisted of 100,000 native oysters and 200,000 bar clams. Research and development was aimed at improving molluscan shellfish hatchery production techniques, testing certain species under winter conditions and conducting research on new species for aquaculture applications. Icelandic cockles are currently being reared under quarantine to evaluate this species aquaculture potential.

DFO (Halifax) produced Atlantic salmon smolts at its Mersey Fish Culture Station (FCS) which are the progeny of wild adult salmon that return to the River Philip and LaHave River in Nova Scotia and to the Saint John River in New Brunswick. These smolts were supplied to four marine salmon farms in Nova Scotia during each year of a four-year program. The program will enable the Nova Scotia aquaculture industry to develop broodstocks from the salmon stock which performs best under local cage conditions. The two Nova Scotia stocks performed as well as the Saint John stock during 1989/90. Mean weights of 3.0-3.5 kg were attained after 16 months in seawater and from 25-36% of the salmon matured as grilse.

Research at DFO Halifax Laboratory investigated the interrelationship between nutrition and immune response in Atlantic salmon with emphasis on the effect of dietary vitamin B₆ and iron levels on resistance to *Aeromonas salmonicida* and *Vibrio anguillarum*. An increase in dietary pyridoxine levels (0,2.5,5,10,20,40 mg/kg diet) showed no beneficial effect in protection from *Vibrio anguillarum* and *Aeromonas salmonicida*. Fish fed unsupplemented diets showed anorexia, poor growth, hyperirritability, lethargy and erratic swimming behaviour. Histopathological examination of the deficient groups showed degenerative changes in liver, kidney, gill lamellae and disintegration of erythrocytes. The iron requirement of Atlantic salmon fingerlings determined on the basis of growth, feed utilization, survival, tissue and vertebrae iron concentration was 40 mg/kg of diet. Preliminary results indicate that dietary iron concentration had no beneficial effect in protection from *Vibrio anguillarum* and *Aeromonas salmonicida*.

A joint program between the Bedford Institute of Oceanography and the St. Andrews Biological Station continues to study the environmental impacts of salmonid cage culture on coastal habitat. Field programs have collected physical, chemical and biological information from the L'Etang Inlet in southwestern New Brunswick, the site of many profitable and expanding Atlantic salmon farms. Emphasis has been placed on determining the impact of wastes on the water in and surrounding the cages and on documenting the degree and spatial extent of benthic impacts such as sediment oxygen demand and ammonia uptake and release. Numerical modelling is an integral part of the project. A model called SITE has been developed which simulates the critical processes that take place within a cage (feeding, growth, respiration, excretion, flushing, etc.). The model is being used to help design field experiments to study the processes which control the level and extent of impacts of cage culture on the environment. In conjunction with a detailed hydrodynamic model, the SITE model will be used to explore the capacity of the L'Etang Inlet to assimilate wastes from salmon farms.

Phytoplankton species composition and associated physical, chemical and biological variables continue to be measured on a regular basis at nine sites (most near aquaculture) in the Bay of Fundy and along the Atlantic coast of Nova Scotia. These data are being compiled into regional data bases and will be analyzed to improve understanding of the processes affecting the occurrence of toxic blooms. Species with the potential of producing toxins (such as *Nitzschia pungens*, *N. pseudodelicatissima*, *Dionophysis norweigica*) are widespread but usually found in very low numbers.

Prince Edward Island

Shellfish:

The Province of Prince Edward Island assisted the mussel culture industry in the development of a number of technology improvements including advancement of mussel grading, holding, screening and inspection technologies, mechanization of mussel dory loading systems, auger-type anchoring techniques, and mechanization of stripping mussels from socks at time of harvest. Methods to improve shellfish seed supply were assessed such as testing an in-water oyster spat grader, comparative methods of growing hatchery and wild oyster seed, and using under-ice rack systems of holding oysters in winter.

DFO (Moncton) studied the recurring problem of summer die-off of mussels (*Mytilus edulis*) that effects a large proportion of the cultured mussel industry in P.E.I. A three-year study is in progress to examine the influence of genetic and environmental factors on summer mortality of P.E.I. mussels using a reciprocal transplant experiment with 6 study sites. Mortality (age, origin of seed), growth (shell) and animal condition (using carbohydrate as an index) are examined at seasonal intervals. The results from the first sampling of the experiment showed an inverse relationship between mortality and growth of the different seed sources which was consistent among sites: mortality ranging from 2.5% to 30% with the average growth increment ranging from 9.9 mm to 5.8 mm.

A study to examine the effects of site specific environmental conditions on quahog (*Mercenaria mercenaria*) growth rate by using a reciprocal transplant experiment in P.E.I. was also initiated. The project will evaluate the growth and mortality differences of two P.E.I. sites (Pownal Bay and West River) using hatchery-produced seed and testing a variety of culture techniques and mechanisms in order to assess the influence of various environmental parameters (temperature, water flow, seston, chlorophyll, bottom type, etc.). A multi-year survey of the parasites and diseases of the main shellfish species (mussels, Eastern oysters, European oysters, giant scallops, bay scallop and quahogs) used in mollusc aquaculture in Atlantic Canada was undertaken. The basic objective of this baseline survey was twofold: to elucidate the seasonal dynamics and species identification of specific bivalve parasites which clearly affect their host's tissues; and compare and contrast the parasites in commercially important species grown in suspension and on the sea-floor (at adjacent sites). DFO (Moncton), in collaboration with the Atlantic Veterinary College at UPEI, showed from morphological and epidemiological observations that the parasite being investigated in the bay scallop (*Argopecten irradians*) was a new species: *Perkinsus karlssoni* n. sp. (Apicomplexa). Transmission experiments remain ongoing at the Atlantic Veterinary College. It is believed that the parasite only becomes pathogenic to the scallop under stressful warm-water condition. The WGPDMO established a sub-group under the chairmanship of Dr. S. McGladdery to review the current molluscan disease control measures of ICES member countries. This review will provide advice for updating the ICES Code of Practice in collaboration with the WGITMO as requested by the parent Mariculture Committee.

Finfish:

The Prince Edward Island conducted performance evaluations on three strains of Atlantic salmon, one being a native strain. Four strains of speckled trout are also being assessed for performance potential. Trials are also underway assessing the feasibility of eel culture and the production of "silver eels". The use of striped bass on a seasonal basis under sea-cage culture conditions is under active consideration.

New Brunswick

Thirty thousand Atlantic salmon smolts were produced by the DFO Fish Culture Station at Saint John for broodstock development purposes within the New Brunswick industry. Performance of these smolts while in marine cages will be assessed and broodstock selected which have demonstrated increased growth rates, delayed sexual maturity and possibly resistance to some salmon pathogens as part of the Atlantic Salmon Federation's Salmon Genetics Research Program. This salmon hatchery also produced 20,000 smolts for the Atlantic Salmon Demonstration and Development Farm operated by the New Brunswick Salmon Growers' Association. These smolts are utilized for research and development studies in the areas of nutrition, disease prevention, technology development, fish culture biology, genetics and physiology.

Research on kelt reconditioning and spring spawning Atlantic salmon, the use of hyper-oxygenated water to enhance salmonid growth and survival, the heritability of disease (Bacterial Kidney Disease) resistance and the comparison of growth characteristics of salmonids reared in flow through versus recirculating rearing systems is carried out by DFO (Moncton). Salmonid enhancement activities are concentrating on the use and development of "soft" technologies such as semi-natural rearing, streamside incubation, satellite rearing, lake-cage rearing and estuarine kelt reconditioning. These technologies are easily transferable for use by interested public/private sector groups. Genetics research focussed on the development of a salmon line mass selected for grilse fork length and compared with a control line. Positive correlated responses in growth and development were observed, with realized heritability of 0.27. Positive responses have been observed in a strain being developed for the aquaculture industry. Under the aegis of the Salmon Genetics Research Program, smolts from the primary breeding populations were distributed to multiplier growers who produce eggs for the local salmon culture industry in the Bay of Fundy.

Finfish culture research at the DFO (St. Andrews) included studies on Atlantic salmon, striped bass and halibut. The sex steroid profiles in the blood of adult striped bass (*Morone saxatilis*) was determined on a seasonal basis for sex determination and for possible use as an index of maturity. Growth responses of glass elvers (*Anguilla rostrata*) were determined for a series of temperatures (14-24°C). Attempts were made to feminize larval lumpfish (*Cyclopterus lumpus*) by exposing them to estrogen in the ambient water and in the diet. Experiments to determine the influence of ambient calcium concentration on yolk utilization of Atlantic salmon (*Salmo salar*) alevins are being performed.

The major research effort was directed at determining the growth performance and survival of juvenile halibut in two grow-out conditions. A two-year study using modified herring weirs was successfully completed and a new study using modified salmon cages was initiated. Considerable effort was directed to the completion of facilities for studies on egg and larval stages and for the holding of halibut broodstock.

The production of underyearling Atlantic salmon smolts was demonstrated as feasible. For the second year, smolt size fish have been produced by September following thermally accelerated incubation and growth. Provision of decreased day length during summer followed by increasing day length in autumn resulted in development of smolt characteristics by November. Long-term survival in seawater was acceptable but less than to be expected of true smolts. Further attempts will be made using different timing of artificially adjusted photoperiod.

The University of New Brunswick (UNB) have several aquaculture research studies underway. In one study it was shown that the noise levels of fibreglass tanks averaged 4 to 16 dB quieter (at 125 and 250 Hz respectively) than those in concrete tanks. This research suggested that the improved smolting rates of Atlantic salmon observed in fibreglass tanks might be influenced by the noise level of the container.

Research on the biology of sea lice, in particular the host finding behaviour, ultrastructure of the larvae and adults, reproductive physiology and the host-immune responses continued. Surveys for sea lice on cultured salmon in the Bay of Fundy showed an average of one to two specimens of *Caligus elongatus* per fish during the summer months of June-August, 1990. Infection levels during September and October, however, rose dramatically to 40-50 specimens per fish in some sites. Although these rates were higher than in previous years, no mortalities were ascribed to sea lice infections. *Lepeophtheirus salmonis* infections were generally low with only occasional individuals being found; at one site, however, infection levels averaged from one to two specimens per fish.

Research also continued on marine anisakines and the potential threat they pose to salmonid aquaculture. With the increasing abundance of both *Pseudoterranova decipiens* and *Anisakis simplex* in wild fish populations, researchers believe it is only a matter of time before cultured fish will pick up infections that are more serious than the present occasional infection.

Research at UNB (Saint John) has shown that growth of the blue mussel, *Mytilus edulis*, was much increased if the mussels were grown in suspended culture compared to growth of natural benthic populations. By placing the suspended cultures around Atlantic salmon cages, and even greater increase of growth was obtained. Although the growth rate was still too slow for commercial operations in the Bay of Fundy due to cold temperatures, the data suggests that under different temperature regimes, co-culture of salmon and mussels might be viable.

A number of cooperatively sponsored aquaculture research projects were initiated in New Brunswick addressing such topics as the identification of

lobster nursery and spawning areas near existing or proposed salmon aquaculture sites, the monitoring of phytoplankton blooms in aquaculture areas, the development of shellfish seedstock and the monitoring of oyster culture sites, the quantitative impacts of salmon culture on benthic habitat, and the assessment of new species - european oyster, quahog, giant scallop, haddock and halibut.

Québec

Pétoncle:

En 1990, Le Ministère de l'Agriculture, des pêcheries et de l'Alimentation avons entrepris en collaboration avec l'Institut Maurice-Lamontagne (MPO) et les industriels de la pêche du pétoncle aux Iles de la Madeleine un important programme de recherche: REPERE (REcherche sur le Pétoncle à des fins d'Élevage et de REpeuplement). Échelonné sur 7 ans, ce programme vise à déterminer la faisabilité biologique, technique et financière de l'ensemencement du pétoncle sur le fond.

Écloserie:

Les expériences sur la production de naissain de pétoncle géant (*Placopecten magellanicus*) se sont poursuivies en 1990 à l'écloserie des Iles de la Madeleine (Québec, Canada). Les objectifs principaux étaient (1) d'évaluer l'effet de nouvelles diètes sur la croissance larvaire et (2) d'améliorer la récolte dans les bassins d'élevage, de larves prêtes à métamorphoser. Des problèmes pour obtenir des gamètes de bonne qualité, de même que des taux de mortalité larvaire élevés dans la majorité des groupes expérimentaux ne nous ont pas permis d'en arriver à des résultats concluants.

Collecte de naissain:

En 1990, un projet pour évaluer le potentiel de captage du naissain de pétoncle géant autour des Iles de la Madeleine a été initié. Les deux principaux objectifs étaient (1) de caractériser le cycle de reproduction de l'espèce sur les fonds naturels et (2) de déterminer les variations temporelles et spatiales de la fixation du pétoncle. Les résultats ont démontré clairement une seule période de ponte se produisant à la mi-septembre. La période de fixation pour *Placopecten* est relativement courte avec un maximum de fixation à la fin d'octobre. La distribution des larves prêtes à métamorphoser a été évaluée sur 20 stations de captage dispersées dans le Sud-Ouest des Iles de la Madeleine. Le nombre moyen de juvéniles par collecteur variait d'un minimum de 26 à un maximum de 1237. La longueur moyenne des juvéniles récoltés à la mi-décembre était d'environ 1.25 mm.

Moules:

Le ministère a continué son projet sur les interactions stocks-sites sur une petite échelle géographique (100 km): les Iles de la Madeleine (Québec, Canada). Cette fois, nous avons transféré du naissain de 4 "stocks" à 5 différents endroits. Le taux de survie a été le paramètre démontrant la plus

grande variation. Il variait surtout en fonction des différents stocks (22 - 93%). La variation était beaucoup moindre en fonction des sites (56 - 65%). Ceci a une conséquence majeure sur la biomasse commerciale. Théoriquement, les producteurs auraient pu augmenter la production commerciale de leurs sites d'un ordre de grandeur (10X) simplement en changeant leur source d'approvisionnement en naissain.

Atténuation de la toxicité des moules bleues en culture:

Une tentative de modification de la méthode de culture en suspension de la moule bleue (*Mytilus edulis*), consistant à élever les structures de contention dans la colonne d'eau en fonction de l'évolution des efflorescences phytoplanctoniques toxiques a été entreprise dans la baie de Gaspé (Québec, Canada). Les résultats préliminaires seront étayés par une seconde saison d'expérimentation. Simultanément, un monitoring du phytoplancton toxique a confirmé la présence d'espèces nuisibles comme *Alexandrium excavatum* et *Dinophysis* spp.

The Centre océanographique de Rimouski (Québec) have several researchers with ongoing studies focussed on the following topics in mariculture:

- ability of migrating (brookcharr, arctic charr) and marine species (American cod, plaice) species to adapt to estuarine environments with particular attention on stress indicators;
- the development of surf clam (*Spisula solidissima*) culture and new technologies for producing triploids in shellfish, especially the giant scallop, and fundamental research on early developmental controls at the embryo stage of marine species;
- developmental biology of marine molluscan invertebrates of commercial interest including the kinetics of development under various environmental conditions including the use of molecular biology and genetic techniques to improve aquaculture production;
- investigation on the uptake of caretones (synthetic and natural) and their influence on the pigmentation of cultured species. A study of occurrence of Omega-3 fatty acids in Atlantic salmon and trout is underway.

Grâce aux installations de la Station aquicole de l'Institut national de la recherche scientifique - Océanologie à Pointe-au-Père dont la vocation première est la recherche appliquée en aquiculture, des chercheurs du Centre océanographique de Rimouski, d'autres universités québécoises ou du secteur privé ont pu contribuer d'une façon notable à l'essor de ce secteur d'activité dans l'est du Canada.

Différents travaux portant entre autres sur la production en éclosion des mollusques et des paramètres régissant la reproduction et la croissance des larves, ou encore sur l'amélioration des techniques de production massive de phytoplancton ont contribué au développement de nouvelles activités aquicoles.

British Columbia

The following information is based on reports received from DFO Pacific Region laboratories at Nanaimo and West Vancouver and from the Department of Animal Science, University of British Columbia.

Fish Health Research:

Investigations (DFO, Nanaimo) on bacterial kidney disease focussed on methods for preventing vertical transmission of the causative bacterium (*Renibacterium salmoninarum*) so that farmers can start off their operations with smolts free of the pathogen. Injection of the brood females, prior to spawning, with one or other of five antibiotics proved effective in significantly reducing vertical transmission of the bacterium in one test. In a follow-up test using erythromycin, the results were even more promising: vertical transmission of the pathogen was completely prevented. Screening of brood females for the pathogen using the indirect fluorescent antibody technique was shown to be an unacceptable procedure because females with ovarian fluid containing concentrations of the pathogen as high as 10^4 per mL fluid went undetected 50% of the time.

Two novel methods for culturing the kidney disease bacterium were developed: the "nurse culture" technique and a variation of this technique in which metabolites produced by the nurse culture are used in place of the nurse culture. The methods result in far more consistent performance of media designed for culturing the kidney disease bacterium; in addition, they result in faster growth of the bacterium and increase the sensitivity with which it can be detected. The techniques should prove invaluable in studies on the epizootiology of the pathogen.

Studies to determine why commercially available anti-vibrio vaccines have been yielding less-than-satisfactory results in the Pacific Region suggest the problem does not lie with the vaccines but rather with the species of salmon being cultured on most farms -- the chinook salmon. The indications are that this species may not be able to benefit from vaccination when it is vaccinated close to the smolting stage (a common practice with this species which attains a size suitable for vaccination at the smolting stage). Tests are underway to determine whether a second vaccination administered following smolting will solve the problem. Interestingly, during these studies an isolate of *Vibrio anguillarum* was obtained, which, with superficial testing, could easily be mistaken for *Aeromonas salmonicida* subspecies *salmonicida* (causative agent of furunculosis) because of its ability to produce the brown diffusing pigment typical of this latter pathogen.

An infectious plasmacytoid leukemia has caused high mortality in netpen-reared chinook salmon, *Oncorhynchus tshawytscha*, at several sites in British Columbia. The disease is called marine anemia by fish farmers. Although most often observed in fish after they are in seawater netpens for over a year, the disease has recently been detected in fish that had only been in seawater for 6 months. Studies demonstrated that the disease is caused by an infectious agent, but the etiology remains uncertain. An intranuclear microsporidium, *Enterocytozoon salmonis*, is found in the nuclei of the proliferating

plasmablasts in many affected fish from the field, and has been associated with a similar disease of chinook salmon in Washington and California, U.S.A. However, this parasite may not be the primary cause of the plasmacytoid leukemia because the disease has been transmitted in several laboratory experiments in the absence of the parasite. Using electron microscopy, we have recently detected retrovirus-like particles in affected tissues. Studies are underway to determine if this putative virus is the cause of the disease.

A toxicopathic liver disease, referred to as netpen liver disease (NLD) is under investigation. The disease affects Atlantic salmon during their first summer in seawater. The disease is most likely caused by a natural toxin, and an algal toxin is suspected. A collaborative study with the University of British Columbia is underway to identify the toxin and the alga. It is suspected that the fish are contracting the disease by feeding on biota growing on the nets. A novel fatty acid with a unique terminal double bond has been identified in the net biota. The fatty acid is produced by the diatom, *Bidulphia*, and is cytotoxic to primary cultures of Atlantic salmon hepatocytes. In vivo studies are underway to determine if this chemical is the cause of NLD

Fish Disease Control:

In 1989, the viral hemorrhagic septicemia (VHS) virus was discovered for the first time in North America in the Northwest corner of Washington State, U.S.A. This virus is reported to cause mortalities among cultured rainbow trout in Europe. Testing of samples collected throughout the Pacific Region of Canada (B.C. and the Yukon Territories) in 1990 failed to reveal the presence of the virus. More than 13,900 fish representing 14 different species of salmonids were sampled from 158 sites. These results suggest that the virus does not have an extensive distribution on the Pacific Coast in Canada.

In 1989, a viral agent was isolated from apparently healthy, Atlantic salmon cultured in B.C. in seawater. The isolate was readily neutralized by antisera specific for the infectious pancreatic necrosis (IPN) virus. The isolate proved to be most similar to a strain of the IPN virus first isolated in Jasper, Alberta, 20 years ago (now known as the "Jasper" strain). This was the first isolation of the IPN virus in B.C. Subsequent work in 1990 has shown that the isolate lacks virulence for Atlantic salmon, coho salmon, chinook salmon, and rainbow trout.

Enzyme-linked immunosorbent assay (ELISA) equipment has been installed in the Fish Disease Control Program's laboratory at the Pacific Biological Station, Nanaimo, B.C. This immunoassay procedure is capable of detecting very small quantities of bacterial antigens and can also be used to measure the severity of infections. The equipment will initially be used to screen ripe parent salmon for the bacterial kidney disease (BKD) agent in an effort to prevent the vertical transmission of this agent. It will also be used to monitor the occurrence and spread of the agent in raceways of newly marked coho fingerlings.

Parasitology:

A new eye disease of pen-reared most-smolt chinook salmon (*Oncorhynchus tshawytscha*), caused by infection with metacestodes of *Gilquinia squali*, has been documented from several fish farms in British Columbia. The pathology of the infection has been described and mortalities associated with the disease reached approximately 10% in one salmon farm. Investigations have been undertaken to determine the distribution, prevalence, and abundance of the adult tapeworm in its definitive host, the dogfish *Squalus acanthias*, and to determine the first intermediate host responsible for transmitting the infection to salmon.

Studies are in progress on the biology and development of sea lice (*Lepeophtheirus salmonis* and *Caligus clemensi*) affecting salmon in British Columbia sea farms. Susceptibility to sea lice varies among salmon species farmed in B.C., with Atlantic salmon being the most susceptible, coho (*Oncorhynchus kisutch*) the most resistant, and chinook occupying an intermediate position. Possible methods of sea lice control are being investigated.

Shellfish:

In 1990, Pacific oysters, *Crassostrea gigas*, from 9 localities, eastern oysters, *Crassostrea virginica*, from 1 locality, Japanese scallops, *Patinopecten yessoensis*, from 6 grow-out localities, Manila clams, *Tapes philippinarum*, from 1 locality, native littleneck clams, *Protothaca staminea*, from 1 locality, mussels, *Mytilus edulis*, from 1 locality, and imported flat oyster broodstock, *Ostrea edulis*, from Scotland and Nova Scotia were examined for parasites and symbionts and/or for the causes of disease and mortalities. Actinomycete bacteria belonging to the genus *Nocardia*, and the microcell protozoan, *Mikrocytos mackini*, were identified as pathogens of oysters. Denman Island disease, caused by *M. mackini*, occurred in experimental oysters held at 8 to 10°C for about 3 months but not in oysters held at 16 to 18°C. Although *Cytophaga*-like bacteria were present on the hinge ligaments of oyster seed being imported from California, there was no evidence that they were pathogenic. High mortalities among Japanese scallops during grow-out in 1989/90 were associated with inflammatory tissue lesions. The cause of the lesions and mortalities was not evident and is currently under investigation.

Salmon Physiology:

A laboratory study (DFO, Nanaimo) of growth and smolting in rainbow trout x steelhead trout hybrids revealed that these traits are controlled by a number of loci. In contrast, another crossing experiment indicated that the difference in photoperiod responsiveness of juvenile chinook salmon having ocean-type and stream-type life history patterns is controlled by a single gene. A computer-controlled system was developed to maintain precise temperature conditions for incubation of sablefish eggs. A production-scale study of feed efficiency in chinook salmon demonstrated better growth and a lower conversion in hand-fed vs. demand-fed groups.

Production of Monosex Salmonids:

Monosex chinook salmon production has become well established in the B.C. mariculture industry. Chinook salmon production in B.C. is 78% of the total cultured salmon production. Close to 100% of these chinook are monosex female stocks.

Research at DFO's West Vancouver laboratory continues toward the generation of monosex stocks of coho and Atlantic salmon and the application of biotechnological methods such as gynogenesis, as a short-cut to monosex production, and monosex female triploids, for the production of sterile salmon. One hundred percent masculinization and feminization has been achieved utilizing single 2-hr treatments at the appropriate developmental stage.

Further studies have been conducted on treatment parameters for the induction of triploidy in coho salmon. Comparison of the effectiveness of heat and pressure shock, and the effect of electroshock during heat shock treatment on triploid yields have been investigated. Preliminary trials have been carried out on the disruption of first mitosis of early zygotes for tetraploid induction.

Studies on the use of aromatizable and non-aromatizable androgens for the sterilization of coho and chinook salmon by immersion alone are underway.

Fish Nutrition Research:

During 1990, collaborative salmonid nutrition research projects included, (1) assessment of the digestibility of conventional and some novel dietary components for chinook salmon in seawater, (2) determination of the digestibility of marine fish protein hydrolysates and herring meal in relation to degree of spoilage of the raw material and processing conditions during fish meal production using chinook salmon in seawater and rainbow trout in fresh water, (3) evaluation of the nutritive value of undephytinized and dephytinized rapeseed protein concentrate for rainbow trout, (4) determination of the influence of dietary protein to lipid ratio on growth and chemical composition of chinook salmon in seawater, and (5) assessment of the influence of dietary amino acid balance on thyroid function of rainbow trout. In addition, research was initiated on (1) determination of the influence of period of starvation and refeeding on performance, endocrine function, and chemical composition of chinook salmon in seawater, (2) determination of the influence of exercise and ration level on performance, endocrine function, muscle physiology, and chemical composition of chinook salmon in seawater, (3) assessment of the nutritive value of extruded canola meal for chinook salmon in seawater, and (4) assessment of the efficacy of various handling and anesthetic approaches and nutritional status on the growth, health, survival, and endocrine function of chinook salmon in seawater.

Some highlights from this research include the following: (1) most fish meals tested contained more digestible (available) energy for chinook salmon than did the other test animal and plant protein sources, (2) a commercial source of canola meal and a novel source of canola meal and rapeseed protein

concentrate (RPC) appear to be highly promising as partial or complete (RPC) replacements of fish meal in diets for chinook salmon, (3) the selection of ingredients for inclusion in formulated diets for chinook salmon should be on the basis of their digestible protein and energy contents, (4) undephytinized and dephytinized rapeseed protein concentrate may comprise about 38% of the dietary protein (fish meal only 11% of diet) for rainbow trout, (5) chinook salmon require >46% protein and 15-20% lipid (dry basis) in their diet for maximum growth rate and feed efficiency, and (6) dietary amino acid balance had a significant influence on thyroid function in rainbow trout.

Genetic Engineering:

Research aimed at the improvement of salmonid stocks for aquaculture through the use of genetic engineering and other molecular genetic methodologies has begun. The focus of this DFO research project is to understand and control growth, reproduction and disease in commercially important species. Two genes have been cloned and sequenced encoding growth hormone from sockeye salmon, and studies have begun on their structure and function. Microinjection experiments are also underway to produce transgenic salmon with improved growth performance and controlled reproduction for use in aquaculture. Insulin-like growth factor genes (somatomedins) have also been examined in Pacific salmon as an alternative approach to controlling growth. 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. The object is to correlate structural variation at these genes with differences in growth performance in natural and domestic stocks. A DNA probe has been isolated from the Y-chromosome of chinook salmon that is capable of determining genetic sex from small pieces of tissue (fin, blood, etc.). This probe is useful for the production of new and verification of existing all-female (monosex) stocks.

Aquaculture Biotechnology:

Peptide and Protein Transport:

Research on Pacific salmon throughout 1990 centred upon growth manipulation. Emphasis was placed on the development and evaluation of novel strategies for the delivery or recombinant somatotropins (rSTH). Studies were also undertaken to compare growth acceleration potential in diploid and triploid coho salmon receiving rSTH therapy. These experiments revealed no difference in growth performance between the two ploidy states.

Collaborative programs with DFO and the University of Victoria were completed with respect to defining the endocrine response of 17β -estradiol primed coho salmon to orally administered LHRH and LHRHa. Joint research with a visiting Spanish scientist examined the effect of injecting various peptides on endogenous (circulating) levels of growth hormone in coho salmon. These preliminary studies indicated that the secretion of somatostatin in coho salmon stunts may be impaired.

A study which monitored the effects of sustained release rSTH priming (≤ 20 wk) on growth has been terminated. This experiment demonstrated that ≤ 20

wk rSTH treatment resulted in elevated growth rates in coho salmon over the entire period of investigation (>52 wk).

University of British Columbia:

Researchers at the Department of Animal Science are addressing a wide range of aquaculture-related topics including:

Energetics of Ion regulation in fish. The energetic requirements to maintain constant blood ion concentrations from hypertonic to hypotonic water salinities may represent a significant component of the energy budget of salmonids. This is being investigated by measuring oxygen consumption growth, and survival of anadromous and non-anadromous salmonids acclimated to a range of water salinities.

Physiology of stress and its effect on disease resistance. Both finfish and shellfish experience stresses in the wild as well as in aquaculture. In finfish, one of the physiological consequences of being stressed is the release of corticosteroids, such as cortisol, which have been shown to have immunosuppressive effects. Research efforts concentrate in two main areas: 1) detailed description of the physiology of the stress response in both shellfish and finfish; and 2) the effects of stress on health, through parameters such as response to inoculation with antigens; haematology; and immunologically relevant parameters such as the antibody-producing ability of white cells.

Physiological differences between hatchery-reared and wild fish. On the assumption that wild fish are selected for conditions in the wild and that hatchery-reared fish are selected for survival under aquaculture conditions, the hypothesis that there may be significant differences in physiology of fish from those two groups is being tested. This collaborative research project is examining the possible differences in swimming performance, osmoregulation, stress resistance, and disease resistance in several stocks of chinook and coho salmon in British Columbia.

Development of methods to detect stress in fish. The early detection of stress in fish may enhance the maintenance of fish health through remedial actions before the negative consequences of that stress can become significant. The reliable indicators of stress in finfish, however, involves the use of sensitive and often expensive laboratory instruments which are impractical for field use. There are relatively simple and reliable instruments, which have been developed for human medicine, that can measure physiological parameters which may reflect stressed states in fish. Some of those include red cell counts, haematocrit, and concentrations of glucose, haemoglobin and total protein. Fish are being stressed in a number of ways and an analysis of those parameters measured with clinical techniques as well as with simple field devices is being compared. If some of those instruments prove useful in detecting stressed states in fish, they will be used to monitor fish health in a commercial fish farm and eventually be incorporated into a kit for use in the field.

Physiology of fish in highly alkaline waters. The acute exposure of ammoniatelic fish to highly alkaline (pH >9.5) waters have been shown to cause severe physiological consequences and death. Research is being conducted on the physiology of salmonid fishes, which are ammoniatelic, that live in alkaline lakes in North America. Research has shown that the ionic content of the water plays a significant protective role. The mechanisms responsible for this protection and the natural conditions where this occurs is under investigation.

Canadian Mariculture Production Statistics (1990 Estimates):

Atlantic Coast:

Newfoundland and Labrador:

Blue mussel	400	t
Rainbow trout	90	t
Cod	210	t
Scallop	0.5	t

Nova Scotia:

Steelhead trout	931	t
Mussels	500	t
Atlantic salmon	300	t
Oyster (american)	135	t
Irish moss	Confidential (only one producer)	
Other shellfish	15	t

Prince Edward Island:

Mussels	2702	t
Oysters	1800	t
Rainbow trout	51	t
Atlantic salmon	1.1	t

New Brunswick:

Atlantic salmon	8181.8	t
Mussels	200	t
Oysters	not available	

Quebec:

Atlantic salmon	50	t
Mussels		
Iles de la Madeleine	98.2	t
Gaspésie	<u>15</u>	<u>t</u>
	113.2	t

Pacific Coast:British Columbia:

Chinook salmon	12,200 t
Atlantic salmon	1,400 t
Coho salmon	350 t
Trout	50 t

DENMARK

by

(Josianne Støttrup)

Danish Institute for Fisheries and Marine Research

Trout.

Trout production (tonnes).

	portion-sized trout	large trout
Production 1989	34.000	6.000
Production 1990	32.000	6.000
Expected production 1991	29.000	6.000

The strict environmental regulations imposed by the government have not yet had an impact on the production of portion-sized trout. However, trout production is expected to decrease as a result of the stricter regulations as well as problems related to the export of the product.

A slight reduction in the excretion of N and P has been observed as a result of improved feed products. Research is concentrated on this area.

Trout production in sea water is stable around 6.000 tonnes per year and is expected to remain at this level. Due to the previous ban and the existing strict regulations imposed, there are very few interested investors.

Since the size of the farm is dictated by the quantity of feed allowed, research is focused on the development of better feed products and on the environmental impact of the sea cages.

Eel.

Eel production (tonnes).

	tonnes
Production 1989	500
Production 1990	700
Expected production 1991	1000

The development in number of farms established has been small. Since 1989, the number of registered farms have increased from around 40 to 45 farms. This number is expected to remain stable during 1991; a few small farms are expected to close and be replaced by larger farms.

On the other hand, production of eels is expected to increase. Regulations on the disposal of waste products from recirculation units are less restrictive.

During 1990, infestations by the parasite *Anquillicola* have been registered in 5 farms. Apparently, the infestation has not severely effected production on these sites. A risk for resistance against anthelmintica may arise from incorrect treatment procedures. This has been confirmed from laboratory experiments. Thus, procedures and methods are being developed to counteract this

development.

Red-head disease, possibly caused by a *Herpes* virus, has been detected and its manifestation may be related to stressful conditions.

Marine flatfish.

Turbot production.	Juveniles (numbers)	Large fish (tonnes)
Production 1990	160.000	6
Expected production 1991	900.000	42

Juveniles are produced by two commercial hatcheries using extensive rearing methods. Both hatcheries started production during 1990. Two on-growing plants based on waste heat and partial recirculation produce larger turbot.

A new research institute has been established; the Danish Institute for Fisheries Technology and Aquaculture (DIFTA). The aquaculture department within DIFTA constitutes the previous Danish Aquaculture Institute (DAI) and the aquaculture department of the Danish Institute for Fisheries and Marine Research (DIFMAR).

Restocking programme.

Turbot restocking and plaice transplantations (numbers).

	Turbot	Plaice
1989	6.659	167.000
1990	6.941	224.000

The restocking programme is jointly financed by government and fisheries organisations.

Restocking of salmonids and eel is the major activity within this programme. An increasing activity in the rearing of marine species for restocking has been registered based on local initiatives. The species being reared include turbot, cod, plaice and Dover sole. However, to date only turbot has been released, whereas plaice have been transplanted from an area with low productivity to another with high productivity.

Small hatcheries have been established for marine flatfish species as well as for cod, and a larger rearing unit is being established at a power plant. An on-growing facility is established for rearing juveniles to a size adequate for external tagging.

Research is concentrated on investigations of potential restocking areas, tagging techniques and the study of methods for the evaluation of the effect of restocking.

FAROE ISLANDS

by

(Guðrið Andorsdóttir)
and
(Ingvarð Fjallstein)

Egg quality and sperm quality are still subject to research on the Fisheries laboratory. Comparisons are made between Faroese wild salmon and farmed salmon.

Feeding experiments have been made with different commercial dry feed. Digestibility experiments have been made with different protein sources, i.e. Blue Whiting, Norway Pout and Squid.

Research on parr size on smoltification was carried out.

In 1990 an Icelandic-Faroese research program on Halibut started.

Extensive research has been made on Salmon lice.

FINLAND

by

(Timo Mäkinen)

Finnish Game and Fisheries Research Institute

1. Production of Fish for Human Consumption

Although a four years project aiming to make the structure of Finnish aquaculture less dependent of one species was just giving his end report is the Rainbow trout (*Oncorhynchus mykiss* Walbaum) practically the only fish species cultured in Finland for human consumption. 99% of the production consist of rainbow trout. The project was common between Ministry for agriculture and forestry, Finnish Game and Fisheries Research Institute and Finnish salmon growers association. 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 growth rate; consequent, farming of this species is still in the experimental stage. At present only 108 tonnes (91 tonnes salmon and 17 tonnes other species, mainly brown trout) other species than rainbow trout are produced. Some interest for cultivating whitefish for human consumption has been shown mainly because the price for flesh and roe of these species has remain at the higher level meanwhile the price of the overproduced rainbow trout has during the last fifteen years lost its real value. Unfortunately the production of whitefish is still in the experimental phase.

Farming of rainbow trout increased considerably in the 1980's, especially in net cages in the sea. By 1989, marine fish farms produced 72% of all the rainbow trout raised in Finland. The main production areas has remained the same as they were in 1988, but the production remained at lower level than was estimated. The fish farming in Finland is experiencing hardest economy crisis of its history during 1988-89, many small farms have suffered bankruptcy in 1990.

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).

Year	Marine Fish Farms		Fresh Water Fish Farms		Total		Est. Value of Prod. Mill. FIM*
	Number	Prod.	Number	Prod.	Number	Prod.	
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	180	13,459	206	5,128	386	18,587	382,0

*(Rate 1 USD = 4.0 FIM)

2. Production of Fish for Stocking

The stockings required by law of power companies and similar compulsory stocking and state stocking have decreased slightly from the highest number 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 1989 a total of 4.9 million salmon, 35 million whitefish and 3.4 million sea trout, one-summer-old and older juveniles were produced in Finland for stocking purposes. A lot of newly hatched larvae which the farms could not sell for on-growing purposes were stocked to rivers having nursery areas.

The rearing and stocking of salmon has maybe passed its highest point in Finland which was in 1988. 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. USD 6 million) in 1988. In 1990 a total of 1.99 million artificially reared smolts was released in Finland to the Baltic sea. The natural smolt production has decreased slowly as it has been from the beginning of 1980's, in 1989 it was already clearly under 10% of the total amount of smolts in Baltic area. Because of the high stockings during the last years the salmon landings will probably increase further for two or three next years; the salmon catch in the Main Basin and in the Gulf

of Bothnia 832 metric tons and in the Gulf of Finland 328 tons. The total catch of the Atlantic salmon of Finland in the Baltic was 1160 metric tons in 1989.

In the Simojoki and Tornionjoki and other rivers flowing to Gulf of Bothnia, which flow into the Gulf of Bothnia 2.9 million salmon fry and 421,509 one-year-old salmon parr were released into the rapids in 1990 to maintain the sharply declining stocks. Extensive monitoring programs are being run in both rivers. The natural smolt production in these rivers is about 1/6 of the potential natural production and the share of farmed juveniles in both rivers is far over 80%. The situation indicates a serious decrease of spawning stock in rivers due to overfishing in the sea. To protect the migrating brood-fish the beginning of salmon fishing with fykenets on the coastal area has been delayed in springs but this measure has not been enough to increase the brood fish number spawning in the rivers. The sea trout stock in the Tornionjoki River is particularly threatened. In 1990 in most electrofishing sites in Tornionjoki River no sea trout parr were found. In 1990, 286,060 sea trout smolts were stocked into the rivers flowing to the Gulf of Bothnia; the total number of sea trout smolts released into the Baltic Sea was 992,000.

3. Research

An intensive selection program to breed rainbow trout is starting in Finland by Finnish Game and Fisheries Research Institute. The aquaculture division has rented a private fish farm to realize a selective breeding program with 400 hundred separate reared families annually.

A plan of mariculture research station, its need and activities has been made and a decision was made to continue with planning towards establishing the station in Rymättylä, in the south-western archipelago.

Research was carried out to investigate the stocking results in the Baltic sea. The studies on this sea ranching investigation included extensive Carlin- and micro-tagging and research aimed to raise the value of reared release fish by improving rearing techniques in addition to food and feeding. The fish quality was valued with the physiological testing method developed. Effective parasite and disease control is under development.

The value of one-year-old salmon smolts for stocking purposes was studied in Kymijoki-river mouth, and comparative experiments of

different tagging methods (Carlin-, coded wire and burn-tagging) for evaluation of vitality of parrs and smolts after stocking were done in Simojoki River.

Studies on the environmental impacts of mariculture (nordic co-operation project) have been continued to the end and a report collecting the main results will be available during this year in English. Some papers from the research project concerning algae as an indicator for environmental changes caused by fish farming in brackish water are published and some more papers regarding the use of model ecosystem for describing the eutrophic effect from fish farming will be published during this year. (see the attached bibliography).

The Department of Applied Zoology of the University of Kuopio has been involved in the mariculture research as follows: Development of immune resistance in cultured fish in cold water conditions; Upgrading of semi-closed cage culture technology; Environmental effects of fish farming in the SW-Archipelago of Finland

4. 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. Spreading of the disease has continued: in 1990 48 farms had furunculosis. Two of them were located in inland areas, but the main area of occurrence was southwestern archipelago.

Two cases of bacterial kidney diseases (BKD) has been observed at marine fish farms since 1989 and one with marine brood fish from nature in 1990.

Vibriosis is still the main problem at marine fish farms, although the number of infected farms has been decreasing during last few years because of the vaccination program. The amount of vibriosis vaccine sold in Finland has increased from 80 litres in 1984 to 1221 litres in 1990. In 1990 23 litres of vaccine against furunculosis was used, too.

In 1987, the first marine fish farm was infected with IPN and six new cases were observed during 1988-89. All IPN cases were in the beginning located on southwestern archipelago but in 1990 three out 15 observed cases were already outside this area. Signs or cases of VHS or any other major, infectious viral fish diseases have not been found in Finland.

To prevent the spread of the diseases, limitations on transfers of fish have been set, and other preventive measures taken by the veterinary authorities.

At University of Åbo Akademi in Institute of Parasitology is starting two projects concerning fish diseases: "Immune prophylaxis in fish farming (a three years project) and "Transmission of disease between farmed and wild fish populations" (a one-year-project).

FRANCE

by

(Henri Grizel)
IFREMER

La production aquacole française 1990 a été répartie comme suit :

- **Salmonidés** : production commercialisée, environ 900 tonnes de truite arc-en-ciel élevée en mer. On peut remarquer la première production notable de saumon atlantique (150 tonnes), dans le cadre du projet SALMOR (élevage en barge flottante).

- **Poissons méditerranéens** : environ 363 tonnes de bar et de daurade (90% de bar), par 34 entreprises. La production d'alevins des écloseries françaises (11 établissements) a été respectivement de 7,7 et 1,7 millions pour les deux espèces, en grande partie pour l'exportation. On peut noter l'apparition de la Pasteurellose, qui a créé un certain nombre de difficultés sanitaires dans les élevages. Le programme de production extensive dans les marais atlantiques a donné des résultats intéressants, cependant caractérisés par une grande variabilité.

- **Turbot** : la production reste marginale (30 tonnes), mais le nombre d'alevins produits a sensiblement augmenté. Plusieurs importants projets de développement sont apparus en 1990, et devraient aboutir à une augmentation sensible de la production en 1991.

- **Crustacés en milieu tropical** : les ventes de crevettes tropicales en 1990 des départements et territoires d'Outre-mer ont dépassé 500 tonnes dont plus de 90% en Nlle Calédonie.

- **Chevrettes** : la production est stable en MARTINIQUE (50 tonnes), ainsi qu'à TAHITI. La production de GUYANE française qui se heurte à de sérieux problèmes de compétitivité sur le marché international est en forte régression.

- **Poissons tropicaux** : une production de Tilapia rouge significative se développe en MARTINIQUE et des progrès sensibles ont été enregistrés à l'échelle expérimentale sur l'élevage du Lates calcarifer (Berramundi) introduit à TAHITI, ainsi que sur l'ombrine sub-tropicale (Sciaenops ocellata) en MARTINIQUE.

- **Productions conchylicoles** : elles ont été de 140.000 tonnes d'huîtres creuses (*Crassostrea gigas*), 3.000 tonnes d'huîtres plates (*Ostrea edulis*) et 600 tonnes de palourdes (*Ruditapes philippinarum*). Les maladies à Protozoaires (*Marteilia refringen* et *Bonamia ostreae*) sévissent toujours dans de nombreuses rivières de Bretagne limitant l'élevage de l'huître plate.

En matière de recherche, on peut noter les éléments suivants :

- **Salmonidés** : premiers résultats encourageants de production de smolts de saumon atlantique de moins d'un an, présentant une forte croissance en mer, et mise en évidence du rôle de l'hormone de croissance dans l'acclimatation à l'eau de mer des parrs de saumon à l'automne.

- **Nutrition** : mise au point d'un aliment destiné au sevrage précoce des poissons marins (SEVBAR), et isolement des fractions de la farine de calmar ayant des rôles de facteur de croissance et de maturation chez les crevettes pénéides.

En conchyliculture les activités de recherche et de développement concernent la gestion des bassins (modèles intégrant la courantologie, les biomasses, des paramètres physico-chimique influençant la capacité trophique), la diversification des élevages (essais de pectiniculture), la mise au point de techniques de télécaptage, d'élevage sur "longligne" en mer ouverte et l'influence du milieu sur les productions conchylicoles. En outre, sont conduits des recherches en génétique (triploïdisation, sélection intraspécifique, hybridation, marqueur génétique, techniques de transfert de gènes), en immunologie (recherche de gènes codant pour des facteurs humoraux, étude fonctionnelle des hémocytes), en physiologie (étude des conditions de maturation, des besoins essentiels pour les élevages larvaires, recherche d'hormones et de facteurs de croissance).

ICELAND

by

(Árni Ísaksson)

Institute of Freshwater Fisheries

The total production of raised salmonids in seawater in Iceland in 1990 was as the following, according to Institute of Freshwater Fisheries statistics.

Species		Quantity
Salmon	(Salmon salar)	2800 tonnes
Brown trout	(Salmon trutta)	20 tonnes

Over 5.6 million smolts were released in ocean ranching operation 1990.

There are two experimental stations in Iceland dealing with the rearing of halibut (*Hyppoglossus hyppoglossus*) and some other marine species, and the production of reared halibut was 10 tonnes in 1990.

THE NETHERLANDS

by

(Renger Dijkema)

Netherlands Institute for Fishery Research

First feeding and growth of glass eel

Acceptation of cod roe and dry feed by elvers was tested. A mixture of both, fed in the form of a frozen paste, resulted a higher growth rate and a higher percentage of growing individuals in comparison with feeding both components separately. In another experiment differences in growth performance were tested of batches of elvers, provenient from different fishing locations in Europe. Despite considerable differences between batches, total biomass increment appeared not to differ significantly after a period of three months under standardized conditions. Unexpectedly, considerable differences in cannibalism among the elvers were observed between groups.

Research into feeding of eels

In a series of experiments, the effects of grading on growth rate were tested by means of brand- tagging a number of the eels. Grading appeared not to result in a higher yield or a more favourite spreading of individual weights within the batches. The growth rate of small animals appeared not to be improved by removing of larger individuals. Also, individuals did not show high growth rates during successive periods: fast growers did not occur.

Technical/biological and economical research into eel culture.

An attempt was made to determine production and elimination of feed rests and fish excretory products in a recirculating eel farm. Water samples were taken during 48 hours from a heavily loaded trickling filter of an experimental farming unit. It appeared difficult to assess the production of suspended material (faeces and food rests). Utilization of dry matter, Phosphorus and Nitrogen appeared to be low: 21, 11 and 16% respectively. The nitrification capacity appeared to be homogeneously distributed over the filter column.

Turbot cultivation in recirculation systems

The principal aspects of feeding in relation with commercial fattening of turbot were the main components of the turbot cultivation project, which in 1990 focused on the relation between macronutrients and increase in weight and fat content of the fish. Commercially available dry feedstuffs appeared to give surprisingly poor or even very bad results; also some especially made high-performance feeds from feed manufacturers gave less good results than fresh fish. For this reason it was decided to work only with home-made moist pellets, based on selected, high-quality ingredients. This made an exact formulation possible and resulted in a very high growth rate and efficient feed utilisation. Two experiments were performed, aimed at determining protein/energy ratios and metabolizability of carbohydrates in comparison with fats in turbot.

NORWAY

by

(Snorre Tilseth)
Institute for Marine Research**ATLANTIC SALMON****Genetics and biotechnology.**

Atlantic salmon (*Salmo salar*) with different trypsin-like isozyme patterns were cross bred. From 33 families, biopsy of pyloric caeca was performed from about 50 smolt of each family to study the distribution of the isozyme pattern and their relative growth rate within the family. Atlantic salmon shows tetraploid characteristics. Within the same family, the fish with the variant TRP-2(92) seemed to grow faster than the ones without. The conclusion of isozyme distribution results must await further interpretation.

The contribution of the isozyme variant TRP-2(92) and growth were observed in 3 different strains of Atlantic salmon parr, Lonevåg, Dale and Voss. The Dale strain which has higher contribution of the allele was significantly bigger than the others with lower contribution. Within Dale strain, the average weight of the fish with the variant isozyme was significantly higher than the ones without.

Since trypsin-like isozyme study has revealed a correlation between genetic variation and growth rate in Atlantic salmon, cDNA for trypsin are cloned to study the genetic background for this observation. cDNA library from pancreatic tissues has been constructed. Twelve of forty positive clones has been confirmed using PCR with primers constructed from conserved regions of trypsin genes. A DNA fragment of predicted length (480 nucleotides) was obtained. Four hundred nucleotides were determined by direct sequencing of PCR fragments. Comparison of deduced amino acid chain showed approximately 80% identity to mammalian's trypsin. The primary sequence showed variation of several nucleotides indicating that the PCR fragments composed of different cDNA which indicated the existence of several mRNAs for trypsin in Atlantic salmon.

Physiology

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

Growth rate studies of salmon postsmolt in closed cages have been carried out. To obtain different temperature regimes during the winter the cages are supplied with water from 25m (warm) and 5m (cold). The effect of different winter temperatures on maturation has been examined.

Physiological effects of freshwater exposure on salmon postsmolts has been studied.

In a tank experiment sponsored by Ministry of Fisheries, individually tagged salmon have been reared under four initial densities from 9 to 79 kg m⁻³ (Mean start weight 1300 g). The ongoing experiment monitors oxygen and total ammonia content in water outlet, individual growth rate, stress, skin coloration and health. The oxygen content are manipulated in each tank, ensuring similar oxygen concentration in current as well as evenly current velocity irrespective of biomass in tank. Densities between 20 and 80 kg m⁻³ seem not so far to have any systematically depressing effects on growth rate or health.

SEXUAL MATURATION

In a feeding experiment (Primo October - Primo February), three different feeds providing three significantly different growth rates as well as condition factors resulted into a significant effect on sexual maturation in females verified by dissection in subsequent summer. Effects of feed availability were also shown, offering feed in small but many portions resulted in higher maturation compared to same feed amounts in fewer but larger portions. Males were not similarly affected.

In a maturation control experiment (sponsored by the Norwegian Fisheries Research Council) on two-sea-winter salmon, a combination of 2 x 9 days of starvation and additional 24 hour surface light reduced sexual maturation with 45% relative to control (untreated). Three other manipulation regimes provided depression effects less than the light/starvation treatment. In

the same project, individual feeding rates were monitored early May in 80 salmon, showing higher feed intake in maturing compared to non-maturing fish. The differences were manifest especially early in each feeding period (fish were fed to saturation in one daily meal).

Behaviour

Atlantic salmon eggs were hatched in flat screen trays or in Astroturf artificial substrate. The alevins were kept under continuous illumination in six different light intensities (3 replicates) from hatching until first feeding. Yolk utilization and growth were monitored. Behaviour of three additional groups, reared in Astroturf or without substrate under minimum (10-3 lux), medium (1 lux) or maximum (10 3 lux) light intensity, were recorded. 3-dimensional swimming activity was registered by two cameras, placed perpendicular to each other, and analyzed by Zeus analysis system. The data are being analysed and the results will be published.

Three groups of Atlantic salmon parr reared under continuous illumination until winter stimulus as change in photoperiod (L:D; 8:16 hours) was presented. One group received winter stimulus before the threshold length (75-mp) was passed, one group at the threshold length and one group when the fish had outgrown the threshold length. A fourth control group received continuous illumination throughout the experimental period. Growth and behaviour were monitored for seven months. Feeding motivation and aggression were compared in different groups, and will be discussed in relation to growth and daylength reduction.

SEA RANCHING PROGRAMME

Within the frame of a National Ocean Ranching Programme aiming at investigating the possibilities of creating an additional livelihood for the coastal population by large scale releases of cod, lobster, salmon and arctic charr,

As a part of the national sea ranching programme we have initiated a full scale sea ranching project on Atlantic Salmon. The project consists of two parts, the remain R&D activities are to be in the vicinity of Bergen, while the full scale operation is located in Helgeland, County Nordland. The Institute of Marine Research started collecting salmon eggs from three rivers in western Norway in 1989. In 1990 these were hatched and reared at Selstø fish farm, Sotra

Island, 40 km west of Bergen. 100 000 of these fish are expected to become one year smolt, and will be released in May 1991. 220 000 eyed eggs from the same three rivers were incubated in late Dec. 1990 at Selstø. An important part of the project is the prophylactic steps taken to ensure that the smolt are disease free when released.

Cod

The Institute of Marine Research has conducted large scale release experiments with coastal cod at different areas in the southern part of Norway since 1983. During 1990, 30.000 reared cod were tagged and released in Masfjorden, western Norway. This was the last of three large scale releases in this fjord. A total of 200.000 reared cod have been released.

Lobster

More than 20.000 reared lobsters (0.5 and 1 year old) were released at Kvitsøy in western Norway in the spring of 1990. This release was the first large scale release conducted by the Institute of Marine Research. The released lobsters showed normal behaviour after release, and no sign of predation was seen. All released lobsters were tagged with internal micro tags.

NUTRITION

Atlantic Salmon (*Salmo salar*) have been feed 8 different periods of time to determine the optimal pigmentation strategy. The concentrations of astaxanthin have been measured in different tissues by analytical methods and the colore of the flesh by colorimetric measurements.

Biological functions of astaxanthin have been studied in different stages of Atlantic salmon. Studies have been done in relation to the survival and development of eggs and yolksac fry, immune response, growth promotion, and anticarcinogenic effect.

Feeding studies with diets containing from 10 to 17 percent ash indicated that increasing dietary ash reduces energy availability to Atlantic salmon.

Diet studies also indicate that casein-gelatin is an acceptable protein source for use in purified diets for Atlantic salmon.

ARCTIC CHARR

Genetics and biotechnology

Two strains of Arctic charr (*Salvelinus alpinus*), an anadromous (Hammerfest, Northern Norway) and a nonanadromous strain (Skogseid, Southern Norway) which have different growth rate and behaviour, can be differentiated by trypsin-like isozyme patterns. A fast growing strain, Hammerfest, has an isozyme pattern similar to the fast growing groups of Atlantic salmon which possess the variant TRP-2(92) allele, an allele which does not exist in slow growing Skogseid strain. Since the Atlantic salmon with the variant allele had a higher specific growth rate during winter than the ones without, this could be a possible reason why the Hammerfest strain which possesses a similar allele can grow faster in cold water in northern area compared to the Skogseid one which does not possess this allele living in waters of somewhat higher temperature in the south.

MARINE SPECIES

Cod

Projects on manipulation of growth dynamics have been conducted. These have aimed at finding methods for controlling the cod's energy investments in growth vs. storage and sexual maturation. In cod culture, gain in liver weight due to lipid storage, and early sexual maturation in both sexes inevitably occur along with high growth rates, probably as a result of excess feeding.

Cod fed two different diets (high and low fat) in two different levels (full and half ration) have been examined. Length and weight were measured on individual cod before and after the feeding experiment. Also growth of gonads and liver size were examined with an ultrasonic scanner. The results show that sexual maturation and thereby gonadal investment can be reduced by a low fat/half ration diet through late summer and autumn.

Also projects on broodstock feeding vs. egg quality have been started. Experimental diets are feed with different levels of vitamin C and different marine oils.

Halibut

The main effort on halibut has been put into the problems of first feeding. Optimal larval age at first feeding was found to be 230 daydegrees after hatching. This finding was based on feeding incidence experiments and larval survival rates. Highest larval growth rates were found at 15 °C, compared to 12 °C and 9 °C. First feeding in "green water" (algal suspension) clearly enhanced first feeding compared to clear water. Also prey capture was better in green water compared to clear water. This was especially pronounced during the three first days of feeding.

Halibut larvae fed wild zooplankton showed increased growth and survival compared to larvae fed on *Artemia*.

In the halibut projects concerning first feeding, development of methods and techniques for full scale production of halibut fry have been included.

Behavioural experiments with halibut larvae have revealed that larvae older than 20 days after hatching respond with positive phototaxis to light as low as 0.01 lux. Feeding behaviour however, is most pronounced at light levels above 1000 lux. Halibut eggs also respond to light. Subjected to light above a certain level, the eggs increase their specific gravity by decreasing the water content and sink. This is probably an anti predator mechanism, efficiently keeping the egg away from the illuminated surface zone. Behavioural responses to stress (turbulence) and prey were also observed. Experiments to reveal quality criteria for halibut eggs have been conducted. So far no clear connection between chemical composition and viability has been found.

Wolffish

A pilot project on reproduction in wolffish (*Anarhicas lupus* and *A. minor*) has been carried out in collaboration with the Biological Research Station at Flødevigen. The objective of the project was to describe some aspects of the reproductive biology, related to gonadal growth in wolffish. Male and female wolffish are readily separated, and ovarian growth monitored by ultrasonography. Seasonal plasma profiles of the sex steroid estradiol-17 β was analyzed

in adult female wolffish. Injection of estradiol-17 β into juvenile *A. lupus* induced *de novo* synthesis of a high molecular weight plasma protein, suggested to be the yolk protein precursor vitellogenin.

Turbot

A start feeding project on turbot larvae has been carried out. The feed consisted of rotifers and *Artemia* enriched with two different marine oils and compared to one commercial enrichment. The oils tested were equally high in HUFAs, but different with respect to lipid classes. The zooplankton enriched with marine oils high in polyunsaturated phospholipids gave significantly better results with respect to growth and survival of the larvae compared to the other marine oil, but similar to the larvae fed zooplankton enriched with the commercial enrichment.

ENVIRONMENTAL IMPACT FROM MARICULTURE

The research activity in 1990 was mainly concentrated on environmental effects of antibiotics and mineralisation of organic matter.

The effects of antibiotics have been studied in a joint project with the University of Bergen. The project include investigations of persistence of commonly used antibiotics, their effect on the sediment bacteria and community and the anoxic mineralisation of organic matter. Furthermore the occurrence of antibiotics in wild fauna was investigated.

The results show that commonly used antibiotics like oxolinic acid and oxytetracyclin remains in the sediment in high concentrations for a relatively long period of time after medication. Total number of bacteria is reduced, the resistance increases strongly, and sulfate reduction rate is decreased. Preliminary investigation shows that wild fish in the vicinity of fish farms may contain high levels of antibiotics shortly after medication, but the concentration decreases rapidly.

Investigations of effects of organic matter from fish farms on the bottom showed the larger fauna disappeared when the sediment thickness reached 20 cm. The decomposition rate as a

function of accumulated organic matter was more than twice as high in sediment with macro fauna compared to sediment without.

A new project was started in 1990 with the aim to study the impact of macro fauna on the mineralisation of organic matter, and to study the connection between sedimentation rate and sediment response.

GENETIC IMPACT ON WILD POPULATIONS FROM FISH FARMING EXPERIMENTS WITH GENETICALLY MARKED BROWN TROUT

A genetically marked population of brown trout (*Salmo salar* L.) was applied as a model to study spawning behaviour and reproductive success of released farmed fish in a river. Genetically marked spawners were released into two spawning areas (A and B) of River Øyreselv, Western Norway. In the higher part of the river, area A, farmed fish could only spawn with freshwater resident trout of a significantly smaller size. In the lower part of the river, area B, however, farmed fish had the opportunity to spawn with wild anadromous trout of similar size.

Fry carrying the genetic marks in heterozygous form as well as in homozygous form have been found, proving that the farmed fish have spawned among themselves as well as with wild individuals. In this study 12.8% of the sampled alleles in area A were attributable to farmed fish, while in area B 7.5% of the sampled alleles in fry were attributable to farmed individuals. Further data on population genetics and populations dynamics are being sampled to study the destiny of the introduced alleles, and to quantify the genetics impact on the wild populations. The relative reproductive success of the released farmed trout are estimated at 18% and 10% of the wild spawners in areas A and B respectively.

DISEASES

Salmon lice

Salmon lice is still the major parasite problem in farming of Atlantic salmon (*Salmo salar*). 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 by 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. 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.

Furunculosis

The hydrophobicity of *Aeromonas salmonicida sub. salmonicida* is studied demonstrating the importance of hydrophobicity as a virulence factor and for the bacteria to exist as a freeliving organism in seawater.

Through infectivity studies Arctic char (*Salvelinus alpinus*) is shown to be susceptible to furunculosis and the gross pathology is similar to furunculosis in Atlantic salmon. By Latent Carrier Test, the possibility of asymptomatic carriers is demonstrated.

Vibriosis

So far, vibriosis has been the most serious bacterial disease in farmed marine fish, causing yearly losses up to 50 % of the total production of cod (*Gadus morhua*) and turbot (*Scophthalmus maximus*) fry. Biochemical, serological and immunochemical properties of pathogenic *Vibrio anguillarum* isolated from different farms, were compared with reference strains isolated from different fish species. According to the results, pilot vaccines for cod, turbot and halibut are produced. The results from field trials are promising. However, further work on vaccine optimization and adjustment to the production line of marine fish, are in progress.

Infectious Salmon Anaemia (ISA)

Infectious Salmon Anaemia (ISA) is spreading and has caused great losses in Norwegian fish farming in 1990. The disease can be transmitted by injection of erythrocytes from diseased fish. ISA is primarily affecting Atlantic (*Salmo salar*) and other salmonides like Arctic char appears to be fare more resistant. Attempts to cultivate the causative agent, have so far failed.

Infectious Pancreatic Necrosis IPN

Infectious Pancreatic Necrosis Virus (IPNV) has in 1989 and in 1990 been isolated from moribund, farmed Norwegian turbot and halibut. All isolates are serotyped to N1. High IPNV titres were detected and histological examinations revealed pancreatic necrosis indicating that IPNV was the probable causative agent of the mortalities. Results from infectivity studies on turbot support this assumption. 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. In 1988 IPNV (N1) was isolated from moribund Norwegian scallops (*Pecten maximus*). In 1989 and 1990 experiments are carried out to investigate the fate of IPNV in scallops and the possibility of scallops acting as disease reservoir and vector organisms.

Shellfish

A new screening program has been started for control of the health and parasite status of bivalve molluscs used in commercial production. Broodstock populations of oysters and clams used in hatcheries and lagoons are the primary subjects of investigation. Histological examinations of Norwegian oyster and clam stocks have not yet revealed any serious pathogens.

Institute of Nutrition, Directorate of Fisheries, Bergen

SALMONIDS - NUTRITION

A large scale feeding experiment on Atlantic salmon fed different levels of n-3 polyunsaturated fatty acids and vitamin E have been running since March 1988 (30 g salmon). In 1990 the metabolism and accumulation of lipids and other essential nutrients in the eggs have been investigated during the sexual maturation of the fish. The chemical quality of the eggs from broodstock fish fed the different diets will be related to the biological performance of the offspring.

The dietary influence of n-3 fatty acids content on fillet from Atlantic salmon was evaluated. Atlantic salmon fed a commercial dry feed were randomly selected from the stock population at the Aquaculture station Matre, and fed ad.lib. an experimental dry feed containing 30% n-3 PUFA in fillet before slaughter, including a time aspect.

Studies have been carried out to evaluate the minimum dietary requirement of ascorbic acid for start feeding Atlantic salmon fry, using ascorbate-2-monophosphate as dietary vitamin C source.

The requirement of dietary vitamin B₆ (pyridoxine) has been evaluated for Atlantic salmon start feeding fry using a semi synthetic diet.

We are continuing our project with the aim of elucidating dietary requirements and interactions of minerals and trace elements in Atlantic salmon.

An experiment was run for three months during start feeding with graded levels of zinc added to a fillet meal based diet. Growth, mortality, condition factor and whole body zinc and iron was measured.

Graded levels of zinc were added to a fish meal based diet and fed to juvenile Atlantic salmon for three months. Growth, feed conversion, serum zinc, organ zinc and whole body zinc was measured.

Two chemical forms of selenium were added to a fish meal based diet at two levels and fed to fish for two months. Selenium concentration in liver, serum and muscle as well as hepatic glutathione peroxidase activity were measured.

Influence of different dietary lipids and vitamin E levels on trace element status during sexual maturation. This is a continuation of the experiment in which the status of trace elements in adult Atlantic salmon has been studied.

Experiments on nutrition and protein metabolism in fish have been carried out. The aim of the studies is to estimate the requirements for essential amino acids and the optimal level of protein relative to carbohydrate and fat in diets to Atlantic salmon. Furthermore studies of the effects of feeding regime as well as swimming activity relative to growth and protein utilization are carried out.

Experiments are carried out to study whether the degree of fish silage hydrolysis affects growth of Atlantic salmon. Atlantic salmon weighing about 300 g are 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. Fish silage, 5 in all, are stored for different periods and are used as moist feed.

MARINE FISH NUTRITION

Cod

The effect of n-3 fatty acids in feed to cod has been studied. Three diets with increasing levels of n-3 fatty acids were fed to cod from 30 g until fertilization. In 1990 the metabolism and accumulation of lipids and other essential nutrition of the fish. The aim of this study was to investigate the effect of dietary long chain fatty acids on egg quality.

An experiment using three different vitamin C levels in feed to cod during sexual maturation was set up to determine the effect of vitamin C on egg quality in cod.

Cod fry, 0.5 grams at start, were given diets with increasing n-3 content to manifest the dietary need for highly unsaturated fatty acids. Growth, survival and retention of fatty acids in liver were recorded.

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 feed to cod and to estimate the limiting amino acids such protein sources. Digestibility studies are included.

Halibut

In co-operation with the Institute of Marine Research, Island, two feeding experiments with halibut have been carried out. In experiment 1 the effects of water temperatures on growth, survival and deposition of nutrients were studied. In a second experiment the effects of different feeds on growth, chemical composition and retention of nutrients were recorded.

Wolffish

In co-operation with the Institute of Marine Research, Flødevigen Biological Station, Norway, two feeding experiments with wolffish were set up. One to determine the effect of dry pellets versus moist pellets on appetite and growth, and one to determine the preferred energy distribution between protein, fat and carbohydrate for optimal growth in feed to wolf-fish.

University of Bergen
Institute of Fisheries and Marine Biology

SALMONIDS

Studies performed in 1990 in cooperation with the Institute of Marine Research regarding growth and parr-smolt transformation in Atlantic salmon have increased our understanding of photoperiod and temperature effects on growth and parr-smolt transformation. Although photoperiod is the major environmental cue for smolting in Atlantic salmon, temperature will significantly affect the timing of development of smolt characters. Continued research has confirmed that Atlantic salmon may be stimulated to complete the parr-smolt transformation as underyearlings.

Photoperiod manipulation of broodstock of Atlantic salmon has resulted in significant alteration of ovulation time. Depending on when photoperiod treatments are performed, Atlantic salmon may be stimulated to ovulated earlier than normal, or postpone maturation. The proportion of maturing fish may also be significantly altered. Studies of growth rate shows that extended photoperiod may increase growth rate of salmonids in seawater.

MARINE SPECIES

Halibut

The early 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. Feeding

experiments with cod juveniles have shown the importance of initial size distribution and grading on growth and survival.

FISH HEALTH

Main areas of studies are basic and applied research on fish disease and profylactic strategies. Studies are carried out in the areas of bacteriology, virology, parasittology, histopathology, imunology and genetic manipulations. The applied research activities focus on vaccines aganinst virus and bacteria, including studies of pathogens, the immune system of the fish, interactions between pathogens, fish and environment.

Norwegian Herring Oil and Meal Industry Research Institute
(SSF), Bergen

SALMONIDS

- * Developing av feed energy evaluation system.
- * Effect of content of water soluble protein in fish meal on growth.
- * Effect of ash content of fish meal (i.e. fish offal meal) on growth.
- * Effect of special product fish meal on growth.

MARINE FISH - TURBOT AND HALIBUT

Optimal consumption of feeds for growing turbot and halibut: Effect of varying protein: carbohydrate: lipid ratios.

FISH FEED TECHNOLOGY

Effect of extruder conditions on the nutritional value of fish feed.

Standardization of fish meal with regard to extrudability.

Feed attractants in fish meal.

National Veterinary Institute, Oslo

RESEARCH ON FISH DISEASES**1: Furunculosis**

- A. Studies of pathogenesis and immune response after infection with *Aeromonas salmonicida* subsp. *salmonicida*, and after immunization with antigens from the bacteria. The aim of the studies is to obtain knowledge as a fundament for the work with obtaining on improved vaccine against furunculosis.
- B. Improving diagnostic methods for the detection of *A. salmonicida*. This work is necessary to be able to diagnose latent carriers of the bacteria. The diagnose is of great significance to health-planning and epidemiological surveys in the aquaculture administration.
- C. Trails of vaccines against furunculosis. Controlled field-trails have shown that losses of fish might be reduced significantly if vaccines are used correctly. Based on epidemiological surveys, valuable knowledge positive and negative effects of vaccinations, is achieved.
- D. Characterization of non-typical *Aeromonas*-species. Different strains have been characterized by biochemical, serological and genetical methods. The State Veterinary Laboratories are reference laboratories for the verification of infection with *A. salmonicida* subsp. *salmonicida*. Reliable methods for characterizations of the bacteria are basic for this work.

2. Infectious Salmon Anaemia (ISA)

- A. Infectious Salmon Anaemia (ISA) is a new disease. The causative agents is not described, and a clinical description of the disease is therefore necessary. Studies of hematological conditions associated with ISA have been given priority.
- B. Pathological aspects of ISA have been described, based on light microscopical and electron microscopical studies. The aim of the electron microscopical investigations has been to identify and describe the causative agents of ISA.
- C. The official authorities have needs for information on disease transmission to be able to make administrative directives. Much effort has been made to investigate the resistance of the causative agents.
- D. A precise diagnosis of ISA is dependent upon a causative agent (probably a virus) which might be cultured. It has not been able to propagate an agent in cell-culture. The stake is now concentrated on finding fish cell cultures which are susceptible to virus growth.
- E. Factors which might be important for the ISA infection are quantified in an epidemiological survey.

3. *Vibrio*-infections

Strains of *Vibrio anguillarum* isolated from salmonid fish species and from several marine fish species have been characterized biochemically, serologically and by numerical taxonomy.

Determination of plasmid size is also used to characterize the strains. This is important to assure that the vaccines used to have the correct compositions. Studies have been performed also with strains of *V. salmonicida*.

4. Paracite-infections

The work has been concentrated on studies of *Gyrodactylus salaris*. Taxonomical aspects are studied in particular. The spreading of the parasite in norwegian rivers has been mapped. The parasitological studies have also as an aim to study the prevalence of of other *gyrodactylus*-species on different fish species.

5. Virus-infections

In addition to Infections Salmon Anaemia, IPN-virus has been further studied. The main aims have been a serological characterization of different isolates, and a clarification of the primary and secondary effects of infections in farmed fish.

6. Immunology and immune prophylaxis

- A. There is a limited body of knowledge on the immune system of salmonid fish species. It has been necessary to establish a series of laboratory tests. These have been used in studies of the specific humoral and cellular immune response in salmonides immunized with different antigenes. A work on mechanisms involved in, and the significance of material immunity is started. One beleive that knowledge on transfer of immunity from genitors to fry in fish, may be applied in immune prophylaxis, as the matter is with higher vertebrates.
- B. In fish farming, several factors influence the protecting immune response after vaccination. Temperature is important. The correction is clarified in vaccination trials with following inoculations with pathogen bacteria.
- C. Immune histochemistry is a field which is widely used within research and diagnostic work. Immune histochemical methods have been established, and are now increasingly beeing used in patho-morphological studies of different fish diseases.

7. Other diseases

"Winter-wounds" on salmonid species has been subjected to further studies to clarify the causative factors, and to describe clinical and pathological aspects. Pancreas Disease and "Cardiomyopathia" are other diseases which have been investigated. The work has been concentrated on discriptions of pathological changes.

8. Gene mapping

The research group at the "Division of Domestic Animal Genetics" has the knowledge on gene mapping on mammals. This work has now been expanded to include salmonid species.

Institute of Aquaculture Research, Ås-NLH

1. INTRODUCTION

The research activities within AKVAFORSK is related to nutrition, breeding and preventive problems. The present note gives a short review of the most important head lines of research activity.

2. SALMONIDS

2.1 Nutrition

A. Feeding dependent factors

- Flesh colour
- Fat content
- Fat quality
- Mineral content
- Synergetic dependence between certain minerals and specific fat content in the feed.

B. Interaction among feed compositions, feeding techniques and waste production.

C. Use of vegetable feedstuff in the diets.

2.2 Breeding

A. Methods for evaluation of breeding values of potential parents of next generation of fish.

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

C. Immuneresponse affected by inheritance and nutrition.

- D. Genetic resistance.
- E. Evaluation of breeding program for Tilapia applicated on Philippines.
- F. Study on breeding in Sea ranching (Island).
- G. Inheritance of resistance againgst Furunculosis.

2.3 Diseases

- A. Interactions between heart-diseases and different nutritienst in the diet.
- B. Pharmacokinety of antibacterial agent in Salmonids.
- C. Reduced amount of antibiotics due to optimalization of doseage regimes.
- D. Bioavailability of oxolinic acid in Atlantic salmon from medicated feed.

3. MARINE SPECIES (HALIBUT)

3.1 Nutrition

- A. Evaluation of startfeeding system
- B. Feeding ration for growth

3.2 Reproduction

- A. Artificial fertilization and handling of eggs until startfeeding period.
- B. Extension of reproduction season by using light.

Foundation of Applied Research at the University of Tromsø,
(FORUT), Tromsø

DISEASES

Fish immunolgy 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 digenstive enzymes in fish larvae.
- Development of assay techniques for monitoring of digestive capacity of marine larvae.
- Development of formulated dry feed for marine larvae.

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

- Moment 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

POLAND

by

(Krzysztof Goryczko)
Inland Fisheries Institute

- (1) Actual research in fishgenetics (brief description of used techniques, aims and species of concern)
- a) Rainbow trout family selection based on 5 strains (third year of realization). Control group of tagged fish reared in commercial farm were analysed (length, weight, gutted weight). Maternal, paternal heterosis effect were calculated.
 - b) The interspecific hybridization among brook, sea, rainbow trout and salmon with and without polyploidization (diploids, triploids and tetraploids) is being realized. The survival, growth rate, karyology and enzyme markers of hybrids were analyzed.
 - c) The programme of "building up" the outbred Vistula sea trout broodstock in SRL Rutki for conservation purposes started in November 1990. Fertilized ova obtained from 131 wild spawners were incubated in Laboratory. Electrophoretic analyses of protein polymorphisms of brood fish was done.
- (2) Planned research in fishgenetics for the next 12 months (continued and/or new):
- a) The results mentioned in 1.a. will enable the selection of 120 brood fish in SRL Rutki to start 60 families in 1991 spring.
 - b) To be continued.
 - c) To be continued.

PORTUGAL

by

(J. Menezes and F. Ruano)
 Instituto Nacional de Investigaçao das Pescas

This report summarizes the research activities concerning mariculture in Portugal being the contributions of different institutions presented separately.

Here follows the institutions included in this report:

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

1. INIP

- 1.1 Aquaculture Department

- a) Finfish:

Sea bass, *Dicentrarchus labrax*, gilthead sea bream, *Sparus aurata*, sole, *Solea senegalensis* and eel, *Anguilla anguilla* were the target species. Research was carried on the physiolog of reproduction, fish behaviour, improvement of juvenile survival rates and health control.

The improvement of eelculture is another objectif, through adequate managemant of glass eels for the increase of survival rate and growth.

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

- b) Shellfish:

Penaeus japonicus adaptation in controlled conditions was continued to achieve continuous spawning and post larvae production.

Molluscs: The improvement of clam, *Ruditapes decussatus*, culture was the main objectif considering that it is the top species of portuguese mariculture. Environmental conditions, management and diseases control are considered to be improved. Studies concerning field adaptation and survival rate of Portuguese oyster *Crassostrea angulata* production were intensified.

Continuous health survey was caried out to establish the epizootology and diseases contol.

Sea scallop, *Pecten maximus*, and flat oyster, *Ostrea edulis*, cultured in off shore systems has been settled by private enterprises along the portuguese coast.

- c) Plankton:

The study of local *Artemia* species and its mass production was intensified, using different diets in different environmental conditions. Rotifers and microalgae mass rearing are managed.

1.2 CRIP - ALGARVEa) Finfish:

Research concerning massive production of juveniles of sea bream and sea bass and field adaptation to extensive and semi-intensive production systems.

Larvae and post-larvae mass production of *Sparus aurata*. Evaluation of nutritional conditions and study of gas bladder formation.

b) Shellfish culture:

The culture of *Penaeus japonicus*, particularly the induced spawning in artificial conditions. Studies on larvae and post-larvae productions, using different diets. Molluscs studies are centered on massive hatchery production of the most important indigenous species: *Ruditapes decussatus* and *Crassostrea angulata*, as well as *Venerupis pullastra*.

Evaluation of survival rates and determination of growth curves for the different species, are the main field jobs.

2. Instituto de Zoologia "Dr. Augusto Nobre"

Growth study of rotifer, *Brachionus plicatilis*, and Artemia, fed different diets, concerning Artemia mass cyst production.

3. Centro de Parasitologia

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

4. University of Algarve

a) Finfish:

- Study on gas bladder inflation process on gilthead sea bream and sea bass and its relation with nutritional factors.

- New techniques for intensive rearing of sea bass fingerlings considering environmental conditions.

b) Shellfish:

Molluscs: improvement of clam spat raising methods and environmental characterization of its culture beds in Ria Formosa.

Crustacea:

- Japanese shrimp semi-intensive culture challenging different seasonal crops.

- Studies concerning different aspects of earthponds building for shrimp rearing.

New species: research was settled on the cuttle-fish, *Sepia officinalis* and the barnacle, *Pollicipes cornucopia*.

SPAIN

by

(Ignacio Arnal)

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Activities in aquaculture research in Spain have continued on the same areas listed in the last annual report.

One important meeting took place in 1990: the III National Congress on Aquaculture. The Congress took place from 24 to 27 September in Santiago de Compostela and more than 150 papers were presented to it. (See Annex 1 for list of papers; people interested on the proceedings of this meeting can address to "Secretaría del Congreso Nacional de Acuicultura; Centro Experimental de Vilaxoán; P.O.B. 208; 36600 Villagarcía de Arousa (Pontevedra); Spain).

Another meeting between representatives of industries and research took place in Madrid. The general aim of this meeting was to increase the cooperation between industries and research bodies.

The annual figures of mariculture production 1989 were:

	Tons	Hatchery production (Units)
<hr style="border-top: 1px dashed black;"/>		
<u>FISHES</u>		
Turbot	271	304 000
Seabass	24	220 000
Seabream	344	9 187 000
Mugilidae	59	-
Seriola	17	
Sole	8	
Tunnidae	237	
Eel	61	
Salmon	150	300 000
Polyculture	90	
<u>CRUSTACEANS</u>		
Shrimp (Penaeus)	87	34 720 000
<u>MOLLUSCS</u>		
Clams	3 885	112 310 000
Oysters	3 289	19 599 900
Mussel	193 010	
Scallops	150	
Others	63	

(Source: Ministry for Agriculture, Fisheries and Food)

Until now, they are not data available about the 1990 productions.

SWEDEN

by

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Introduction

The yield of Swedish aquaculture in 1989 was 7 693 metric tonnes (round fresh weight). The species dominating the culture was the rainbow trout (6 634 tons). Furthermore, there were 241 tonnes of cultivated blue mussels (*Mytilus edulis*) harvested. The total value of the aquaculture production in Sweden in 1989 amounted to about 171 million SEK (approximately 28.5 million US dollars). The compensatory programme for releasing smolts of salmon and brown trout comprised 3.5 million in numbers in 1989, which was the same amount as previous year.

Fishery management

For compensatory purpose 3.5 million smolts of salmon and brown trout were released in 1989 in Swedish rivers.

Species Number of released smolt (1000) in 1989 into
rivers leading to

	Baltic	Lakes	Kattegat	Total
Salmon	2 3 8 8	2 0 7	1 7 2	2 7 6 7
Brown trout	0 5 9 9	1 3 0	0 0 4	0 7 3 3

Commercial production

The commercial production of fish and shellfish in 1989 according to the official statistics (round weight in tons).

	Total production	Marine production
Rainbow trout	6 634	3 565
Salmon	0 771	0 771
Brown trout	-	-
Arctic char	0 098	-
Eel	0 190	-
Total fish production	7693(100%)	4366 (56.4%)
Blue mussel	0241	0241
Oyster	-	-
Freshwater crayfish	0004	-

The fish production has increased slightly compared to the previous year. The mussel production has decreased from 2,556 tonnes in 1987 to 858 tonnes in 1988 and to 241 tonnes in 1989. The number of enterprises engaged in aquaculture was 488, of which 284 produced fish for consumption, 27 produced fish for consumption and juvenile fish for stocking and 128 establishments cultivated juvenile fish for stocking. 5 companies produced blue mussel, 2 oysters and 72 freshwater crayfish. The number of enterprises engaged in fish production, either for consumption or stocking purposes, of various species were as follows:

Species	Number of enterprises
Rainbow trout	258
Salmon	018
Eel	007
Arctic char	023
Brown trout	007
Total	314

Diseases

The number of outbreaks from furunculosis has increased very much in 1990. BKD is still a big threat in Swedish aquacultural operations.

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 (B).
3. The nutritional status of fish, 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 composition (F).
9. Lake water cage culture of arctic char (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 the Baltic Salmon (H).
12. Sea-ranching with Baltic Salmon. Non-river bases experiments with delayed release (H).
13. Feeding behaviour of arctic charr (H).
14. Genetic studies of arctic charr (H).
15. Sociobiological interactions in size and sex structure of Baltic salmon parr populations (H).
16. Disease resistance in stocks of cultivated fish (H).
17. Effects of culture on fish: A genetic and ecological perspective (K).
18. Population regulation in sea trout (K).
19. Genetic and ecological characterization of species and stocks of salmonids (O).
20. Conservation and fishery management work with salmon and brown trout from the Gullspång river (O).

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 (B).

Freshwater crayfish:

1. Investigations 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. Parasites and diseases on freshwater crayfish and other crustaceans (L).
6. Population dynamics of freshwater crayfish and interactions between *Astacus astacus* and *Pacifastacus leniusculus*. (K).
7. The cultivation of crayfish in areas above the natural climatic border distribution (K).

Disease problems:

1. The effects of vibriosis vaccination on the survival and antibody production of rainbow trout and various conditions (J).
2. Investigations on *Aeromonas salmonicida* infections (I).
3. Biochemical and molecular studies on immune reactions in crustaceans and insects (L).

The environmental impact of aquaculture:

1. Biochemical processes in fish farm deposits (M).
2. Nutrient loading models for coastal waters (N).

Research bodies:

- A. Institute of Marine Research, P. O. 4, S-453 00 Lysekil.
- B. Institute of Systems Ecology, Stockholm University, S-10691
Stockholm
- C. Department of Zoology, Stockholm University, S-10691 Stockholm
- D. The Wenner-Gren Institute, Stockholm University, S-10691
Stockholm
- E. Swedish University of Agricultural Sciences, Department of Animal
Nutrition and Management, P. B. 7023, S-750 07 Uppsala
- F. Department of Zoophysiology, Uppsala University, Box 560,
S-751 22 Uppsala
- G. Länsstyrelsen i Norrbottens Län, S-951 84 Luleå
- H. Department of Aquaculture, Swedish University of Agricultural
Sciences, Box 1457, S-901 24 Umeå
- I. Swedish Salmon Research Institute, S-810 70 Älvkarleby
- J. National Veterinary Institute, S-750 07 Uppsala
- K. National Board of Fisheries, Institute of Freshwater Research,
S-170 11 Drottningholm
- L. Department of Physiological Botany, University of Uppsala,
Box 540, S-751 21 Uppsala
- M. Department of Analytical and Marine Chemistry, Chalmers
University of Technology and University of Göteborg,
S-412 96 Göteborg
- N. University of Uppsala, Department of Hydrology, Västra
Ågatan 24, S-752 20 Uppsala
- O. National Board of Fisheries, Fisheries Experimental Station
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UNITED KINGDOM

by

(V. Bye)

Fisheries Laboratory, Lowestoft
and

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BIVALVE PRODUCTION

There were approximately 400 business located at 550 sites engaged in bivalve culture. Three hatcheries in the UK produced around 60 million Pacific oyster (*Crassostrea gigas*) and 50 million Manila clam (*Tapes philippinarum*) seed, valued at £1.1 million. As well as these non-native species, smaller quantities of native flat oysters (*Ostrea edulis*) and palourdes (*Tapes decussatus*) were also produced.

Farmed production of bivalves in coastal waters was as follows:

Species	Production, mt	Value £million
Pacific oyster	600	1.2
Flat oyster	100	0.5
Mussel (<i>Mytilus edulis</i>)	3600	0.5
Manila clam	20	0.1
King scallop (<i>Pecten maximus</i>)	20	0.03
Total	4340	2.33

Total value of hatchery production and farmed production was £3.43 million.

Farmed production of Pacific oysters is expected to increase by 30% per year due to a decline in TBT levels in UK coastal waters.

Constraints to the further expansion of the industry as a whole include marketing, financial pressures and conservational pressures. The latter constraint is particularly applicable to the farming of non-native species.

The Fisheries Directorate is monitoring the impact of shellfish farming on the environment and is assessing the development of triploidy in non-native species. This research, at a cost of £0.4 million pounds, is expected to alleviate some of the conservational pressures.

Fish production

Salmon farming recorded 32,350 tonnes of production in 1990 compared to 28,553 tonnes in 1989, a 13% increase. Estimates of tonnage for 1991 and 1992 based on smolt numbers placed in sea water in 1989 and 1990 and smolt estimates for 1991 show a plateau in production at 33,000 tonnes. This plateau in production will be the first time no increase has been recorded in 10 years of continuous growth. Poor market conditions and poor survival in sea water are the major factors causing lack of confidence. Scotland has exhausted good, and cheap to develop, sea sites, and a variety of new regulations controlling expansion of existing sites and use of pesticide medicines are additional brakes on expansion.

Poor survival at sea, 64% was recorded for the recovery of the 1988 year class of smolts, is mostly due to the combined presence on many sites of furunculosis and sea lice. Resistance to the four licensed antimicrobial drugs has made control of furunculosis by antibiotic therapy impossible at a small number of sites which have had to be fallowed. New vaccines for the control of furunculosis will be field tested this year as will several new treatments for sea lice control.

Rainbow trout production declined slightly to 3,182 tonnes compared to 3,512 tonnes in 1989. Poor trading conditions were blamed for this fall. Trout farmers face increasing controls on the quality of effluents.

Molluscan Production

Molluscan aquaculture produced 457 tonnes of mussels, 1.4 million oysters (native and Japanese combined), 105,000 scallops, 1.4 million queens and trial quantities of clams (*Tapes semidecusata*). All figures show no increase on the previous two years. Some large scale developments in mussel and scallop culture should boost these figures in future years.

A recent report indicates that in the UK as a whole over £5 million was spent on various aspects of aquaculture research. Most was spent on fish with the top priority subject areas as disease control, environmental studies and shellfish hygiene. The report also showed that a large number of undergraduate and post graduate courses in aquaculture were available in the UK.

Due to the problems caused by lice infestation of farmed salmon much interest has been shown in the use of cleaner fish species to control lice. Difficulties collecting sufficient wild fish have directed research to breeding the goldsinney wrasse as a candidate cleaner fish. Initial trials have shown the species is relatively easy to rear to beyond feeding fry stage. The work continues.

USSR

by

(A.A. Elizarov)
(VNIRO)

In 1990 research was proceeded on development of technology of planting material (smolt) rearing and Atlantic salmon farming in the sea water, methods of preventive inspection and treatment of young salmon diseases in the Murman hatcheries, technology of rainbow trout rearing in the White Sea during a summer period.

As a result of studies, the instructions were drawn for rearing the planting material to be used in Atlantic salmon farming in the sea. The instructions include all technological stages of smolt rearing: fishing and keeping of spawners in cages, separation of eggs and milts, egg fertilization and incubation, keeping of pre-larvae in trays placed in running water, change over active feeding of larvae, rearing of larvae to smolt stage in larger cages during the summer period, smolt transportation and planting in the sea water. Standards of smolt rearing are also given.

The studies carried out in 1990 allowed to diagnose and plan preventive measures and ways of treatment of two diseases of young salmon found in salmon hatcheries and known as a kind of "smallpox" and "eye falling".

To improve the technology of summer trout production on the basis of the results obtained in the White Sea in 1990 the norms of trout feeding in cages in the sea water were revised. It is shown that the increase in food amount by more than 1.6 fold as compared to the freshwater fish leads to the food coefficient rise. An actual growth of trout is described by an equation of expected increment with an error not above 5% given the water temperature to be measured at the 1 m depth from the sea surface.