

F - Mariculture Committee

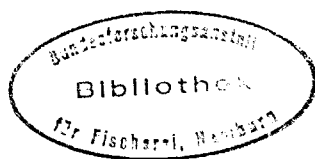
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MARICULTURE COMMITTEE

by

Hans Ackefors

1992

Belgium

by

(Patrick Sorgeloos)
University of Ghent

UNIVERSITY OF GHENT, LABORATORY OF AQUACULTURE & ARTEMIA
REFERENCE CENTER

Development of substitute for live algae in bivalve hatcheries.

Characterization of the microbiological environment in marine fish hatcheries and its relation to the larval health status of seabream, seabass and turbot (in cooperation with the Laboratory of Microbiology, University of Ghent; the Laboratory for Ecology and Aquaculture, Catholic University of Leuven; Cephalonian Fisheries, Greece and Tin Menor, Spain).

Development of disinfection procedures to reduce bacterial contamination levels in live food preparations.

Application of the bioencapsulation technique for incorporating antibiotics and vaccines in Artemia to treat bacterial infections in the larval stages of fish and shrimp (in cooperation with the Laboratory of Medical Biochemistry and Analytical Chemistry, University of Ghent; School of Biological Sciences, University of Thessaloniki, Greece).

Screening for and evaluation of probiotic bacteria for application in marine larviculture.

Effect of processing and storage conditions and diapause termination techniques on hatching quality of Artemia franciscana, A. urmiana and A. sinica cysts.

Development of an off-the-shelf diet for controlled rearing of the brine shrimp Artemia on a laboratory scale.

Study of (phospho-) lipid requirements of marine fish from weaning onwards and postlarval shrimp using a semi-purified artificial diet.

Development of enrichment products containing high HUFA and/or DHA/EPA ratio's and Vit C and their effect on production characteristics survival and pigmentation of turbot, seabass, Macrobrachium and Penaeid larvae.

Development of a culture technique for the super intensive culture of the rotifer Brachionus plicatilis fed on an artificial diet.

Broodstock nutrition studies on seabream (in cooperation with

I.E.O., Murcia, Spain) and Macrobrachium, and its effect on larval quality.

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, Singapore, Spain, Thailand, UK and USA).

Fatty acid and Vit C composition of turbot larvae reared in different culture systems (in cooperation with the Danish Institute for Marine Research and the Instituto Oceanografico, Vigo, Spain).

Consultancy missions regarding Artemia and/or larviculture applications for different official organizations and private companies to Egypt, Norway, Thailand, Singapore, Taiwan, PR China, Vietnam, Philippines, Iran, S-Korea, Ecuador and the USA.

ARTEMIA SYSTEMS *NV/SA*

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

CATHOLIC UNIVERSITY OF LEUVEN, LABORATORY FOR ECOLOGY AND AQUACULTURE

Continuation of research in the farming of European seabass *Dicentrarchus labrax* and eel *Anguilla anguilla*, and initiation of studies dealing with sex-differentiation, controlled reproduction and molecular genetics of marine fish.

Characterization of the bacterial flora in diseased fish (cooperation study with University of Ghent, see above).

The population biology of the recently introduced swimbladder nematode *Anguillicola crassus* is studied in the final host (eel) and in the paratenic hosts (various freshwater fish species). No clear seasonal fluctuations of *A. crassus* have been found in a heavily infected different families have been found infected with third stage larvae of *A. crassus*. All experimental infections in the laboratory were positive.

The role of multicellular parasites in marine and estuarine ecosystems has been studied since 1990. Firstly attention has been paid to the population dynamics of ecto- and endoparasites of fish. The infection dynamics and the dispersion patterns of parasites of the genus *Lernaeocera* (Crustacea) are studied in the North Sea and the Western Scheldt. These parasites show variable degrees of specificity towards intermediate (flatfish) and final hosts (gadoids). In a next step the effect of parasite-induced host mortality on the fish population structure will be estimated. Secondly, the parasite faunas of two sympatric goby

species are studied. Significant quantitative and qualitative differences in their respective parasites were found. This may be due to the pronounced niche segregation which has been documented for these species.

Finally, parasites of marine fish have been collected at the Kenian coast : Several new species were described and their life cycles and intermediate hosts studied.

Canada

by

(R.H. Cook)

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This report is a partial summary of the research and development on mariculture in Canada, based on information provided by researchers in universities, government and private research institutions.

At the national level, the Department of Fisheries and Oceans has appointed a Director of Aquaculture Policy and Planning. This office organized a Canadian Aquaculture Planning Forum in September 1992 involving federal, provincial and industry representatives. Forty-seven recommendations were developed, addressing all aspects of aquaculture development in Canada. In addition, DFO is preparing:

- Amendments to the Fish Health Protection Regulations and the Manual of Compliance. All finfish species, molluscs and crustacea will be covered by the new Regulations (compared to the present regulations which apply only to salmonids). New approaches such as zoning and establishment of national and regional disease surveillance programs are being developed. Client groups are providing significant input during the drafting process. The revised regulations should be ready for implementation in 1994.
- A national policy on transgenic aquatic organisms. "Transgenics" are defined as organisms carrying new genetic material transferred from other organisms. The policy will apply to research with transgenics and release of transgenic organisms, including their use in aquaculture. The purpose of the policy is to minimize impacts of transgenic aquatic organisms. The policy should be ready for implementation in 1994.

A national policy on Introductions and Transfers of aquatic Organisms. This will formalize many of the procedures already established on a regional or provincial basis and ensure national consistency of approaches to the introduction and transfer of aquatic organisms for fisheries management and aquaculture. The policy will take 12-18 months to complete.

Newfoundland and Labrador:

Non-maturing salmonids

The Newfoundland Region of DFO has been working with the salmonid aquaculture industry in Bay d'Espoir to evaluate technology for the production of non-maturing salmonids. A low-cost pressure vessel system has been assembled for inducing triploidy in salmonids. Testing of the pressure apparatus has been very encouraging, both to industry and to DFO. The system is portable, easy to use and preliminary results indicate that the system is effective in producing a high triploid rate among pressure treated eggs. Red blood cell sizes of alevins of the experimental (triploid) and control (diploid) groups have yet to be quantified but is apparent that triploid cells are larger, suggesting a high rate of success among treated eggs. Work over the next several years is being structured to demonstrate the performance of diploid relative to triploid salmonids under marine aquaculture conditions.

Aquaculture Performance of a Newfoundland Salmon Stock

Since 1989, a program to evaluate performance of Grand Codroy salmon stock as a potential source of brood for Newfoundland salmon farming has been underway. Results to date suggest superior performance of the Saint John River stock, relative to Grand Codroy origin salmon, with respect to growth and incidence of maturation. However, mortality of Grand Codroy stock, due to atypical furunculosis, was considerably lower. Though there was a greater incidence of "runts" among the Grand Codroy fish, many of the maturing fish were in this category (i.e., salmon <2.5 kg). All maturing Grand Codroy salmon, plus salmon less than 3.5 kg were eliminated from the Grand Codroy cages in November. A total of 500 Grand Codroy salmon have been retained for potential application to a breeding program to improve the performance of Grand Codroy stock as an alternative brood source for Newfoundland aquaculture.

Cause of Recent Mussel Spat Collection Failure in Notre Dame Bay

Many mussel farmers in Notre Dame Bay, on the northeast coast of Newfoundland, reported substantial losses of settled mussel spat on spat collectors in 1991 and 1992. Analysis of planktonic mussel veliger populations and settled spat at an experimental site within the affected area, indicated the occurrence of settlement stage veligers was much delayed in 1990 and 1991. The settled spat on collectors in the autumn were also much smaller than normal in both these years. Over the winter, the collectors became heavily fouled with a cold water species of red algae, *Polysiphonia flexicaulis*. It is believed that unusually cold water conditions in the spring of 1990 and 1991 delayed mussel development and contributed to the heavy growth of algae which were able to displace the small mussel spat from the collectors.

Bio-economic Modelling of Scallop Culture

Attempts to develop a scallop culture industry in Newfoundland has keyed in on producing a juvenile scallop in the shell as a market item rather than the traditional meat produced by the capture fishery. Biological and technical data collected so far have demonstrated a good potential for industry development. A spreadsheet based model has been developed for use in a bio-economic analysis of the culture industry. Results to date are encouraging but considerable market promotion seems to be necessary before the new product gains widespread market acceptance.

Scallop Spatfall Prediction and Recruitment

A multi-year study by the DFO Gulf Region (Moncton) on the recruitment mechanisms will terminate a multi-year of spatfall prediction and recruitment of giant scallops (*Placopecten magellanicus*) in Port au Port, Newfoundland that will help determine why this particular site is consistently an excellent area for spat collection. A histological study (MSc) examining the gonadal and sexual development of juvenile scallops in suspended culture will be completed in 1993.

Nova Scotia:

The Province of Nova Scotia announced a major initiative for aquaculture development in December 1992. This will involve

environmental surveys along the entire coastline, the designation of aquaculture development areas in such areas as Yarmouth and the Annapolis Basin, and an enhancement in the provision of extension services to support aquaculturists.

A synopsis of the disease, nutrition and molluscan research studies carried out at DFO's Halifax Fisheries Research Laboratory included the following:

Disease

The prevalence of IPN virus (strain VR299) appears to have increased in 1992 in farmed Atlantic salmon in the western Bay of Fundy and east coast Nova Scotia based on the results of disease surveillance programs. Although the virus is present in the carrier state in market fish and does not cause mortality, the increasing prevalence is of concern because the agent is vertically transmitted and can cause serious mortality in early fry stages.

No carrier-state furunculosis was detected in salmon smolts destined for sea cage sites in New Brunswick during the spring monitor program. Clinical outbreaks of the disease were reported at two sites during the spring but these were effectively controlled by oxolinic acid treatment. The recent withdrawal of this chemotherapeutant is causing concern amongst farmers. Although alternate treatments are available, this is the only one currently used to eradicate the carrier state when in New Brunswick.

Bacterial Kidney Disease continues to cause low level, chronic mortality at many salmon farms in New Brunswick and Nova Scotia. The impact of the disease is more severe during the freshwater stage. Vertical trans-mission is controlled through brood monitor programs where the agent is detected in reproductive fluids by the fluorescent antibody technique. Affected eggs are discarded. This program, co-operatively developed by DFO and the provincial government, has been in place in New Brunswick for a number of years. This year a similar program was started in Nova Scotia.

Vibriosis due to *Vibrio anguillarum* biotypes I and II continues to cause some low level mortality at many salmon cage sites in New Brunswick and Nova Scotia in spite of extensive vaccination. Mortalities are effectively controlled with chemotherapy. *V. anguillarum* biotype I has been commonly detected in wild striped bass populations in New Brunswick. Coldwater vibriosis caused by *Vibrio salmonicida* was identified for the first time in a Canadian.

salmon farm in New Brunswick in 1989, it was reported in Nova Scotia in 1990. The disease was identified in two U.S. sites in the Gulf of Maine and one site in Grand Mannan, New Brunswick in 1992. Previous identifications were made in summer when mortalities were minimal. The latest occurrences were in February when water temperatures were close to 0°C; mortalities were high. Previous episodes were effectively controlled by oral chemotherapy in the feed. Oral therapy is not practical when water temperatures are low. Control is currently limited to containment and disinfection of processing wastes.

Basic histological work was done on the eastern oyster, *Crassostrea virginica*, and on cod (*Gadus morhua*) larvae. Although extensively studied species, large gaps yet exist in our knowledge of their normal histology, which leads to difficulties in interpreting pathological states caused by disease and pollution.

Fish immunology research, using an macrophage bactericidal assay demon-strated that virulent strains of *Aeromonas salmonicida* (strains which possess a surface A-layer) are more resistant to the bactericidal activity of brook trout peritoneal macrophages than avirulent strains devoid of an A-layer. The efficacy of two furunculosis vaccines, formalin-killed whole cell and an attenuated live vaccine, are being compared.

Nutrition

A study utilizing casein-corn gluten meal-based diets supplemented with crystalline amino acids was conducted to determine the arginine requirement of Atlantic salmon smolts reared in sea water. Triplicate groups of Atlantic salmon were fed ad libitum diets containing 2.7, 4.1, 5.4, 6.9 and 8.0 g arginine/16.0 g N for a period of eight weeks. Growth, feed utilization and nitrogen retention data showed the requirement of arginine to be 4.1 g/16.0 g N of the dry diet. An arginine requirement of 4.1 g/16.0 g N of the dry diet was also obtained from broken-line regression of expired $^{14}\text{CO}_2$ [(following an intraperitoneal injection of L (U- ^{14}C arginine))] versus dietary concentration. Except for the appetite loss, resulting in a low feed intake and depressed growth, no nutritional deficiency signs were observed in fish fed an arginine deficient diet for 98 days. Several biochemical indices were also remeasured, including liver arginase activity and plasma arginine, insulin and growth hormone levels.

Research on halibut culture technology is currently underway at the St. Andrews Biological Station in New Brunswick. The

determination of the nutrient requirements of the species is a fundamental requirement in order to develop defined diets and research is about to start in this area at the Halifax Lab. This work represents a change from crustacean nutrition to marine, finfish nutrition and, specifically, halibut, a potentially important mariculture species.

Mollusc Culture

Mytilus edulis and *M. trossulus* recently were discovered to co-exist in Nova Scotia waters. Comparative studies on distribution, morphology and reproduction indicated that the two species have maintained purity while occupying the same niche, spawning in synchrony and hybridizing to some degree. The species are difficult to distinguish except as adults when shell length and height differences are most pronounced. *M. trossulus* is slower growing than *M. edulis*. has a lower condition index and shells are longer more fragile and more easily fractured on processing. Methods are being explored to preferentially collect wild *M. edulis* seed where both species exist.

At the DFO Bedford Institute of Oceanography, a multi-disciplinary program designed to quantify the impacts on the environment of salmon farms in the L'Etang Inlet, New Brunswick, included the development, through contract with ASA Consulting Ltd., of a hydrodynamic/water quality model in 1990. The model output provides detailed maps of both the hydrodynamics (tidal currents and flushing), and altered water quality (enhanced plant nutrients and lowered dissolved oxygen levels) arising from waste released from existing or proposed new farm sites. In terms of impact on dissolved oxygen levels, the original model provided only a mapping of the oxygen deficits arising from the decomposing salmon farm wastes (BOD). However, respiration by the salmon held in the cages also extracts large quantities of dissolved oxygen as the water is flowing through the cages. The addition of a new software package (NAUTILUS), provided through contract with ASA, enables the user to include both respiration and BOD, and view the resulting reduction in dissolved oxygen distribution throughout the Inlet. NAUTILUS provides an integrated tool for environmental analyses and modelling. It is designed as a shell, a program that can run other applications within it, so that the user can acquire different configurations depending on their applications. The package also provides increased flexibility in visual displays, including such things as smoothing of data, colour changing, adjustment of contour intervals, etc. This new software system is presently installed on PC's at BIO.

This set of models for the prediction of the environmental impacts of fish farm effluents was developed and presented at several meetings, including workshops in St. Andrews and international conferences in Kiel and Hamburg, Germany. These have been incorporated in a preliminary version of a Decision Support System (DSS) which will be used to combine models with environmental data bases in a form what can be used directly by regulatory bodies. A prototype of the DSS was completed and demonstrated at conferences in Kiel and Hamburg, and the underlying concept was the subject of an invited talk at the ICES Statutory Meeting in Rostock.

A 3-year program to provide baseline data on the taxonomy and numbers of phytoplankton present in the coastal waters of Nova Scotia was completed in December 1992. These data are presently being analyzed and the information will be published in the near future. Two coastal sites have been selected for the continuation of this program and a long-term commitment has been made for their support. The principal objective is to acquire a long-term data base on the concentration and species of phytoplankton normally found in these waters for the purpose of determining temporal changes, particularly in the occurrence of toxic algal blooms in proximity to shellfish aquaculture sites.

Other research projects at BIO include:

(a) Physical Oceanography in Conjunction with the Phytoplankton Monitoring Program

A CTD has been fitted with an oxygen sensor for aquaculture impact studies. Physical oceanographic data from this monitoring program is of use in mariculture related decisions.

(b) Exchange Between Offshore Waters and the Estuaries, Inlets and Coastal Embayments of the Scotia-Fundy Region

Work continued on the documenting and classifying water exchange in various types of inlets. These results will have application in fields of mariculture, waste disposal, recreation, etc.

(c) Long-Term Temperature Monitoring (LTTM)

Instrumentation was upgraded to yield more accurate estimations of extreme low temperature events (especially important for salmon aquaculture). Additional sites were chosen in areas with potential for mariculture development. This project continues to be valuable, yielding rapid access to basic regional statistics of marine water temperatures in coastal areas.

(d) Classification of Estuaries, Inlets and Coastal Embayments

This involves the development of a proto GIS System to answer "simple" questions about the hydrography of various coastal inlets (e.g., inlet area/depth, exchange rates, freshwater discharge, etc).

(e) Nutrient Dynamics in Ship Harbour, Nova Scotia

This project studied the complicated nutrient chemistry of this site with possible application to mussel mariculture problems in 1991 (red mussels).

New Brunswick:

Mariculture research is carried out at a number of research institutions with the general focus on finfish in the Bay of Fundy and shellfish in the Baie de Chaleur and Northumberland Strait.

The Salmon Genetics Research Program of the Atlantic Salmon Federation serves as the primary breeder for the New Brunswick Salmon Growers' Association. A selection index on pedigreed stock involves percent S1 smolt, percent non-grilse, market size and bacterial kidney disease resistance. Gains from selection are being monitored through the use of control lines.

The rearing through fry and parr stages of two families versus a single family per tank, reveals that families shift rank for growth in the two systems. Selection, therefore, on a population of fish that has all been grown in the same tank or cage, involves a component of competition. The use of 13 cm as the smolt cut-off length (in February) has been discontinued in favour of 16 cm length, showing improved smolt performance in sea water.

Work also continues on developing triploid Atlantic salmon for possible use by the Canadian aquaculture industry.

Investigations have begun on possible genetic interactions between wild salmon and aquaculture escapees on a salmon river in close proximity to the aquaculture industry in the Bay of Fundy.

At DFO's St. Andrews Biological Station, the following research is underway:

Atlantic Salmon

An experiment using 6, 12 and 18 mo photoperiods reaffirmed that smolting commences during the season of decreasing day length; sexual maturation begins during increasing day length. Certain size/energy thresholds are necessary for commencement of these activities. Photoperiod entrains the onset and completion of these processes. It is possible to regulate the timing of smolting and sexual maturation through photoperiod manipulation.

Coronary arterial lesions (arteriosclerosis) are first seen in juvenile Atlantic salmon and continue to develop through all life stages. Rate of increase in incidence and severity of lesions is directly related to growth rate.

Provision of extended day length with artificial lighting on sea cages during fall-winter resulted in enhanced growth rate but increased maturation as grilse.

Sexual maturation of male salmon parr does not preclude completion of smolting the following spring. If mature males are large enough when they mature, they can commence smolting and perform as well after transfer to sea water the following spring as previously immature smolts.

Deprivation of feed during alternate week periods in autumn-winter and/or winter-spring of the first post-smolt winter in sea water resulted in a lower incidence of maturation as grilse. This work with a Canadian stock of Atlantic salmon in the Bay of Fundy environment confirmed earlier work in Scotland.

Striped Bass

Yolk utilization and growth of striped bass (*Morone saxatilis*) larvae were studied at three salinities (1, 5, 10 ppt) and five temperatures (14, 16, 18, 20, 22°C). A salinity of 5 ppt produced larger first-feeding fry than did 1 or 10 ppt at all test temperatures. Larger

first-feeding fry were obtained at 14 and 16°C than at higher test temperatures.

Water uptake of halibut eggs during hardening was investigated at five salinities (22, 27, 32, 37 and 42 ppt). Water uptake was reduced at 37‰ and abolished at 42 ppt.

Marine Fish

Lumpfish (*Cyclopterus lumpus*) larvae were successfully feminized by feeding them artemia which had been fed a diet enriched with 17 B-estradiol. Incorporation of the hormone into artemia was also verified.

Research on the culture of Atlantic halibut and haddock continued at the Biological Station in St. Andrews. This included studies on Atlantic halibut ongrowing in a modified salmon cage and a bottom cage. the results indicated good growth and survival rates in the Bay of Fundy area. Several thousand first feeding halibut fry were produced but problems with larval quality and food availability resulted in no survival three weeks past first feeding.

A research program was initiated on the culture of winter flounder at the Huntsman Marine Science Center in St. Andrews. This species shows strong potential for commercial development in the Bay of Fundy.

Research at DFO's Gulf Region research centre at Moncton was focused on the following topics:

Parasites and Diseases

A multi-year survey of the parasites and diseases of the main shellfish species (mussels, eastern oyster, European oysters, giant scallops, bay scallops and quahaugs) used in Mollusc Aquaculture in Atlantic Canada was completed. The results of the baseline survey are being summarized into a document describing and illustrating the common parasites and diseases of the commercially important mollusc species in Atlantic Canada. Transmission experiments with *Perkinsus karlssoni* from bay scallop will terminate in 1993. There has been no evidence of parasite transmission among species thus far which will result in the lifting of the moratorium on Bay Scallop aquaculture activities in P.E.I in 1993.

Oysters

DFO (Moncton) initiated a 5-year study of oyster seed performance used in the aquaculture production of cocktail oysters (*Crassostrea virginica*). Seed collected from sites in New Brunswick and P.E.I. will be used in a reciprocal transfer experiment to examine the environmental and genetic factors influencing survival and production. This is a collaborative project with NBDFA, PEIDFA, Université de Moncton and oyster aquaculturists.

Mariculture research conducted by the University of New Brunswick included the following:

Parasitology

Parasitology research centered on sea lice (*Lepeophtheirus salmonis*, *Caligus elongatus*, and *C. curtis*), sealworm (*Pseudoterranova decipiens*), and other anisakines as parasites of cultured Atlantic salmon. There are indications that sea lice are attracted to light, prefer surface rather than deeper water and are found in larger numbers in warmer water. Salmon naturally infected with sea lice have no immune response to them; work is underway to examine the effects on the immune system of crude vaccinations with sea lice extracts. A similar approach has demonstrated that the immune response to challenge with sealworm prevents any infection in Atlantic salmon following injection with macerated sealworm larvae. Research is underway on developing methods to interfere with, and thereby interrupt, the life-cycles of these parasites, on determining the sibling status of marine anisakines in seals and on developing a predictive model of their population dynamics.

Bacterial Diseases

Bacterial disease work centres on developing rapid, reliable tests to detect disease in cultured Atlantic salmon. The objective is to provide growers with accurate and sensitive systems for checking disease status in their fish stocks at any time. Bacterial kidney disease (BKD) is the disease for which methods are being tested and basic work with furunculosis has also been done. Progress has been made on developing and testing immunological assays and investigating the detection of asymptomatic infections. Research on development and testing of DNA probes and PCR amplification for BKD detection is presently being carried out.

Triploidy

Triploidy research centres on determining the suitability of triploids as sterile fish for the aquaculture industry. Mixed-sex triploids have been produced of brook trout, Arctic char and, in collaboration with the Atlantic Salmon Federation, Atlantic salmon. In the latter case, a 2-litre commercial-scale pressure vessel designed and constructed in New Brunswick was used. Hormonal sex control as a means to produce all-female triploids is being developed for Arctic char and Atlantic salmon. Experiments completed in 1992 demonstrated that triploid and diploid salmonids are no different in their primary and secondary responses to an acute handling stress, their critical thermal maxima or their learning abilities.

Development of a Bioassay for Growth in Cultured Salmonids

This research is designed to determine whether ornithine decarboxylase (ODC) activity can be used as a simple bioassay for growth rates in cultured salmonids subjected to environmental, nutritional or hormonal growth stimuli. Preliminary results showed that hepatic ODC activity is extremely sensitive to starvation and refeeding, and to the injection of mammalian growth hormone. More recently, a clear relationship between epaxial muscle ODC activity and specific growth rate has been demonstrated for underyearling Atlantic salmon exposed to four different photoperiods.

Molluscan Shellfish

The focus of the molluscan shellfish research is on establishing the relationships between quality of food supply, rates of particle uptake and utilization and growth rates. Techniques of physiological energetics are being used to construct energy budgets and provide predictive equations of physiological rate functions for feeding, respiration, etc. This information, along with knowledge of local oceanographic conditions, can then be used to select the most appropriate sites for grow-out and to predict the carrying capacity for potential aquaculture sites in Atlantic Canada.

Prince Edward Island

Two important highlights in P.E.I. mariculture in 1992 were:

- (i) the lifting of a moratorium on the commercial development of the Bay scallop, based on scientific reassessment; this moratorium was put in place because of the concern that the parasite *Perkinsus karlsoni* might be transferred to indigenous commercial bivalve species.
- (ii) the positive results from rearing trials for the culture of sea scallops.

Quahaugs

A two (2) year study on the growth of quahaugs *Mercenaria mercenaria* in P.E.I. is now concluded. Environmental (biological, physical and chemical) and genetic factors were evaluated in order to improve the knowledge on site and stock selection for aquaculture consideration. Based on the information collected from this study and information gathered from commercial quahaug farms in the U.S.A., experimental quahaug aquaculture is continuing in DFO's Gulf Region.

Mussels

DFO (Moncton) completed a 3-year study examining the influence of genetic and environmental factors on summer (and seasonal) mortality of P.E.I. mussels (*Mytilus edulis*) using a reciprocal transplant experiment with 6 study sites. Results from the 2 field experiments show clearly the inter-annual variation in mortality and growth of the different seed sources. Mortality appears directly related to the geographic source of the seed and indirectly to the prevailing water temperatures of the grow-out site. Some sources of seed performed equally well between experiments while others performed equally poorly. The possibility that this is a result of thermal preconditioning of the larvae and spat in their native site is being examined. Shell growth, however, appears under more direct control of the environmental conditions of the grow-out site, with some mussels growing more slowly in some estuaries (Murray River) than other during the study.

Quebec:

Mariculture research at the DFO Maurice Lamontagne Institute concentrated on two species.

Cod

While cod have been shown to be very tolerant to low salinities (>5ppt) (they acclimate rapidly, with no sign of stress, they have similar resistance to hypoxia and they exhibit 100% survival), it was further shown that cod do benefit from intermediate salinities.

For example, growth was 104% over 2 months in the spring (10°C stable temperature mean size of 300 g) at a salinity 14 ppt, compared to 82% at a salinity of 28 ppt (local sea water). Growth rate was lower in the fall, probably because specimens were of larger size (700 g) and starting to mature, but growth was nevertheless faster at 14 ppt than at 28 ppt. Superior growth was associated to better conversion ratios.

A preliminary project to study the influence of density of growth of cultured cod showed that growth decreased significantly (-20%) with increasing densities between 2 kg/m³ and 50 kg/m³. This reduction in growth was associated with smaller food intake while conversion ratios were relatively stable.

Further research in 1993 will attempt to develop feeding strategies to promote better growth at higher densities (starting densities of up to 50 kg/m³).

Growth experiments showed that the activity of key enzymes were correlated with growth and can be used as a reliable indicator of good or poor growth status. This tool should be valuable in research to develop suitable culturing conditions but could also be used in the field to monitor the growth conditions of wild cod over time and space.

Snow Crab Aquaculture

Snow crab is considered as a valuable species for aquaculture. Current projects aim at increasing the availability of fresh crabs on the markets off season. Snow crabs were deprived of food and kept at a density of 28 kg/m² and temperatures ranging from 0 to 10°C for periods up to 6 months. Preliminary results show that crabs survive well to low temperatures with a slow depletion of muscle mass and a slight increase in muscle moisture content. The analyses are in progress to show the patterns of depletion of energy stores.

Research at the Département d'Océanographie, Université du Québec à Rimouski is placing emphasis on the developmental biology of giant scallop *Placopecten magellanicus*. Analysis of kinetics of meiotic and mitotic divisions under the various

temperatures, salinities and pH. studies include the production of triploid giant scallop.

The Centre Oceanographique de Rimouski have the following studies underway:

1. Post Mortem Biochemistry of Aquatic Species:

The preservation and/or recovery techniques of value-added components (amino acids, nucleosides, flavouring agents, omega 3 fatty acids, carotenoid pigments) of fish (roe and flesh) and shellfish waste are studied, as well as their potential use in human and aquaculture species nutrition.

In order to minimize protein denaturation of trout fillets during the frozen storage, some cryoprotective agents were identified and used in a preliminary dehydro freezing treatment. Shrimp waste silage (pH=2) was shown to efficiently protect some valuable but fragile molecules like astaxanthin forms (carotenoids) and long chain polyunsaturated fatty acids (PUFA) for at least 4 months at 5-10°C. Nine week feeding trials with brook trout (*S. Fontinalis*) showed that 10% shrimp waste silage inclusion in a dried pelleted diet induced some small astaxanthin accumulations in flesh and skin without significant effect on growth rate. Some technico-economic parameters were identified for optimization of surf clam (*Spisula solidissima*) production.

2. Environmental Physiology and Ecotoxicology

The studies of the seasonal physiological response to life in estuarine waters in various anadromous and marine species are underway (brook char, Arctic char, Atlantic cod and American plaice). The objective of this work is to exploit the use of St. Lawrence estuary water resources for fish production.

3. Reproduction du Pétoncle Géant

Les travaux portant sur le contrôle de la maturation du pétoncle géant en dehors de la saison normale de reproduction et sur la congélation des spermatozoïdes et des embryons de mollusques d'intérêt aquicole important permettent de réaliser des productions larvaires hivernales en vue du transfert des naissains en milieu naturel dès le début de l'été.

4. Production de Biomasse Algale

Des recherches se poursuivent sur le développement de l'optimisation des procédés de cultures d'algues en vue de leur application dans des activités aquicoles (conchyliculture) et dans la valorisation de la biomasse algale en agro-alimentaire.

British Columbia:

The following studies were carried out by the Aquaculture Division, DFO Pacific Region:

Research and Development Activities at West Vancouver Laboratory

Research continued on the development of monosex female culture technologies for chinook, coho and Atlantic salmon, including direct feminization, sperm from masculinized gynogens and development of new sex specific DNA probes. Studies are also underway on the reproduction of monosex female triploid salmon, including the development of tetraploid fish as a source of diploid sperm.

Significant progress has been achieved in the development of early smolting, fast growing transgenic salmonids using "all fish" and "all salmon" DNA constructs. Progress has also been achieved in the development of efficient means of administering proteins of the somatotropin-prolactin family to salmonids to accelerate smolting and growth. Success has been achieved on a laboratory scale in the complete replacement of fish meal in trout diets with a specially processed plant protein source. Considerable cost savings have also been realized in the feeding of farmed salmon through the appropriate application of feed cycling technology.

DNA probes have been used to detect stock specific genetic variations in chinook, chum and coho salmon. In a selective breeding program for coho salmon, the rate of smoltification (as 0 age fish) and salt water size have been increased in two generations of selection.

Fish Culture Research at the Pacific Biological Station - Nanaimo

A pilot-scale rearing experiment was continued with ocean-type and stream-type chinook and their hybrids to compare their suitability for stocking in netpens at S0 and S1 smolts, demonstrating significant differences in growth and age at sexual

maturation in relation to age at sea water transfer. Captive sablefish which had been conditioned in chilled water became sexually mature and ovulated spontaneously for the first time. A program was initiated with growth of the toxic alga *Nitzschia pungens* in the laboratory and study of the transference of the toxin domoic acid into commercially important species.

Research for 1992 by Fish Health Section at the Pacific Biological Station is divided into two broad areas: finfish and shellfish investigations:

(a) Finfish Studies - Diseases of Salmonids Farmed in Sea Water:

Plasmacytoid leukaemia (PL) is a common disease in pen-reared chinook. Recent studies strongly suggest that PL is caused by new retrovirus, called SLV - salmon leukaemia virus. This conclusion was reached by transmission studies using 0.22 μ m filtrates, conducting assays for reverse transcriptase (an enzyme unique to retroviruses), visualization of the virus by electron microscopy, and characterization of the viral proteins.

Ivermectin has been proposed as an oral treatment for sea lice on farmed salmonids. Experiments were conducted to determine the toxicity of ivermectin to chinook, coho and Atlantic salmon and steelhead trout. Coho salmon showed the highest tolerance to the orally administered drug, followed by chinook, then Atlantic salmon. There was no evidence of pathological changes in the major organ systems which could be attributed to the feeding of ivermectin. No treatment associated mortalities or effects on fish behaviour were noticed during this study. Also, experiments were initiated to determine the toxicity of hydrogen peroxide to chinook and Atlantic salmon, as well as to determine its efficacy against *L. salmonis*.

The first outbreak in sea water of infectious haematopoietic necrosis (IHN) occurred in cage cultured Atlantic salmon. In relation to this finding, it is of interest that the IHN virus has for the first time been isolated in returning wild sockeye while the first were still in sea water. Virus titres in the visceral tissues indicate that the virus was replicating in these sockeye.

A rickettsial bacterium, similar to *Piscirickettsia salmonis* reported to cause significant mortalities among sea cage cultured salmonids in Chile, has been isolated from Atlantic salmon and Pacific salmon in B.C. The bacterium was found only in sea cage reared salmonids and in each case mortalities were low. The serological relationship between *P. salmonis* and the B.C. isolates is being investigated. The rickettsial agent has been successfully cultured using tissue culture methods.

Netpen liver disease (NLD) is a common toxicopathic disease of Atlantic salmon smolts during their first summer in sea waste netpens. Recent research results indicate that microcystin is probably the cause of the disease. This toxin is a well-recognized liver toxin that is produced by freshwater blue-green algae and has recently been detected in the marine environment in sponges, mussels and in the liver of fish with NLD. Affected fish probably contract the disease by feeding on invertebrates that carry the toxin.

Bacterial kidney disease remains an important fish health concern in B.C.'s aquaculture industry. Attempts to produce a vaccine against the causative bacterium, *Renibacterium salmoninarum*, by testing the effect of immunomodulators were unsuccessful and showed no promise.

Research on the proliferative kidney disease (PKD) has shown that chinook smolts from enzootic waters may enter the sea water with subclinical infections and then later develop the disease. Fish with PKD in sea water exhibited elevated plasma magnesium levels, indicating that these fish have impaired osmoregulatory capabilities. Therefore, PKD may affect sea water survival of stocks of fish from enzootic river systems.

(b) Shellfish Problems - Cultured Oysters and Scallops:

A protozoan of unknown etiology (named SPX) occurred again in cultured Japanese scallops with resulting mortalities exceeding 90%. During this occurrence, additional morphological forms were observed in the juvenile scallops.

Procedures were developed for isolating the microcell protozoan, *Mikrocytos mackini* (that causes Denman Island disease in Pacific oysters, *Crassostrea gigas*) from tissues of infected oysters. The isolated microcells were used in the preparation of monoclonal antibodies that will eventually be incorporated into a specific and sensitive diagnostic technique. Preliminary host specificity studies,

conducted by inoculating isolated microcells into oysters, indicate that other species of oysters (*Crassostrea virginica*, *Ostrea edulis*, *Ostreola conchaphila*) are more susceptible to infection than the usual host, the Pacific oyster.

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CANADIAN MARICULTURE PRODUCTION STATISTICS
(1992 ESTIMATES)

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ATLANTIC COAST:

Newfoundland and Labrador

	<u>m t</u>	<u>CDN \$(000's)</u>
Blue Mussel	147.5	275.0
Sea Scallop	1.0	6.5
Atlantic Salmon	24.5	222.0
Steelhead	70.0	490.0
Rainbow Trout	15.0	50.0
Arctic Char	1.0	7.5
Cod	2.0	3.2
Subtotal	<u>261.0</u>	<u>1,054.2</u>

Nova Scotia:

Blue Mussel	194.571	319.875
American Oyster	51.508	90.345
European Oysters	6.298	19.800
Atlantic Salmon	625.0	4,812.5
Steelhead	285.0	1,567.5
Rainbow Trout	179.162	1,168.643
Subtotal	<u>1,341.539</u>	<u>7,978.663</u>

Prince Edward Island:

Blue Mussel	4,020.0	4,400.0
American Oysters	1,300.0	2,000.0
Arctic Char	15.0	210.0

Rainbow Trout	16.0	158.0
Speckled Trout	(eggs and fry only)	32.0
Atlantic Salmon	(parr and smolt only)	30.0
Subtotal	5,351.0	6,830.0

New Brunswick:

Blue Mussel	125.0	137.5
American Oyster	114.0	300.0
Atlantic Salmon	10,000.0	82,500.0
Rainbow Trout	375.0	2,351.0
Subtotal	10,614.0	85,288.5

QUEBEC:

Atlantic Salmon	80.0	460.0
Blue Mussel	110.0	225.0
Subtotal	190.0	685.0

PACIFIC COAST:**British Columbia:**

Marine salmonids (Chinook, Coho, Atlantic Steelhead Salmon)	22,400.0	110,000.0
Rainbow Trout	125.0	715.0
Pacific Oysters	5,000.0	4,000.0
Manila Clams	200.0	700.0
Subtotal	27,725.0	115,415.0

TOTAL ESTIMATED CANADIAN MARICULTURE PRODUCTION (1992)	45,482.54	217,251.36
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FINLAND

by

(Timo Mäkinen and pekka Tuunainen)
Finnish Game and Fisheries Research Institute, Helsinki

I Production

1.1. Fish farms and the production

Production of fish for human consumption increased rapidly in the 1980s and has reached 19,271 million kg (99 % rainbow trout) in 1991, of which only 4 068 tons was reared in fresh water. The total production was a little more than in 1991 when the production for the first time in ten years decreased. 79 % of the fish is reared in brackish water in net cages. The value of the food fish production in 1990, calculated as the producer price, was 70 million USD (1 USD = 5.5 FIM).

The amount of rainbow trout exported were increasing since mid 1980's and was approximately 3000 tons/a ungutted fish till beginning of 1990's (Table 1). Less gutted fish is exported nowadays than in the beginning; in 1990 already half of the amount consisted of filets. Because of the devaluation of the Finnish currency a new increase of export is waited to take place in coming years.

Table 1. The export of rainbow trout in Finland in 1990 - 1992, gutted weight, according to the Custom Statistics

Year	Export thousand t/a
1986	236
1987	782
1988	3830
1989	3073
1990	3057
1991	1179
1992	1709

In 1990 the total number of fish farms in Finland was 370 (45% in inland water) and in addition natural rearing ponds were used with a total area of 8 271 hectares. The rainbow trout is practically the only fish species farmed for food in Finland, although a few attempts have been made to develop the farming of Baltic salmon, whitefish and arctic char in net cages in brackish and fresh water. There is also growing branch of crayfish farming.

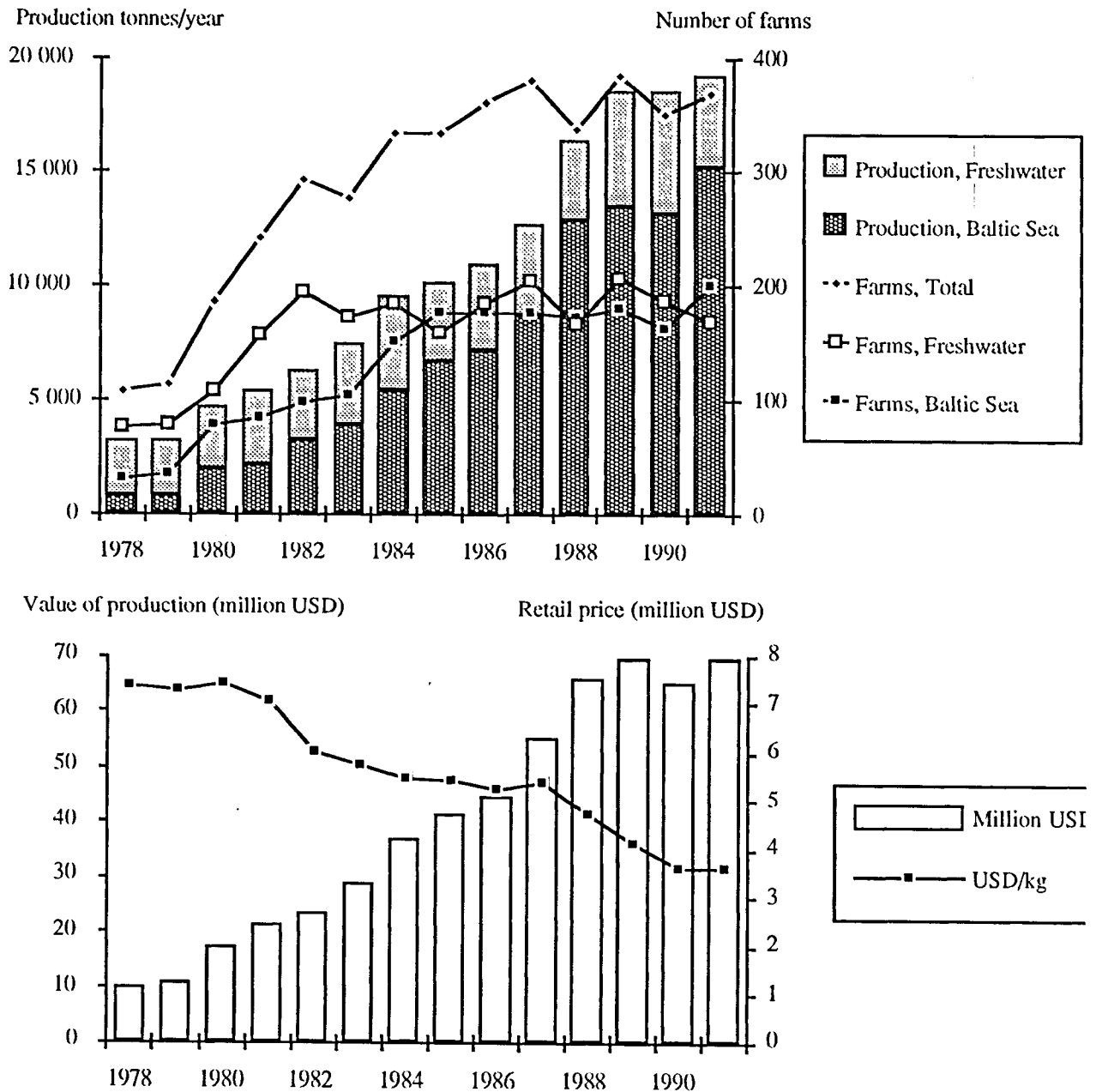


Figure 1. Production amount, number of farms and the value of production (without corrections) with the average retail price (The effect of inflation corrected according to the index of living costs in Finland) in US dollars (exchange rate used 1 USD = 5.5 FIM).

Fish for stocking are produced either intensively in land-based fish farms (mostly salmonids) or extensively in large ponds with a natural food supply (mostly whitefish, grayling, pike and pike-perch and some cyprinid species). Many farms producing rainbow trout also rear other salmonids for stocking. In 1991, the number of salmonids produced for stocking purposes, excluding newly hatched larvae, was 13 million. The natural freshwater rearing ponds produced about 49 million mostly one-summer old juveniles. In 1991, the

value of juvenile production of rainbow trout was about 20 million USD and that of other species produced for stocking purposes in natural waters about 17 million USD.

1.2. Introductions

During 1991 and 1992 the animal health authorities permitted the import of eels (120 000 and 113 000, respectively) from Swedish quarantine for stocking purposes of some small lakes in southern Finland.

II FISH DISEASES

The official Fish Health Control system conducted by National Veterinary Institute was replaced by a new program during 1992. New dangerous bacterial diseases were not observed in 1992.

At the beginning of 1980's vibriosis was the most important fish disease in Finland. Vaccination against vibriosis has been fairly effective and thus other bacterial diseases have now become more important.

Furunculosis occurs not only in coastal regions but also in some freshwater hatcheries. Furunculosis was diagnosed in 48, 85 and 43 different farms during 1990, 1991 and 1992, respectively. Most of the farms are situated in the archipelago and the coastal area of the Baltic Sea, where also most of the rainbow trout production takes place. Effective vaccines against furunculosis are not yet available and thus therapeutic antibiotics are commonly used with results in residues and eventual bacterial resistance.

Bacterial kidney disease (BKD) has been diagnosed in one farm per year during 1989-1992, all of which are on the island of Ahvenanmaa. The mainland is still free of BKD. Transport of eggs and live fish from Ahvenanmaa to the continent is prohibited.

IPN virus was isolated seven times during 1992 in comparison to 7 isolations from different farms during 1990 and one in 1991. There has not been clinical signs of IPN.

III RESEARCH

3.1. Fish and fish farm effluents

The main factor limiting the growth of the fish farming industry in Finland is the problem of fish farm effluents. In fresh waters, the main nuisance is eutrophication caused by phosphorus; organic loading and direct oxygen uptake are of less importance. Net cage farming on the Baltic coast can

cause changes in the primary production because of nitrogen loading.

Fish farming is mainly increasing in the sea (see Figure 1). A new project aimed promoting the use of herring as raw material for the feed used in Baltic aquaculture was started in 1990. This was done in order to reduce the nutrient loading coming to the Baltic Sea from outside the region. Because there is no manufacturer of fish meal based on the Baltic herring fishery the use of herring is based on the direct use of the fresh fish. For this reason, as a first step, the effect of the herring content in the feed on the growth and the consequent nutrient load in fish farming has been studied. In 1992 a separate supplementary feed to be used as an addendum with pure chopped herring feeding was tested and the results were promising: the growth was better and nutrient load markedly lower than with pure herring diet.

If the herring were used as a basis for feeds in Baltic fish farming, it should be possible to double the recent production without increasing the nutrient load. The decision to reduce nutrient load before 1995 to half of the level of 1987 would still be attainable (Ruohonen & Mäkinen 1991).

3.2. Environmental changes threatening fish farming

Increased mortality of eggs and newly hatched larvae has been observed in salmon egg batches supplied from natural spawning fish. In Finland culturing of brood fish for egg production at fish farms is a common practice and only some eggs are taken from natural spawners. In cultured brood fish eggs or newly hatched larvae no increased mortality has been observed.

The reasons of increased mortality, called M 74 at swedish side of the Baltic Sea, will be a main focusing point of the research activities in the near future.

REFERENCES

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Appendix 1.

Fish Culture in Finland 1991

Food fish production¹

	Brackish water	Fresh Water	Total	Value
(M\$S ²)				
Production, 1000 kg				
Rainbow trout	15 055	4 068	19 123	69
Salmon	143	3	146	0.5
Other species (Brown trout and whitefish)	0	2	2	0
Total	15 198	4 073	19 271	70
Farms	200	170	370	

1) In ungutted fish

2) Exchange rate used 1\$ = 5.5 FIM

Production capacity

	Brackish water	Fresh Water	Total
Net cages, 1000 m ³	1060	315	1 375
Ponds and tanks, 1000 m ³	59	1 173	1 232
Natural food rearing ponds, ha	1	8 270	8 271

Output of juveniles¹

Species/group and size class

		Output for stocking	Amounts in the
hatcheries		and on-growing 1 000 individuals	at the end of the year 1 000 individuals
Rainbow trout	under 20 g	15 852	2 557
	20 - 200 g	5 367	7 043
	over 200 g	2 331	7 641
Atlantic salmon	under 20 g	2 097	3 595
	20 - 200 g	1 898	3 112
	over 200 g	13	134
Sea trout	under 50 g	2 282	2 029
	over 50 g	1 513	1 257

Brown trout	under 50 g	2 506	4 918
	over 50 g	2 404	2 233
Char and brook trout	under 50 g	49	413
	over 50 g	116	367
Coregonids	under 20 g	33 105	37
	over 20 g	676	43
Grayling ²	all sizes	3 193	91
Pike-perch ²	all sizes	7 519	2
Pike ²	all sizes	3 866	0
Cyprinids ²	all sizes	665	0
Crayfish species ²	all sizes	113	18
Others ³	all sizes	112	4

1) Output of newly hatched larvae excluded

2) Usually one summer old fingerlings under 10 g in size

3) Burbot

Value of juvenile production:

Rainbow trout 12 Million USD

Other species 17 Million USD (70-80% of which for stocking)

FRANCE

by

H. Grizel

(IFREMER, La Tremblade)

La production conchylicole française est toujours stabilisée autour de 120.000 t d'huître creuse (*Crassostrea gigas*), 60.000 t de palourde (*Ruditapes philippinarum*).

Plusieurs réseaux de contrôle soutiennent ces activités :

(1) Les réseaux REMI et REPHY destinés à vérifier respectivement la qualité bactériologique des eaux et des produits et la présence de phytoplanctons toxiques.

(2) Le réseau zoosanitaire pour étudier les causes de mortalités, déceler de nouveaux agents pathogènes et contrôler l'évolution des situations épidémiologiques.

(3) Le réseau REMORA destiné à obtenir pour chaque bassin conchylicole français des informations sur la croissance, la qualité des produits et pour chiffrer les mortalités.

En zootechnie, le télécaptage d'huîtres creuses est maîtrisé, et de bons résultats ont été obtenus avec du naissain d'huître plate et de moule. L'élevage intensif de juvéniles a été amélioré grâce à l'utilisation de système upwelling et à la maîtrise de production intensive de *Skeletonema costatum*. Ces procédés se sont également avérés intéressants pour l'affinage des huîtres (Région de Bouin - Vendée).

Les modèles de gestion des bassins conchylicoles sont en cours d'amélioration grâce :

(1) Aux expériences de 1991 et 1992 de nouvelles lois écophysiologiques sont en cours d'élaboration pour introduction dans un modèle de croissance de l'huître :

- efficacité de rétention et biais induits dans les calculs de la filtration,
- filtration, fonction de la charge sestonique,
- tri pré-ingestif par les pseudofécès.

Pour réaliser ces expériences, de nouveaux protocoles expérimentaux ont été mis au point avec de nouveaux protocoles analytiques. Ainsi un doseur de carbone, azote particulaire et un cytofluorimètre ont été acquis pour travailler plus finement sur les processus de tri et de digestibilité de la nourriture phytoplanktonique.

(2) Aux deux étapes clés franchies dans l'élaboration des modèles trophiques conchylicoles :

- la validation des modèles en boîte, par le calcul de probabilité des temps de résidence des masses d'eau dans les boîtes comparé au temps de résidence calculé avec un modèle hydrodynamique à maille fine,
- la réalisation d'un modèle d'érosion-sédimentation, maille fine, généré par l'action du courant.

Parallèlement, le bilan du carbone, ainsi que les modèles de flux d'azote ou d'énergie ont été élaborés pour le bassin Marennes-Oléron, tandis qu'un premier modèle du cycle de l'azote était élaboré pour l'étang de Thau.

En génétique, une technique de polyploïdisation faisant appel à un nouveau produit a été mis au point pour les mollusques. Les études comparatives des performances de croissance et de

stabilité de la qualité, entre diploïdes et triploïdes, sont en cours pour les huîtres plates et creuses ainsi que pour la palourde.

Des premiers résultats obtenus pour *C. gigas* confirment le maintien de taux élevés de glycogène chez les triploïdes au cours de la période de reproduction. Les techniques d'obtention d'animaux gynogénétiques ont été améliorées et paraissent efficaces. Reste à vérifier la viabilité des produits obtenus. Le programme de sélection d'huîtres plates résistantes à *Bonamia ostreae* est poursuivi, de nouvelles techniques d'obtention des générations à sélectionner étant mises en place en 1993.

L'étude des mortalités estivales survenues chez l'huître creuse dans le bassin de Marennes-Oléron et à Arcachon révèle que ces mortalités ne sont pas liées à une étiologie infectieuse, mais plutôt à une déficience physiologique. Les expériences d'infections expérimentales croisées entre *Ostrea edulis* et *Crassostrea gigas* ont permis, en association avec les résultats d'épidémiologie, de démontrer l'absence de rôle de porteur de *C. gigas* pour les deux maladies à Protozoaires de l'huître plate, *Bonamia ostreae* et *Marteilia refringens*. Des anticorps monoclonaux spécifiques du *Vibrio* responsable du syndrome des anneaux bruns de la palourde ont été obtenus et sont en cours d'utilisation pour la mise au point d'un test ELISA.

Concernant les études sur la physiologie de la reproduction des médiateurs hormonaux susceptibles d'intervenir dans les mécanismes de maturation et de ponte de la coquille St-Jacques sont actuellement recherchés. L'importance des acides gras et des vitamines sur la maturation et la croissance larvaire est en cours de démonstration. Ces résultats mettent en évidence la nécessaire maîtrise des productions phytoplanctoniques, la composition des espèces variant selon l'âge de la culture.

Enfin, les essais de diversification des élevages sont poursuivis avec la coquille St-Jacques (Rade de Brest, baie de Quiberon). Un essai de testage de *C. virginica* est en cours, mais les premiers résultats révèlent un arrêt de la croissance lorsque les températures sont inférieures à 13°C.

Iceland

by

Stefán E. Stefánsson and Björn Björnsson
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Atlantic salmon (*Salmo salar*)

In 1992 5,9 million salmon smolts were produced and over 4,6 million of those were released in ocean ranching. 1,3 million were used for ongrowing in landbased farms and netpens.

2.585 tonnes of salmon were produced, whereof 1.413 tonnes were in landbased units, 712 tonnes in net pens and 460 tonnes from ocean ranching.

Production in 1993 is estimated around 2.700 tonnes.

Other salmonids

Production of Arctic char (*Salvelinus alpinus*), Rainbow trout (*Oncorhynchus mylis*) and Brown trout (*Salmo trutta*) was 399 tonnes. Most of the production is Arctic char or 321 tonnes. About 1,1 million smolts were produced of these three species.

RESEARCH ACTIVITIES OF ATLANTIC SALMON

Ocean ranching

Selective breeding in Ocean ranching. A nordic project started in 1987. The main purpose is to estimate the genetic parameters for homing and growth in freshwater and in the sea, by releasing families of salmon. The genetic parameters will be used to estimate the possibilities for selective breeding in ocean ranching. Until now 4 yearclasses have been released in all 500 families. Results are promising.

A large scale research program to determine the optimum size of smolts, release methods and time of release is under way in cooperation with companies in commercial ranching.

Fish farming

Selective breeding program for fish farming of Atlantic salmon is under way with breeding goals including growth rate, late maturity and disease resistance. 100 families are being used each year. Research is also under way to estimate the most practical ways to run land based units, where different units as well as different environmental conditions are compared. The aim is to improve the performans of salmon in rearing and ranching operations, using Icelandic and Norwegian stocks. The development of year-round Atlantic salmon egg production was included in the breeding programme by using artificial photoperiode. The programme can already offer salmon ova all year around in Iceland and for salmon farming on a world wide basis in 1994.

ARTIC CHAR (Salvelinus alpinus)

Research is under way for rearing of arctic char. The most important projects are: comparisons of different stocks and selective breeding in land based units, feeding experiments, rearing at different light regimes and temperatures.

DISEASE CONTROL

Research is under way to find ways to control bacterial kidney disease in aquaculture. Furunculoses caused by Aeromonas salmonicida subsp. achromogenes is a problem in on-growing of salmonids. Vaccines are being developed. Disease control is also under way for marine species.

MARINE SPECIES

Halibut

The Marine Research Institute (Hafrannsóknarstofnun) carried out breeding trials with halibut for the third season at its Mariculture Laboratory (ML) near Grindavík SW-Iceland. About 20 larvae survived past metamorphosis. A private firm Fiskeldi Eyjafjarðar (FE) N-Iceland managed during its fourth larval season to produce 2000 metamorphosed fry.

Growth rate experiments with halibut fry from FE were carried out at ML to study the effects of temperature and different dry feeds on growth rate. The results suggest that optimal temperature of halibut decreases with increased size. For 10-100 g fry the optimal temperature was near 13 °C but for 100-500 g juveniles it was close to 10 °C.

Catfish

A growth rate study of spotted catfish (Anarhichas minor) at different temperatures was carried out at ML. The results suggest that optimal temperature of juveniles of this species is near 10 °C.

Cod

Early life history studies of cod were initiated at ML. A positive relationship between size of female and egg size was observed, also between size of larvae and size of eggs. A few hundred juvenile cod (1 kg) were collected for growth rate studies.

Abalone

Experimental breeding trials were continued with red abalone (Haliotis rufescens) at ML. There was good success with spawning, fertilization, hatching and larval settlement. At the end of the year there were 200 sixteen month old animals alive (31 mm), 1800 thirteen month old (18 mm) and 4000 three month old animals (3 mm).

LATVIA

by

Andis Mitans
(Latvian Fisheries Research Institute, Riga)

Rainbow trout

The production of rainbow trout in sea cages (Gulf of Riga) in 1992 was 163 tonnes. In some Baltic salmon hatcheries rainbow trout was reared for local consumption. No scientific research is going on in this field.

Stocking

In the period 1984-1991 every year up to 800 000 young rainbow trout (age I+) have been stocked in the Gulf of Riga. However, trout recovery by fishery was low relative to output and therefore in the 1992 stocking programme was stopped. Salmon smolt realized for stock enhancement amounted to 575 000 in 1992.

Diseases

Disease monitoring was carried out at the salmon hatcheries. *Myxobacteriosis* seems to be a principal problem in Latvian hatcheries. No vibriosis and furunculosis were observed. Attempts have been made to find new drugs against bacterial diseases. A disease study has been started with Baltic herring. *Ichthyophonus* was not still observed.

THE NETHERLANDS

by

Renger Dijkema

(Netherlands Institute for Fisheries Research, Yerseke)

The industry

The developments in the field of molluscan culture are dealt with in the Activities Report of the ICES Shellfish Committee. Production of rainbow trout in sea cages by one firm remained the same. In the field of ragworm culture, one firm is dominating the production, there are two or more small firms.

Production:

Mussel culture (<i>Mytilus edulis</i>) (season '92-93):	52,000 t
Flat oysters culture and fishery (<i>Ostrea edulis</i>)	225 t
Pacific oysters culture+fishery (<i>Crassostrea gigas</i>)	1,500 t
Rainbow trout: (<i>Oncorhynchus mykiss</i>):	20 t
Ragworms: (<i>Nereis virens</i>):	20 t

Research

Molluscan reserach is dealt with in the activity report of the ICES shellfish Committee. Culture of turbot (*Scophthalmus maximus*) in an experimental recirculation system was studied at the Netherlands Institute for Fisheries Research in IJmuiden. A feasibility study of commercial turbot culture in recirculating systems was carried out in cooperation with the Institute for Agro-economic Research (LEI-DLO). Based on experimental and literature data, the study was based on three growth scenarios, in which a weight of 2 kg was reached in 22, 25 and 28 months respectively, departing from 5-grams fingerlings. As maximal attainable stocking density in the rearing basins 60 kg/m² was considered for the largest individuals. The investment costs for a 50-tons recirculating plant were estimated on the basis of existing successful recirculating culture units for eels and African catfish (*Clarias gariepinus*). They appeared to be in the order of magnitude of DFL 38.- per kg production capacity. The turbot market was estimated to be 10.000 tons per year; a price of DFL 19.- per kg to be expected for a farmed turbot weighing 2 kg. The main incertainties in this study is the growth rate in the range between one and two kg individual weight. It was concluded that, departing from the higher growth rate scenarios, recirculating culture of turbot is economically feasible, but that further, pilot-scale research is still necessary. In the north of the country, a pilot-scale experiment started with fattening of turbot in a flow-through system. On an experimental scale, small batches of sea bass (*Dicentrarchus labrax*) were successfully cultured during the summer months in sea cages in a commercial farm in Zeeland.

NORWAY

By

Snorre Tilseth

(Institute of Marine Research, Bergen)

This report is a summary of the main research activities in Norway in government institutions and universities. The report is focused on some of the results and progress in the research activities carried out at the different institutions. A summary of the state of the art of finfish diseases in fish farming in Norway is given by The National Veterinary Institute, Oslo.

In table 1 is presented the production statistics of salmonids in Norway in 1992. Arctic char is now commercially produced in Norway. Progress have been achieved in commercial production of Atlantic halibut. Five companies had established halibut broodstock, hatchery facilities and produced halibut fry in 1992. One company has specialized in halibut egg production and developed a method and facilities for natural spawning. A total of 1.2 m³ of halibut eggs were produced in Norwegian private hatcheries and governmental institutions in 1992. The first batch of commercially produced halibut will be on the market in 1993.

Atlantic cod, European lobster fry and Atlantic salmon smolts are produced for sea ranching and/or stock enhancement experiments. Two private organizations are involved in Atlantic salmon sea ranching, and two private companies are producing Atlantic cod fry for releases in coastal ranching experiments. The lobster project is run by The Institute of Marine Research in cooperation with the local fisherman organization at the release site.

Table 1. Production statistics of salmonids in Norway in 1992.

1992	Tonnes produced
Salmon	140.000
Trout	6.000
Arctic char	ca 400
Cod	500 kg

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Atlantic salmon (*Salmo salar* L.)

Genetics and biotechnology

cDNA library from pancreatic tissues of salmon has been constructed. Five different trypsin genes have been characterized. Three of them appear to be alleles from the same locus, and the other two seem to be coded from different loci. Four genes code for anionic forms of trypsin and one for cationic form. The distribution between anionic and cationic forms are similar to that observed by isoelectric focusing of trypsins from the pyloric caeca.

Nutrition

Through the study of postprandial plasma free amino acids, the association between the pre-sence of trypsin isozyme *TRP-2* (92) in the pyloric caeca and better growth of salmon appears to be primarily due to better digestion and absorption of the dietary protein. Higher muscle free amino acids, special the amino acids involved in energy metabolism, suggested more active protein metabolism in the muscle of salmon carrying trypsin isozyme *TRP-2* (92).

Dose-response effects of dietary astaxanthin supplementation on flesh pigmentation have been studied in relation to feeding regimes. Atlantic salmon (*Salmo salar*) was fed 8 different astaxanthin supplemented diets. The astaxanthin supplementation were 10, 20, 40, 60, 80, 100, 150 and 200 mg astaxanthin/kg feed. The pigmentation in the fillet was determined by chemical methods, colorimetric measurements (Minolta Chroma meter) and visual evaluation using the "Color Card for Salmonids".

A dose-response effect was observed in the muscle but the relationship between the tissue concentration and the dietary level is non-linear. The retention of astaxanthin in the muscle decreased with increasing dietary levels. The colorimetric measurements showed a non-linear relation between the measured values of a^* , b^* , L^* , C^*_{ab} , and hue. The a^* value is concluded to be the best for predicting astaxanthin content and the color level of the fillet. The Color Card scores from the final sampling gave correlation well with astaxanthin content.

Biological function of astaxanthin has been studied in different stages of Atlantic salmon. Effects of astaxanthin on survival and development of eggs and yolksac fry, growth promotion and immune response have been investigated.

Eggs with a wide range of astaxanthin content was incubated and the mortality registered from the incubation to hatching. The astaxanthin concentration in the egg did not effect the egg survival. In a start feeding trial the interaction between vitamin A and astaxanthin was studied. Poor growth and low survival was observed in start feeding salmon fed diets low in astaxanthin regardless of the vitamin A content.

Physiology

Factors affecting the development of bimodality in Atlantic salmon populations were studied. The daylength during the autumn is an important signal which affects both the

number of smolts and their size. The absolute daylength is more important than the number of hours reduction. Different river stocks respond differently to the reduction in the daylength and the number of 1+ smolts is affected by a combination of factors like behaviour, social interactions and growth potential.

The effect of photoperiod on the development of the desmoltification process and the development of total immunoglobulin and the specific antibody after vaccination against *Vibrio salmonicidae* at different times during the smoltification process were studied.

Arctic charr (*Salvelinus alpinus* L.)

Nutrition

Increased growth due to higher lipid deposition affects slower absorption rate of the dietary protein. Char with higher protein deposition shows faster absorption rate of the dietary protein with higher postprandial essential free amino acids and amino acids involved in energy metabolism in the muscle.

MARINE SPECIES

Cod

Photoperiodic control of reproduction in cod

The effect of photoperiod manipulation on sexual maturation and spawning in cod are studied. A condensed cycle, with normal annual variation in daylength occurring in six months gave an advancement in maturation and spawning by two months the first year of treatment. Correspondingly, an eighteen month-cycle will result in a delay in maturation. The respective treatments will be followed by "normal", out-of-phase annual variations, and the maturation process will be followed for one more year.

HALIBUT

Control of reproduction in halibut

Photoperiod manipulation of sexual maturation in halibut resulted in spawning male and female fish in August to October, six months out of the normal season, both in 1991 and 1992. High water temperatures in this period gave problems with egg viability, due to shorter ovulatory cycles and faster deterioration of ovulated eggs ("overripening"). Fertilized eggs were incubated at 5°C and hatched normally.

The endocrine regulation of sexual maturation and ovulation in halibut are studied.

To control larval feeding conditions, determination of the different parameters of a bioenergetic model for halibut larvae was initiated. As a first step, growth, metabolism and excretion were measured.

SHELLFISH AND CRUSTACEA

Pecten maximus

Experiments were undertaken in April to investigate the effect of surface water (3 m) on growth and survival of young king scallop spat after metamorphosis. The experiment was designed to separate the effect of phytoplankton and the effect of dissolved organic materials (DOM) in the surface water. Cultured food consisted of at least two algal species, and was added in specific concentrations. The results showed that phytoplankton in surface water enhances the growth of scallop spat.

Cancer pagurus

Traditionally the customers experiences large differences in crab quality. These variations are mainly due to seasonal variations in food and molt stage. After molting the crabs are water-filled and not suited for human consumption. It is now possible to sort out well filled crabs from partially filled and water-filled crabs. The filled crabs can be sold or processed, the "water crabs" discarded and research is going on to find a method to improve the quality of wild-caught, partially filled crabs by feeding in captivity. The project aim at finding suited food, adequate temperature and water quality requirements needed to achieve high quality crabs.

SEA RANCHING

The programme is part of a large scale national programme for investigating the potential of sea ranching of cod, lobster, arctic char and Atlantic salmon as additional livelihood for coastal areas where a considerable part of the fishing income was lost when drift net fishing for salmon was closed in 1989.

Atlantic salmon

Within the frame of the programme 39.000 smolts originating from three regional rivers were released by the Institute of Marine Research at Sotra island (SW-Norway) in 1992. Another cooperating project at Helgeland (mid-Norway) released 100.000 smolts at Vega island originating from Vefsna river. The aim is to study possible ecological consequences of large scale releases. The returns to the release sites of the 1991 releases were recaptured at a rate of 0.33 and 1.8 percent respectively.

Cod

In the period from 1988 to 1990 the yearly releases of cod in Masfjorden, north of Bergen, were 30-83.000. The released cod contributed significantly to their year-classes in the release area. Density-dependent mortality on the 0- & 1-group group stages reduced the abundances, and at recruitment to the fishery as 2-groups, the abundances of cod in the release were not statistically different from a control area. From 1991 marked cod (84.000) were also released in open coastal areas at Øygarden NW of Bergen where the production potential are supposed to be higher. Due to a bloom of poisonous algae in the production pond (Parisvatnet) there were no releases of cod in 1992.

Lobster

In 1992 35.000 reared lobster juveniles from the production unit at Kyrksæterøra were tagged. Most were released in a large scale stocking experiment at Kvitsøy (SW-Norway). This experiment started in 1990 and only a small part of the lobsters have yet recruited to the fishery (> 24 cm TL). In 1992 the percentages of non-recruited lobster in the catches (18-24 cm) were estimated to between 40 and 60%.

DISEASES.

Salmon lice.

Experiments on alternative treatment have developed a new administrative principle for oil-soluble chemotherapeutics. A natural extract from flower heads of chrysanthemum (*Chrysanthemum cinerariaefolium*) called Pyrethrum, has been found to be effective. When applied to the salmon skin surface a delousing efficiency of 90% or more was achieved. Exposure for two and up to 10 seconds gave no difference in this effect. Commercial methods for applying Pyrethrum have been developed. Both vaccination/delousing and sorting/delousing have been carried out in the same operation. Tests with

garlic as a delousing agent has proven ineffective. No effect was registered even after eight weeks of feeding.

Furunculosis.

Through infectivity studies and observations from field trials it has been shown that *Aeromonas salmonicida* subsp. *salmonicida* can be transmitted to cod, halibut and wrasse are susceptible to furunculosis. However, these species are more resistant to furunculosis than Atlantic salmon. In addition, no carrier state was demonstrated in marine fish surviving a challenge experiment.

Cohabitation experiments do not reveal transmittance of *Aeromonas salmonicidae* subsp. *salmonicida* from infected cod, halibut and wrasse to Atlantic salmon. However, such transmittance can not be excluded.

Vibriosis.

So far, vibriosis has been the most serious bacterial disease on farmed marine fish, causing yearly losses up to 50% of the total production of cod and turbot fry. Biochemical, serological and immunochemical properties of the pathogenic *Vibrio anguillarum* isolated from different farms revealed species specificity. These analysis form the basis for development of vaccines. Results of immersion vaccination of cod in a field trial with a vaccine based on two isolates of *V. anguillarum* are promising. Also vaccination of turbot fry in laboratory scale followed by an artificial challenge resulted in high relative percent protection. However, further work on vaccine optimization and adjustment to the production line of marine fish are in progress.

Infectious Salmon Anaemia (ISA)

The disease can be transmitted by injection of blood cells (erythrocytes and leukocytes) and plasma from diseased fish. There are strong indication that both granulocytes and monocytes are infected. Injection challenges using fractions from equilibrium density gradient centrifugation of plasma from fish with acute ISA, revealed a band of infectivity in the range 1.184-1.262 g/cm². Treatment of plasma with lipid solvent chloroform, showed that the etiological agent of ISA contained essential lipids, probably as a viral envelope. ISA is primarily affecting Atlantic salmon, even though the susceptibility varies among families of the species. Wrasse, turbot, Arctic char and rainbow trout seem to be resistant.

Infectious Pancreatic Necrosis (IPN)

Infectious Pancreatic Necrosis Virus (IPNV) has since 1989 been isolated from moribund farmed Norwegian turbot and halibut. There are results indicating that mortality due to IPNV infections occur in the weaning periode. However, the virus may have been introduced to the population previously without causing any disease outbreak. All isolate so far belong to serotype N1.

Also in 1992 there are reports of serious mortality of Atlantic salmon smolts after transfer to seawater. IPNV has been proposed to be the cause or contribute to this mortality. Experiments are in progress to investigate the nature of this mortality.

IPNV are accumulated in scallops. It has also been shown that virus are transmitted to prawns grazing upon contaminated scallops. Accordingly, invertebrates may be vector organisms for the virus.

Shellfish.

A screening program is continued to control the health and parasite status of bivalve molluscs used in commercial production. Broodstock populations of oysters and clams are the primary subjects of investigation. Histological examinations of Norwegian oyster and clam has not yet revealed any serious pathogen. Additional samples are collected from stocks of indigenous clams and scallops which are or will be used in commercial production.

Interactions between environment and aquaculture

In 1992 the main research activities have been concentrated on the processes that control the accumulation of organic matter (sedimentation rates and mineralization) and on the fate of antibacterial agents.

The aim of the first issue is to provide a method that can be used to adjust the local impact of a given fish farm to the holding capacity of the site. A first approach will be to predict the load that ensures a functional infauna community beneath the cages. This will be useful both for regulatory purposes and for farm management.

Investigations of wild fish in the vicinity of fish farms confirm earlier findings that 70 to 100% of the fish will contain residues of antibacterial agents shortly after medication. About 50% of the fish have tissue concentrations below 0.5 ppm, but the variation is great, and maximum levels may reach 10 to 15 ppm. Laboratory experiments have shown that it takes three weeks for such a concentration to reach low values. Experiments with an acoustic feed control system and a device that collects waste feed indicates that this equipment reduces the residues in the wild fish considerably.

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Studies 1 - 3 performed at DFO, Biological Station, St. Andrews, N.B., Canada, as a cooperation between Richard Saunders (DFO), James Duston (Connors Bros.) and Sigurd Stefansson (University of Bergen). Study 4 was a cooperation between Tom Hansen at the Institute of Marine Research, Bergen, Norway, Geir Lasse Taranger (University of Bergen), and Stolt Sea Farm Ltd., Norway.

1. Production of 0+ smolts of Atlantic salmon. A refined method has been developed for the stimulation of salinity tolerance in underyearling Atlantic salmon. Further insight into the size and time requirements for smolting in 0+ Atlantic salmon has been gained. The results point to a commercially feasible production plan for high quality, underyearling smolts.

2. Temperature and smolting in Atlantic salmon. A study of the importance of winter temperature for smolting in Atlantic salmon indicated a negative effect of elevated winter temperature on the completion of smolting. Further, the size relationship between lower and upper mode salmon and smolting was obscured, with smolt sized fish failing to develop smolt characters. A refined experiment has been designed and is carried out in 1993.

3. Desmolting in Atlantic salmon. The loss of smolt characters as a consequence of time and feeding has been described for Atlantic salmon. The results point to the importance of proper feeding of post-smolts in order to prevent the loss of smolt characters. A refined experiment has been designed and is carried out in 1993.

4. Growth and sexual maturity in Atlantic salmon. Exposure of salmon post-smolts reared in sea-water to continuous light from October or January onwards, enhanced growth and reduced the proportion of fish maturing at the grilse stage. Further studies are carried out in 1993.

Marine species

Halibut

The histology of the developing halibut eye has been partially completed and shows that the retina attains an "adult" or fully developed form, with all eight layers being present, at 150 daydegrees or 50% yolk absorption. A cone mosaic appears concurrent with metamorphosis.

Feeding trials with juvenile halibut (about 1 gm wet weight at start of experiment) are almost complete. Preliminary results show that growth is better at 14°C than at 11°C, and that within these temperatures ambient light conditions could also improve growth. Keeping the spectral distribution constant, a light intensity of 1 lux has resulted in better growth at 10 or 400 lux. The ranking was consistent between groups at 14°C, but a more complex picture appears at 11°C. The experiments will continue with individually tagged fish, and examine histology of muscle development. The fish are maintained in the AquaHall of ILAB at the High Technology Center in Bergen.

Lobster

A growth trial of lobster larvae was carried out in cooperation with The Inst. of Marine Research field station in Kyrksæterøra. Larvae were clipped of either the right, left, or both claws or left intact, and then placed in small containers with no substrate, plain substrate or calcium enriched substrate. Preliminary results show significant differences in weight, though not in carapax length, and differences in claw development. Further analyses will be conducted in cooperation with the Department of Nutrition, Directorate of Fisheries, to determine calcium content in the lobsters and in the sediment.

Wolffish

A small feeding trial is being conducted with 160 wolffish juveniles kept in 1m square tanks in the AquaHall of ILAB at the High Technology Center in Bergen. Preliminary results show better growth at 11°C as compared with 14°C.

Cod

Mouth morphology of cod shows that they should be more effective cannibals at around 20 mm body length. The ratio of mouth size to body height reaches a maximum at that body length.

Turbot

An investigation of maturity rates as a result of different temperatures histories is being carried out on maturing turbot at the ILAB facilities of the High Technology Center in Bergen. Preliminary results suggest that early maturation is stimulated by high temperatures but not by low. Some turbot had developing gonads as 1+.

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Salmonid nutrition

The amount of soluble protein, present as amino acids and peptides, in the feed is important for growth and protein synthesis. This has particular relevance with regard to the use of fish silage in the diets. Experimental data indicate that the amount of soluble protein should not exceed 30 % of the total amount of protein in the diet in order to achieve optimal growth and protein utilization. At least one feed mill in Norway uses a small amount of silage in fish meal based dry diets.

Comprehensive studies on the function and metabolism of polyunsaturated fatty acids and vitamin E in Atlantic salmon have been carried out during the period 1988 - 1992. Basic and applied research in relation to growth, health, smoltification, reproduction and product quality are now being prepared for publication. In summary, the results show that these dietary parameters affect physiological responses as well as the chemical composition of the fish profoundly. The studies range from basal metabolism to applied aspects which have direct relevance for the aquaculture industry.

General metabolism, minimum dietary requirement and optimum dietary level for health and disease resistance (cooperation with the Institute of Marine Research) were studied for the vitamins biotin, B₆, C and E in Atlantic salmon. In short, the data show that the minimum dietary requirement for vitamin B₆ is 6-8 mg/kg, and for vitamin C 10-20 mg/kg. High supplementations of vitamin C positively affect some of the immunological factors, and increase survival following challenge against furunculosis. This was not observed for vitamin B₆. The minimum dietary requirement for vitamin E during the start feeding period is 60 mg/kg, while the optimum level seems to approximate 120 mg/kg. Preliminary data suggest that the requirement for biotin is covered by the natural ingredients present in standard composition feeds for salmon. Five manuscripts on these subjects have been submitted for publication, and some are still in preparation.

The minimum dietary requirement of iron (as iron (II) sulfate) in Atlantic salmon parr was found to be approximately 60 mg/kg diet. Some interesting interactions with vitamin C were observed in these experiments which awaits further studies.

A study on the biological availability of different chemical forms of iron showed that metallic iron was less available than iron(II)sulfate and heme iron (blood meal).

Studies on utilization of manganese (Mn) and copper (Cu) from fish meal were initiated in 1992. So far, the results indicate that it is required to supplement fish meal based diets with 10-20 mg Mn (as MnSO₄).

Marine fish nutrition

Nutritional growth studies with cod using natural prey have been carried out in cooperation with the Institute of Marine Research. The objective was to gain more knowledge on the growth potential of this species to be used in growth models in a natural ecosystem. These studies are relevant for the potential development of sea ranching in Norwegian coastal waters.

As in salmonids, studies are being conducted to evaluate to what extent marine fish can utilize soluble protein in the diet. It has been shown that cod has a limited ability to utilize free amino acids, and studies are in progress to evaluate the potential to increase protein quality by supplementing amino acids in feeds.

The requirement of vitamin C in broodstock feed for optimum reproductive performance has been studied in cod and in turbot. Further, studies have been performed to evaluate the requirements of vitamin C for growth and disease resistance in young turbot. The results indicate that these species have a low requirement for vitamin C in the diet. The data are being prepared for publication, and further details will be presented later.

A comprehensive set of analyses have been performed on organs of turbot during different stages of maturation. The objective of this study was to generate basic knowledge on levels and organ distribution of important nutrients (gross chemical composition, vitamins and minerals) in order to detect possible critical factors which should be further studied in order to improve broodstock feeds.

It has been demonstrated that cod can tolerate a high inclusion of carbohydrate in the diet during maturation (27 %), and that fish health and chemical composition of the eggs are affected to a minor extent.

Preliminary studies on nutrition in cod and halibut larvae were initiated in cooperation with the Institute of Marine Research. The results indicate that palatability and water content of formulated diets are crucial factors for survival success of the larvae.

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Fish disease status for Norway 1992

No notifiable List A disease was recorded in Norwegian fish farms in 1992. The only recorded List A disease in 1992 was crayfish plague (*Aphanomyces astaci*-infection) in noble crayfish from a river system previously to be infected.

The main disease problems in Norway in 1992 were furunculosis, infectious pancreatic necrosis (IPN), infectious salmon anemia (ISA), and salmon lice (*Leptophtheirus salmonis*). Although many farms still are under restrictions due to ISA, the number of farms with clinical disease due to ISA has been reduced from 100 to approximately 7 farms due to sanitary measures. Furunculosis and salmon lice seem, however, to cause increasing problems and in spite of more effective vaccines against furunculosis, the disease continues to spread to new areas.

Cold water vibriosis (*Vibrio salmonicida*), vibriosis (*V. anguillarum*) and bacterial kidney disease (*Renibacterium salmoninarum*) are bacterial diseases that are of some significance. Cold water vibriosis is still giving some losses in Northern Norway despite the vaccination programme in force. Work is in progress to elucidate this lack of protection.

In 1992 a *Piscirickettsia salmonis* like organism was isolated for the first time in connection with an outbreak of necrotizing hepatitis in Atlantic salmon. Immunohistochemical examinations of formalin fixed material from a similar disease condition has led to the conclusion that the *Piscirickettsia* like disease was occurring already in 1988. The mortality due to the disease has been limited.

An eye disease, reported as varrachalbmi (= bloodeye in Lappish) caused by a *Pasteurella* like organism has been described in Atlantic salmon reared in seawater.

Hexamitosis (*Hexamita salmonis*) was reported at a new farm site in Northern Norway. No connection with previous outbreaks seemed to have occurred.

Research on fish diseases

Furunculosis

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 on improving vaccines against furunculosis.

Improving diagnostic methods for the detection of *A. salmonicida*. This work is necessary in order to diagnose latent carriers of the bacteria. A sensitive and specific diagnostic method is of great significance for the prophylactic work against the disease. Trials with vaccines against furunculosis. Controlled field trials have shown that losses are reduced significantly if vaccines are used in a correct way. Based on epidemiological studies, information about the positive and negative effects of vaccination are achieved.

The antibiotic resistance patterns of *Aeromonas salmonicida* have been studied. The investigations showed that 36% strains were resistant to one or more of the antimicrobials tested.

Infectious Salmon Anaemia (ISA)

Infectious Salmon Anaemia (ISA) was first reported in Norway in 1984. The clinical pathological, ultrastructural and haematological aspects of the disease has been described.

The causal agent of ISA has not been identified. However, strong evidence exists that it is an enveloped virus. So far, the causal agent has neither been propagated in cell cultures nor been identified by immunological methods. The work is now focused on finding fish cell cultures that are susceptible to virus growth. Recent research suggests that it might be possible to propagate the infectious agent in leucocytes from Atlantic salmon.

Efforts have been made to establish specific antibodies to the ISA agent. Antiserum produced in Atlantic salmon, immunized with the ISA agent, has shown promising results in several serological assays. Attempts are also being made to produce monoclonal antibodies to the ISA agent.

The authorities need information on disease transmission to be able to make administrative directives. Much effort has been made to investigate the resistance of the causative agent. The ISA agent is sensitive to chloroform, diethylether and formalin as well as heat, and low and high pH.

Factors which might be important for the ISA infection are quantified in an epidemiological survey.

Vibrio-infections

Two previously undescribed psychrophilic vibrios systematically isolated from kidneys and dermal ulcerations of Atlantic salmon suffering from "winter ulcers" have been described previously. One of these vibrios seems to play a particularly significant part in the pathogenesis of the condition. The isolates have been described as novel genospecies and suggested names are:

- * *Vibrio viscosus* spes. nov.
- * *Vibrio wodanis* spes. nov.

Additional infection experiments are planned to achieve further information on the pathogenicity of the bacteria.

Norwegian *Yersinia ruckeri* isolates have been reclassified on the basis of a new O-serotyping system.

A *Piscirickettsia salmonis* like organism has been isolated in connection with necrotizing hepatitis in Atlantic salmon. By means of immunohistochemical examinations the agent has also been found in material from 1988, thus backdating the disease by 4 years.

An eye disease, presently described as Varrachalbmi (= blood-eyed in Lappish) has been studied both pathologically and microscopically. The causative agent, not yet taxonomically characterized, shows similarities with *Pasteurella* spp. Further studies will be carried out in order to classify the bacteria.

Parasite-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 and fish farms has been mapped. A study on unspecific skin reactions of *Salmo salar* against *G. salaris* is in progress. The parasitological studies carried out at the National Veterinary Institute have also as an aim to study aspects and infestations of other *Gyrodactylids* on different fish.

species. Disease problems with systematic hexamitosis in fish farms located in Northern Norway are also studied. Screening for freedom of *Anguillicola spp* are also carried out.

Virus-infections

In addition to Infections Salmon Anaemia (ISA), 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. The studies have shown that the Sp. serotype is the most frequent isolate. Work on rapid diagnostic test for IPN is in progress.

Immunology and immune prophylaxis

Studies on the mechanisms involved in the transfer of maternal immunity in fish indicate that transfer of specific immunity to the bacterial infection yersiniosis from mother to fry is not of great significance. Non-specific immune mechanisms, however, seem to play an important role in the protection of fry.

Studies on various methods of administration of furunculosis vaccines in Atlantic salmon show that the injection method gave higher protection and stronger immune responses against the infectious agent, than dipping or oral administration of the vaccine, and that booster immunization had a positive effect on the protection.

Immune histochemistry is an important field both for research and diagnostic work. Immune histochemical methods have been established and are now used in pathomorphological studies of different fish diseases.

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Aquaculture activity in the SINTEF group, 1992

The activity regarding intensive tank culture of live food and startfeeding of marine larvae has continued, and the results are now used in a commercial production farm for halibut fingerling production.

A patent application of a completely new cage system, called the Tension Leg Cage, is made, and the first prototype is in operation in the sea. Research on this system used for grow out farming of halibut is also started.

Two patents application concerning tank systems for landbased farming are made in 1992, and these products are now industrialised of commercial companies. The idea of this system ECOFISH is to create better water quality and growth environment for the fish, and less impact of the farming activity on the surrounding environment. Research regarding optimization of closed salmon production technology has continued, including testing of pure oxygen versus air as oxygen source, physiological testing of fish reared under different conditions. Further documentation of the BIOFISH recirculation technology system has also continued with arctic char and brown trout with good results.

Parallel long term tests with different types of treatment of effluent from fish farm has been run, and the possibilities of sludge treatment by thickening and anaerobic digestion are being evaluated. The activity of treatment of effluent from fish slaughtering have also continued in 1992.

The quality of the fish going to the market is becoming more and more important in aquaculture production. SINTEF has for two years now had a strategic program for finding new methods for objective registration of fish meat quality as firmness, freshness, fat content and distribution etc., and to use these methods to get more knowledge of the effect on different kind of treatment (stress) of the fish meat quality. Several promising results and new knowledge has been produced already.

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Salmonids

Atlantic Salmon

Studies of the influence from daylength on endocrine parameters during smoltification have been performed. The results demonstrate a seasonal change and a diurnal rhythm of thyroxine (T_4), cortisol and growth hormone (GH).

Stress related studies have verified that the smoltification process of salmon is not influenced if the animals are subjected to handling and/or exposure against antihelminth-therapeutica like formalin.

Stress related studies (handling and transportation) have demonstrated a reduction in LPS-stimulated B-lymfocyte mitogenic capacity.

Arctic char

Studies of hypoosmoregulatory capacity have verified that this species do undergo a smoltification process during spring (outdoor) and under simulated spring.

Use of metomidate have proved to be a very efficient anaesthetic for scientific purpose (e.g. blood sampling etc.).

A production unit ("Biofish"-tank) has been developed, allowing a reduction of waterflow (95-97% reduction) and a stabile high water temperature (10-17°C) by use of airpumps (oxygen supply) and nitrogen fixating bacteria. A very good fish growth pattern is documented.

Parameters related to migratory activity and growth in sea water (during summer) have been documented for subarctic (northern Norway) and higharctic (Spitzbergen, Svalbard) freelifving strains of arctic char.

Marine species

Cod

Egg quality studies have concentrated on maternal effects on egg and larval viability. Egg groups from wild Arcto-Norwegian cod females in different stages of spawning were selected for further studies on egg quality and vitality of early larvae. The results so far showed that fertilization rate decreased with increasing stage of spawning, and that a high incidence of normally developed embryos was always correlated to a high fertilization rate. Larval vitality also seemed reduced in groups originating from cod females at the end of their spawning period.

Halibut

Organ development of yolk-sac larvae (6°C) have been studied by histomorphological methods (light and electron microscopy). Organs such as kidneys, pancreas, liver, gall bladder and gut seemed functional within the first 24 days. Judging from feeding observations of live larvae and ultrastructural observations, it seemed that halibut larvae were able to digest food particles between day 24 and 26 after hatching (50% yolk absorption and 150 daydegrees).

Studies on weaning halibut fry (>0.5 g) from live feed to various types of processed food were performed in cooperation with Institute of Marine Research. Histological studies of the digestive system revealed that water content and physical properties of the food had a profound effect on liver and gut epithelium appearance.

Turbot

Studies on lipid digestion in fish larvae have been initiated. Feeding experiments on various lipid enrichment in rotifers on development of first feeding turbot larvae were performed in cooperation with SINTEF Center of Aquaculture. Morphological studies of these larvae showed that the lipid composition clearly affected the absorption and intracellular digestive pattern in the intestine. Larvae reared on rotifers enriched by a marine oil (Super-Selco) had an absorption and a further intracellular transportation to the serum and liver. Larvae reared on soybean oil enriched rotifers had gut absorption of lipids, but the enterocytes did not seem able to process biochemically these lipids. The ratio DHA/EPA in the feed seem to correlate with development of larval pigmentation.

General

A fully automated mobile unit for registration of migratory activity (from freshwater to seawater) have been designed and tested for salmonid fish. The system can operate both in field and within laboratory facilities).

Poland

by

Józef Wiktor

(Sea Fisheries Institute, Gdynia)

The rearing of salmon (*Salmo salar*) spawning stock in sea cages was continued to obtain eggs necessary for reintroduction of this species into Polish rivers.

The observation on effectiveness of delayed releasing of sea trout (*S. trutta*) smolts in brackish water were conducted.

Effectiveness of montee eel stocking in the brackish waters of Szczecin Firth and Firth of Vistula was continued.

The stocking material of whitefish (*Coregonus lavaretus*) for culture trials in sea cages (brackish water) and reintroduction to the Bay of Puck was prepared.

SPAIN

by

Ignacio Arnal

(Instituto Espanol De Oceanografia, Madrid)

Research on marine aquaculture has been developed on topics and by organizations that were described in previous annual reports.

In June 1993 a meeting took place in Alicante to review the state of marine science in Spain, and in that meeting the "state of art" of marine aquaculture research in Spain was also reviewed. The main items considered were:

- The evolution of mariculture research from 1982-1991.
- The participation in international research programs.
- The evolution of mariculture production from 1985 to 1991.
- The main topics for research in next years.

In relation with production, figures presented in that meeting were:

MARICULTURE PRODUCTION 1985-1991 (Tm)

FISHES	1985	1986	1987	1988	1989	1990	1991
Scophthalmus	40.0	40.0	50.0	97.0	271.1	640.3	825.0
Dicentrarchus	29.0	30.5	37.5	29.0	23.8	30.7	92.1
Sparus	127.2	123.8	109.2	160.2	343.7	564.6	1 072.9
Mugil	--	165.0	89.9	--	58.9	118.1	56.0
Seriola	13.0	9.0	20.0	13.0	17.4	20.8	31.0
Solea	--	10.0	5.8	--	8.4	7.1	9.1
Tunnidae	38.0	60.0	108.7	46.5	236.7	357.7	16.3
Anguilla	20.2	25.8	29.4	31.2	61.4	124.8	98.1
Salmo	150.0	150.0	150.0	150.0	150.0	355.0	553.0
Polyculture	--	--	--	8.8	89.8	--	--
TOTAL FISHES	417.4	614.1	600.5	535.7	1 261.2	2 219.1	2 753.5

CRUSTACEA	1985	1986	1987	1988	1989	1990	1991
Penaeus	15.8	16.0	19.7	55.0	86.6	40.6	32.0
Palaemon	40.0	--	40.0	--	--	160.0	60.0
Procambarus	--	--	--	--	--	5.9	4.5
TOTAL CRUSTACEA	55.8	16.0	59.7	55.0	86.6	206.5	96.5

MOLLUSCA	1985	1986	1987	1988	1989	1990	1991
Clams	706.0	689.3	423.1	3 541.4	3 884.7	4 157.2	3 922.3
Oysters	3 263.5	3 170.0	3 155.5	3 269.1	3 289.1	2 857.4	2247.0
Venus verrucosa	5.8	1.5	1.5	2.0	2.0	10.0	3.0
Scallops	150.0	150.0	150.0	150.0	150.0	120.0	120.0
Tellerina	--	--	--	60.5	60.5	97.0	--
Mussels	245 645.0	246 995.0	245 455.0	243 010.0	193 010.0	173 300.0	195 220.0
TOTAL MOLLUSCA	249 770.3	251 005.8	249 185.1	250 033.0	200 396.3	180 541.6	201 512.3

	FISHES	CRUSTACEA	MOLLUSCS	TOTAL
1985	417.4	55.8	249 770.3	250 243.5
1986	614.1	16.0	251 005.8	251 635.9
1987	600.5	59.7	249 185.1	249 845.3
1988	535.7	55.0	250 033.0	250 623.7
1989	1 261.2	86.6	200 396.3	201 744.1
1990	2 219.1	206.5	180 541.6	182 967.2
1991	2 753.5	96.5	201 512.3	204 362.1

Developments in aquaculture production are more or less progressive in all the species, but in shrimps difficulties have been found to achieve the estimated productions at market prices.

Two important events have been prepared for 1993. One international, the *World Aquaculture'93* convened by WAS and EAS at Torremolinos (Andalucía) for May 1993, and other national, the *IV National Aquaculture Congress*, convened at Isla de Arosa (Galicia) for September 1993. In the agenda of the *World Aquaculture'93* a seminar on the turbot production is scheduled.

Scotland, UK

by

A L S Munro

(Marine Laboratory, Aberdeen)

Annual salmon production was 36,101 tonnes compared to 40,593 tonnes in 1991. The cause of this decline was blamed mostly on poor market conditions. It is anticipated that production in 1993 will be of the same magnitude as the previous two years, possibly marginally higher if survival in the sea phase improves as the industry has been predicting. Sea phase survival has been as low as 60% in recent years due to a combination of disease problems, including furunculosis and sea lice and less frequently other disease conditions. Numbers of smolts placed in sea water have been relatively constant in recent years (approximately 20 million) another reason for predicting that salmon production can only increase in the short term if survival increases.

Sectors of the industry have found that the furunculosis problem may be diminished by the adoption of several preventative approaches including, fallowing of sites and some times of whole areas where waters are share, the use of smolts considered to be free of carries infection, and the use of vaccines. Use of these combined techniques has resulted in relatively few outbreaks of furunculosis were they have been used. An additional bonus has been a drop in the number of recorded cases of multiple resistance to antibiotics.

The techniques adopted for furunculosis prevention have moderated the sea lice problem as well but have not resulted in the same degree of success as for furunculosis. Treatment of lice is only possible by bathing in the proprietary dichlorvos based medicine, Aquagard, to which many lice populations are showing same degree of resistance. Research into alternative treatment methods has been significant and it is probable that hydrogen peroxide bath treatments will be licensed this year.

Cohabiting salmon with cleaner wrasse is also popular but has been found to be a much less effective control with large salmon in their second sea year.

Pancreas disease continues to be a sporadic problem occurring unpredictably at sea sites all over Scotland. An infectious cause is now firmly established. Experimental and field evidence has been gathered that surviving fish are immune to further attack. Using regulatory control measures IPN virus is seldom found in fresh water sites but it has been widespread in sea sites. Controversy still exists as to the significance of the virus in sea fish. It was concluded from the results of an EC commissioned survey that the viruses of VHS and IHN were not present in Scottish salmonid fish. Research continues into developing techniques for the large scale rearing of the Atlantic halibut.

Shellfish production continues on relatively small but increasing scale. Production of 2.6 millions of Pacific oysters and 200,000 native oysters was recorded along with 500,000 scallops and 1.5 million queen scallops. Some 900 tonnes of farmed mussels were also produced.

Sweden

by

P-O Larsson

(Institute of Marine Research, Lysekil)

The development of Swedish oyster cultivation continued at Tjärnö Marine Biological Laboratory. In 1992 the main activity was the construction of an experimental hatchery for bivalves. The hatchery is 145 m² and with an aimed production of 1 million spat per year. In 1992 the production was very limited as the hatchery was not ready in time for the spawning season.

At the Institute of Marine Research, Lysekil, further research and development work was done with the hatching and rearing system for cod, plaice and turbot, intended to produce fish mainly for stock enhancement releases. Part of the work (regarding hatching of cod) is in cooperation with the Ar laboratory (on Gotland) of Stockholm University. Some production of all three species but only cod released in 1992. A few hundred 12 - 17 cm cod of the Skagerrak coastal (fjord) cod were tagged and released in a fjord near Lysekil. About 500 cod fry, 4 - 6 cm, of the Baltic eastern stock were transported to a rearing plant at the coast of the Bothnian Sea, to study adaptation problems to the low salinity in that area. The problems were larger than expected and caused rather high mortality until an optimal method was established. A few hundred remaining fish will be tagged and released in the Bothnian Sea early 1993.

Flatfish fry produced at the Institute of Marine Research were used in experiments by the Institute of Microbiology, Gothenburg University, aiming at developing probiotica.

Test of a photobioreactor for production of microalgae in cooperation with the Danish Institute of Marine Research (Hirtshals). So far successful continuous production of *Isochrysis* and *Rhodomonas* with a minimum of labour. One reactor was also installed at the Ar laboratory at Gotland.

Development of a system for sieving out natural zooplankton of selected sizes from water pumped up from optimal depth. The zooplankton were used for start feeding fish larvae.

Hatching and rearing of lobster to a size of 6-10 cm, when they are released in a protected area, where survival and growth will be studied. About 600 lobsters were released in 1991, but none in 1992.

Net-pen farming and land-based farming experiments with cod in cooperation with two private firms at the Skagerrak coast. Small cod, obtained as by-catch in fyke nets for eel, were transferred to a net-pen and tanks with pumped through water and fed various kinds of food till consumption size. Survival and growth were excellent with all kinds of food tested.

At the Ar laboratory research continued on the basic mechanisms in cod (egg/larvae) adaptation to the troublesome environmental conditions in the Baltic, especially low salinity and oxygen content, making mariculture activities still more difficult with Baltic cod than with Atlantic cod.

The Salmon Research Institute, Älvkarleby, continued experiments with delayed release of salmon (post-)smolts at the Baltic coast. Results continue to be very high, in several experiments exceeding 50% reported as recaptured. Apart from that, emphasis has been given to diseases, especially "M74" (see below) and vaccination methods. Also a number of genetic projects were started, regarding several aspects related to the aquaculture activities.

The Institute of Aquaculture in Umeå has concentrated its activities on freshwater species like Arctic char and noble crayfish, but some basic research on Baltic salmon has bearing on the delayed release experiments with that species. Net-pen rearing of Arctic char at the coast of the Bothnian Sea and Bay has been considered but still not tested.

At the Department of Zoophysiology, University of Göteborg, research continued on nutrition and reproductive physiology in fish. The species in focus are salmonids and flatfishes, i.e. turbot and halibut. The work involves quantification of reproductive hormones, controlling the initiation and development of sexual maturation and ovulation. Further, characterization of requirements of essential fatty acids for female broodstock, egg and larvae. The transfer of fatty acids from the female to the eggs is of special interest.

The Department of Physiological Botany, Uppsala University, has continued R&D on cultivation of marine algae. Experiments were done also with co-cultivation of algae and rainbow trout.

Commercial aquaculture enterprises produced in 1991 5.800 tonnes of rainbow trout, of which about 60 % in the sea, 600 tonnes of blue mussels and 160 tonnes of Atlantic salmon. Further 160 tonnes of eel, about 100 tonnes of which were produced in a land-based farm using sea water. For all species this is a decrease from 1990 and preliminary figures for 1992 indicate a further decrease for rainbow trout to about 3000 tonnes.

Compensation releases of hatchery-reared salmon smolt were about 2.1 million to the Baltic (Subdivisions 25, 27, 30 and 31) and about 175.000 at the west-coast (Division IIIa). About 570.000 sea-trout smolt were released to the Baltic (same areas as salmon) and 3.500 at the west-coast (the Skagerrak).

Diseases

Vibriosis, Furunculosis, BKD, Yersiniosis and IPN were also in 1992 dominant problems. For rainbow trout and salmon/sea trout 11 and 2 cases respectively of vibriosis were detected. This is a decreasing trend due to successful vaccination programmes. On the other hand six new farms have been infected with furunculosis, giving a total number of 32. For BKD and yersiniosis the situation is more stable with respectively 2 and 1 new cases, giving a total of 23 and 9. IPN has been detected in 1 salmon farm only.

The so called M74-disease, which is a disease acting at and killing off yolk-sac fry of Baltic salmon, has increased considerably during the last years. In 1992 50 - 90% of yolk-sac fry suffered from this abnormal mortality in the hatcheries for Baltic salmon. The disease is believed to be connected to high load of contaminants in the parental fish, and the Swedish Environmental Protection Agency and the Salmon Research Institute have appointed a group of experts to evaluate available data and to propose a strategy for further research activities.

USA

by

John B. Pearce

(National Marine Fisheries Service, Woods Hole)

General

In that region (Northwest Atlantic) of the United States, of greatest interest to member nations of the International Council for the Exploration of the Sea (ICES), culture of salmonids, and increasingly other fish species, as well as the propagation of bivalves, especially mussels and oysters, continue to be mariculture activities of considerable interest.

There has been success in mariculture endeavors in Canada and other areas which is reflected by increasing visibility of cultured salmon and lake trout in U.S. fishmongers and fisheries departments of supermarkets. Moreover, many resource managers are taking an even broader view of mariculture, seeing fish not being reared solely for immediate consumption, but also to augment certain wild stocks. In an article in Fisheries (Nickum, 1992), the idea of rearing fishes to augment stocks was covered in considerable detail. The American Fisheries Society is presently considering how operation of hatcheries can be improved so as to propagate fish that can then be stocked into ecosystems in a way that will not alter natural biological communities. It is anticipated that controversy surrounding this activity can be

resolved, based on greatly improved scientific information and hatchery methodologies.

Gulf of Maine

The Northeast Regional Office, National Marine Fisheries Service, was contacted by the Quebec-Labrador Foundation, an environmental organization interested in developing high school and technical programs in aquaculture. A high school biology teacher in Eastport, Maine, is concerned about the fact that local people are not being hired by, and consequently not benefiting from, the local successful aquaculture industry. NMFS staff has provided background information on aquaculture and identified curricula that may be helpful. For additional information contact Mary Colligan (508) 281-9116.

Southern New England

The National Marine Fisheries Service, Milford laboratory, is expanding its mariculture endeavors after over a decade of concentrating on contaminant effects on individual species and ecosystems. It sponsored an aquaculture/shellfisheries seminar that brought together 96 individuals from 11 coastal states, the District of Columbia, and South Africa. Most presentations to this aquaculture seminar included descriptions of new diseases of juvenile oysters, marine genetic techniques to confer disease resistance, and follow-ups on methodologies used in scallop aquaculture in China. It is worth noting that the very productive program in China is based on scallops originally furnished as early juvenile stages to Chinese industry by the Milford Laboratory. The laboratory is also researching effects

of pollutants and habitat decline in certain contaminated harbors and associated seafood safety issues. For additional information contact Dr. Walter Blogoslawski, (203) 783-4235.

The Milford Laboratory is doing collaborative studies with personnel of the University of Maryland, looking at the fatty acids and/or sterol contents of over 30 phytoplankton strains that are cultured and used as mariculture "forage". In addition, Milford personnel are working with Dr. Roxanna Smolowitz, University of Pennsylvania and the Marine Biological Laboratory (Woods Hole), on effects of dinoflagellates upon survival, growth, and development of the eastern oyster, Crassosytrea virginica. For details, call her at (508) 548-3705.

The Milford Laboratory is also engaged in other collaborative studies with state agencies and academic institutions, as well as commercial interests, in regard to setting of the eastern oyster, Crassoystrea virginica. Work is being done to identify phytoplankton pigments responsible for the unique coloration in edible tissues of the Arctic surf clam, Mactromeris polynyma. Recommendations are being developed for specific phytoplankton culturing techniques to provide foodstuffs that will intensify clam pigmentation, which is a desirable trait in product sold to certain nations and regions. For more information, call the Officer-in-Charge, Milford Laboratory, (203) 783-4240.

The Milford Laboratory also continued maintenance of a microalgae culture collection consisting of over 170 strains, most of them axenic; these provide starting cultures for over 100 foreign and national institutions that have requested them.

The State of Connecticut is applying for grants of over \$2KK to substitute new setting materials to mitigate loss of setting shell substrata on 950 acres of a state oyster bed off Bridgeport, Connecticut.

Mid-Atlantic Bight

Scientists at the NMFS Sandy Hook facility anticipate research funds to enhance hard clam populations on 135 acres of unproductive bottom by spreading new shell on them.

In the State of Virginia, heights of oyster reefs in the James River and other areas are being modified and brood oysters planted near them so as to improve recruitment, settlement, and enhance production of oysters from the rivers.

Generally, mariculture is in a "time of flowering" in the northwest Atlantic, and there is no doubt that hundreds of research programs conducted at scores of institutions, agencies, business, and academic centers will increase our knowledge of species used in mariculture and enhance commercial opportunities.