International Council for the
Exploration of the Sea

C.M. 1986/F:1
Report of Activities

MARICULTURE COMMITTEE

J. E. Stewart

Report for 1986

BELGIUM

(P. Sorgeloos)

Experimental work was conducted by Prof. Ollevier et al at the Catholic University Leuven on the following:

- larval culture of sea bass Dicentrarchus: effect of food quality, light conditions;
- growout of sea bass and sea bream in thermal effluent of nuclear power plant near Antwerp;
- distribution of Leptocephali in North Atlantic and influx of elvers in the European estuaries.

At the Artemia Reference Center, Ghent State University, the following experimental work was conducted by Dr. Sorgeloos et al:

- development of an algal substitute for feeding Penaeid Shrimp and Brachionus;
- development of enrichment diets for Brachionus and Artemia;
- joint testing with CENMAR, commercial fish farm in Yugoslavia, of Brachionus and Artemia enrichment feeds for European sea bass and sea bream larvae;
- comparative study of Artemia strains: cyst, nauplius and adult characteristics - cross breeding results.

Work conducted by a private company, Artemia Systems Sa, included production and marketing of selected artemia cysts, algal substitutes, Brachionus and Artemia enrichment diets and of shrimp maturation diets; start-up of culture unit for intensive artemia biomass production.

CANADA

(J. E. Stewart)

ATLANTIC COAST (R. Drinnan)

Commercial Aquaculture Development

New Brunswick - The marine cage culture of salmonids is the most significant commercial activity. Production is increasing with the availability of

smolts. The six established commercial operations marketed salmon in 1986; three of these and ten of the developing salmonid operations also marketed rainbow trout. Atlantic salmon production is forecast to increase threefold in 1987.

Blue mussel culture is limited by Paralytic Shellfish Poison in southern New Brunswick. Exploratory culture of the giant scallop is underway to assess viability by establishing data on seed supply, growth and mortality rates, etc.

Newfoundland - A salmon hatchery has been established on the south coast using the warm effluent of a hydroelectric generating station, and will produce smolts in 1987. A number of exploratory marine cage sites locally have demonstrated that winter conditions are suitable for survival.

Two operations marketed mussels in 1986 including export. Several others will market in 1987. Culture of the giant scallop is continuing. Seed supply was limited in 1986 and none was exported.

Nova Scotia - Both participation and production in mussel and salmon culture continue to increase. Production of both species is projected to double in 1987. A major increase in rainbow trout production is forecast for 1987, largely due to a move to production of large fish in sea cages permitted by the development of overwintering sites.

Prince Edward Island - The blue mussel continues as the major commercial species. With the present and projected increase in production, diversification of products is underway. A number of processed products are under development for test marketing.

Salmonid culture development is constrained by lethal winter conditions, for which potentially useful technology is under test. Three certified hatcheries are producing rainbow trout for both local use and export.

Salmonid Demonstration and Development Farm - This facility, established in southern New Brunswick in 1986, has completed its first year of testing and developing technology to maximize efficiency and competitiveness of the marine rearing phase of the salmonid industry.

Salmon rearing nets, treated with a commercially available net anti-fouling compound, do not show significant fouling for at least a year. This will allow rearing of a crop of smolts to market with only one net change, to allow increase of mesh size in the first fall or following spring. In comparative trials of commercial moist and dry feeds, both one and two-year smolts showed similar food intake and growth up to the end of August. Fish on the dry diet showed lower food intake and growth to the end of the year. This resulted in differences in mean fish weight in December of 294 g and 170 g, in two year and one year smolts respectively. Analyses of the diets showed that they were not isocaloric, as intended. The moist diet had a significantly lower lipid level. Investigation of this phenomenon and extended feeding studies are planned for 1987 and subsequent years.

Aquaculture Technology Unit, Canadian Institute of Fisheries Technology, Halifax, Nova Scotia

This Unit was established early in 1986. Development activities of the Unit include design and testing, in conjunction with Nova Scotia salmonid farmers, of prototype feeding and surface culture cage systems. Research activities have continued in the area of subsurface cultivation techniques for Atlantic salmon, which can be used in avoidance of severe weather conditions in the harsh regions of Maritime Canada. Emphasis has been placed on the importance of access to gulpable air to salmonids in the prevention of stress caused by the development of a state of negative buoyancy. A program is presently underway for the transfer of subsurface cultivation techniques to the private sector using both the Canadian and Scandinavian technologies available.

In addition, the Unit has become involved with site evaluations and feasibility studies for private sector interests within Nova Scotia. Recently interest has been shown in on-shore salmonid cultivation using both coastal and salt water well sources. Projects involving mussel cultivation systems and under-ice harvesting have been continued, with particular interest in the development of a variably buoyant long-line system. (R. Ablett)

Professional and Technical Training

The Atlantic Veterinary College took in its first class of 50 students in September 1986. A fish health unit is contained within the modern new facility and will contribute to fish health research, teaching, extension and veterinary medical service.

Holland College in Prince Edward Island began a 40 week Aquaculture Technician Training program in September 1986.

Blue Mussel

Significant post-spawning mortality and retarded growth were observed at a number of sites in Prince Edward Island and, to a lesser extent, at one location in Nova Scotia. This phenomenon, apparently similar to experiences in other parts of the world, is under investigation into possible environmental or physiological causes.

Salmonids

Photoperiod and pre-smolt growth - Exposure to 16-hr daylength from late September to late December greatly increases growth of presmolt salmon. Following return to normal photoperiod in late December, the salmon undergo smoltification. This environmental manipulation is easily done and at little expense. Prevailing temperatures at most smolt production plants are favorable for feeding and growth during October and much of November. The treatment appears to be an effective one for production of more and larger 1+ smolt. (R. Saunders)

Environment and maturation - Further evidence of environmental effects on age and size at sexual maturity of *Salmo salar* was obtained using a Newfoundland stock of salmon all of which mature as grilse under natural conditions. These fish, following rearing to the age 1+ smolt age in the laboratory and grow-out

for 18 months in a Bay of Fundy sea cage, gave fewer than 60% grilse. Some aspect of the sea-cage environment, perhaps thermal regime, diet, feeding regime, crowding, stress or growth pattern appears to have influenced the maturation process. (R. Saunders)

Atlantic salmon kelt conditioning - An experimental salmon farm was set up on the northeast coast of Newfoundland under joint sponsorship of two regional development associations. DFO (Science) provided technical input. Data from the kelt experiments have not been completely analyzed to date. Preliminary indications are that kelt reconditioning for meat or for eggs is relatively simple as long as marine temperatures are at least 10°C. At temperatures of less than 10°C, kelt salmon did not feed well and many died, apparently of malnutrition. (V. Pepper)

Marine salmon overwintering experiments - Winter marine temperatures in Newfoundland coastal waters generally range from -1.0 to -1.5°C from December until April. Such temperatures are lethal to Atlantic salmon. A prototype salmon cage that utilizes an underwater wood stove is under evaluation on the northeast coast of Newfoundland. Water temperature within the cage has been maintained at about 5°C since December. Marine temperature outside the cage has been steady at -1.2°C. To date (February 1987), salmon in this cage are behaving normally and respond well to food. (V. Pepper)

Nutrition (S.Lall)

In a preliminary study to determine the vitamin E requirement of Atlantic salmon fingerlings, graded levels of DL-alpha tocopherol acetate (0, 10, 30, 60, 120 and 240 I.U. per kg of diet) were added to purified diet. The basal diet contained 10% lipid and 5.6 mg of alpha tocopherol per kg of diet. Growth, feed efficiency and mortality were not significantly influenced by dietary vitamin E levels. Histopathological examination of tissue showed myocardial degeneration in the deficient group. Studies on the effects of alpha tocopherol on immune response did not show any significant effects. There was also no evidence of the disease protecting role of vitamin E against Aeromonas salmonicida.

Digestible energy value and digestibility coefficients of major nutrients in herring, cod and dogfish and their acid-preserved silage (1.5% W/W) formic acid and 1.5% (W/W) sulphuric acid were measured for Atlantic salmon in sea water. The digestible energy contents of all three fish silages were significantly lower than whole fish. In general, herring was more efficiently utilized than dogfish and cod in either form.

Fish Health

Stock importation - In 1986, 1.4 million eggs and 133,000 fingerlings of rainbow trout were imported to the region under Fish Health Protection Regulations. No salmon stock was imported.

Furunculosis - All smolts transferred to sea cages are screened for infection with Aeromonas salmonicida, including stress testing for the carrier state. In 1986 no infections were observed in cage sites.

Bacterial Kidney Disease (BKD) - Two cage sites continue to show infections with BKD. Eggs from these sites are only used by the industry if their parents are found negative for BKD in reproductive fluids. Resulting smolts show no infections. The continuing marine site infections suggest that transmission from year class to year class is occurring in the cages.

Lobster

Temperature, photoperiod and spawning - A study on the effect of photoperiod on spawning in American lobsters revealed that temperature determines the lobster's response to photoperiod. Low winter temperature synchronizes vitellogenesis and spawning in lobsters, but when winter temperatures are abnormally high (10°-15°C), then photoperiod becomes the regulatory parameter. (D. Aiken)

Eyestalk ablation and growth - Bilateral eyestalk ablation increases growth and molting rates in American lobsters, but long-term survival is poor. However, unilateral ablation enhances growth of juvenile lobsters without a corresponding decrease in survival. After only 125 days, unilaterally ablated lobsters were 10% larger and 39% heavier than intact controls. These results indicate that unilaterally eyestalk ablated lobsters will survive as well as intact lobsters but will reach market significantly sooner. (D. Aiken)

PACIFIC COAST (L. Margolis)

Mussel Culture - Efforts focused on: (1) characterizing mussel growth and survival characteristics at 19 sites throughout B.C., ranging from Sooke to Prince Rupert; (2) investigating growth and survival characteristics of mussels from various sources transplanted to common grow-out sites; (3) investigating growth and survival of deep-subtidal, shallow subtidal, and intertidal mussels from a common population; and (4) monitoring growth and survival in relation to spawning pattern. About 25,000 mussels were individually tagged, with growth and survival of an additional 25,000 being monitored.

Scallop Culture - *Patinopectin yessoensis* received from Japan in February was spawned to mid-July. Of 20 attempted spawnings, 17 were successful, yielding 22.7% success through embryonic development and 18% success through larval growth and development. Currently, about 10,000 juveniles have been produced, 1 cm in size at three months. About 30 million three-day-old larvae were used for a series of nutritional experiments assessing energy depletion/assimilation through larval development. Native rock scallop, *Crassodoma gigantea*, yielded 12 out of 15 successful spawns, with 30% survival to the end of the embryonic phase and 6.5% to the end of the larval growth phase.

Sablefish Culture - The program is directed toward development of procedures for egg incubation and feeding of larvae. During 1986, eggs were obtained from captured wild broodstock and fertilized successfully. The temperature and salinity conditions required during egg incubation were determined. Preliminary experiments indicated that larval rearing is feasible. Some success was achieved in growing postlarval stages using an artificial diet of intermediate moisture content. Experiments were also conducted to develop techniques for inducing ovulation in sablefish.

Salmonid Controlled Reproduction - Research is being conducted to provide additional data on sex control methodology for salmon farming. Masculinized coho salmon are being reared to develop a source of female milt for the mariculture industry.

Biotechnology - Several experiments were conducted on modes of administration of recombinant growth hormones to shorten the production cycle in salmon farming. Experiments on the use of triploidy to control sexual maturation were conducted and a large pressure chamber was constructed for testing on pilot scale.

Fish Nutrition - Experiments were conducted to assess the nutritive value of hake meal for feeding salmon in sea water and to evaluate the merits of fish silage as a source of dietary protein and lipid for cultured sablefish and Pacific salmon. Pilot scale experiments were conducted in sea water netpens to determine the influence of diet and rearing density on growth and survival of coho salmon and to determine the influence of dietary lipid composition on reproductive performance in chinook and coho salmon. A two-day workshop on nutrition was conducted for the mariculture industry.

Chinook Broodstock - Six river stocks of chinook salmon were reared on four commercial farms and in the Experimental Fish Farm in Nanaimo in order to evaluate genetic and environmental influences on growth, survival and age at maturity. The program is also designed to provide eggs for the mariculture industry at completion.

Salmon Genetics - An experiment comparing production characteristics among stocks of coho salmon was completed, providing information for design of a selective breeding program to develop improved strains for salmon farming.

Salmonid Mariculture - Laboratory experiments demonstrated the feasibility of applying a constant short-day photoperiod for 2 months for the time of first feeding to accelerate smolting in coho and stream-type chinook salmon. Tests were conducted to develop criteria for transport of chinook salmon smolts. Pilot scale experiments at the Experimental Fish Farm examined the growth rate of sterile and triploid coho and tested the effect of seawater transfer time on growth of accelerated coho smolts. Atlantic salmon smolts were transferred to sea water netpens at the Experimental Fish Farm, in order to evaluate the suitability of this species for salmon farming on the Pacific Coast. A workshop on coho rearing strategies was held for the salmon farmers.

Disease Control Research - Studies were conducted on development of anti-furunculosis vaccines, on the effects of fish cultural practices on the immune responses in fish vaccinated against Furunculosis and Vibriosis, and on the efficacy of current vibrio vaccines.

Diagnostic Services - The service responded to numerous calls for assistance from private salmon farms, carried out inspections required to ensure compliance with the Canadian Fish Health Protection Regulation, tested efficacy of new drugs and methods for their administration, monitored Atlantic salmon in quarantine facilities, and reported on Proliferative Kidney Disease, a new disease recognized for the first time in the Region.

Shellfish Diseases - Investigated summer mortality problem in mussels; produced an illustrated manual on normal larval scallop anatomy; investigated biology of abalone parasite in order to devise control measures.

Production and Value of Mariculture Species

Note: Official statistics for 1986 are not yet available. The B.C. Salmon Farmer's Association estimates 1986 sales of coho and chinook salmon at 500 tonnes. Oyster production is estimated to be similar to 1985 values (see below):

1985 Production and Value - Pacific

	Rainbow trout*	Chinook salmon	Coho salmon	Oysters
Weight	83 tonnes	54 tonnes	65 tonnes	3,420 tonnes
Value	$435,000	$426,000	$383,000	$2,613,000

* Rainbow trout production 97% from freshwater farms.

1986 Production and Value - Atlantic

SPECIES	PRODUCTION (TONNES)	VALUE (US$, '000's)
European Flat Oyster (*Ostrea edulis*)	5.4	45.0
Blue Mussel (*Mytilus edulis*)	1,777.0	2,036.0
Giant Scallop (*Placopecten magellanicus*)	0.2	1.1
Atlantic Salmon (*Salmo salar*)	297.0	2,702.0
Rainbow Trout	111.0	505.0

DENMARK

(H. P. Bak)

Research concerning mariculture is increasing in Denmark. Traditionally, research and development in aquaculture has been carried out by the Danish Institute of Fisheries and Marine Research (DIFMR) and Danish Aquaculture Institute (DAI). Recently some universities are emphasizing aquaculture and in 1986 some of these universities established permanent lecturer positions.

Salmonids

The research activities of salmonids and especially rainbow trout (or rainbow salmon) *Salmo gairdneri* were concentrated in: (a) Genetics; (b) Smoltification; and (c) Diseases.

(a) Genetics

During 1986 a small scale genetic breeding program was started in cooperation between DAI and DIFMR due to a grant from the Technology Counsel in Denmark. The program contains a screening of different stocks of rainbow trout in order to find out if different strains of rainbow trout exist in Denmark.

Also, fish were collected from some commercial sea farms to build up a broodstock of sea water adapted individuals. The outspring from these groups will be tested in the coming years.

(b) Smoltification

A group of researchers and master thesis students from DIFMR and several universities together formed a "smoltification group" where all the available knowledge was put together and a coordinated row of projects were discussed and carried out. During year 2, Master theses were obtained and three more will follow in 1987 within this subject.

There have been projects concerning feeding with pellets containing a high amount of NaCl, observations on blood parameters from trouts of different size and living at different temperatures, and finally tests with dosage of T4-Thyroxine and measuring the Na-K-ATP-ase activity.

(c) Diseases

Research on disease is mainly carried out at DIFMR's Laboratory for Fish Pathology and National Veterinary Laboratory in collaboration with other laboratories. In 1986, the diseases in Danish sea farms were Vibriosis, Furunculosis and VHS, of which the most severe was Furunculosis.

At DIFMR's laboratory, the number of bacteriological diagnostics concerning rainbow salmon were:

- from Freshwater farms: 353
- from Seawater farms: 244

Production

The production of sea farmed rainbow salmon raised considerably during 1986. The total amount was close to 3500 tons, which is about 1000 tons more than 1985.

Marine Species

Danish aquaculture has tried to diversify the production, and research and development is going on with the following species:

Turbot (Scophthalmus maximus)
Bream (Sparus auratus)
Sea Bass (Dicentrachus labrax)
Prawns (Penaeus monodon)

At DIFMR there is an intensive research with turbots. Most effort has been concentrated on the larval stages where DIFMR's Laboratory for Marine Aquaculture is working with both a highly intensive rearing system and with an extensive system in open ponds.

In 1986, the extensive system gave a survival of nearly 60% of the number of larvae introduced to the system. All the survivors were fully (natural) pigmented and showed a high growth rate in the following time.

The intensive rearing system is based on live production of phytoplankton, mainly Rhodomonas baltica, and the copepod Acartia tonsa. With this combination, it is possible to produce well pigmented turbots, however, the survival rate is still too small. A number of experiments with artificial diets for larvae have been made, however, still without brilliant results.

At DAI there has been continued research in both culture of breams and bass, and penaeid prawns as well. The life cycle of the bream is now being fully controlled in the Laboratory, which operates a small recycling sea water system. The main effort has been put into hormonal control of breeding time.

Difficulties with spinal deformities seem to be overcome by the use of slightly lower salinity (20%) during the larval and fingerling stages.

Until now, breeding of sea bass has failed, however, the trials continue.

Also at DAI, with the penaeid shrimp, Penaeus monodon, attempts are being made to obtain successful breeding without the traditional eyestalk ablation. Tests have been made by changing the environmental parameters without any effect and now hormonal injections are being tested.

Other Aquaculture

The Danish production of rainbow trout in freshwater is rather stable and the yearly production is about 22,000 tons, of which 1000 tons are used for sea farming.

Also Eel production has gradually grown to reach about 200 tons in 1986. Eel production numbers cover 32 farms of very different size, ranging from 2 to nearly 100 tons per year.

Mussel and oyster farming has still not been successful in Denmark. At the last meeting in Copenhagen, questions were raised concerning mussel production. There is one company producing mussels by rope culture method and there is no registered production, however, there is a very intensive mussel fishery going on in the Limfjord, the Waddensea and the Isefjord. The fishermen are dredging mussels and the annual production is around 100,000 tons. Also there is a growing industry of processing these mussels, but again no production from mariculture activity.

FINLAND

(K. Westman and P. Tuunainen)

Production of Fish for Human Consumption

Rainbow trout (Salmo gairdneri) is practically the only fish species cultured in Finland for human consumption. Farming of rainbow trout increased considerably in the 1980s, especially in net cages and enclosures in the sea. By 1985, marine fish farms produced 66% of all the rainbow trout raised in Finland.

Table 1. Number of fish farms and production of fish for human consumption in Finland in 1979-1985 (based on statistics from the Finnish Game and Fisheries Research Institute).

Year	Marine Fish Farms		Fresh Water Fish Farms		Total		Estimated Value of Production, Million FIM
	Number	Production	Number	Production	Number	Production	
1979	36	794	157	2481	193	3275	59,0
1980	78	1958	164	2712	242	4670	95,7
1981	85	2211	253	3175	338	5383	116,8
1982	98	3226	296	3099	394	6325	128,4
1983	105	3910	287	3601	392	7511	158,0
1984	151	5381	302	4112	453	9493	204,0
1985	176	6647	285	3427	461	10074	227,0

Production for Stocking

The stockings required by law of power companies and similar compulsory stockings and state stocking have sharply risen in the 1980's in regard to salmon (Salmo salar), sea trout (Salmo trutta m. trutta) and migratory whitefish (Coregonus lavaretus) in marine waters. In 1985, a total of 2.4 million salmon, 11.2 million migratory whitefish, and 1.2 million sea trout, 1 summer old or older juveniles were produced in Finland for stocking purposes.

In the Simojoki and Tornionjoki Rivers, which flow into the Gulf of Bothnia, stocking has continued of 1-year old salmon parr in the rapids to maintain the sharply declining stocks. In the Simojoki River in 1986, 15,000 salmon parr were stocked; and in the Tornionjoki River, 255,000 parr. Extensive monitoring programs are being run in both rivers. Genetic studies of the salmon and sea trout stocks continued. The sea trout stock in the Tornionjoki River is particularly threatened.

Research

Research studies were carried out to investigate the results of stockings made for sea ranching. These studies included extensive taggings with both Carlin and micro tags. Other research included studies aimed at improving the quality of reared fish young by investigating food and feeding, improving rearing

methods, and the use of ADP in fish culture monitoring and management. Effective control of parasites and disease was studied, and fish quality was measured using the physiological testing methods developed.

Studies have also been continued to the end of improving stocking results by decreasing the mortality rate of stocked salmon smolts, e.g., by the use of release ponds and delayed release, and by developing better transport methods and equipment. Extensive research continued into methods to decrease the water pollution caused by fish farms. Studies on rearing of 1-year old salmon smolts in the warm water effluents of nuclear power plants, and comparative studies on the genetics of wild and reared salmon and sea trout stocks are also being continued.

Fish Diseases

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

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

Outline for Statistical Information on Mariculture Production - 1985

Species	In Metric Tons	Approx number in 100 000	Value in [1] 1 000 US $
Rainbow trout in enclosures more than 0.5 kg each	6,647	--	34,133
Salmon smolts for introductions, 1 year and older	--	24.55	3,706
Other salmonids (specify): Sea trout for introductions 1 summer old and older	--	11.88	1,322
Others (please specify): Migratory whitefish for introductions 1 summer old	--	112.02	1,778

[1] Rate $1 US = 4.4 FMK

CONDENSED FROM FAO FORM FOR REPORTING STATISTICS ON AQUACULTURE

From Sheet No. 1

Method of Culture	Freshwater Culture		Brackishwater Culture	
	No. of Units	Hectares	No. of Units	Hectares
Fishes				
Ponds	3,974	4.7		
Enclosures) Cages)	285	16.6	1,467	35.7
Raceways (earth ponds)	1,774	85.8		
Others: natural food rearing ponds	771	9,293		

HATCHERY OUTPUT

- see attached statistics "Fish culture in Finland 1985", production to stockings

From Sheet 2

Species Cultured	Freshwater Culture		Brackishwater Culture	
	Metric Tons	Price/ Kg	Metric Tons	Price/ Kg
Fishes (live weight)				
Ponds:				
99% kirjolohi, *Salmo gairdneri*; 1% lohi, *Salmo salar* and taimen *Salmo trutta*	3,427	22.5 FMK		
Cages:				
99% kirjolohi, *Salmo gairdneri*; 1% lohi, *Salmo salar* and taimen *Salmo trutta*			6,647	22.5 FMK

FISH CULTURE IN FINLAND IN 1985

Number of Fish Farms and Hatcheries	Brackish Water Cage Farms	Fresh Water Farms and Hatcheries	Natural Rearing Pond Breeders	TOTAL
	176	285	216	677

PRODUCTION CAPACITY OF FARMS AND HATCHERIES	Incubation Capacity		Rearing Space				
	Glass Incubation	Tray Incubation	Artificial Tanks	Earth Ponds	Net Cages and Enclosures: Sea Area	Net Cages and Enclosures: Freshwater Area	Natural Rearing Fish Ponds
	Egg Liters		kpl 3,974	1,774	1,467	285	771
			1,000 m²				ha
	14,870	18,190	47	858	357	166	9,293
Farms and Hatcheries	72	85	97	224	176	22	216

Food Fish Production of Fish Farms	Brackish Water Cage Farms	Fresh Water Farms	Total	Value of Production M Fmk
	Production - 1,000 kg[2]			
	6,647	3,427	10,074	227
Farms	176	159	335	

[1] 99% of production rainbow trout. The rest salmon and brown trout.

[2] Production in kg ungutted fish.

PRODUCTION TO STOCKINGS IN 1985	(3) Newly Hatched	(4) 1 summer old	1 year old	2 summers old	2 years old	3 summers old	3 years old	older	Total (Excl. Newly Hatched)
	Stockings 1,000 fish								
Whitefish, Coregonus pidshian (Gmelin)	246	2,631	--	1	--	--	--	--	2,632
Whitefish, Coregonus lavaretus (L.)	86,086	11,202	--	--	--	--	--	--	11,202
Whitefish, Coregonus muksun (Pallas)	2,082	19,215	52	--	--	--	--	--	19,267
Whitefish, Coregonus peled (Gmelin)	16,700	2,217	1	--	--	--	--	--	2,218
Whitefish, unidentif. Coregonus sp.	--	847	--	--	--	--	--	--	847
Vendace, Coregonus albula (L)	990	--	--	--	--	--	--	--	--
Atlantic salmon, Salmo salar L.	112	17	326	3	2,097	3	26	--	2,472
Landlocked salmon, Salmo salar L. m. sebaco Girard	26	--	--	8	118	3	--	--	129
Sea trout, Salmo trutta m. trutta L.	1,316	27	40	115	921	61	24	--	1,188
Brown trout, Salmo trutta m. lacustris L.	6,004	220	313	218	986	173	215	2	2,127
Brown trout, non-migratory Salmo trutta m. fario L.	1,163	13	20	28	1	--	--	--	62
Rainbow trout, Salmo gairdneri Richardson	--	104	38	78	26	9	19	--	274
Char, Salvelinus alpinus (L.)	397	58	1	--	29	--	1	--	88
Brook trout, Salvelinus fontinalis Mitchill	--	30	--	--	--	--	--	--	30
Lake trout, Salvelinus namaycush (Walbaum)	171	4	--	--	46	--	45	--	95
Crayling, Thymallus thymallus (L.)	183	1,239	8	--	--	--	--	--	1,247
Pike, Esox lucius L.	11,945	1,500	--	--	--	--	--	--	1,500
Bream, Abramis brama (L.)	--	287	--	--	--	--	--	--	287
Carp, Cyprinus carpio L.	--	--	--	6	1	1	--	--	8
Id, Leuciscus idus (L.)	--	366	--	--	--	--	--	--	366
Pike-perch, Stizostedion lucioperca(L.)	241	1,353	--	--	--	--	--	--	1,353
Crayfish, Astacus astacus L.	21	9	1	--	--	--	--	--	10
American crayfish, Pacifastacus leniusculus (Dana)	6	4	--	--	--	--	--	--	4

(3) Salmonids free-swimming fries.
(4) Pikes a few weeks old younglings.

Value of stocking-production 1985 M Fmk 74,0

FRANCE

(Dr. H. Grizel)

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

1. La modélisation de la production par bassin; ce travail nécessite la connaissance de la biomasse en élevage, mais aussi celle de filtreurs compétiteurs, la capacité nutritionnelle du bassin et le système de répartition des eaux.

   Des recherches complémentaires sont entreprises pour réaliser ce programme. Les principales sont la mise au point de techniques d'évaluation (traitement d'image), une meilleure connaissance de la physiologie des animaux, l'adaptation de méthodes mathématiques.

2. L'étude des maladies, notamment la compréhension des relations existantes entre l'hôte et les agents pathogènes: la mise au point de techniques de purification de Protozoaires a permis d'envisager l'obtention de modèles in vitro, et l'obtention de diagnostics sérologiques. Par ailleurs, des données épidémiologiques sont régulièrement acquises sur les différents cheptels d'élevage et naturels le long du littoral français. Enfin, des études sont réalisées pour tenter d'obtenir des souches résistantes à la bonamiose.

3. Les travaux de diversification des cultures et de reconstitution de gisements se poursuivent; notamment pour la palourde, Ruditapes philippinarum et la coquille St-Jacques Pecten maximus. Les techniques d'élevages étant acquises, il apparaît maintenant nécessaire de développer des recherches thématiques (physiologie, pathologie, environnement, etc....).

4. L'ensemble de ces recherches est complété par des expériences sur le rôle des facteurs d'environnement, en particulier des polluants, et par le contrôle des développements d'eaux rouges et des pollutions.

Production Des Mollusques D'elevages en France en 1986

Huîtres creuses	Crassostrea gigas	106,000 tonnes
Huîtres plates	Ostrea edulis	2,000 tonnes
Moules	Mytilus edulis	50,000 tonnes
Palourdes	Ruditapes phillippinarum	500 tonnes

(J. Guillaume)

Salmonides - L'élevage de salmonidés en mer a progressé en 1986 sur les côtes de l'Atlantique et de la Manche: la production de truite Arc-en-ciel a été de 600 T, celle de saumon Coho de 50 T tandis que celles de saumon Atlantique et de truite Fario, encore pratiquement expérimentales, peuvent être estimées à 6 et 14 T respectivement. Dans la station expérimentale commune à deux instituts de recherche (Institut Français de Recherche pour l'Exploration de la Mer et Instuit National de Recherche Agronomique) des comparaisons

d'espèces et de souches ont été poursuivies; elles ont en particulier montré que la truite Fario (Salmo trutta) bien que se développant très lentement en eau douce avait, en mer, une croissance au moins égale à celle de Salmo gairdneri. Elle est plus apte que cette dernière à la production de gros poissons (2 à 4 kg) par suite de sa bien meilleure survie en période estivale (température dépassant 17°C, salinité 35-36%). Des expériences ont également permis de définir les densités maximale et optimale d'élevae de la truite Arc-en-ciel en eau de mer ainsi que les relations entre ration alimentaire, taux de transformation, croissance et état d'engraissement. Sur le saumon Atlantique, les essais en cours visent la définition des normes d'élevage dans le contexte breton.

Poissons Marins - L'élevage des poissons marins sur la côte Atlantique est resté à un niveau faible aussi bien pour le turbot (Scophthalmus maximus) (environ 200,000 alevins, 10 T de poissons de consommation produits) que le bar (Dicentrarchus labrax) dont l'élevae français reste centré sur la Mediterranée. Ces élevages souffrent des périodes de froid hivernal. Il faut noter cependant qu'au niveau de la recherche de notables progrès ont été accomplis: pour le turbot les techniques d'élevage des larves ont été améliorées par un meilleur contrôle de la population bactérienne des rotifères proies. Pour le bar, les résultats de sevrage ont été également améliorés par l'addition d'attractants aux aliments sevrage. Notons que, pour ces deux espèces, des mesures de digestibilité sont en cours; elles devraient permettre une meilleure formulation des aliments.

Crevettes - On assiste à un développement de l'élevage de la crevette impériale (Penaeus japonicus) qui, bien que faible, a été trois fois plus élevé que l'année précédente; la production totale française a été de 12 T d'animaux de 15 à 30 g; elle se pratique surtout dans D'anciens marais salants et l'intensification des méthodes sur poursuit.

FEDERAL REPUBLIC OF GERMANY

(K. Tiews)

Crassostrea gigas

There were four different activities along the German North Sea coast and at Flensburg fjord to develop commercial oyster; promising results were obtained. A total of some 360,000 oysters were grown, using the methodology developed by the Institut für Küsten- und Binnenfischerei at its former Langballigau field station located on the fjord of Flensburg and which was closed in April 1985 after the task to develop a culture system for the Pacific oyster applicable under the conditions of the German coasts had been more or less completed.

Salmonid Fish

Some 30 tons of rainbow trout were grown in cages in the Kiel Bight on a commercial basis in continuation of former experiments carried out by the Institut für Meereskunde an der Universität Kiel. In October 1986, all fish were killed when a severe oxygen depretion occurred in the farming area.

Turbot

Studies on the reproduction of turbot, the rearing of fry and the fattening of fingerlings, including the development of feeds formerly carried out at the Institut für Meereskunde an der Universität Kiel, were continued by the Institut für Hydrobiologie und Fischereiwissenschaft der Universität Hamburg in the former field station of the Institut für Meereskunde in Kiel-Bülk.

Intensive Farming Systems

Experimental investigations on the influence of dissolved gases on fishes were continued at the Institut für Küsten- und Binnenfischerei.

Work at the Biologische Anstalt Helgoland has focused on a wide array of different activities in marine and brackish water systems, with special reference to water quality and water management, rearing different development states of Mugil and Turbot and the rearing of indigenous species.

Ten fields of research activities have been attended to, in particular:

1. Environment oriented management of aquaculture systems with special consideration of the effects of salinity on the analytical accuracy in the determination of total ammonia.

   Optimization of brackish and marine systems regarding biofilters (nitrification and denitrification) and elimination of suspended solids.

   Use of mass spectrometry for the continuous determination (monitoring) of dissolved gases.

2. Investigation on the behaviour (swimming, spatial distribution) of aquaculture species under varying conditions of densities, flow rate, feeding intervals, etc., employing video systems.

3. Feeding and growth experiments with juvenile mullet and turbot under conditions of standard aquaculture systems, as well as impact of the application of different anesthetics during handling procedures.

   Experimental use of newly developed artificial feeds for juvenile turbot, plaice and cod.

4. Investigation of cyclically occurring phenomena in intensive aquaculture systems.

5. Effects of factors such as stocking density, anesthetics and state of nutrition during air shipment of young mullet on water quality.

6. Nutritional requirements for the rearing of young mullets and determination of rate of excretion of various metabolites.

7. Testing of exotic species as potential aquaculture candidates and application of quarantine measures to prevent spreading of diseases.

8. Determination of feed-, species- and maintenance-specific BOD, total ammonia and pH in commercial aquaculture enterprises raising alevins, smolts and juveniles of Atlantic salmon and the American lobster on artificial feeds.

9. Development of methods for the propagation of commercially important aquaculture candidates such as Macrobrachium rosenbergii.

10. Rearing and propagation of potentially endangered species such as Salmao trutta, S. salar and Coregonus oxyrhynchus (white fish) in brackish water systems (μ 15‰S) with the aim to produce a spawning stock for artificial propagation.

Fish Pathology

Studies to develop methods with which to describe stress conditions for fish in intensive aquaculture systems was continued at the Institut für Hydrobiologie und Fischereiwissenschaft of the University of Hamburg.

Statistics

	Tons	Value in 1,000 US Dollars
Blue mussels (Mytilus edulis)	29,400	5,000
Pacific oysters (Crassostrea gigas) from vertical cultures	24	150
Eel (Anguilla anguilla) not fresh water	40	400
Rainbow trout (Salmo gairdneri)	30	175

GERMAN DEMOCRATIC REPUBLIC

Nil Report.

ICELAND

(B. Björnsson, A. Helgason, S. T. Einarsson and I. Johannsson)

Aquaculture in Iceland during 1986

The interest in fish farming in Iceland has increased vastly in the last few years, and in the country there are great expectations linked with the possibilities of establishing a competitive production of farmed fish. These hopes are particularly based on the country's abundance of geothermal energy

and high quality well water, which can be utilized for fish farming at a relatively low cost.

Fish farming in Iceland is currently confined to farming of salmonids. Atlantic salmon (Salmo salar) is of greatest importance, but rainbow trout (Salmo gairdneri), brown trout (Salmo trutta), and arctic char (Salvelinus alpinus) are farmed as well on a small scale. However, other species are also under consideration, e.g. halibut, eel, mussel, and Macrobrachium.

Methods

Based on the type of production, the Icelandic fish farms can be divided into two major categories, but within these categories there are several groups depending on the farming method.

1. Producers of Juvenile Salmon

   All producers rely on use of geothermal energy and produce mainly one-year salmon smolts.

2. Producers of Adult Salmon for Consumption

   2.1 Farming of salmon in sea pens - Typical "Norwegian method" where 30-50 g smolts are grown to a marketable size of 2-4 kg at natural sea temperatures. Production time up to 28 months.

   2.2 Farming of salmon in land based units - On-growing from smolt size to 2-4 kg in land based tanks. Sea water is pumped into the tanks and either heated with geothermal energy or used at ambient temperatures (5-10°C) from wells. Production time is expected to be approximately 12 months shorter than in cage-rearing (2.1).

   2.3 Mixed rearing - A combination of 2.1 and 2.2. The fish are grown to a size of approximately 1 kg in land based units and then transferred to sea cages where they are grown for 6-8 months to a size of 2-2.5 kgs.

   2.4 Ocean ranching - Salmon smolts are released into the ocean from an ocean ranching site. In 1-2 years time some of them return to the site as adult salmon where they are trapped and slaughtered.

Production

The majority of fish farms in Iceland are newly established and most have not completed their first production cycle. The few exceptions are smolt farms, but smolt production has a 30 year tradition in the country.

In 1986 there were more than 100 salmon farming sites registered in the country, as opposed to 80 in 1985. These companies are involved with one or more types of salmonid culture. Production figures for 1985 and 1986 are:

Type		1985	1986
		(x 1,000)	(x 1,000)
Parr	*1000	1000	1528
Salmon smolts	" "	822	1910
Juvenile trout/char	" "	460	1100
		Tons	Tons
Salmon from culture tons	" "	91	123
Ocean ranching	" "	58	65
Adult trout/char	" "	12	150

The production figures above do not truly reflect the investment in aquaculture that has taken place in Iceland. It has been estimated that in 1986 there was the capacity in Iceland to produce 15 million smolts and three thousand tons of adult salmon, and in the near future the capacity is expected to increase further.

Ownership of Icelandic aquaculture companies is quite variable. Some of the companies are owned jointly by Icelandic and foreign partners, but by law foreigners are not allowed to hold more than 49% of the stock.

At present the value of Icelandic aquaculture production is small. Estimated gross value of the 1986 production is 266 million IKR (approximately $7 million).

Research

In Iceland there are several governmental institutions and a number of private consulting companies that participate in aquaculture research. The governmental institutions are listed below, along with a brief description of the current programs in aquaculture.

1. Institute of Freshwater Fisheries (Veidimalastofnunin) P. O. Box 5252, Hverfisgötu 116, 125 Reykjavik

   - production of juvenile salmonids
   - ocean ranching
   - cage-culturing

2. Marine Research Institute (Hafrannsoknastofnunin) P. O. Box 390, Skulagata 4, 121 Reykjavik

   - ongrowing of halibut
   - culturing of blue mussels
   - environmental monitoring

3. Icelandic Fisheries Laboratories (Rannsoknastofnun Fiskidnadarins) P. O. Box 1390, Skulagata 4, 121 Reykjavik

   - development of fish feed

4. National Center for Hygiene, Food Control, and Environmental Protection (Hollustuvernd Rikisins) P. O. Box 5276, Sidumula 13, 125 Reykjavik

   - pollution caused by aquaculture

5. Institute for Experimental Paqthology (Tilraunastöd Haskolans i meinafraedi) Keldur v. Vesturlandsveg, P. O. Box 8540, 110 Reykjavik

   - fish diseases

6. Agricultural Institute (Rannsoknastofnun Landbunaðarins) Keldnaholt, 112 Reykjavik

   - selective breeding

7. National Energy Authority (Orkustofnun) Grensasvegi 9, 108 Reykjavik

   - water supply and chemistry: freshwater, seawater, and geothermal water

8. The Fisheries Associatin of Iceland (Fiskifélag Islands) Höfn Ingolfsstraeti, P. O. Box 820, 121 Reykjvaik

   - production of adult salmon in fresh water

9. University of Iceland (Haskoli Islands) Grensasvegur 12, 108 Reykjavik

   - fish physiology, smoltification of salmon

10. The National Research Council (Rannsoknarad Rikisins) Laugavegi 13, 101 Reykjavik

    - future developents of aquaculture in Iceland
    - allocation of research funds

Administration

The institutions mentioned above are under the following Ministries:

- Ministry of Agriculture (1,6)
- Ministry of Fishery (2,3,8)
- Ministry of Health (4,5)
- Ministry of Industry (7)
- Ministry of Education (9,10)

IRELAND

Nil Report.

THE NETHERLANDS

(Renger Dijkema)

Eels

Aquaculture in the Netherlands still enjoys increased interest which is mainly focused on intensive fattening of eels and cultivation of the African Catfish in recirculated, heated fresh water. Until now only one eel cultivation project in sea water has been in operation. A bottleneck for eel cultivation appears to be the supply of eel fingerlings from the inshore and coastal waters. Conflicting interests of eel fishermen and eel farmers have hitherto resulted in a limited supply of fingerling eels, which in the future will be insufficient for the fast growing eel farming industry.

The eel farms which started last year are for the most part designed to be based on elvers or fingerlings which are produced by specialized firms, instead of from small eels taken from the wild. In some instances, small, lean eels are purchased from dealers and upgraded. A possible threat is the eel parasite, Anguillicola crassa (Nematoda), which is now found in most of the inshore eel population and causes growth reduction.

Government research into intensive fattening of eel is now being carried out at the Netherlands Institute for Fishery Investigations and at the Agricultural University in Wageningen. Most of the research is aimed at resolving the zootechnical problems connected with acclimatization, husbandry and the feeding of the glass-eel.

Salmonids

Cage farming of rainbow trout in sea water is being practiced in three projects, which are run on a semi-commercial basis. Coming of age of this type of aquaculture is still hampered by mortalities occurring during periods of high water temperatures in summer. In the past years, the final cause of this mortality had been attributed to bacterial diseases, induced presumably by undermining of the resistance of the fish by osmoregulation problems at the prevailing temperature and salinity: above 17° C and 31 g/l. During the summer of 1986, intensive bacteriological monitoring of the fish showed no signs of infection. Nevertheless, a substantial mortality occurred, predominantly in smaller individuals. Affected fish showed increased blood plasma osmolarity and that hematocrite and blood protein levels were lower than in healthy fish. Bacterial infections did not appear necessarily to be the cause of summer mortalities at high temperatures and salinities.

An experimental batch of Coho salmon, imported from France, also showed high mortalities at water temperatures above 17° C. An experimental batch of Atlantic Salmon smolts was imported from the United Kingdom. After a successful acclimatization and good initial growth, 100% of the fish died when the water temperatures passed 17° C.

Ragworms (Nereis virens)

Ragworm cultivation in 1986 was practiced in at least 10 commercial projects of different size. The type of cultivation varied from one earthen-pond unit to a number of flow-through units in unheated water or a few recirculated systems using heated sea water. Combinations of the last two systems also occur. Larvae were obtained from wild-caught parent stock. Stripping and in-vitro fertilization are rather easy. As the reproductive season in nature is compressed into a few weeks per year, a problem in ragworm cultivation is the necessity to lengthen the period of the supply of small worms to ensure a year-round harvest. The Netherlands Institute of Fishery Investigations has started research on artificial propagation and larval rearing of ragworms, with emphasis on growth control at low temperatures. In experiments carried out last year, lengthening of the juvenile stage for two months appeared possible, after which the animals resumed their development at higher temperatures.

Fish-cum-oysters (O. edulis)

Suspended culture of the European flat oyster in lantern nets is carried out on an experimental scale in one of the inundated construction pits of the storm-surge barrier in the Oosterschelde. Due to its protection against wind, waves and currents, the phytoplankton content in this basin is high, compared with surrounding waters, resulting in a good growth of the oysters. The lantern nets are hung from the cages of a salmonid farming project, the objective of the project being to combine both cultures. As in former years, growth and meat development of seed oysters was very favourable. Also, the development of small seed oysters, imported from Maine (USA), was very favourable. Problems with fouling organisms could be overcome with relative ease. As the final objective is to depend solely on native seed oysters, experiments were carried out to collect oyster spat on mussel shells, suspended in polyethylene sleeves, suspended in iron frames placed on the sea bottom. This system, borrowed from our French colleagues, appeared to function very satisfactorily and might be one of the main sources of seedlings for suspended oyster culture in future.

Total aquaculture production, except fish for restocking:

Species	Production (tonnes)	Numbers (x 1000)	Value in US $ (March 87 x 1000)	Number of firms
Rainbow trout (sea)	10	7	40	3
Rainbow trout (fresh)	200	1,000	710	10
Eel	180	1,062	1,200	11
African catfish	350	583	1,089	40
Ragworm	9	1,800	120	6

NORWAY

(I. Opstad)

Introduction

Research on problems related to aquaculture is carried out by the following institutions in Norway:

1. Division of Aquaculture, Institute of Marine Research, Directorate of Fisheries, Bergen, with two research stations, one at Matre and one at Austevoll.
2. Institute of Nutrition, Directorate of Fisheries, Bergen.
3. The State Biological Station, Flodevigen, Arendal.
4. Institute of Aquaculture Research, The Agricultural Research Council of Norway, As, with two research stations, one at Sunndalsora and one at Averoy.
5. University of Bergen:
   - 5.1 Department of Fishery Biology
   - 5.2 Zoological Museum, Division of Ecology
   - 5.3 Department of Biochemistry
   - 5.4 Department of Microbiology and Plant Physiology
   - 5.5 Department of Marine Biology
6. Institute of Fisheries, University of Tromso.
7. Regional College, Sogndal.
8. National Veterinary Institute and Veterinary College, Oslo.
9. Norwegian Herring Oil and Meal Industry Research Institute, Bergen.
10. Norwegian Institute for Water Research (NIVA).
11. Nordland Research Foundation, Bodo.
12. The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF), Trondheim.
13. Institute of Fisheries Technology Research (FTFI), Bergen.
14. University of Trondheim, Department of Zoology.
15. University of Tromso, Department of Marine Biology.

In the following report, the institutions are referred to by number.

Quantitative Genetics

Breeding experiments with Atlantic salmon and rainbow trout were continued (1) and (4). The following sub-projects were included:

(a) Selection programs to increase growth rate (1) and (4), reduce mortality (4), and reduce early maturation (1) and (4). At Sunndalsoyra and Averoy about 300 families of Atlantic salmon and rainbow trout are tested in each year class in the selection program.

(b) Study of phenotypic and genetic parameters in production traits including flesh pigmentation (1) and (4).

(c) Study of inbreeding depression (4).

(d) Study of heterosis effect (4).

(e) Induction polyploidy to obtain a triploid fish which does not develop gonads and production of all female triploids (4).

(f) Induction of gynogenesis (4).

(g) Study genetic variation in stress measured by cortisol and glucose level (4).

(h) Study of genetic and environmental interaction in different forms along the coast has continuously taken place since 1973 (4).

(i) Study of genetic variation in immunological parameters (4).

At (1) the following projects have been carried out:

- Research on the connection between the environment and production-quality of salmon, with two sub-projects:

  (i) Smolt in commercial fish farms along the coast of Norway.
  (ii) Genetic and environment.

- Research on genetic variation and feed utilization.

- Research on genetic characterization of salmon from different rivers.

- Research on finding morphological genetic marks on salmon fishes.

- Research on population genetics of natural stocks of herring and cod.

- Research on genetics of released cod.

- Research on mitochondria - DNA of fish.

- Studies on arctic char in a joint project between (1) and (5.1).

Rearing of Marine Fish Larvae

Species: Halibut (1, 3, 4 and 6); cod (1, 6); turbot (1, 3); sole (3); plaice (11, 12) and wolf-fish (3).

The program on mass-rearing of halibut juveniles in plastic pens (1) and in tanks of different size continued (1) and (4). Also the mass-rearing of cod juveniles in enclosed ponds continued (1). The tagging and release program on juvenile cod continued (1). Experiments with production of turbot and sole juveniles in basins (3) and plastic pens (1) were carried out. Production of plaice is going on at (11) and (12).

Optimal start feeding conditions were studied for flatfishes at (12). Plaice are used as a "model species" in order to develop incubator systems and methods for intensive rearing of flatfish juveniles.

A committee with scientists from (1, 15, 4) are preparing objective criteria for determining egg quality.

A broodstock of wolf-fish has been established at (3).

Pathology

The following projects have been carried out at (1):

- The research on cold-water vibriosis (Hitra-disease) continued. The bacterium causing the disease have been characterized and described as a new species, and given the name Vibrio salmonicida. Vaccination against V. salmonicida started in 1986.

- Plasmid investigation on V. salmonicida and V. anguillarum in connection with pathogenicity started. Histological research on fish given cold-water vibriosis experimentally have also been carried out.

- Research on gill damage in connection with poor environmental condition continued.

- Investigation on reconcentration of negivon in fish, mussels and oysters with C^{14} labelled negivon was carried out. The effect of negivon and nuvan on lobster, crabs and mussels was also examined.

- Resistance formation in V. anguillarum was coupled through trimoptrim and vibriostat 0/129. Several V. salmonicida races with coupled resistance have been found.

- Vibriosis vaccination to cod was given through the food.

- A self-produced vaccine against vibriosis on turbot was examined.

- V. anguillarum was isolated from halibut juveniles.

- The project on registration of pathological condition in marine organisms continued.

At (8) the following projects were carried out also:

- The use of vibriosis vaccine in Norwegian fish farms - how the vaccines are given in practice.

- Oral vaccination on fish - improve the method.

- Epidemiological, clinical and pathological research of hemorhagiske syndrome (Hitra-disease).

- Epidemiological and clinical-pathological conditions of Yersina ruckeri infections on fish - Characterization of plasmids.

- Use of clinical chemistry on farmed fish - try out methods and look at the use of these in disease diagnostics on farmed fish.

Shellfish

At (6) a project on Chlamys islandica is going on. The possibility of this species in intensive and extensive aquaculture has been examined.

The project on culture of oysters at different localities along the coast of South Norway continued at (3).

Hydrography in Oyster Ponds - Describe the hydrographical variations through a year in different types of ponds in the south of Norway. The utilization of these ponds for aquaculture purposes has been looked at (3).

At (3) conducting research to find a method, technical and biological, to prevent mussels from getting in touch with toxic algae, and a method for detoxification of mussels.

At (11) the following projects have been carried out:

- Growth on C. islandica on localities fertilized with upwelling.

- Development of technology in farming C. islandica.

At (5.5) the project on culturing Pecten maximus continued. Registrations on growth of oysters and survival of different populations from different ponds (1). Developing methods for production of oyster juveniles in plastic pens (1).

Registrations on growth, survival of queen scallop, in different depths related to temperature, salinities and nutrition (1).

Developing methods for farming Astacus fluvilatilus.

Behaviour

Research on the behaviour of salmon under different rearing conditions has been carried out in cooperation among scientists at (1), (5.1) and (13). The aim of the project is to characterize the behaviour of salmon in net cages typical of an optimal situation with rapid growth, and to be able to identify early warning signals.

Studies on two species culture, salmon in duo-culture with char and rainbow trout, were carried out at (5.1) and (1).

At (1) the following projects have been carried out:

- The behaviour of released salmon smolt. Mowing behaviour in relation to the hydrography in the surface.

- The condition of salmon smolt and antipredator behaviour.

- The behaviour of trained cod - trained to feed at special sound signals.

- The behaviour of marine fish larvae before and after startfeeding.

- Try to map the behaviour of mature halibut.

- Cannibalism on cod larvae and among cod juveniles.

Physiology and Nutrition

Silage conservation of fish feed including long-term effect, health and meat quality was studied by (4). Use of shrimp wastes for salmonid feeding was further tried out (1) and also experiments comparing different carotinoids were continued (2), (4), (5,4) and (9). Comparison of different feeding intensities and feeding regimes were carried out (4).

At (1) the following projects have been carried out:

- Trying out new types of fish feed, and research on nutritional demand of salmon fishes.

- Research on environmental consequences of salmon: The effect of salinity and temperature on osmoregulation and the effect on egg quality.

- Light and hormone regulation on ovulation in salmon.

- Nutrition biology on larvae and juvenile marine fishes.

- Connection between nutrition and the growth of cod larvae.

- Developing dry feed to juvenile turbot, cod and halibut (1) and (9).

- Physical stress on egg and larvae of marine fishes. The aims are to improve handling procedures and to optimize the rearing conditions.

- Induced spawning in marine fishes. The aims are to induce maturation and ovulation on marine fishes, either with hormone injection or with different light regimes, to displace the spawning period on halibut, cod, turbot and plaice.

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

  The following sub-projects are included:

  (a) The conditions in the tanks and amount of smolt.
  (b) The conditions in the tanks and quality of the smolt.
  (c) The conditions in the tanks on the behaviour of the smolts.
  (d) Optimum energy utilization during development.

- A project on the quality of salmon at the time of slaughter. The aims are to investigate the importance of inheritance, composition at the feed, utilization of the feed and the environment on slaughtering quality of salmon. The look of the fish, fat content and pigmentation. Absorbtion and deposition of different amounts of the pigment astaxantin and canthaxantin in feed.

- Hatching and juvenile quality in connection with:

  (i) Different density;
  (ii) The effect of temperature and O_2 - content.

- Pigment content in shrimp from different places and collected at different times.

- Physiological investigation on egg and larvae of marine fish. Connection between change in environment and osmoregulation.

- Drinking activities of halibut larvae at different salinities.

At (9) and (4) a project on making dry feed for use at low sea water temperatures and the influence of protein quality and fish oil as dietary energy supplement was carried out.

At (2) the following projects are going on:

- Making an optimum feed for cod.

- The connection between egg quality and nutrition.

- Connection between nutrition and Hitra disease.

- Nutrition biological studies in a fjord in connection with extensive farming.

At (5.3) the following projects were continued or started during 1986:

- Studies of the biochemical mechanisms in the transport processes in the gills.

- Metabolism of branched aminoacids in rainbow trout muscle together with (1).

- Composition and optimalization of synthetic start feed for marine fish larvae together with (1).

- Studies of the P450 system in fish, and metabolism of extraneous particles and steriod hormones.

- The chemical structure of the fish egg shell at fertilization, hardening and hatching.

- Nucleases from marine fish waste.

- Studies on pituitary hormones from marine fish.

- Studies of larvae growth indicators.

Laboratory experiments on dietary carbohydrates on feed conversation and growth of salmonids and flatfishes are studied together with work on improvement of physical and qualitative properties in fish feed (12).

Research activities have been initiated to develop new methods and processes in fish feed production (12).

Studies on factors responsible for egg quality and larval viability are investigated in plaice (Pleuronectes platessa) (12).

Research on culture conditions of microalgae and microzooplankton have started at (12) in order to develop culture systems and process technology for mass production of larval fish feed. Methods for manipulation of the nutritional value of microzooplankton are investigated.

Aquaculture Technology

The behaviour and physiology of salmonids during simulated transport conditions were investigated in order to develop new transport systems (12). Systems for recirculation of fresh water, and treatment of acid water for smolt production, were studied and improved by scientists at (1). Trying out new equipment and improving the working procedures (1). Heat pumps in smolt production (1) and (12). Trying out net cages for flatfish (1).

Improve the environment for salmon (1). Different types of tanks in smolt production (12). Recirculation in fish farms on land (12). Acoustic instruments to measure the biomasses in net cages (12). Biocensor to measure ammonium, temperature, salinity and O_2 in tanks (12).

At (10) the following experiments were done:

- Evaluation of methods for aquaculture in parts of Norway with low winter sea temperatures (deep water pumping).
- Research in and development of a model for evaluation of pollution from aquaculture activities.
- Disinfection of sea water.
- Antibiotics in sea water and in sediment around fish farms.
- Water quality in connection with use of recirculation constructions.
- Pollution from fish farm in connection with amount of feed.
- Algae in controlled biological production.
- Treatment of acid water in smolt production.
- Fouling on nets in North Norway.
- Water chemistry and fish mortality.
- Research on optimal localization of fish farms. This project is part of a larger research program on utilization of the coastal zone.
- Oxygenation in fish farms.
- Fouling in heat pumps.
- The degree of toxicity of fluorosilicic acid on fish.

At (11) the following experiments were done:

- Transportation of juveniles and smolt (salmon and rainbow trout).

- Biological effects of pumping fish: stress, damage, disease and mortality.

Development of New Methods

Optimization of smolt production (1), (5.1), (5.2) and (5.4).

- Producing ½ year old smolt (1).

- Preliminary research on char in farms in South Norway (1) and 5.1).

- Natural spawning - marine fish (1).

- Farming marine fish to market size (1).

Environment

Studies of the environmental influence on Atlantic salmon was carried out at (1). The connection between water quality and fish health and growth was investigated, and so was the accumulation of organic sediments and leakage of nutrients and salts from the sediments. An investigation at (1) and (5.5) on the influence of fish farming on the surrounding area was conducted.
The effect of ammonium/ammoniacal concentrations on salmon was conducted (1).

Mapping of suitable localities for production of marine juveniles was carried out (1).

At (11):

- Environment and health watching in smolt production farms in North Norway.

- Heavy metals in fish.

- The utilization of the coastal zone in the county of Heroy.

- Looking at areas suitable for aquaculture purposes.

- Database for fish farming. Collecting environmental measurements and look at the connection with mortalities, diseases and low growth rate.

At (6), the program aimed at developing Arctic char, (Salvelinus alpinus), as a salmonid for farming in northern regions, continued. The consequences of long lasting moderate exercise on growth in connection with different amounts of char. Histological and biochemical investigation of different parts of the body have been investigated.

At (14):

- Comparisons of smoltification and sea water tolerances of different populations of char.

- Smoltification and seawater tolerances in production of under yearling smolt (14) and (4).

- Temperature tolerances of char in sea water (14) and (13).

- Effects of different types of manipulations on smoltification and sea water tolerances of salmon (14).

Statistics

The main aquaculture production in Norway is still Atlantic salmon and rainbow trout:

Salmon in enclosures	45,494 tons
Rainbow trout in enclosures	4,248 tons
Arctic char in enclosures	2 tons
Mytilus edulis	100 tons
Crassostrea angulata: in numbers	72,000
C. gigas: in numbers	16,000

POLAND

(J. Wiktor)

Experimental rearing of 2nd and 3rd year classes from selected genetic lines of rainbow trout in sea water continued in 1986. Their survival and growth rate, as well as immunity to diseases, were compared with those featured in young rainbow trout from inland waters transplanted for the first time into brackish water. Eggs were taken from selected, mature specimens of rainbow trout reared in the sea; the survival rate of eggs and young fish was observed after and before their transplantation into brackish water. Some fish were tagged and released into the Gulf of Gdansk.

The first attempt to rear reproducers of Atlantic salmon in salt water pens was made. The pens were stocked with one-year old smolts reared from salmon eggs from Latvia.

No commercial fish farming in the sea was carried out in 1986. Production for experimental purposes and experimental release into the sea was about 5 tons of rainbow trout of varying age (0+ to 6 year olds).

PORTUGAL

(J. Saldanha Lopes)

Finfish

Two aquaculture experimental centers were built in 1986 - one at the headquarters of the National Institute of Fisheries at Lisbon, with a support

of NATO funds through the Science for Stability Program, and another at the South Department of that Institute, under the Regional Development Programs.

Both Centers were conceived for research and development studies, but also as demonstration centers and to provide, in the future, conditions for the establishment of short courses.

The Lisbon facilities with a total area of 900 m^2 include:

1. A broodstock area for seabream, sole and shrimp (Penaeus japonicus).

2. A larval development area with a capacity of 30 tanks of 250 L capacity each.

3. A nursery area with 20 tanks of $3m^3$ capacity each.

4. A food chain production area.

5. A fish disease laboratory.

6. A nutrition area for ensays on experimental foods for seabream and eels using fish silage.

During 1986, besides the construction of the building, some experiments of weaning of Solea senegalensis with decapsulated Artemia cysts was done, with some promising results. A new seabass broodstock was meanwhile adapted to captivity.

At south facilities, mainly devoted to the seabream production, the artificial spawning of the captivity broodstock was obtained using hormones (H.G.C.). The larval development through enrichment of rotifers on fatty acids was done. Low survival was obtained, especially at the end of the larval development when the temperature reached 11°C.

Crustacea

Ongoing experiments on outdoor earthponds at the south of Portugal had been carried out with Penaeus japonicus. A survival of 40% and an average production of 280Kg/ha/year, showed a food performance of this species in Portugal, and a promising species for summer production, particularly in areas at the south.

Molluscs

At the south aquaculture facilities, the reproduction of Ruditapes decussata was obtained with the production of several hundreds of small clams.

Microalgae Production

- Upkeep of phytoplankton stock cultures (Phytoflagellates, Diatoms, Dinoflagellates, Chlorophyceae, Cyanobacteria).

- Development of 10 to 100 litres laboratory cultures to feed herbivorus in culture and as seed to open air raceway ponds.

- Open air mixotrophic production in 2000-6000 litre raceway ponds to treat effluents and to produce SCP or alive feed to aquaculture purposes.

- Studies on the nutritional value of microalgae.

- Implementation of natural food chains in earthponds to support experiments of Penaeus japonicus and Artemia production in the South of Portugal, and studies on the phytoplankton evolution.

- Participation in the ICES Working Group on "Exceptional Algal Blooms".

- Research on the biology and life histories of bloom organisms which affect commercial species.

Planktonic Herbivorous

- Upkeep of the zooplankton stock cultures (Copepods, Cladocerans, Branchiopods, Rotifers and Ciliates).

- Production of the rotifer Brachionus plicatilis in laboratory conditions in 12 to 200 litre volumes to feed first stages of fish and crustacean larvae and to innoculate bigger tanks in the open air.

- Assay of massive production in 5 litre volumes of the rotifer Hexarthra jenkinae, which was isolated by us from samples collected in Algarve in December 1985.

- Massive production of Brachionus plicatilis with microalgae, in the open air, in $3m^3$ race-way tanks with paddle wheels for bigger scale aquaculture support and animal protein production for feedstuff.

- Laboratory production experiments with the marine copepod Tigriopus brevicornis in 20 litre volumes using microalgae with different inert feed, and nutritional quality evaluation.

- Artemia cysts harvest from various salines along the Portuguese Coast. Treatment and upkeep of the cysts in durability conditions and characterization of some more Artemia strains.

- Decapsulation of Artemia cysts to feed Solea senegalensis larvae which were reared in the Aquaculture Experimental Center of the National Institute of Fisheries at Lisbon.

- Implementation assay of Artemia production on a saline of the south coast of Portugal with inorganic fertilization.

- Qualitative and quantitative study of zooplankton samples collected from an earth pond, at the south of Portugal where growing experiments of Penaeus japonicus were carried out.

Marine Fish Diseases

1. Fish disease surveys were carried out on coastal areas suitable for fish culture in order to know the nosology of those areas and the risks concerned. Commercially important species as sea-bass, sea-bream, sole and mullets are surveyed since 1985.

   The most important pathogens isolated were:

   Parasites - crustaceans isopods (Paragnathia) and copepods (Caligus)

   Bacteria - Aeromonas, Pseudomonas, Streptococcus

2. Sanitary survey of fish catches from commercial fishing boats and scientific cruises concerned with stock assessment.

3. Sanitary support of aquaculture.

Introduction of P. japonicus in Portugal

In July of 1985, INIP, through its Aquaculture Department, proceeded with an importation of approximately 1000 post-larvae of P. japonicus from one hatchery localized at south of Spain. Two main reasons conditioned these introductions.

- To know locally, in our country, the behaviour of the species.

- To obtain a little broodstock in order to get a successful spawning in captivity.

Therefore the rules or codes prescribed at ICES and EIFAC (FAO) PROCEDURES, were used in order to avoid the risks and possible adverse consequences of this introduction.

SPAIN

(G. Roman and M. Torre)

Following the entrance of Spain to the EEC, the Spanish and foreign investments in mariculture have increased surprisingly. The main foreign investment in mariculture in Spain is coming from Norway.

Commercial mariculture production is limited to the following species: clams (Venerupis decussata, V. pullastra and Ruditapes philip pinarum), Mussel (Mytilus edulis, M. galloprovincialis), flat oyster (Ostrea edulis), Portuguese and Japanese Oyster (Crassostrea gigas and C. angulata) and small amounts of other molluscs, such as scallop (Pecten maximus), Cockle (Cerastoderma edule), etc.

There is also some shrimp farming, mainly Penaeus japonicus, and a small amount of P. kerathurus. There is production of gilthead seabream (Chry sophrys aurata), sea bass (Dicentrarchus labrax) and turbot (Scophthalmus

maximus) and small amounts mainly from extensive culture of eel (Anguilla anguilla), mullets (mugil and similar genera) and sole (Solea solea). There is also some floating cage production of yellowtail (Seriola dumerilii). A private company for the first time in Spain is producing and selling artemia cyst for mariculture purposes.

The Spanish administration has also shown great interest in mariculture development. In June 1986 they opened a new research plant for fish culture at Vigo, NW Spain, another one for research in mass production of marine fish in Tenerife, Canary Islands, and two more - one (depending from regional administration) at Puerto de Santa Maria (near Cadiz-SW Spain) and another at Puerto Real (depending from the Consejo Superior de Investigaciones Cientificas - Superior Council for Scientific Research), also near Cadiz, SW Spain.

The building of a new state owned fry production plant was started at Mazarron (Murcia - SE Spain), to be completed around August 1987. The Ministry of Agriculture, Fisheries and Food approved the construction of two more research plants (at Santander, North of Spain) - one for algae culture and the other for fish culture.

The detailed activities are as follows:

Molluscs

Mussel (Mytilus Edulis)

In the famous and known area of Galicia, NW Spain, where the mass production of mussels takes place, morphology and genetics were studied and the possibility of these mussels belonging to the species Mytilus galloprovincialis was unveiled. IEOC-USC.

Veneridae

Studies were made about the comparative growth and reproduction cycle of Venerupis decussata and Ruditapes philippinarum and tests of bottom and hanging culture of the last species. IEOC-IEOS.

In IATS, the feeding of Ruditapes philippinarum with different kinds of Diatomeae was tested.

Scallop (Pecten maximus)

Tests of spat collection with long line and onion bag collectors continued. IEOC-IEO M.

Oyster (Ostrea edulis)

Studies on the reproduction cycle of this species in the Atlantic and Mediterranean Seas, their larval abundance and tests about spat settlement on various kinds of collectors were made. IEOC-IEOMM.

The genetical characteristics of oyster from different areas of Spain were studied, as well as the chemical composition and mortality of oysters in Galicia, NW Spain. IEOC.

The flat oyster stock inside a hypersaline coastal lagoon was evaluated (Mar Menor - SE Spain) at the Mediterranean Coast. IEOMM-IEOC.

Crustaceans

Comparative studies were made in order to know the potential of shrimp aquaculture of Penaeus japonicus and P. kerathurus. Tests were also made of artificial food for both shrimp species. IATS.

Oxygen consumption and growth of Penaeus japonicus in old salt ponds used nowadays as fish culture ponds was measured.

Artemia

Investigations were conducted on the production of cyst and adults of artemia using salt ponds and studying their physio-chemical conditions in order to fertilize them. IATS.

Quality controls of artemia cysts (eclosion rate) and nauplius (nutritional value, pufa, etc.) from different origins in Spain were made. IATS-IEOMM-ICMA.

Comparative studies between an American strain of artemia and other Spanish ones were made.

Fishes

Turbot is now one of the main species in fish culture. The natural and advanced or delayed spawning through photoperiod and temperature management (IEOS), its larval culture with natural and microencapsulated food and natural enriched food, and its nutrition are being studied. IEOS

The whole production cycle of sea bass and gilthead seabream with the aim of mass production continued to be researched (IEOMM-IEOTF-CTPO), especially the larval feeding of this last species. IATS.

The natural spawning and larval culture of red sea bream (Pagellus bogaraveo) and its growth started to be researched. IEOS.

Physiology, metabolism and nutrition of sea bass, and reproduction and their management, were investigated at IATS. Growth of sea bass and gilthead seabream in floating cages in the Mediterranean Sea started at research and commercial scale. Yellowtail culture is being examined in Balearic Islands. EAPA.

Microalgae

At IATS, research was made on the physiology and biochemistry of marine diaotomeae (Thalassiosira and Skeletonema) and their use as food for the culture of various species of molluscs, crustaceans and fishes. IATS.

Macroalgae

At IEOS, research was done on "in vitro" reproduction of gelidium sesquipedale and implantation on artificial substrates. IEOS.

Pathology

The studies on the pathology of fishes and shellfish are increasing every year in Spain. The main studies were on gilthead seabream and sea bass at IATS and ICMA; IEOS and USC for turbot; and USC, IEOV, CEV, IEOC for mussel and oyster parasites (bonamia, marteilia, mytilicola). There is also some research on artemia parasites. IATS.

KEY

IEOC	-	Instituto Espanol de Oceanografia - La Coruna
IEOM	-	Instituto Espanol de Oceanografia - Fuengirola-Malaga
IEOMM	-	Instituto Espanol de Oceanografia - Mar Menor, Murcia
IEOTF	-	Instituto Espanol de Oceanografia - Tenerife, Canary Islands
IEO V	-	Instituto Espanol de Oceanografia - Vigo
USC	-	Universidad de Santiago de Compostela
CEV	-	Centro Experimental de Villajuan
IATS	-	Instituto de Acuicultura de Torre de la Sal - Castellon
ICM A	-	Instituto de Ciencias Marionas de Andalucia - Cadiz
EAPA	-	Estyacion de Acuicultura de Puerto de Andratx - Majorca
CTP	-	Centro Tecnologico Pesquero - Telde - Las Palmas, Canary Island

Statistics for Mariculture Production in Spain in 1986

Rainbow trout (freshwater production)	-	15,000 tons
Salmon (*Onchorhynchus*)	-	150 tons
Turbot	-	25 tons
Gilthead Sea Bream	-	80 tons
Sea Bass	-	20 tons
Yellowtail (*Seriola dumerilii*)	-	10 tons
Mullet (various species extensive)	-	70 tons
Eel (extensive)	-	20 tons
Sole (extensive)	-	5 tons
Other (extensive)	-	5 tons
Shrimp (*Penaeus japonicus*)	-	16 tons
Mussel	-	230,000 to 240,000 tons
Clams (*Venerupis decussata*, *V. pullastra* and *Ruditapes philippinarum*)	-	300 tons
Flat Oyster (*Ostrea edulis*)	-	2,000 tons
Crassostrea (*gigas* and *angulata*)	-	60 tons

SWEDEN

(H. Ackefors)

Introduction

Sweden has an extensive program for the conservation of its fishery. Salmon and sea trout are annually stocked in Swedish rivers aimed for the Baltic and the Kattegat-Skagerack area. In addition to that, there are many hatcheries

producing juveniles of various salmonids, such as lake trout, rainbow trout, arctic char, American brook trout, American lake trout and grayling for restocking waters for the benefit of sportfishermen. The development of commercial acquaculture is still slow. The dominating fish species is rainbow trout. Minor quantities are produced of salmon, arctic char, eel and carp. The blue mussel production has decreased due to the problems with toxic microalgae.

Fishery Management

About 1.8 million salmon smolts and 0.4 million sea trout smolts were released in the Baltic area. In addition to that, 0.1 million salmon smolts were released on the Swedish west coast.

Commercial Production

The market for produced fish was bad in 1986 and the blue mussel producers were not allowed to harvest during certain periods due to high levels of toxic substances. During the last two years, production of blue mussels has decreased by 70%. Good production units for eel cultivation have been established. One big unit using waste heat water from three sulphuric acid plants is now operating in the Sound area (SW Sweden); in full operation, the production will be 100 metric tons per year.

The official statistics are only available for 1985, which are given below in metric tons (round fresh weight):

Species	Marine Production	Total Production
Rainbow trout	1,772	2,532
Salmon	81	81
Brown trout		1
Arctic char		5
Eel		47
Carp		1
Total fish production	1,853	2,665
Blue mussel	415	415

The number of operation units for fish production in marine waters was 89. Six operations produced blue mussels.

Disease Problems

IPN has occurred in a few production units during 1985-86, but in general, the viral diseases are a minor problem in Sweden. Among the bacterial diseases, Vibriosis, Furunculosis, Infectious Dermatitis, Enteric Redmouth Disease (ERM), Bacterial Kidney Disease (BKD) and Parasitic Didney Disease (PKD) have been recognized in 1986. BKD occurs in the southern part, as well as in the northern part, of Sweden in sea cage units producing rainbow trout. ERM has been recognized in two freshwater units. Vibriosis is the most common disease in Swedish aquaculture, while Furunculosis is rather rare.

The treatment of disease with antibiotic agents is rather moderate. In 1983, 13 metric tons of feed with antibiotics were used. This corresponds to a use of 125 kg active substance, which is a small quantity compared to other countries. The withdrawal time (from treatment to harvest) is 30 days in water temperatures of about 9°C and 60 days in colder water when oxytetracyline and sulfamerazin have been used.

DSP and PSP Toxins in Swedish Blue Mussels

In November 1983, it was discovered that blue mussels contained DSP toxin. In October 1984, the harvest of blue mussels was stopped by Swedish authorities, since several persons were poisoned by DSP after eating blue mussels farmed on the Swedish west coast. A routine screening for DSP was started and later also for PSP.

From October 1984 until July 1986, harvest of blue mussels during certain periods was forbidden:

Toxin	Periods of Ban for Sale
DSP	October 1984 to March 1985
PSP	April 1985 to July 1985
DSP	October 1985 to March 1986
PSP	May 1986 to July 1986

During the winter of 1986-87, the amounts of toxins have been low and mussels have been harvested. There is now an ambition to improve the methods for analyses. The original bioassay method (mouse-test) will probably be abandoned in the near future and replaced with chemical analyses. In cooperation with international scientists, the high performance liquid chromatography technique is being developed. Several toxins have been isolated. A maximum concentration of 40 µg okadaic acid per 100 g musselflesh will be permitted for harvest and 80 µg per 100 g on the market. Experiments with detoxification of DSP in blue mussels have been performed without any success.

UNITED KINGDOM

ENGLAND AND WALES

(C. E. Purdom)

Activities conducted in England during 1986 are as follows:

1. R&D on intensive cultivation of marine fish has ceased and current activity centers on stock enhancement practice and extensive culture using Solea solea;

2. R&D on salmon and trout sex control work is almost complete, as are the programs on sterilization; future programs will extend current research on domesticated strains and on sea ranching;

3. a limited program on biotechnology has begun;

4. a broadly based program on bivalve mollusc production continues with emphasis on hatchery techniques and costed trials at sea;

5. lobster stock enhancement programs continue with first commercial returns imminent.

The following is the estimated Production of Species for 1986:

Trout	10,000 tonnes
Salmon	100 tonnes
Turbot	75 tonnes
Carp	60 tonnes
Eel	30 tonnes
Oysters (Ostrea Edulis)	400 tonnes
Mussels	700 tonnes

SCOTLAND

(A.L.S. Munro)

Commercial Atlantic salmon culture in Scotland produced 10,332 tonnes in 1986 compared to 6921 tonnes in 1985. Numbers of sea sites were 168 (128 in 1985), of which 11 were land based tank systems, the rest sea cage units. Returns showed that 4345 tonnes (av wt/fish 3.89 Kg) were from the 1984 smolt intake and 5987 tonnes (av wt/fish 2.49 Kg) were from the 1985 smolt intake. In 1986, some 6.59 million smolts were put in sea water, and in 1987 estimated production of smolts is 15 million. Estimated production of salmon in 1987 is about 16,000 tonnes. The industry directly employed 1020 persons, some 29% in a part-time capacity.

Commercial rainbow trout culture produced 2317 tonnes (2256 tonnes in 1985), of which 207 tonnes were used for stocking angling waters. Some 593 tonnes of production were fish greater in weight than 1 lb. Commercial mussel, oyster and scallop culture continue to develop, and it is hoped that by next year production figures will be available.

Research continues on the problems of Exocrine Pancreas Disease, Furunculosis, Bacterial Kidney Disease, sea lice, dietary requirements of salmon in particular vitamin E and selenium, maturation control, carcass quality and methods of humane slaughter.

UNITED STATES

Nil Report.

USSR

(A. A. Elizarov)

For the purpose of biological substantiation of cage rearing of salmon in the White Sea coastal zone, PINRO carried out research to improve the methods of marketable trout cultivation.

The trout farm using heated water which was located near the Imandra Lake delivered the material for stocking. The optimum weight of planting material was determined, densities of fish stocking were compared during the cultivation and peculiarities of the trout growth dependent on various food objects were studied.

The results of the research showed that the one-year old rainbow trout, 100-140 g in weight, were the optimum planting material for the White Sea, which after 120 days of summer cultivation yielded the marketable fish weighing 350-400 g. The food coefficient equalled 2.2. The use of automatic feeders decreased the food expenses per unit of increment to 1.6-1.7. The best stocking density for cages measuring 3x4x2 m was 10 kg/m^2 which ensured the weight increment and 30-35 kg/m^2 of fish production. The growth rate of trout consuming the experimental food was higher (3.2-3.6 g/day) than that of trout feeding on standard food (3.0-3.1 g/day).

In 1986, research on the growth acceleration of young salmon was continued to obtain the stocking material for cultivation of marketable Atlantic salmon in sea water. The cultivation of young salmon at 12-12°C resulted in the increase of length and weight of the one-year olds to 5-10 g, in comparison with 0.8-1.0 g in single aged fish reared without water heating.

A study of the chloride cells of the gill epithelium showed that the water heating did not affect the smoltification mechanism though it accelerated the process 2-3 fold.

Artificial reefs were further investigated in the Baltic, Azov and Black Seas. Experimental and industrial runs proved that they were effective for protecting young fish, reproduction of some hydrobionts and raising of biological productivity of coastal areas.

The biotechnology of growing mussels in the White and Black Seas was developed, with the density of 50/60 t/hectare on the substrate. The cultivation to marketable size took four years in the White Sea and 1.5 years in the Black Sea. For the Black Sea, a storm resistant construction was developed which could stand the storm of 6-7 force without losses of production.