International Council for the
Exploration of the Sea

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

MARICULTURE COMMITTEE

J. E. Stewart

Report for 1985

BELGIUM

(Dr. P. Sorgeloos)

In 1985, the following activities were carried out at the Artemia Reference Centre - State University of Ghent, Belgium:

- continued research in Belgium on Artemia strain characterization; intensive production techniques for adult biomass, nauplii and cysts; cross breeding and quantitative heritability; enhancement of nutritional quality through bioencapsulation in nauplii and adults;

- organization of the 4th International Artemia Training Course (Ghent, July 15 to August 14, 1985) attended by 35 trainees from 20 different countries (mainly third world countries);

- co-organization or the 2nd International Artemia Symposium (Antwerp, September 1-5, 1985) attended by 250 participants from 40 countries;

- start of cooperative project in Thailand with the Kasetsart University, Bangkok, through the Belgian Administration for Development Corporation; set up National Artemia Reference Center; improved Artemia production in solar saltponds, optimization of the use of Artemia in local fish and shrimp farming;

- assistance in the organization of a national Artemia workshop at the Shandong College of Oceanography, Qingdao (China, May 10-15, 1985);

- characterization of natural sources of Artemia from Tunisia; cooperation project of the Belgian Administration for Development Cooperation and the "Institut Scientifique et Technique d'Océanographie et de Peche";

- long-term training in Artemia techniques of students from Peru, Brazil, Indonesia, Tunisia and Vietnam;

- successful introduction/demonstration of Artemia production in small saltworks near Malindi in Kenya; cooperative project with the Kenya Marine Fisheries and Research Institute sponsored by the Belgian Administration for Development Cooperation.

(F. Redant)

Fisheries Research Station

Nothing to report for 1985.

CANADA

(James E. Stewart)

ATLANTIC - R. E. Drinnan

Salmonids

Demonstration and Development Farm

A Salmonid Demonstration and Development Farm has been established by the Department of Fisheries and Oceans in southern New Brunswick, to meet the technology development needs of the rapidly expanding Atlantic salmon sea-cage culture industry in the Bay of Fundy. The facilities consist of a two-acre shore site, office and laboratory building and an adjacent sea cage site using Jamek and local cage designs. The initial experimental program includes comparative studies on the growth performance of diet formulations, of 1+ and 2+ smolts and of different fish densities, and the effectiveness of various husbandry practices. The farm will also participate in the broodstock selection activities of the Salmon Genetics Research Program in St. Andrews.

Department of Fisheries and Oceans

Disease:

Bacterial Kidney Disease (BKD) is seen as an emerging problem affecting Atlantic salmon smolts in New Brunswick. The disease manifests itself clinically in fish in fresh water, but causes particular problems when smolts are moved to marine cage sites. The disease is transmitted from broodstock in marine sites through the egg to be resident in progeny in fresh water. Transmission is difficult to control because the agent is transmitted in the yolk and is not affected by normal disinfection procedures. A control strategy, originally devised for west coast salmon, was evaluated in 1984 & 1985. This involved monthly injections of brood fish with an antibiotic, erythromycin phosphate, and subsequent monitoring of reproductive fluids by sensitive serological methods which screen out eggs from infected fish. Progeny are being monitored over a two-year program and the results to date appear promising.

The fatal bacterial disease, Furunculosis, severely limited Atlantic salmon smolt production in New Brunswick in 1984. Originally only observed in wild salmon runs on the Restigouche River in the north of the province, the disease moved in 1983-84 into the Saint John River System which supports a number of culture facilities supplying smolts. In 1984 the first outbreak of this disease occurred at several cage sites and was attributed to the movement of infected smolts. This occurred in spite of the existence of a Regional Fish Health Guideline advocating requiring testing of all stocks prior to transfer. The transmission was thought to be related to the movement of uninspected fish, as well as to carrier infected smolts which were undetected by normal inspection procedures. A control program was initiated in 1985 involving vaccination as well as cortico-steroid carrier testing of all smolts. Although the program was not 100% effective in curbing the spread of disease to the cages, in 1985 the areas of weakness have been identified.

Nutrition

Digestive energy values and digestibility co-efficients of major nutrients for marine by-products (white fish meal, herring meal, squid meal, shrimp meal, crab meal, crab protein concentrate and meat meal) widely available in Atlantic Canada were established for Atlantic salmon. Herring and white fish meal were utilized more efficiently; crab meal showed poor digestibility.

In a broodstock brook trout (Salvelinus fontinalis) experiment, a low manganese diet (7.2 mg/kg) caused significant reduction in spermatocrit, heavy embryonic mortality and poor hatchability of eggs. There was some accumulation of manganese from the aquatic environment in eggs after fertilization. Results indicate that the manganese requirement of broodstock brook trout is approximately 55 mg/kg of diet.

An Atlantic salmon starter diet was developed and tested under hatchery and laboratory environments. This starter formula is now being manufactured by commercial fish feed producers according to the Department of Fisheries and Oceans' specifications.

Artificial Propagation

Swimup fry, reared from fertilization at 4 C, were fed for one month at 4, 8, 12, 16, 20 and 24 C (raised 1 C/d from 4 C). Initiation of feeding was most effective, and growth rates highest, at 16 C and 20 C.

Physiology

The effect of continuous light in inhibiting smolting has provided a useful tool for examining osmoregularity and metabolic aspects of the parr-smolt transformation. From several experiments, two in the laboratory under controlled light-temperature conditions and one in a production rearing station, it was concluded that artificially extended daylight periods (artificial spring) in autumn/early winter greatly increases the growth of juvenile Atlantic salmon during a period of reduced growth rate under natural, seasonal photoperiod conditions. Such enhanced growth is possible under seasonally declining but reasonably high temperatures. Other studies have

shown that the number and apparent activity of pituitary growth hormone (GH) cells increase under the influence of naturally increasing or artificially extended daylength. It is suggested that the enhanced growth of pre-smolt salmon subjected to extended daylength (16-24 hr light/day) in autumn is due to a GH response. Restoration of natural photoperiod in mid-December allows those fish above a length threshold of 12-13 cm to complete smoltification the following spring. Such photoperiod manipulation to enhance growth during autumn offers promise as a way to increase the incidence and size of 1+ smolts.

Arteriosclerotic lesions in coronary arteries of Atlantic salmon are rare and of minor severity in naturally produced juveniles in fresh water. The incidence and severity of lesions increases sharply during the first months of marine life. Large, immature salmon in the Greenland area have many severe lesions. Sexually mature, returning salmon and post-spawning kelts have the highest incidence and most severe lesions. It was established during 1985 tha artificially reared salmon showed a similar low incidence of lesions during the pre-smolt stages and dramatic increases in both incidence and severity of lesions during grow-out in sea cages.

Salmon Genetics Research Program, Atlantic Salmon Federation and Department of Fisheries and Oceans

Strain Development

A preliminary selection experiment was initiated with Strain A (comprised of crosses of several river stocks) in 1985 to test responses to selection for length after 18 months growth in sea cages, in contrast to a control line. The results in the progeny from this experiment will give indications of expected selection response for a more complex index of traits to be commenced on this population in 1989, following a mixing of the genes through the current random matings in the control lines.

Disease Resistance

Strain B, from a genetic base similar to that of Strain A, succumbed to the Furunculosis outbreak at the Salmon Research Center in 1984. The mortality was ranked for 100 progeny in each of 42 full-sib families. Family selection for resistance was performed on individuals that had been moved to a sea-cage. Selections were made from the high and low resistance families. Matings within each of these subgroups will allow a laboratory challenge to the progeny to determine whether resistance to Furunculosis is heritable.

Tank Effects

Strains C and D were derived from Saint John River stock in 1983 and 1984 spawnings, respectively. Analysis of growth data on these strains revealed that density and unaccountable effects between tanks represents 15% of the variance in fry growth, emphasizing the importance of replication and density control in family comparisons. Also, fiberglass 25 foot rearing tanks, as opposed to similar cement tanks, produced significantly higher growth and proportions of smolt.

Spawning Synchronization

Two broodstocks in sea cages were injected with LHRH using a dosage of .02 mg/kg of fish in each of two injections, four days apart. Spawning was completed in a 12-day period as compared to a spread of approximately three months in previous years when no hormone treatment was involved.

Feed Flavour Experiment

Artificial flavours of beef, chicken, liver, shrimp and cod, at a concentration of 2% by weight in commercial starter feed, were fed to first-feeding fry. The results showed no enhanced growth or decreased survival. Ground natural beef liver was superior to any of the five artificial flavours tested.

Sex-reversed females

Examination of grilse fed 10, 20 and 40 p.p.m. of methyl-testosterone at first feeding showed apparent sterility. Another group, treated with 3 p.p.m. exhibited male secondary sex characteristics but no free flowing milt. Internal examination showed developed testes with milt but no sperm ducts.

Huntsman Marine Laboratory, St. Andrews, N.B.

Chromosome engineering and hybridization of Arctic char (Salvelinus alpinus) and Atlantic salmon (Salmo salar) for aquaculture

In work initiated at the Salmon Research Center, the application of chromosome engineering and hybridization techniques to commercial culture of salmonids is being evaluated. Two lots of char/salmon hybrids were produced by fertilizing Atlantic salmon (New Brunswick stock) eggs with Arctic char (NWT stock) spermatozoa. Heat shocks were applied to one lot of hybrids after fertilization to induce triploidy. Lots of pure salmon eggs were similarly treated. Subsequent growth of hybrids as juveniles significantly exceeded that of both parent stocks. Seawater challenge tests indicated triploid char (extra maternal salmon chromosome set) were intermediate to diploid hybrids and pure salmon in salinity tolerance. The absence of primordial oocytes suggests the hybrids may be sterile. Continuing studies involving gill ATPase activity, chloride cell activity (and ultrastructure by EM) and sea cage grow-out of the various experimental lots are indicating greater salinity tolerance among triploids.

Shellfish

Department of Fisheries and Oceans

Standard Reference Diet for Crustacean Nutrition Research. A semi-purified diet (HFX CRD 85) containing a protein concentrate from the crab (Cancer irroratus) was found to give acceptable growth and survival of experimental: lobsters (Homarus americanus), cold water shrimp (Pandalus monodon, P. vannamei and P. stylirostris), Dungeness crab (Cancer magister), freshwater prawn (Macrobrachium rosenbergii) and freshwater crayfish

(Cherax tenuimanus), and has been adopted internationally as a Standard Reference Diet for Crustaceans.

Based upon the work with HFX CRD 85, a semi-practical diet using a crab meal produced from Cancer irroratus has given excellent growth of juvenile lobsters and feed conversion of 1.22 g feed/g gain. It is expected that a relatively inexpensive dry pellet diet will be available for lobster culture in the near future. Feeding trials now underway are evaluating the effect of several different methods of producing crab meal on the nutritional value and production cost of feeds based on this product. The rock crab, Cancer irroratus, is a by-catch of little commercial value in the lobster fishery.

Scallop Culture. In Newfoundland, where scallop culture efforts began in 1971, natural seed supplies are unreliable and insufficient to support a commercial enterprise. Current research on hatchery propagation may eventually provide more abundant and reliable spat for aquaculture efforts. Scallop culture research is underway at federal laboratories on both coasts, and a new program is developing around the sea scallop in the Bay of Fundy.

Commercial Lobster Culture. Advanced Lobster Technology Inc. (Marine Lobster Farms Ltd.) have spent a year selecting a site for their planned 2,700 square metre plant on Prince Edward Island. The new facility will include physical systems for growing lobsters, plus space for an affiliated company, Aqua Health, to work on vaccines against gaffkemia. A second affiliated company, Composite Technology Inc., will produce and market lobster holding systems. The three companies are owned by a parent, BRO Industries.

Lobster Culture Research. The American lobster must be raised at 20-24 C to obtain the required rate of growth, but those temperatures interfere with egg maturation and spawning. Recent research has shown that this problem can be avoided by transferring maturing females to natural cold water cycles. A second problem in broodstock management has also been solved. Lobsters normally mate when they molt, but in a segregated culture facility this is impossible, and infertile broods often result. Artificial insemination is the solution to this problem. The techniques currently available permit insemination to be performed by the grower at any time of year.

PACIFIC COAST - N. Bourne

Shellfish

Pacific oyster, Crassostrea gigas, production, of which about 75% was cultured, was 3,540 t in 1984. Total landings were comprised of 240,000 dozen single oysters for the half shell trade and 330,510 litres of shucked meat. Total landed value was $2 million. Preliminary data indicate landings will increase by over 10% in 1985. In 1984, 340 oyster leases were held by 180 growers, total area under lease was 1495 hectares. A second commercial oyster hatchery was built and operated in British Columbia in 1984 to produce seed (juveniles) and eyed larvae for sale. Most growers now rely on setting eyed larvae at their facilities for their source of seed.

One commercial blue mussel, Mytilus edulis, culture operation continued in British Columbia in 1985, but production was under 5 t. Severe summer mortalities continued to be a major problem preventing expansion in mussel culture operations. Investigations were begun to determine if these severe summer mortalities are site specific and if they are due to environmental or genetic causes.

Experimental attempts with manila clam, Tapes philippinarum, culture was continued in 1985 by three commercial companies. Nursery methods developed by one company can now produce manila clam seed 1 cm in length in three months. Planting larger seed decreases mortalities and the time to commercial harvest.

Experimental work continued investigating the feasibility of scallop culture. Research effort was concentrated on the exotic Japanese scallop, Patinopecten yessoensis, and the native rock scallop, Chlamys gigantea. About 20,000 Japanese scallop spat were raised in 1985, of which 1,500 were put out in the natural environment to assess growth and mortality rates. About 5,000 rock scallop spat were also raised. By the end of December 1985, some Japanese scallop juveniles measured 4 cm in shell diameter.

The one commercial hatchery for northern abalone, Haliotis kamtschatkana, continued to operate in 1985 but no commercial sales were made.

MARICULTURE PRODUCTION IN ATLANTIC CANADA
1985 (January 1 - December 31)

Species		Production (Metric Tons: *Number)	Value (US$ 000's)
American Oyster (Crassostrea virginica)		Not available	-
European Flat Oyster (Ostrea edulis)		*12,500	4
Blue Mussel (Mytilus edulis)		886	814
Giant Scallop (Placopecten magellanicus)	Seed	*25,000	-
	Meat	* 2,500	-
Atlantic Salmon (Salmo salar)		188	1,688
Rainbow Trout (Salmo gairdneri)		96	304

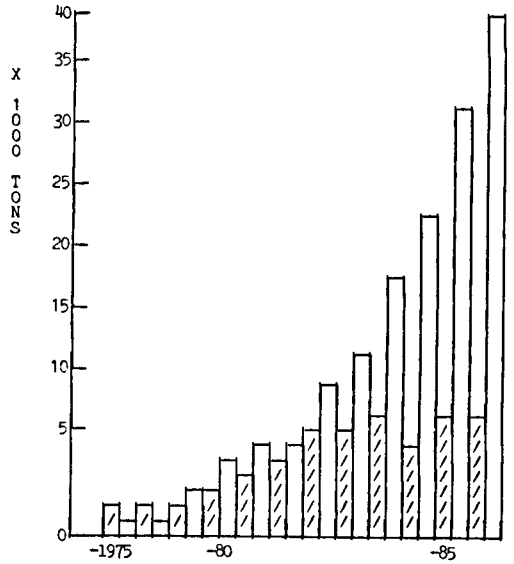
DENMARK

(Hans Peter Bak)

Rainbow Trout

Mariculture in Denmark consists mainly of culturing Rainbow trout in floating cages, in landbased tanks or earthen ponds.

The production has been increased considerably regarding both the number of farms and the amount of tons produced (Figure 1). Since last year, the Ministry of Fisheries has collected all data from the producing farms, and permission to establish a sea cage culture has been revalued. Now every farm is allowed to use a maximum amount of feed and it is up to the individual farmer to raise the most effective production.



The table shows the number of sea water farms and athe maximum allowed amount of feed related to the different geographical regions in Denmark in 1985 and in 1986 as well.

Table 1

	1985		1986	
DISTRICT	NUMBER	FEED CONSUMPTION (MAX)	NUMBER	FEED CONSUMPTION (MAX)
Vestsjell	2	1200 t	4	1870 t
Storstrom	1	90 t	9	1515 t
Bornholm	2	--	0	--
Fyn	0	--	1	170 t
Sonderjyll	3	830 t	4	1070 t
Vejle	7	1220 t	7	1220 t
Aarhus	4	523 t	4	523 t
Limfjord	5	360 t	5	360 t
IALT	24	4473 t	33	6738 t

As seen in Table 1, the number of farms has been increased by 37.5% and production is expected to increase by 20% to 2,700 tons.

1985 has been a very good production year with low summer temperatures, but unfortunately there has been very adverse weather conditions. Especially primo September and primo November, many farms suffered from losses of fish due to damage of the cages. The total loss of fish related to these events is estimated at 200 tons or 5- 10 mio. DKK.

Other Marine Species

The culture of other marine species such as Crassostrea gigas and Mytilus edulis have yet to reach commercial scale production. Several companies have started production, but most of them without any success.

Research

Research in marine aquaculture is carried out by the Danish Institute of Aquaculture, and the Danish Institute for Marine Research and Fisheries.

The main field is optimization of sea water culture of Rainbow trout through:

- genetic selection and breeding
- smoltification
- feed
- construction and test of landbased seafarms.

Among other aspects of research are experiments with Red seabream, turbot, halibut and Peneid shrimp. The results are preliminary, but are very interesting.

FINLAND

(P. Tuunainen and K. Westman)

Mariculture in Finland is based on sea ranching and cage culture. Salmon (Salmo salar), sea trout (Salmo trutta trutta) and migratory whitefish (Coregonus lavaretus) are introduced into the sea as smolts of salmonids or one summer old young whitefish. Rainbow trout (Salmo gairdneri) are grown in net cages and enclosures for human consumption. Mariculture production is continually increasing.

In Simojoki and Tornionjoki, flowing into the Bothnian Bay, one-year old salmon parr have been stocked into the rapids to maintain the stocks; constant monitoring programs are carried on. Genetic studies on the stocks have been carried out. In Tornionjoki, the sea trout stock is declining alarmingly.

Study programs were also carried out to discover the biological and economic success of the introductions made for sea ranching, to improve the quality of reared young fish, to measure the quality by physiological tests and by tagging the fish. Work has also been done to improve the rearing methods to decrease natural mortality rates of stocked salmon smolts by using release ponds and delayed release, and to decrease water pollution caused by larger fish farms. These experiments include also rearing in warm effluents of nuclear power plants, as well as studies on the genetics of the wild and reared salmon and sea trout stocks.

For the UDN of the Baltic salmon reported in the middle of the 1970's, limitations imposed on transfers of fish between the sea and freshwater area, as well as between the inland watercourses exist. IPN has not been reported in Finland in 1985.

The vibriosis disease still causes considerable harm and better vaccines against it are being developed, especially for Rainbow trout culture in the sea area.

The quality of reared salmon and sea trout smolts has gained more attention and therefore physiological studies on the quality of wild and reared smolts, as well as the criteria for reared smolts, have been objects of interest. Three studies have been connected with tagging experiments with the Carlin tags as well as with micro tags.

OUTLINE FOR STATISTICAL INFORMATION ON MARICULTURE PRODUCTION FOR FINLAND
Mariculture Production 1984 (figures for 1985 not yet available)

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	5,381		20,993
Salmon smolts for introductions, 1 year and older		21.96	2,790
Other salmonids (specify): Sea trout for introductions 1 summer old and older		15.47	1,800
Others (please specify): Migratory whitefish for introductions 1 summer old		90.19	820

[1] Rate $1 US = 5.5 FMK

FISH CULTURE IN FINLAND IN 1984

Number of Fish Farms and Hatcheries	Brackish Water Cage Farms	Fresh Water Farms and Hatcheries	Natural Rearing Pond Breeders	TOTAL
	151	302	222	675

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 Ponds
	Egg Liters		kpl 3,518	1,807	1,303	154	780
			1,000 m²				ha
	16,050	17,759	40	958	427	119	8,499
Farms and Hatcheries	59	65	83	228	151	24	222

Food Fish Production of Fish Farms	Brackish Water Cage Farms	Fresh Water Farms	Total	Value of Production M Fmk
	Production - 1,000 kg[2]			
	5,381	4,112	9,493	204,0
Farms	151	184	335	

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

[2] Production in kg ungutted fish.

PRODUCTION TO STOCKINGS IN 1984	(3) Newly Hatched	(4) 1 summer old	1 summer old	2 summers old	2 years old	3 summers old	3 years old	older	Total (Excl. Newly Hatched
	Stockings 1,000 fish								
Whitefish, Coregonus pidschian (Gmelin)	3,188	2,139	6	20					2,165
Whitefish, Coregonus lavaretus (L.)	86,735	7,895		1,124					9,019
Whitefish, Coregonus muksun (Pallas)	10,435	21,447		68		13			21,528
Whitefish, Coregonus peled (Gmelin)	21,195	1,934				1			1,935
Whitefish, unidentif. Coregonus	38	126	20						146
Vendace, Coregonus albula (L)	1,475								
Atlantic salmon, Salmo salar L.	1,566	123	421	18	1,606		27	1	2,196
Landlocked salmon, Salmo salar L. m. sebaco Girard		22			27	1	20		70
Sea trout, Salmo trutta m. trutta L.	1,524	424	81	248	727	64		3	1,547
Brown trout, Salmo trutta m. lacustris L.	3,580	252	361	177	764	25	151	16	1,746
Brown trout, non-migratory Salmo trutta m. fario L.	860	5	5	17	43				70
Rainbow trout, Salmo gairdneri Richardson		63	288	2	5		0		358
Char, Salvelinus alpinus (L.)	805	69		4	22	4	22		121
Brook trout, Salvelinus fontinalis Mitchill		20			1				21
Lake trout, Salvelinus namaycush (Walbaum)	100			47	71				118
Crayling, Thymallus thymallus (L.)	525	572	6	3					581
Pike, Esox lucius L.	13,100	1,572							1,572
Bream, Abramis brama (L.)		220						10	230
Carp, Cyprinus carpio L.				6	1	1			8
Id, Leuciscus idus (L.)		104							104
Pike-perch, Stizostedion lucioperca(L.)	112	1,447							1,447
Crayfish, Astacus astacus L.		1							1
American crayfish, Pacifastacus leniusculus (Dana)		3							3

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

FRANCE

(J. Guillaume)

Les recherches ont été poursvivies sur les espèces suivantes: salmonidés, (Salmo gairdneri, Salmo trutta, Salmo salar, Oncorhynchus kisutch), bar (Dicentrarchus labrax), turbot (Scophtalmus maximus) et crevette impériale (Penaeus japonicus) ainsi que sur les proies vivantes (Artemia salina et Brachionus plicatilis) et, dans une moindre mesure, sur les sparides.

Les principaux points acquis sont les suivants:

Influence de la présentation du granulé sur la croissance de la truite arc-en-ciel élevée en mer

Les aliments composés utilisés pour l'élevage des truites arc-en-ciel en milieu marin peuvent être fabriqués par pressage à froid ou par cuisson extrusion. Ces derniers pouvant être distribués soit secs, soit réhydratés à l'eau douce ou à l'eau de mer. Une expérience réalisée en cages flottantes a permis d'évaluer l'effet de la présentation du granulé sur la croissance et l'indice de conversion alimentaire. La croissance la plus faible a été obtenue avec l'aliment pressé à froid. Par cuisson-extrusion, un gain de croissance de 10% a été obtenu pour l'aliment distribué sec, et de 20% pour l'aliment réhydraté à l'eau douce ou à l'eau de mer. Ces différences sont statistiquement significatives. Les indices de conversion alimentaires sont meilleurs pour les aliments réhydratés (1,36 et 1,37) et pour l'aliment extrudé sec (1,38) que pour l'aliment pressé (1,67). Il faut également noter que la digestibilité apparente de l'énergie des aliments extrudés (81%) est supérieure à celle de l'aliment pressé (75%).

Elevage de larves de crevettes avec des microparticules

Les microparticules constituent une solution de remplacement des proies vivantes pour l'élevage des larves de crevettes mais n'avaient jamais été testées sur les larves de P. vannamei. Un essai d'élevage de larves de P. vannamei sur microparticules agglomérées par du Kappa-carraghénane, a été entrepris a l'échelon du laboratoire entre les stades zoé 2 et postlarve. Les résultats montrent clairement la capacité des larves à accepter ce type d'aliment inerte. La croissance a été voisine sinon supérieure (selon les régimes) à celle des larves nourries avec proies vivantes. Par ailleurs, l'utilisation des microparticules nous a permis d'incorporer des quantités variables d'extrait de calmar (qui avait un rôle de facteur de croissance chez les juvéniles). Une accélération significative de la croissance a été observée dans le lot nourri avec les microparticules renfermant 10% d'extrait de calmar.

Amélioration de la qualité des proies vivantes

La quantité d'huile de foie de morue apportée dans les aliments composés pour animaux proies a été augmentée dans le but d'améliorer la teneur des proies en acides gras longs polyinsaturés (AGLPI) de la série n - 3. Chez les rotifères on obtient un taux d'AGLPI n- 3 de 1,7% de la matière sèche avec un aliment renfermant 20% d'huile de foie de morue contre 0,7% avec un aliment à 4% d'huile; la production des cultures s'en trouve améliorée. Chez Artemia on obtient un taux de 2,5% de la matière sèche avec 20% d'huile contre 0,9% avec

4% d'huile. Pour les taux élevés d'huile alimentaire, l'incorporation des AGLPI n - 3 est plus importante si les Artemia sont cultivés à forte concentration (20 par ml) plutôt qu'à faible concentration (10 par ml) avec un même apport d'aliment par unité de volume. Les croissances les plus rapides sont obtenues avec 10% d'huile dans le régime.

Besoins du loup ou bar juvénile

Le bar ou loup, poisson carnivore, a des besoins protéiques élevés. Une épargne des protéines de la ration par les glucides peut cependant être envisagée.

Une incorporation de 15% d'amidon prégélatinisé dans le régime améliore la rétention protéique sans modifier les performances de croissance. A l'opposé, quel que soit le taux de protéines, des régimes renfermant moins de 5% de glucides entraînent une diminution de tous les paramètres nutritionnels.

Dans l'état actuel des connaissances, 45% de protèines, 15% de glucides et 12% de lipides représentant un bon équilibre pour le juvénile de bar.

Nutrition des larves de poissons

La teneur en acides aminés libres permit de décrire l'état nutritionnel de la larve de bar: très élevée à l'éclosion, cette teneur décroît rapidement jusque vers 150 degrés-jours chez les larves à jeun, en raison d'une intense activité de synthèse protéique. L'alimentation avec des rotifères accélère cette décroissance et c'est seulement après 200 degrés-jours - lorsque les larves sont nourries avec Artemia - que la teneur en acides aminés libres remonte, à l'exception du tryptophane qui n'est plus détecté après 90 degrés-jours. La disponibilité des acides aminés des rotifères - et surtout celle du tryptophane - semble insuffisante. If faut essayer de l'améliorer car le rotifère reste une première proie indispensable pour assurer une bonne croissance des larves de bar.

Endocrinologie

La prolactine apparaît avoir un rôle clair dans l'osmorégulation chez les salmonidés en eau douce. En eau de mer, les niveaux circulants sont très bas quel que soit le niveau de régulation hydro-minérale. Des relations marquées composition de l'eau douce - prolactine plasmatique chez la truite arc-en-ciel apparaissent: effets du calcium et rôle sur l'adaptabilité à l'eau de mer. Cette hormone est très intéressante à suivre en eau douce.

Les hormones thyroïdiennes ne varient pas ou peu au cours de transferts d'eau douce en eau de mer ou d'eau de mer en eau douce. Elles ne sont pas influencées par le jeûne avant un transfert en mer. Elles fluctuent par contre intensément en cours de smoltification chez le saumon atlantique mais n'apparaissent pas reliables à l'acquisition de l'euryhalinité. Elles semblent avoir un rôle déterminant dans le déclenchement du comportement

migratoire et la réceptibilité aux stimuli externes. Pour l'adaptation à l'eau de mer, la (Na + -K +) - ATPase branchial apparaît être un meilleur critère que la T4.

Les hormones thyroïdiennes apparaissent chez les salmonidés être bien liées au métabolisme et à la croissance. Elles sont influencées par le courant dans les bassins d'élevage.

Nous cernons assez bien maintenant les fluctuations ATPases branchiales - hormones thyroïdiennes et pouvons imaginer les meilleures stratégies utilisables pour le transfert en mer ou le relacher de salmonidés migrateurs.

Les statistiques de la production aquacole marine sont les suivantes:

Salmonidés de culture intensive en mer: 490 tonnes (Salmo gairdneri 410 tonnes, Oncorhynchus kisutch: 75 tonnes, Salmo salar et Salmo trutta: 5 tonnes).

Bar (Dicentrarchus labrax): 60 tonnes environ, essentiellement sur la côte méditerranéenne.

Crevette (Penaeus japonicus): 3,5 tonnes, dont 1/3 de culture extensive dans les étangs méditerranéens et 2/3 de culture semi-intensive sur la côte Atlantique.

(H. Grizel)

Mollusques

Les principaux axes de recherches amonts sont:

- la modélisation des paramètres du milieu et de la nourriture en relation avec la biomasse.

- la pathologie (cultures cellulaires, diagnostic ELISA, mécanisme de défense).

- les facteurs agissant sur le recrutement.

- des tests génétiques.

Les programmes de suivis qui sont conduits concernent l'évaluation de croissance et de stocks, la surveillance du milieu (pollutions, eaux rouges, salubrité) et l'épidémiologie.

Enfin des programmes d'innovation biotechnique et techniques sont réalisés notamment sur Pecten maximus (production en écloserie, nurserie, élevage) sur Ruditapes philippinarum (amélioration des techniques d'élevage) et sur Mytilus edulis (culture en filière).

FEDERAL REPUBLIC OF GERMANY

(K. Tiews)

Crassostrea gigas:

The mariculture field station of the Institut für Küsten- und Binnenfischerei, which had been operated for some 15 years in Langballigau on the Fjord of Flensburg, 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. With the closing of the field station, the work carried out by this Institute related to Crassostrea gigas was discontinued. It is hoped that the research results obtained over the last 15 years by the Institute will now be commercially applied.

Salmonid fish:

Studies on the development of techniques for marine intensive culture of salmonid fish in the Kiel Bight were continued at the Institut für Meereskunde, Kiel.

Turbot:

Studies on the reproduction of turbot, the rearing of fry and the fattening of fingerlings including the development of feeds were continued at the Institut für Meereskunde, Kiel.

Eel:

Research on eel farming in heated effluents of conventional and nuclear power stations was continued at the Institut für Küsten- und Binnenfischerei. The experimental field station in the harbour of Emden of the Institute, operated for more than 10 years, was closed down at the end of 1985 after the tasks for which the field station was erected were completed.

Scaling up experiments for the mass rearing of elvers in silos were continued by the same Institute in its laboratories in Hamburg and Ahrensburg.

Intensive Farming Systems:

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

Work at the Biologische Anstalt Helgoland continued to focus on management problems in intensive farming systems. Studies were performed on the extent of daily water quality fluctuations under various culture conditions (i.e. flow rates, stocking density, tank design, feeding regime). Experiments were carried out in brackish water, as well as in sea water. Long-term variations in three experimental recirculation systems were also monitored. Specific investigations concentrated on: (a) the performance of a rotating biofilter

under various water loads; (b) the efficiency of an unaerobic denitrification unit (integrated into a recycling system for fish culture in relation to substrate availability and carbon source; and (c) behavioural aspects related to the influence of fish distribution in culture tanks on water mixing and exchange.

Species investigated in the experimental culture systems include mullet, turbot, eel and tilipia.

Development of Aquaculture Methods:

Work on the artificial reproduction of endangered species in German coastal waters was started at the Biologische Anstalt Helgoland. At the same Institute, the development of aquaculture methods for the mass reproduction of aquaculture candidates for tropical developing countries was begun. Species selected are Macrobrachium and Penaeid shrimps.

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. Immunobiological studies on Rainbow trout were continued at the Institut für Meereskunde, Kiel.

Statistics - Federal Republic of Germany

	Tonnes	Value in 1,000 U.S. $
Blue mussels (Mytilus edulis)	20,940	2,700
Pacific oysters (Crassostrea gigas) from vertical cultures	5	30
Eel (Anguilla anguilla) not fresh water	12	72
Rainbow trouts (Salmo gairdneri)	12	40

GERMAN DEMOCRATIC REPUBLIC

(W. Loos)

Production of marine organisms for human consumption in brackish waters on a commercial scale in GDR was carried out with Rainbow trout (Salmo gairdneri) in net cages. The total production in 1985 was about 570 tonnes of fish in the 1000 g size.

Fifty percent of the fingerlings were overwintered in freshwater and are transferred to the brackish water farms in April/May. The other fifty percent were overwintered by a special regime in brackish water.

The mean size of the overwintered fish is 50 to 70 g. Normally a total growth of about eight to ten times the initial weight is expected during the following season. The food is standard dry pellets and the feeding is mostly done by hand. The food conversion rate is equal to 2.5.

Experiments on the rearing of the Rainbow trout from egg to the marketable fish in one year were continued at the Institut fur Hochseefischerei, Rostock.

A new centre for rearing and selection of spawners of trout was opened. Spawners maturing in October/November were reared.

Experiments on the rearing of carp in heated brackish water were carried out. Studies on stocking open brackish waters with carp are prepared.

Immune/biological studies on Rainbow trout were continued.

ICELAND

(Björn Björnsson)

Marine Research Institute, Icelandic Fisheries Laboratories and Iceland Salmon Ltd., started a joint research program in 1985 to study the feasibility of collecting young halibut for ongrowing in landbased tanks. Every year Icelandic draggers get as by-catch hundreds of thousands of 3-4 year old halibut each weighing around 1 kg. If these fish could be brought to shore alive and fed for 2-3 years, their value could presumably be increased several-fold. The interest in the ongrowing of halibut results from its high marketprice.

A preliminary experiment was initiated in December 1985. A total of 143 halibut were collected with a commercial dragger and brought to the experimental tank which is situated on the south coast of the Reykjanes peninsula. Of these fish, 92% were alive four months later. The fish consumed some food three days after collection, but it was not until 2-3 months later that the halibut ate well the moist pellet which is made of capelin, vitamins and binding powder.

More extensive experiments are planned to study the growth rates of different size-classes of halibut at various densities.

(Ingimar Johannsson and Solmunder T. Einarsson)

The total production of salmon smolts in 1985 was around 820 thousand. About 420 thousand smolts were released from ocean ranching stations. Recapture at the ranching stations came to approximately 58 tons, and the production of farmed salmon reached about 90 tons.

About 250 thousand salmon smolts were sold to Norway for farming. Many salmon farming stations are now being put up, amongst them is Islandslax at Reykjanes, which is one of the biggest pump-ashore farms in the world. Their estimated yearly production is 500 tons of salmon, and it is estimated that the production of salmon in Iceland will reach at least 1-2 thousand tons in a few years.

At present, the Marine Research Institute and Islandslax are cooperating in experiments with halibut farming. The experiments are mainly carried out to ascertain the growth rate of small halibut gathered from fishing vessels using dragnets. The halibut is being farmed in tanks on land, into which sea water is pumped.

NETHERLANDS

(R. Dijkema)

Aquaculture in general in the Netherlands is still enjoying increased interest. Most new developments, however, are concerned with freshwater culture of eels and African catfish in recirculation systems in freshwater. One eel farming project was started in seawater, using the heat of a power plant annex freshwater factory.

Sea farming of salmonids is still being practiced by about three firms using cages. In one case in particular, which is situated at a location which in many respects is very promising for cage farming, high water temperatures during warm spells in summer are causing problems, due to mortality after infection with bacterial disease. As a consequence, this project is still lingering in the experimental phase and a major constraint is being felt for further developments in this area. A research program is underway to assess the combinations of environmental factors which bring about physiological stress and subsequent disease problems. In this program the incidence of disease is being followed and pathological blood parameters are being investigated. Another trial with the administration of vitamin C is being prepared.

In order to create a more stable production scheme which is less dependent on the vicissitudes of summer temperatures, experiments are being carried out with a combination of suspended culture of the European flat oyster (Ostrea edulis) at the farm site. The possibilities for such a combination are favoured by the fact that the base of the fish farm is a derelict inshore tanker, in the (perforated) holds and along the side there are lots of opportunities to attach lantern nets for oyster cultures.

The oysters are showing a very good growth, which is only exceeded by growth of oysters on the bottom in nearby Lake Grevelingen. The meat development of the oysters has hitherto been better than anywhere in the area and, consequently, the oysters were received well by the traders. Labour in the oyster part of the project seems up to now not to interfere with the activities in fish culture.

In 1985 a number of small-scale experimental setups in the cultivation of the Ragworm (Nereis virens), which is much in demand as sea-anglers' bait, have been so successful that at present about three commercial ragworm farms are in operation, albeit in the initial stages. Their nominal production level has not yet been reached. Another three farms are in the building or in the preparatory phase. Ragworm larvae are obtained from wild-caught animals; year-round reproduction has not yet been achieved. The Netherlands Institute for Fisheries Investigations has started a research program to take away the major bottlenecks in the cultivation, the most important of which appeared to be the year-round availability of larvae or young individuals. Besides artificial food trials and experiments with different stocking densities, this problem will receive most of the attention.

The infrastructure for aquaculture in the Netherlands has improved with the deployment of a government consultant for fish farming in the Ministry of Agriculture and the amplification of the tasks of a number of governmental fishery consultants towards fish culture. Also an amplification of the tasks of the Central Veterinary Institute on fish diseases is being realized. Possibilities are being considered for improvement of education facilities in the field of aquaculture.

Statistical Data - Netherlands

Species	Tonnes	(Numbers) (x 1000)	Value in US$ ((Feb 86)(x 1000))	Number of firms
Rainbow trout (sea water)	50	33	206.7	3
Rainbow trout (fresh water)	200	1,000	676.7	10
Eels	10	50	56.4	10
African catfish	70	233	315.8	25
Ragworms	2	400	26.3	3

NORWAY

(G. Dahle)

Research on problems related to mariculture 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 in Matre and 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, in Sunndalsora and 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 (FIFI), Tromso.

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

RESEARCH PROJECTS

Quantitative Genetics

Experiments with selective breeding of Atlantic salmon and Rainbow trout were continued, (1) and (4). The following sub-projects are included:

a. Selection programs to increase growth rate (1) and (4), reduce mortality (4), improve meat quality (1) and (4) and reduce early maturation, (1) and (4). At Sunndalsora 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. Induce polyploidy to obtain a triploid fish which does not develop gonads and production of all female triploids (4).

f. Induce gynogenesis, (4).

g. Study genetic variation in stress measured by cortisol level, (1) and (4).

h. Study of genetic and environmental interaction in different forms along the coast has continuously taken place since 1973 (4) and by stationing out 100 family groups of Atlantic salmon in 7 fish farms in order to study productive traits (1).

At (6) the program aimed at developing Arctic char, (Salvelinus alpinus), as a salmonid for farming in northern regions was continued. Progeny obtained on wild fish from 11 different and widely separated populations in Northern Norway are being raised in order to establish base populations for later selective breeding programs. Growth rates, age-at-maturity and osmoregulatory ability in seawater are the parameters of immediate interest.

Preliminary studies on Arctic char were also undertaken in a joint project between (1) and (5.1).

Behavior

Fish behavior studies in connection with fish farms in freshwater lakes are being studied in a cooperative project between (1), (5.1), (5.2) and (5.4). In order to avoid disease and increase growth and fish quality a system for monitoring the behavior of salmon in culture in relation to environmental factors and different rearing conditions has been studied at (1), (5.1) and (13).

Physiology and Nutrition

Laboratory experiments on nutrition, digestion, growth, metabolism and energy budget of cod, Rainbow trout and Atlantic salmon were continued (1) and (2). Use of shrimps wastes for salmonid feeding was further tried out (1) and also experiments comparing different carotenoids were continued (2), (4), (5.4) and (9).

Silage conservation of fish feed including long term effect, health and meat quality was studied by (4).

Nutritional quality studies on silage conservation of fish feed has been performed at (2).

A large scale experiment to study the effect of nutrition upon the outbreak of the "Hitra-disease" (Hemorrhagic syndrome) in Atlantic salmon has been carried out (2).

Studies on protein, fat and carbohydrate level in fish food, digestibility, feed consumption at different temperatures and of varying fish size, and comparisons of wet and dry diets in salt water at low temperatures were

carried out by (4) and (1). Also effects of different "new" feed ingredients were examined at (4). Possible effects of environmental factors including feed and quality of feed on the hemorrhagic syndrome (4).

Studies of factors responsible for varying egg quality of reared salmonids were continued by (1), (2) and (4). Particularly, investigations concerning the metabolism of vitamin C supplementation in Rainbow trout were carried out by (1) and (2).

Laboratory experiments on dietary carbohydrates on feed conversion and growth of salmonids and flatfishes are studied together with work on improvement of physical and qualitative properties in fish feed. Special attention is payed to corn products as binders 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 micro-algae 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.

Use of binders in salmon feeds (to increase feed efficiency and reduce water pollution) was studied by (4). The distribution of trace elements in various tissues and organs from cultured and wild Atlantic salmon was studied by (2). In collaboration between (2) and (9), studies on growth and feed consumption with different fish oil and meal qualities in salmon feed were continued.

Dry salmon feed for use at low sea water temperatures and the influence of protein quality and fish oil as dietary energy supplement was studied at (9).

Weaning feed constituents in diets for cod, turbot and sole were studied (9).

The environmental conditions of reared salmon and mussels were studied and related to stress and growth in blue mussels and Iceland scallops (11).

At (5.3) the following projects were continued or started during 1985:

- Studies of the biochemical mechanisms in the transport processes in the gills.
- Metabolism of branched aminoacids in Rainbow trout muscle.
- Hormone control of cod larvae nutrition consum, development and growth in cooperation with (1).
- Composition and optimalisation of synthetic start feed for salt-water fish larvae in cooperation with (1).

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

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

- Studies of larvae growth indicators.

- Studies of digestive enzymes and growth hormones from salt-water fish.

Pathology

Work on vaccination and vaccines against vibriosis was continued both for salmonids at (1), (6) and (8), and for cod and turbot (1). Special attention has been given to the cold-water vibriosis or Hitra-disease at (1), (6) and (8). At (1) the following projects were continued:

- plasmid related pathogenicity in vibrio infections and resistance against vibriostat 0/129 paired with antibiotic resistance.

- destruction of Neguvon r in fish and mollusces with C^{14} - labelled Neguvon r.

- studies of gill damage in connection with poor environmental conditions and in costiasis in sea-farmed salmonids.

At (8) the following projects were continued:

- registration of IPN virus in Norwegian fish farms and wild fish populations.

- studies for identification of Ichtyobodo necator infection in salmon in sea water.

- methodology development for detection of residues of drugs in fish .

- occurrence of sporozooans in Norwegian fish populations.

Aquaculture Technology

The behavior and physiology of salmonids during simulated transport conditions are investigated in order to develop new transport systems (12).

Systems for recirculation of fresh water and treatment of acid water for smolt production were further studied and improved by (1).

Experiments on raising of smolt in net pens in fresh water stressing ecological aspects were carried out in a joint program by (1), (5.1), (5.2) and (5.4).

Devices for scaring eider ducks in rearing plants for blue mussels were tested (11).

At (10) the following research programs were continued:

- Development of advanced, landbased fish farming plants with special attention to water quality, energy conservation and water demand. Most of the work has been done with Tilapia as a "model" fish.

- Research in and development of a model for evaluation of pollution from aquaculture activities.

- Evaluation of methods for aquaculture in parts of Norway with low winter sea temperatures (deep water pumping; use of heated effluents).
- Integrated research (social, natural and technological) on optimal localization of fish farming plants. This project is part of a larger research program on utilization of the coastal zone. One part of this program is an UNESCO-project under the program; Man and the Biosphere (MAB), coastal zone management in Fusal (methodical development).

- Research through interviews to describe and group conflicts in connection with aquaculture in natural resource connected and localized conflicts.

- Effects of combined low temperature and changes in salinity on salmon and Rainbow trout in aquaculture.

- Development of research "rings", groups of 20-25 fish farms that cooperate through a ring leader with sampling and evaluation of information regarding management and environment in the fish farm.

Rearing of Marine Fish Larvae

The program on mass-rearing of cod juveniles in an enclosed pond, initiated in 1980, was continued also in 1985 (1). The pond was treated with rotenon to exterminate predators on the cod larvae and juveniles. THe larvae were released at the yolksac stage and the surviving juveniles were collected during summer and autumn. The tagging and release program on juvenile cod in plastic bags in the sea was continued (1), and a program for composing an artificial or semi-natural feed for cod larvae was continued (1). A brood stock of halibut has been established and hatching and startfeeding experiments are carried out (1) and (4). Experiments with hatching and rearing marine fish larvae and juveniles were also continued by (3) in land-situated basins. Investigations on a polyspecies experiment on large outdoor basins were carried out with turbot, lobster and oyster (3). A special experiment was carried out with eggs and larvae from mature cod which had been hatched and reared in the laboratory two and three years ago (3).

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

Environment

Studies of environmental influence on Atlantic salmon is carried out at (1). The connection between water quality and fish health and growth is

investigated. So is the accumulation of organic sediments and leakage of nutrion-salts from the sediments. A program at (1) and (5.5) is investigating the influence of fish farming on the surrounding recipients.

Other Projects

Experiments on commercial culture of blue mussels were continued, (1), (3) and (7). Similar experiments on culture of scallops were continued on a small scale (1), (5.5), (6) and (7). Developmental studies of hatching systems for increased production of oyster larvae were initiated (1). Experiments with culture of oysters were carried out at localities along the coast and in large outdoor basins (3).

Feeding experiments with newly hatched larvae of lobster were ended, and the effect of various food was investigated (3). Technology for raising lobster in large scale is being tried out by a private firm, and 1 year old lobster were released in large scale in the sea in selected areas (3).

Production of microalgae for larval feed was studied at (5.4).

Occurrence of the tape worm Eubotherium crassum in bred salmon and Rainbow trout is studied at (7).

STATISTICS

The main mariculture production in Norway is Rainbow trout and Atlantic salmon. The public statistics give no breakdown on production in fresh and salt water, and the production in fresh water is not reported in the inland fisheries statistics. The total production therefore is given in the following table:

Species	In Metric Tons
Rainbow trout in enclosures	5,141
Salmon in enclosures	28,655
Arctic charr in enclosures	1.75

Concerning other species, some minor quantitites of blue mussel and oysters were produced.

POLAND

(J. Wiktor)

In 1985, the following investigations and experiments were continued:

- the rearing of brood stock of Rainbow trout in brackish water and their selection aimed at producing a breed hardened to living conditions in the Baltic and with reduced migratory tendencies;

- improvement of the acclimatization process in the case of juvenile rainbow trout released into the Baltic, aimed at reducing mortalities and the tendency of emigration from the release area;

- heredity of such features as early sexual maturation and early migration from the sea to rivers by certain specimens of sea trout/Salmo trutta.

Egg incubation and rearing of smolts of rainbow trout, salmon, and sea trout were carried out in fresh water in order to experiment with them later in sea water.

There was no commercial production in mariculture in Poland in 1985.

PORTUGAL

(Maria Teresa Dinis)

Under the support of the NATO "Science for Stability Program", a National Aquaculture Project was initiated by the end of 1984 and its activities were developed further during 1985. This project, a Research and Development one, is concerned with three main areas:

1. hatchery/nursery for marine fishes;

2. nutrition on marine and freshwater fishes with emphasis on total use of local available raw materials. The use of fish silage was considered a priority;

3. pathology of marine and freshwater fishes.

Different Portuguese institutions are involved, with support and cooperation from the national feed industry.

A Workshop on Nutrition of Fishes was held at the National Institute of Fisheries in 1985. Several papers were presented and are in the process of being published.

A Workshop on European Fish Market for Aquaculture Species and Marine Fish which were underexploited on the Portuguese fishing grounds was held at the National Institute of Fisheries. A report of the Market Study was presented.

Shrimp Culture

Experiments were done on a small scale on comparative growth of Penaeus japonicus post-larvae under laboratory and extensive production; these trials represented the first attempts at production of this species in Portugal.

Fish Culture

Sparus aurata

Under a natural circannual rhythm the quality of the gametes as well as the ultrastructure of the oocytes was studied in the protandric species Sparus aurata.

Methods for control of spawning and larvae were developed after artificial fertilization.

Studies based on data obtained in the wild environment of the Portuguese Coastal area were collected for Sparus.

Regression lines of length-weight relationships were obtained using length and weight of fish for both sexes, and the age of individual fish determined by scale measurements.

Dicentrarchus labrax

Research on the Swimbladder infection problem was analyzed by the determination of the total gas saturation in the water and further interpretation was done using histological methods.

Research on growth and survival of the fry was carried out using an available Spanish food and natural food.

Solea senegalensis

Natural spawn of this species was obtained by the second year. The possible utilization of this species as a new species for aquaculture was analyzed.

The improvement of the methods of juvenile production, and growth of juveniles on semi-extensive conditions are the following lines for the research project on this species.

Oyster Culture

On a coastal lagoon, south of Lisbon, experiments on growth of Ostrea edulis (abundant in the lagoon) and Crassostrea angulata transplanted from a southern region were carried out. The aims are the determination of:

- the growth curves;

- reproduction cycle;

- utilization of different types of collectors;

- environmental parameters.

SPAIN

(G. Roman and M. Torre)

During the year 1985, diverse aspects related to marine aquaculture were studied and researched.

Some studies on the environment in relation to mariculture were made. The main subjects studied were the lagoons of SW Spain and the delta of the Ebro River in the Mediterranean Sea. Studies underway included nutrient regeneration in the natural environment, the enzymatic activity in water and sediments, and the phosphatase and the proteolytic activities and excretion rates of different species in this environment (I.C.M.).

An integrated study of the delta of the Ebro River is being carried out in order to learn the determinant factors of the biological production (IIP - B).

In other areas, the water quality as an environment for mariculture was studied. Thus in NW Spain, water quality parameters in zones where there are commercial mollusc hatcheries and especially bacterial analysis and their influence on larval mortalities (XG) were investigated. Also in other zones (IEO S) N. Spain as Santander and Mar Menor (IEO M), water quality was studied.

Research about macroalgae culture was continued in Santander (N. Spain) (IEO S) to achieve control of the reproduction of the algae.

Research was also carried out on food organisms for mariculture. In the south of Spain (ICM) the physiology and mass production of rotifera (Brachionus) (ICM) was investigated.

In Santander, chemical parameters in relation to phytoplankton culture (IEO S) was studied. Experiments to produce microalgae in high volume (mass production for hatchery purposes (IEO G and JA) were also carried out.

Experiments were made in order to produce copepodes by culture for the purpose of feeding fish larvae and fry (IEO S and EAPA). A species that is under study in Spain is Artemia salina. During 1985, the IBERIAN ARTEMIA GROUP (Portuguese and Spanish researchers) continued to meet and interchange knowledge and opinions. The main studies on Artemia are focused on comparisons of different strains, food value and producing cysts and adults in lagoons in the Mediterranean (IEO M and IATS) and Atlantic sea (JA and CTP).

Molluscs

Much work was done on molluscs in 1985. The main species under investigation were clams, oysters and scallops. Experiments on oyster settlement (O. edulis) using different collectors in coastal lagoons (IEO M) and delta (IIP B) and in hatchery tanks (IEO G) were conducted. Investigations were also made on conditioning, spawning, larval development and spat production in hatcheries with the clam species R. phillippinarum, R. decussatus and O. edulis (IEO G and JA).

The nursery growth of those species was studied in S. Spain (JA) and in hanging culture in NW and SW Spain (IEO G and JA). In this last zone C. gigas was also studied.

The growth, mortality and reproduction of Ruditapes philippinarum was studied in culture sand flats in Galicia, NW Spain, (IEO G) and comparative growth and gonad development of R. decussatus and R. philippinarum in Santander (N. Spain) (IEO S) was measured. The growth of the oyster, O. edulis, in the delta of the Ebro River (IIP B) and in hanging culture from rafts in Menorca-Balearic Islands (EAPA) was studied; an experiment was also made on culture of Venus verrussa.

Some research was begun on Bonamia and Marteilia in the oyster, O. edulis, (X G) and diverse pathogens, parasites, etc., in the oyster and mussel (IEO V).

Research on Pecten maximus was made mainly in the Alboran Sea (S. Spain - Province of Malaga) as studies on spat and seed collection on collectors (onion bag type) in Fuengirola and Velez-Malaga and on-growing in long-lines and baskets (IEO A).

Abalone, Haliotis discus and Haliotis coccinea canariensis were examined as possible subjects for culture (IAT S).

Experiments were made on nutrition of Sepia officinalis and S. elegans in captivity (IIP V).

Sampling for genetic characteristics was done on the "loci" of natural populations of the oyster, O. edulis, from Galicia, NW Spain (Catedra de Genetica - University of Santiago).

Crustaceans

The main group studied was the Peneidae-P. kerathurus and P. japonicus, and the main subject was postlarvae mass production and extensive growth in lagoons (JA and ICM) or also with both species jointly (ICM).

The larval production and extensive culture in lagoons of Palaemon serratus (ICM) was examined and research was made on the culture of Liocarcinus puber (egg and larval development, and growth) in the laboratory (IEO G).

In Cadiz, the biomass transformation and ingestion rate of crustacean and fish larvae (Palaemon, Palaemonetes and Sparus) (ICM) were studied.

Finfish

Three investigated species were seabass (Dicentrarchus labrax), gilthead sea bream (Sparus aurata) and turbot (Psetta maxima).

The seabass conditioning research was done in different institutions and laboratories, but previous research was continued in the IAT S.

Investigations on gilthead bream conditioning, spawning, egg incubation, larval development, fry mass production, nursery growing (fingerlings) and on-growing in ponds to commercial sizes (more than 300 g of individual weight) were done in S. Pedro del Pinatar - MURCIA (IEO M), Las Palmas de Gran Canaria (CTP) and Santa Cruz de Tenerife (IEO C).

Sea bass reproduction and larval development and growing to commercial sizes was also done in IEO M and EAPA.

On-growing of fry and fingerlings of gilthead seabream and bass to commercial sizes in floating cages was investigated in San Pedro del Pinatar, MURCIA - SE Spain (IEO M); Puerto de Andratx, Mallorca, Balearic Islands (EAPA) and Tenerife-Canary Islands (IEO C).

Research on turbot was studied mainly on the sequential spawning control and larval culture with diverse living prey as food (IEO V); in Santander (IEO S) the spawning, fecundation, egg incubation, larval development and fry growth was examined.

The on-growing of turbot from fry to commercial sizes in tanks and floating cages was also investigated in Vigo - NW Spain (IEO V).

In Santander, research was started on reproduction, fry production in hatchery and growth in tanks of common sea bream, P. bogaraveo (IEO S).

In Mallorca, experiments were made on reproduction, fry production and growth in floating cages of the sea bream, P. puntazzo, and of floating cages of yellowtail with fingerlings caught from the wild (EAPA).

In Tenerife, the culture of white sea bream, D. sargus, was investigated.

We must point out that in the salina area of SW Spain studies were made on the annual cycle of fry and fingerling catch (ICM).

In Santander (IEO S) the food value (fatty acids, proteins, etc.) of the species of trash fish used in mariculture was studied.

In October in El Grove (Pontevedra), the 1st Congreso Nacional de Acuiculture took place. Its proceedings will be published in 1986.

KEY:
- CTP - Centro Tecnologico Pesquero de Taliarte Gran Canaria
- EAPA - Estacion de Acuiculture de Puerto de Andratx Mallorca
- IATS - Instituto de Acuicultura de Torre de la Sal Castellon
- ICM - Instituto de Ciencias Marinas Puerto Real - Cadiz
- IEO A - Instituto Espanol de Oceanografia - Fuengirola-Malaga
- IEO C - " " " " - Sta. Cruz de Tenerife
- IEO G - " " " " - La Coruna
- IEO M - " " " " - San Pedro del Pinatar Murcia
- IEO S - " " " " - Santander
- IEO V - " " " " - Vigo - Pontevedra
- IIP B - Instituto Investigaciones Pesqueras - Barcelona
- IIP V - " " " - Vigo - Pontevedra
- J A - Junta de Andalucia
- X G - Xunta de Galicia

SWEDEN

(Hans Ackefors)

Introduction

The aquaculture program for fishery management is of great importance to maintain the stocks of salmon and brown trout, especially in the Baltic. There has been a rather slow development of commercial aquaculture. The main species in production are Rainbow trout, salmon and blue mussel. Minor quantities of Arctic char, trout, carp, eel and oysters are produced. The blue mussel industry still suffers from toxic microalgae outbreaks.

Fishery Management

About 1.9 million salmon smolts and 0.4 million sea trout smolts were released mainly in the Baltic area. Together with the production of smolts from other nations, about 3.6 million specimens were released in 1985, which is an increase of 30% compared to 1984 (cf. table 1).

Table 1. The release of salmon and brown trout in the Baltic in 1985 in million specimens.

	Salmon	Brown trout
Sweden	1.8	0.43
Other nations	1.8	1.40
Total	3.6	1.83

In addition to that, about 0.1 million salmon smolts were released in rivers on the Swedish westcoast. Results from tagging research of smolts indicate that there was a good survival and growth of those smolts raised in 1982-84 compared to the 1981 smolt year class.

Commercial Production

Commercial cultivation for direct human consumption consisted of 1925 tons of fish and 1278 tons of blue mussel in 1984 according to the official figures. In addition to that, 10,000 oysters were harvested. Probably the real figures for fish production were 50% higher. In table 2, a summary of the total production as well as the marine production is made.

Species	Marine Production	Total Production
Rainbow trout	916	1,849
Salmon	50	59
Brown trout		1
Arctic char		≤1
Eel		15
Carp		≤1
Total Fish Production	1,925	1,925
Blue mussel	1,278	1,278
Oysters	10,000 specimens	10,000 specimens

The number of operation units aimed for fish production in marine waters was 78. Sixteen operations produced blue mussels.

Research

Research on aquaculture projects was conducted at the following Swedish laboratories:

- Swedish University of Agricultural Sciences, Uppsala;
- Salmon Research Institute, Älvkarleby;
- Fishery Board of Sweden, Kälarne, Drottningholm, Älvkarleby;
- University of Gothenburg, Department of Zoophysiology, Göteborg;
- Tjärnö Marine Biological Laboratory, Strömstad;
- Chalmers' University of Technology, Department of Marine Chemistry, Göteborg;
- University of Uppsala, Departments of Zoophysiology and Limnology, Uppsala;
- University of Stockholm, Department of Zoology and Askö Laboratory, Stockholm;
- University of Umeå, Department of Zoological Ecology, Umeå.

The research is mainly concentrated to salmonids. There is a wide range of topics within both basic and applied research concerning genetics, nutrition, physiology, ecology and pathology. Research aimed to study ranching techniques, e.g. delayed release of smolts, is now implemented in practical use for salmon in the Baltic. Cultivation techniques for oyster rearing, as well as toxic microphytoplankton in relation to mussel rearing, is being studied. Environmental impact by net cage rearing in marine environments is being investigated with in situ techniques in order to study leakage of nutrients of sediments into the water.

UNITED KINGDOM

ENGLAND

Nil report for 1985.

SCOTLAND

(A.L.S. Munro)

Commercial Atlantic salmon culture produced 6921 tonnes valued at £30 million compared to 3912 tonnes in 1984. Some 6.5% were from tank units using pumped sea water, the rest from floating sea cages. The number of new sea sites increased to 128 from 83 in 1984. Numbers of smolts placed in sea water wered 5.6 million compared to 3.6 million in 1984. Some 70% of smolts were produce in tanks, the rest by cage culture in freshwater, and 91% of smolts were one year old. The industry reported over 700 people employed directly in the fish culture process.

Commercial Rainbow trout culture produced 2256 tonnes (2082 tonnes in 1984), of which only 81 tonnes were produced in sea water. Commercial culture of turbot in thermal waste waters produced over 100 tonnes and production of turbot juveniles reached 200,000, significant numbers of which were exported. Commercial trials involving the co-cultivation of turbot and salmon in specially designed floating cages are in progress. Commercial culture of mussels by off-bottom techniques is developing quite rapidly, especially in the Western Isles. Production is of the order of several hundred tonnes. Oyster culture continues, mainly of the Japanese oyster, but no production figures are available. Significant investment is on-going in scallop and queen scallop culture.

Research on the exocrine pancreas disease of farmed Atlantic salmon continues at the Marine Laboratory, Aberdeen, and at the Institute of Aquaculture, Stirling, but no firm conclusions on cause are yet available. Similarly both institutions are actively researching in a collaborative manner the virulence mechanisms of Aeromonas salmonicida, the causative agent of Furunculosis, as the best basis of developing methods of controlling this disease which continues to cause problems for salmon farming.

Research continues in other areas of salmon farming as well, including dietary requirements, maturation control, detracting predators and carcass quality.

UNITED STATES

(A. Crosby Longwell)

In 1985 the U.S. Sea Grant Program of the National Oceanic and Atmospheric Administration in the Department of Commerce spent 4.41 million dollars on 121 aquaculture projects in various universities about the country. This is an increase over the prior year's appropriation for aquaculture research.

The Office of Sea Grant, using statistics collected by the National Marine Fisheries Service, reports that aquaculture production more than doubled over the last 5 years for several species - marine fish, salmon, mussels, catfish, crawfish and baitfish. Production is expected to increase further when results of genetic, nutritional and pathological research are integrated into commercial production systems.

An analysis of subject areas funded in 1985 showed increases in genetic and endocrinological research. This was probably brought about by heightened interest in biotechnology; more particularly chromosome engineering, although some work is ongoing on recombinant DNA. By species, greatest increases in funding went to research on marine shrimp and algae. Several new marine finfish projects were begun - on snook, red snapper and dolphin fish. Strong financial support continues for studies on oyster, hard clam, salmon and striped bass.

There is new recognition of the importance of understanding the genetic bases of the domestication and cultivation process as it will influence future development of better aquaculture strains.

In the same year, the U.S. Department of Agriculture provided a total of 7.5 million dollars for aquaculture research (on both fresh water and marine species), education, extension services, and technology transfer in various agriculture universities about the United States. The National Aquaculture Information Service provided by the National Agriculture Library has strong backing. Marketing and consumer issues are receiving special attention.

The Department of Agriculture has recommended establishing 4 regional centers for aquaculture in different parts of the country. These are to be groups of cooperating institutions which will administer USDA funds to their scientists on a competitive basis for the purpose of aquaculture research. The following organizations in the northeast are named as cooperating institutions: Universities of Rhode Island, New Hampshire, Southeastern Massachusetts State and Connecticut; Tufts University; Milford Laboratory of the National Marine Fisheries Service; Woods Hole Oceanographic Institution.

In the laboratories of the National Marine Fisheries Service, aquaculture is now restricted by policy to use in a supporting role for fisheries ecological pollution and recruitment research. An exception is in the responsible maintenance and monitoring of artificially used strains. Also, some more strictly aquaculture research is conducted by individuals in cooperation with Sea Grant recipients. The Fisheries Service continues to be active in transfer of marine aquaculture technology to universities and to the private sector and is keeping abreast of new developments. Several investigators have begun, rather independently of one another, to question what significance chromosome engineering, selected strains and extensive aquaculture generally will have on fishery management.

USSR

(S. A. Studenetsky)

Nil report on USSR activities for 1985.