

MARICULTURE COMMITTEE

by

K. Tiews



Belgium

(G.Persoone and F. Redant)

At the Institute for Marine Scientific Research several research programmes on mariculture will be continued in 1978, in collaboration with the Laboratory for Mariculture at the State University of Ghent. They are dealing with mass culturing of microscopic algae on either mineral nutrients or biodegradable wastes. Both indoor and out-door (pilot-scale) experiments will be carried out on different algal species, with simulation of the utilization of heated effluents. Experiments are in progress on the technology of automatized mass culturing of the brine shrimp Artemia salina in raceways with artificial heating. Research is also carried out on the nursery culturing of bivalve molluscs in heated effluents.

At the Fisheries Research Station experiments on the embryonic and larval development of Crangon crangon and Solea solea under artificial conditions are planned for 1978. Special attention will be given to the influence of physico-chemical factors, food requirements and intra-specific competition.

The European Mariculture Society (the registered office of which is located at the Institute for Marine Scientific Research) is still increasing the dissemination of maricultural information through the publication of quarterly Newsletters and Special Publications.

Canada  
(J.E. Stewart)

The mariculture (including aquaculture) program in Canada consists of a number of separate studies conducted in different parts of the country. These studies are loosely coordinated between regions and attempt to provide the basic scientific information required for successful culture. In addition, a number of larger scale developmental trials and preliminary commercial ventures are underway.

Pacific Region (Nanaimo Biological Station)

The overall objective of this Program is to develop and advance the basis for commercial aquaculture of anadromous and marine fishes. All the effort of the past four years has been devoted to the successful rearing of Pacific salmon through studies under the following:

A. Experimental Fishfarm

a) Salmon production

The objective for the 1977 production of salmon was to raise a crop of 20,000 coho and 6,000 chinook for testing of density effects and incidence of kidney disease particularly in near-market size fish (300 g) and brood stock (1,000 g and over - from 1976). In addition, a crop of pink salmon (17,000) and chum salmon (8,000) were cultured for testing production problems for these two species that readily tolerate sea water as young fry; great losses from disease (furunculosis and PEN) has seriously impaired earlier efforts. To these production targets a further crop, for release purposes, was added: 30,000 chinook, 10,000 coho, and 15,000 sockeye. The chinook stock was split, with an early release (July 4, avg. wt 28 g) and a later release (August 18, avg. wt 49 g).

Freshwater survival of all but the pinks was 90% or better; early feeding problems and pinheads reduced pinks to 50% by the time of saltwater transfer. Saltwater survival of all stocks except the early chinook release (98%) was seriously affected by an unusually early, dense bloom of the spiculated diatom, Chaetoceros, which rose in concentration well above the critical level from August 19-25. Because of this onset, all but a small number of coho were released earlier than planned, along with the approximate assigned number of chinook and sockeye. Up to that date sea survival has ranged from 84% (chinook) to 92% (sockeye). The stocks carried through to this fall (chinook, chum, pink) show an average survival of 79% from fry. The practices of non-feeding and of induced "sieving-effect" from partially fouled nets helped to reduce expected heavy losses from algal gill damage, especially in chums and pinks with finer gill rakers than chinooks. The forced release of the coho eliminated the possibility of a density test on large fish.

Earlier experience with KD has shown incidences of 60% infection of stocks of large fish. Losses to date in 1976 brood stock that were unvaccinated, vaccinated, and held 3-4°C lower than normal have only averaged 3%, with no treatments conferring any significant benefit.

With the exception of the Chaetoceros problem, which needs further attention, the 1977 results confirm the suitability of coho and chinook salmon as excellent farm fish. The present evidence from seapen rearing adds pink and chum to this list, with the advantage to chum salmon for better fry survival but not for better saltwater growth which favors pink salmon.

b) Farm development projects

i) Inventory check - A stock of chinook salmon (10.5 cm, 12,8 g) of known number (36,550) was subjected to the Peterson mark-and-recapture population estimate. Approximately 14% (5,000) were sprayed with red fluorescent dye and returned to mingle with the main population. Three subsequent samples of 2,300 ( $\pm$  300) were examined for marks. Inventory estimates were in error by +40%, 15% and -39%. An error not

exceeding  $\pm$  10% was expected. Excessive deviations resulted from non-uniform spraying, stress, behaviour differences, and questionable random sampling. This will be repeated using a less stressful mark (Bismark brown).

ii) Hake as feed - Because of abundant, unutilized hake in the Strait of Georgia preliminary tests on feeding minced, raw fish to chinook salmon (169 g) were conducted. The trials were sufficiently successful to suggest that a diet cheaper than the Oregon Moist Pellet could be developed using raw hake.

iii) Brood stock fertility - A factorial mating experiment was performed to compare the fertility of pen-reared and wild coho salmon (Rosewall). Underyearling and 2-yr-old cultured males were as fertile as wild males. However, eggs from pen-reared female averaged 68% fertility compared with 93% for wild females.

It was concluded that the fertility of pen-reared brood stock is sufficient to permit the initiation of a selective breeding experiment. Nevertheless, there is a need to improve their husbandry to restore the fertility to the level found in wild females.

## B. Physiology

The major objectives are 1) to determine the physiological basis for the activities of growth and smoltification in order to develop new and improve existing methods to prepare juvenile salmonids for marine culture, and 2) to conduct selective breeding experiments to determine the potential for genetic improvement of cultured stocks.

### a) Influence of temperature, photoperiod, and salinity on growth and smoltification

It was concluded that a natural photoperiod cycle is more favorable for growth and smoltification of underyearling coho than are accelerated photoperiod cycles. A mean temperature of 10° under a natural photoperiod appears sufficient to induce a majority of underyearling coho to smoltify 18-20 wk after first feeding in late January (i.e. by mid-June).

Chinook display a propensity to migrate before smoltification is completed. Survival to the adult stage might be improved if release of juvenile chinook is delayed 3-4 wk beyond the time that migratory restlessness is first observed.

b) Minimum oxygen requirements

Apparatus has been assembled to control and continuously monitor oxygen levels in ten 200-liter growth-metabolism tanks.

Yearling coho in 15°C fresh water have been held at O<sub>2</sub> levels ranging from 3.0-10.0 ppm. During the 6-wk experiment the fish have been fed all they would eat four times a day. Initial indications are that fish survive and grow as well at 3.0 ppm as at higher levels, an unexpected finding which is thought to be the result of a complete absence of interacting factors.

c. Influence of fluctuating temperatures on growth of sockeye

Individual growth rates of underyearling sockeye salmon were measured for 8 wk on five constant temperatures between 7.5 and 17.5° as well as two diurnal fluctuating temperature cycles of 7-13° and 5-15°.

Growth appeared to acclimate to the maximum temperature of the cycle. Thus raising the water temperature for only a few hours each day provides a more cost-effective method of growth acceleration than the usual practice of heating to a constant high temperature.

Central Region (Winnipeg Freshwater Institute)

Research activities of the aquaculture project at the Freshwater Institute are based on four types of culture system; extensive trout culture in prairie lakes (ranching concept), hatchery culture, cage culture in lakes and intensive pond culture. Extensive culture of rainbow trout began in 1970 and continues to command a major share of research input. Hatchery culture of various species was begun at the same time, primarily to provide experimental stocks for the extensive culture. It has, however, led to research into the improvement of hatchery techniques themselves. The

biological feasibility of cage culture of rainbow trout was demonstrated in 1972/73, and further research is planned to improve techniques and investigate economic feasibility on a pilot scale. Research on intensive culture of trout in standing water ponds is relatively recent, although much of the technology developed in extensive and hatchery culture systems is applicable.

Internationally, members of the aquaculture project have served as technical advisors in the following areas:

- aquaculture recommendations - Thailand
- genetics program design - Thailand
- analysis of water quality problems - Philippines
- aquaculture program - El Salvador.

The aquaculture project is also involved with student training within its own research objectives. Students and biologists from Thailand (6), India and Finland have taken training in aquaculture under the supervision of project members.

#### Maritimes Region

The developmental program in this region is notable for its diversity and includes work on Atlantic salmon, Trout (mainly Rainbow Trout), Lobsters, Mussels, Oysters and a few other species such as the Bay Scallop, Argopecten irradians and certain seaweeds.

#### Salmonids

Smolt Readiness - Gill ATPase activity is a sensitive indicator of the ability of Atlantic salmon to osmoregulate in seawater, but it is not as good an indicator of readiness to migrate to sea as lipid-moisture content, high salinity tolerance, and migratory behavior.

Maturation and Smolt Growth - The slow growth of male Atlantic salmon parr observed during gonad development does not continue after maturation, and growth of mature and immature parr is similar. Salmon parr can become smolts in the spring if they matured the previous fall, but they are significantly smaller than parr that did not mature in the fall.

Enhancement of Growth by an Anabolic Steroid - The synthetic androgen 17 $\alpha$ -methyltestosterone was mixed in doses of 0.2 and 1 mg/kg into the diet of Atlantic salmon (Salmo salar) parr. During the 106 days of feeding the diet both doses enhanced growth in weight and length significantly. The greatest gain in weight (23.6% over control) and length (6.6%) was produced by the lower dose. Protein and lipid composition of the muscle was not affected by the treatment, but the 1 ppm dose caused a small but significant decrease in moisture content. Some changes in the structure of the testes occurred in androgen-treated fish, but ovaries were not affected.

#### Salmonid Nutrition

The salmonid nutritional studies have been aimed at determining whether salmonids grown in seawater have dietary requirements which are different from salmonids grown in fresh water. To date the studies indicate that fish grown in seawater require higher levels of protein and have different mineral requirements.

#### Salmonid Diseases

The diseases being investigated at the present time are: Bacterial Kidney Disease, Furunculosis and Vibrio infections in seawater. The geographic distributions, modes of infection, resistance factors and control measures are being determined.

Water Reuse System - An experimental water reuse system has been evaluated with Atlantic salmon and rainbow trout. The latter grew as well at 95% recirculation as others did in a single pass system and did so at a spectacular savings in heating cost. In the single pass system water heating costs came to \$11.45 per kg of trout, as opposed to only \$.95 per kg in the reuse system.

Sea Ranching - Atlantic salmon have been chemically imprinted and released at the Biological Station, a site with no nearby river system. This year 100 grilse returned to gill nets set in Brandy Cove. More than 200 returns are expected next year, and these will be used to start restoration of the St. Croix River in a joint program with the North American Salmon Research Center.

Salmonid Hybridization - Crosses of indigenous salmonids have been evaluated for their potential in aquaculture. A salmon-char cross increased from 105 g to 1400 g in 5 1/2 months. F<sub>2</sub> and back crosses have eyed and some have hatched, demonstrating fertility among some of the hybrids.

Pink Salmon Introduction - Approximately 5000 pink salmon eggs have been imported from the West Coast and approximately 98% of the imported eggs hatched normally.

Tuna Feed Lot Operation

Large tuna (400-800 lb wt) after spawning follow food fish into St. Margarets' Bay, N. S. They become entangled in mackerel traps and are then rescued and placed in large net cages. The spent fish are fattened over the summer and early fall gaining approximately 25% in weight. Since the fish are butchered and transported to Japan where the discriminating market pays particular attention to fatness and colour, the diet becomes all important in this operation. This is a large operation this year involving approximately 1000 fish weighing around 800 lbs each.

Lobsters

Culture Plant - A lobster culture plant completed by mid-1977 is being used to develop, test and evaluate equipment and techniques under actual grow-out conditions. In the first six months 200,000 larvae have been hatched and 900 are now between four and six months of age.

Growth Studies - The amount of space required for unrestricted growth has proved to be a density phenomenon from which an equation has been derived to predict optimum communal stocking density for different size lobsters. Lobsters in communal tanks are aggressive and injure one another, but this aggression is reduced and growth enhanced if the major claws are immobilized. Small lobsters reared communally grow at widely differing rates, and within two months the largest may be three times the size of the smallest. We have found that a greater number of larger lobsters can be obtained if stocks are periodically sorted and re-stocked by size.

Extra Maternal Hatching - Expensive space is now tied up in holding brooding females in lobster culture facilities. We have been studying various chemical and mechanical means for holding eggs isolated from the female, and to date achieved disease-free development and hatching in the final month. Ultimately we hope to remove the eggs as soon as they develop eye spots.

Size and Growth Enhancement of Lobsters (Eyestalk Ablation)- Currently there is a good market for live lobsters although prices are quite sensitive to patterns of supply. There are opportunities to extend this market without materially altering prices. The natural supply, however, is limited since the resource is being fished at or in some instances beyond its maximum sustainable yield.

Independent and joint studies conducted at and between the Halifax and St. Andrews Laboratories have demonstrated that lobsters captured commercially can be induced to molt far in advance of the usual molt time. This is achieved through eyestalk ablation which when combined with an adequate diet at moderate temperatures (12-15C) results in good survival and a weight gain/molt of between 65 and 72 percent with some lobsters doubling their weight. In addition to the increased value resulting from the increased weight there is an increase in unit value as the size increases i.e. a premium/lb is paid for the larger sized lobsters.

Lobster Nutrition - The gross dimensions of the problem have been worked out. It is now known that a high protein diet is required, cholesterol is essential and marine oils are more effective than vegetable oils. The more refined determinations are well underway including comparisons of the differences between the dietary requirements for normal lobsters versus eyestalk ablated lobsters.

Lobster Disease - Studies on the fatal bacterial infection of lobsters are continuing. Emphasis currently is placed on development of an inexpensive effective vaccine and an understanding of the lobsters defenses against disease.

### Oysters

Maritime oyster culture operations are based on a system of sea-bottom leases. A new computerized administration system for these 2,039 leases is presently in the detailed design phase. Once operational, this new system will provide a high level of data capture on culture operations and allow better overall management of the resource and servicing of shellfish culturists. Regular feedback from shellfish culturists should allow the clear definition of areas influenced by environmental, disease or other problems, and allow more effective response by the Fisheries and Marine Service.

Oyster spat collecting areas in Cape Breton and Prince Edward Island were managed to ensure rational use of the resource through collector quotas and space allocation.

### Bay Scallops

A preliminary assessment of the feasibility of introducing the bay scallop (Argopecten irradians) to Maritime waters was completed. Based on this study and presently-available knowledge of Maritime environmental conditions, it is questionable whether this species has significant mariculture or fishery potential in this Region.

### Blue Mussels (Mytilus edulis)

The Nova Scotia Department of Fisheries has continued experimental suspended culture of the blue mussel (Mytilus edulis). A number of promising sites have been investigated, appropriate culture techniques tested and developed and a variety of products processed using a high degree of mechanization. Test marketing of these has met considerable success. Three private commercial ventures are scheduled to begin operations in 1978.

Newfoundland

The Sea Scallop, Placopecten magellanicus

Research into scallop culture was conducted by our agency in cooperation with the Newfoundland Department of Fisheries.

Spatfall on vertically suspended polyethylene collectors has been increased significantly by placing collecting units in waters deeper than 5 m and through better timing in the setting out of collectors.

A clearer definition of settlement times of the mollusc and one of its major predators, the starfish (Asterias sp.), has also led to a significant reduction in spat mortality. Further refinements in the design of collectors as well as new substrates are being tested this year.

One of the main disadvantages of holding scallops in off-bottom culture is the cost related to maintenance. Ranching possibilities are, therefore, also being investigated. Premature transplanting could lead to high mortality through predation; if delayed, we face increased costs. A balance between the two must be established.

Denmark

(E. Hoffmann)

Nothing to report.

Finland

(P. Tuunainen)

Experiments with the rearing of Baltic salmon (Salmo salar) smolts for stocking purposes in the brackish cooling water of an electric power plant were continued. Comparisons

between net cages and plastic basins for culture purposes as well as between brackish and fresh water were made. To avoid the problems caused by oversaturation of dissolved nitrogen in the cooling water, aeration was used. Plastic basins proved to be more suitable for cultivation than the net cages. The use of warm water (about 10 °C) for rearing in winter considerably increased the growth rate and in brackish water it was clearly higher than in fresh water. In warm brackish water the young salmon grew to 13-15 cm and to about 22-33 g in one year. Conventional rearing requires 2-3 years for the same amount of growth. Aeration of the water eliminated gas bubble disease. Successful experiments with the rearing of older salmon (3-summer old) were carried out in winter 1976/77.

The commercial production of rainbow trout, Salmo gairdneri, in net cages in Finland's southwestern archipelago has increased, amounting to 250-300 t in 1977.

#### France

(J. Audouin et M. Girin)

#### Mollusques.

##### Pectinidés - Expériences de captage.

5 000 collecteurs ont été immergés en Baie de Saint Brieuc Rade de Brest, Baie de Seine et Baie de Camaret (CNEEXO-COB).

Le rendement moyen de captage a atteint 8 coquilles Saint Jacques (Pecten maximus) par collecteur, en Baie de Saint Brieuc, 10 à 70 en Baie de Seine et 30 à 50 en Baie de Camaret.

En Baie de Camaret, 500 pétoncles noirs (Chlamys varia) et 1 500 pétoncles blancs (Chlamys opercularis) ont été obtenus par collecteur et en Rade de Brest 3 000 à 10 000 pétoncles noirs.

2 000 collecteurs ont été immergés en Baie de Quiberon (ISTPM). Les résultats du captage ont été moins favorables que l'année précédente (en moyenne 200 pétoncles noirs par collecteur). Le naissain obtenu a été immergé dans le secteur de Ré-Oléron.

Dans un but de repeuplement, 27 000 coquilles de 27 à 30 mm collectées en 1976 en Baie de Saint Brieuc ont été immergées en Rade de Brest. On a observé une croissance analogue à celle du milieu d'origine et un bon taux de survie (CNEEXO-COB).

Le captage des pectinidés est caractérisé par une grande variabilité en fonction des secteurs et des années.

### Vénéridés.

Des expériences d'élevage du clam Mercenaria mercenaria ont été faites à partir du naissain d'écloserie (ISTPM).

En surélévation, la mortalité forte la première année, atteint 50 % au bout de 3 ans et la taille moyenne obtenue est voisine de 3,7 cms. Des essais de grossissement en claires, à partir de mollusques importés ont également été effectués.

Les tentatives d'élevage de la palourde Venerupis decussata en surélévation se sont soldées par une mortalité élevée: en 3 ans elle atteint 90 % et la taille moyenne est proche de 2,5 cm.

Des essais d'élevage de la palourde Venerupis semi-decussata portant sur 15 000 sujets d'écloserie, ont donné des résultats plus favorables. Après 3 ans la taille obtenue est de l'ordre de 35 mm (11 g) et la mortalité n'a pas dépassé 35 % en surélévation (ISTPM).

Une expérience portant sur 30 000 Venerupis semi-decussata a été menée d'Avril 1975 à Avril 1977 en bassin à fond drainé à l'Ile Tudy (CNEXO-COB), à l'abri des prédateurs. 10 000 palourdes d'un poids moyen de 17,6 g ont été obtenues.

Une extension de cette technique portant sur 250 000 palourdes est en cours depuis avril 1977.

### Haliotidés.

L'écloserie d'Argenton (CNEXO-COB) poursuit sa production de jeunes ormeaux en vue d'expériences d'élevage. 60 000 juvéniles de 10 à 23 mm âgés de 10 à 12 mois ont été immergés sur parcs aménagés en deux points de la région Nord Bretagne (Kerlouan et Saint Jean du Doigt).

### Algues.

Des essais de culture en bassin de l'algue rouge Chondrus crispus sont actuellement pratiqués en Bretagne (ISTPM). La culture consiste à accélérer le développement de fragments d'algues maintenus en suspension dans de l'eau de mer enrichie de sels minéraux. Les bassins sont alimentés en circuit ouvert. La production moyenne obtenue est de 2kg/m<sup>2</sup>/mois.

Au cours de l'année 1978, on tentera de mettre au point la technique du recyclage, de résoudre le problème des épiphytes et de préciser l'influence de la température.

### Crustacés.

Crevette (Penaeus japonicus) : la ponte en captivité est actuellement maîtrisée et peut être obtenue à n'importe quelle période de l'année avec une programmation "à 15 jours près" (CNEKO-COB). On a observé une fécondité plus élevée à la deuxième génération (5 millions de nauplii en 15 pontes dont une ponte de 1 million de nauplii).

La mise au point d'aliments inertes gélifiés permet désormais de pratiquer l'élevage larvaire sans apport de proies vivantes. Un ali ent composé a entraîné une croissance supérieure à celle obtenue à partir de chair de moules.

La production de l'année 1977 a atteint 500 000 post-larves et 3 tonnes de crustacés de taille marchande (DEVA Sud).

### Homard (Homarus gammarus).

La production de post-larves des Ecloseries a été la suivante en 1977 :

Ecloserie de l'Ile d'Yeu (ISTPM) : 132 000.

Ecloserie de l'Ile de Houat : 35 000.

Ecloserie de l'Ile de Sein : 5 000.

L'étude comparative de la croissance en captivité du Homard européen, du homard américain et des hybrides s'est poursuivie (ISTPM).

## POISSONS

### Truite en eau de mer.

En 1977, 4 fermes ont produit au total 35 tonnes de truites en eau de mer. Il s'agit essentiellement des animaux de 200-250 g et 800-900 g, commercialisés d'avril à juin. Le passage en eau de mer reste mal maîtrisé à grande échelle au-dessous de 150 g.

Les quantités de poissons transférés en mer à l'automne devraient garantir un doublement de la production en 1978.

### Saumon (Coho).

La commercialisation est actuellement concentrée sur le poisson de 350-400 g, entre novembre et mars. Elle devrait totaliser 90 à 100 tonnes pour l'hiver 77/78, provenant pour l'essentiel de la SODAB (Tréguier).

Les principaux facteurs limitant de l'élevage restent le passage de l'été ("summer disease") et l'approvisionnement en oeufs. Les pontes obtenues sont encore limitées et de mauvaise qualité, ce qui impose des importations d'oeufs des U.S.A. et du Canada. Le problème fera l'objet d'un programme expérimental prioritaire en 1978 (CNRZ, Jouy-en-Josas ; Centre Océanologique de Bretagne, Brest).

#### Saumon (Salar).

Un stock de reproducteurs captifs a été constitué, une première série de pontes a été obtenue, mais l'incubation n'a pas fourni de bons résultats. Les programmes de repeuplement restent limités à une petite échelle, à partir d'oeufs importés (Norvège, Ecosse, Irlande).

#### Bar.

Les essais de grossissement menés sur les côtes méditerranéennes ont permis d'obtenir 3 t de poissons commercialisables (250 g) en 20 à 24 mois depuis l'éclosion. Ils ont été réalisés surtout en eau de source chaude (18° C en hiver) à faible salinité (Méditerranée Pisciculture, Salses), mais aussi en eau de mer avec le cycle thermique naturel (DEVA/Sud, Maguelone ; Station de Biologie Marine, Sète).

La ponte en captivité a pu être avancée expérimentalement de 6 mois (Centre Océanologique de Bretagne, Brest). La production de juvéniles pour 1977 peut être estimée à 400 000 individus (principalement DEVA/Sud, Maguelone ; Poissons du Soleil, Balaruc-les-Bains).

#### Sole.

Des essais de grossissement menés dans un étang à marées breton ont donné un poids moyen de 200 g 18 mois après l'éclosion (fourchette de températures : 5-25° C), alors que l'élevage en bassins avec apport de nourriture inerte, dans les mêmes conditions, n'a pas permis de dépasser 100 g au même âge.

240 000 juvéniles ont été produits en 1977, la moitié pour élevage extensif en lagunes saumâtres. Le sevrage pour élevage intensif avec apport de nourriture a été amélioré (jusqu'à 90 % de survie), mais les résultats moyens restent bas (10 % de survie).

#### Turbot.

Des essais de grossissement en bassin, à 18° C pendant la première année, puis en conditions thermiques naturelles (5 à 25° C), ont permis d'obtenir un poids moyen de 400 g 20 mois après l'éclosion, avec une alimentation inerte humide.

La ponte en captivité a pu être avancée de 5 mois. L'élevage larvaire, qui reste le facteur limitant essentiel de l'élevage a été amélioré par une augmentation de la turbulence de l'eau pendant les premières semaines, et l'emploi d'aliments inertes secs pour le sevrage. Ces modifications ont permis d'obtenir 2 000 poissons métamorphosés et sevrés (Centre Océanologique de Bretagne, Brest).

Dorade.

La progression sur cette espèce reste limitée par les mauvais résultats de l'élevage larvaire.

German Democratic Republic

No report received.

Federal Republic of Germany

(K. Tiews)

Mytilus edulis:

Raft culture experiments in power plant effluents in the Kiel bight were continued as well as the use of Mytilus as fish feed in rainbow trout fattening experiments at the same installation (Institut für Meereskunde, Kiel).

Crassostrea gigas:

Indoor experiments on the reproduction and rearing of spat were continued as well as <sup>out-door experiments</sup> on the fattening of spat to marketable sizes. The growth of oysters in power plant effluents was studied at Wilhelmshaven.

Container culture experiments on various places along the German North Sea and Baltic coasts were also continued to be carried out (Institut für Küsten- und Binnenfischerei, Hamburg).

Fish nutrition:

Work focussed on the development of fish feeds for rainbow trouts in which fishmeal as protein source was substituted by other conventional and unconventional protein sources (Institut für Küsten- und Binnenfischerei, Hamburg; Institut für Meereskunde, Kiel). Development of eel feeds was continued (Institut für Küsten- und Binnenfischerei, Hamburg).

Utilisation of warm water effluents of power stations for Mariculture:

Apart from the work described under *Mytilus* and *Crassostrea*, growth and rearing experiments of *Anguilla anguilla*, *Siganides*, *Dicentrarchus labrax*, *Tilapia zilli* and *Tilapia mosambica* was continued at the experimental station Emden of the Institut für Küsten- und Binnenfischerei, as well as cage farming experiments of salmonid fish in the western Baltic by the Institut für Meereskunde, Kiel, and the Institut für Küsten- und Binnenfischerei, Hamburg.

Recirculating seawater systems:

Work on the development of recirculating seawater systems was continued at the Institut für Küsten- und Binnenfischerei and the Biologische Anstalt Helgoland, Hamburg.

Marine bio-production:

Work on the development of techniques for the mariculture of marine invertebrates was continued at the Kile-Bülck station of the Institut für Meereskunde, Kiel.

Iceland

Fisheries Association of Iceland (I. Jóhannesson)

During the year 1977 research work took place in several localities on the south-west and north coasts of Iceland in regard to fish farming. Mainly this research was carried out at Lake Lón in the district Kelduhverfi on the north coast. Lake Lón is a 2 km<sup>2</sup> estuary. There are hot springs at the bottom of the lake, which results in the water temperature being from 10°C - 15°C all the year round. Estimated quantity of warm spring water flowing into the lake is approximately 7 m<sup>3</sup>/sec. This site seems to be ideal for fish farming experiments and research will be continued there.

Feeding experiments with salmon in floating pens were in abeyance in 1977. However, it is planned to resume those experiments again during this year, adding also other species of salmoids.

In the years 1976-77 experiments with farming of salmon in float cages were carried out in Fáskrúðsfjörður (a fjord on the east coast) by a private enterprise. Those experiments have turned out fairly well in spite of rather difficult conditions, amongst others because of low water temperature in the wintertime.

Marine Research Institute (S. Einarsson)

Experiments with Mytilus edulis rope culture finished in 1977. It seems that Mytilus edulis grows very slowly in Icelandic waters or about one centimeter (cm) per year. The south coast of the country appear to be the only possible place for rope culture, because of the high sea temperature. The problem is that the Icelandic south coast is very open, with only a few fjords or lagoons. This with bad weather conditions during the winter, makes such rope culture very difficult and economically almost impossible. Further rope culture experiments with Mytilus edulis are planned in geothermal areas.

Ireland

No report received.

Netherlands

(Th.J. Tienstra)

From 1 February 1978 we contracted a biologist for one year who will trace from literature and with the help of interviews with experts and observations whether commercial fishing hatchery in seawater in the Netherlands will be possible, or trace which explorations would be necessary to answer this question in a positive or negative way.

Norway

No report received.

Poland

(J. Wiktor)

Investigations on mariculture conducted in 1977 concerned the following problems:

1. The incubating of eggs and rearing of fry of the salmonides /rainbow trout and sea trout/ in sea water with a salinity of 7 do 10 ‰.

2. Rearing of rainbow and sea trout in floating cages in the Baltic and in river estuaries.

As regards incubating of eggs and rearing of fry in the Baltic water, the research conducted in 1977 confirmed the results of previous investigations and suggests that this method might be applied on a wider scale in respect of both rainbow and sea trout.

As regards rearing in floating cages, investigations carried out in 1977 indicate the possibility of commercial breeding of large two-year-old and older trout including spawners, in a multi-season process.

The rearing of one-year-old trout still comes up against certain technical difficulties, as well as those resulting from susceptibility to disease.

No positive results have as yet been obtained in the rearing of sea trout from the smolt stage in floating cages.

Investigations as discussed above will be continued in 1978.

Portugal

(Maria José de Figueiredo and Maria Elisa R.C. de Vasconcelos)

"Instituto Nacional de Investigação das Pescas"

A 4,6 ha tidal pilot-station for fish-farming experiments was started to be built in August 1977, including a reservoir of 2,5 ha and a system of 20 independent ponds of 200, 600 and 2.400 m<sup>2</sup>. The species to be cultivated are the local finfish species such as Mugil cephalus, Mugil auratus, Dicentrarchus labrax and Solea solea, and the prawn Palaemon serratus.

A pilot-experiment was started in March 1977 on the cultivation of the marine red-worm Marphysia sanguinea (Montagu) by developing an artificial substratum near the oyster and clam beds in the estuary of River Sado. This experiment was meant to take advantage of the large areas of the estuary no longer populated by those bivalves and also to increase the production of the red-worm in order to be exported as a bait for sport-fisheries.

Aquarium "Vasco da Gama"

The activities of the Aquarium related with mariculture are the growth and behaviour of some local species, in small aquaria, such as the eel (Anguilla anguilla) and the sole (Solea solea) and the collecting and preparation of living food for these species, as Artemia salina (freezing of the adults and processing of the cysts) and Anguillula silusiae

Spain

No report received.

Sweden

(B. Holmberg)

Farming of fish for direct consumption is not very common in Sweden. Most farmed fish will be used for stocking purposes.

According to the Water Law about 2 millions of salmon smolts are stocked every year in the Baltic. Sea-trout have been stocked in coastal areas with good results for the local commercial and sport fisheries. Short migrating strains of sea trout have been tested in certain areas. The most important task is to increase the survival of the smolts to increase the yield. The effects of smoltsize, time of releasing, adaptation to seawater and natural food are investigated.

Farming of rainbow trout for consumption have been tested in floating net cages in lakes and some coastal areas. It is not possible to culture fish in net cages during the winter because of the low water temperatures. To eliminate this problem fish farming in recirculated systems have been analysed, specially by private companies.

The possibility of using cooling water from nuclear power plants for fish farming are under investigation. A pilot fishfarm have been constructed in connection with a power plant and brackish water (7 ‰) is used. Research programme: rearing technique for salmon, sea trout, rainbow trout and eel, growth and nutrition, diseases, testing the suitability of produced fish for stocking purposes or consumption.

A few pilot mussel farms are operating on the west coast. The production costs are still too high for the canning industry so most of the mussels are sold on the fresh market. New products of mussels will be investigated. Farming of oysters (Crassostrea gigas) are under testing.

United Kingdom

England

(C.E. Purdom)

1. Fish Cultivation - Fisheries Laboratory, Lowestoft.

Relocation of the Port Erin research team at Lowestoft is almost complete and the consequential reduction in duplicated effort on marine flatfish permits an expansion of the salmonid research programme towards parity with the flatfish programme.

Turbot

Larval rearing to metamorphosis remains the priority subject for research. Problems highlighted in the past year include the need to pay attention to the quality of eggs and the efficiency of incubation systems, the phasing of different parts of the life-food schedule and the maintenance of larvae immediately after weaning.

Biochemical studies of live food requirements continued. Long chain fatty acids may be a critical factor in some diets.

Photoperiod manipulation of spawning time continued to be successful in the production of eggs earlier than normal. Attempts to delay spawning until autumn were unsuccessful but there are indications that resorption of eggs was not complete and that the fish may spawn in early spring one season late.

Sole

Weaning of newly metamorphosed remains the most important project.

Cod

1-group fish of about 100 grams weight collected in February 1977 matured in January 1978 at a weight of about 1300 grams. Larval rearing trials are in progress.

Salmonids

Collection and characterisation of domesticated strains of rainbow trout continues. Studies are directed primarily at assessments of growth rate, adaptability to salt water, spawning time and egg size. The genetic control of sexuality in rainbow trout is also being studied by sex reversal and chromosome manipulation techniques.

2. Shellfish Cultivation - Fisheries Experiment Station, Conwy.

Bivalves

The efficiency of production of *C. gigas* and *O. edulis* spat in large-scale larval rearing was similar to 1976. Efficiency values in terms of spat obtained per litre of sea water medium used throughout larval rearing were 83.4 and 115.6 respectively compared with 77.6 and 119.9 in 1976.

Offspring of a hybrid line of *C. gigas*; *C. angulaga* made in 1975 were shown to be fertile and a second generation is being reared. These grew more

rapidly and survived better in the hatchery than progeny of comparative within species crosses.

The bioassay technique developed in 1976 for detecting variations in sea water quality with developing embryos of *C. gigas* has been improved. Greater standardization of the control synthetic medium was achieved and eggs were routinely analysed for lipid content. The proportion of embryos showing normal development in the synthetic medium was significantly related with their lipid content. A variety of chemical and physico-chemical pre-treatments of sea water were successful either consistently or occasionally in improving water quality. Sea water was routinely analysed for salinity, pH, chlorophyll, inorganic and organic particulate content and dissolved organic carbon as an aid to the interpretation of bioassay data.

A study began into methods for the preparation of various types of micro-capsules containing nutrients as artificial diets for oyster larvae and small spat. Axenic culture techniques are being developed for controlled testing of the encapsulated diets. Preliminary trials have shown that the animals are able to ingest the capsules but, as yet, significant growth has not been observed.

Experiments on methods of handling hatchery reared spat until they are large enough to lay on the ground continued. An exercise with about 0.5 million *Crassostrea gigas* showed that costs of spat:materials:labour were in the ratio 72:21:7. For commercial profitability an on-growing scheme would require 40% survival to 1 g mean weight.

*Crassostrea gigas* of 1 g mean weight were laid at densities of 150-2,000/m<sup>2</sup>; growth was reduced at over 600/m<sup>2</sup>. Growth of oysters of 10 g mean initial weight laid in April was not affected by density at up to 200/m<sup>2</sup>; by December their mean weight was 61 g, with 72% survival.

0.95 t of *Mytilus edulis*, mean length 20 mm, relaid from Morecambe Bay inside a crab-proof fence on the Menai Straits in July 1976 yielded 4.6 t of mussels of mean length 38 mm in June 1977.

A further 3.4 t of mussels, mean length 22 mm, were relaid inside a crab-proof fence in August 1977; by December 1977 their mean length was 26 mm and the crop weight had doubled.

Rope spat collectors set out in Morecambe Bay in the spring of 1977 and later moved to the Menai Straits yielded 2-3 kg/m of mussel spat of 18 mm mean length when stripped in August.

#### Crustacea

The migration of naturally maturing prawns (*Penaeus monodon*) was simulated after 28 weeks growth at 20 and 30‰ by an increase of salinity of 5‰. The effect was tested on intact and single eyestalk ablated females but, with one exception, only ablated animals spawned. Infertile eggs were spawned 27 times in nine weeks among 24 one-eyed females. Isolated females spawned four to seven times on one intermolt period and produced 9,000 to 240,000 eggs per spawning. Under natural lighting conditions evidence of copulation was found on four occasions but no spawning occurred.

Heavily loaded rearing systems (1,000 l capacity) in which 2.3 kg of 25 g *Penaeus monodon* were produced in 28 weeks contained large numbers of bacteria

(1.2 to 4.6 x 10<sup>6</sup>/ml) although ammonia and nitrite were held within acceptable limits (0.1-0.3 and 0.3-0.7 mg N/l respectively) by biological filtration. Continuous foam treatment was effective in controlling bacteria in 150 l capacity systems where the water was not changed for seven weeks.

Weekly counts averaged 61 and 390 x 10<sup>3</sup> bacteria/ml in foamed and unfoamed systems respectively. Used together with moderate mechanical filtration, foaming further reduced bacteria, suspended matter and improved water clarity.

Batches of 50 lobsters are being reared every three months for culture to market size (80 mm carapace length) to study problems of regular production and identify major cost areas. Hatching of larvae from wild caught females is regulated routinely by temperature control, although there are some problems in producing healthy broods between November and February. The first three batches are surviving well (80-98%) on a fresh food diet of mussel and shrimp but growth in the first two batches is slightly less than that required to obtain market size in 2½ years. Two diets were compared with a fresh mussel and shrimp control: an alginate bound mussel-shrimp brawn prepared every three days, and a formulation (WFA 6) containing white fish meal bound as an agar jelly. The poorest growth was found with WFA 6 although a high survival indicated the absence of any major deficiency. Growth was best with brawn and may have reflected the increased amount of crustacean material in the diet compared with the other two diets.

The effect of bilateral eyestalk ablation during a 4½ month trial with lobster demonstrated that growth was enhanced by a shortening of the intermoult period and greater growth increments at moulting. Survival, however, was 19% compared with 81% among the controls.

#### Scotland

(A.L.S. Munro)

The report comprises some of the work at six research institutes in Scotland.

#### Salmon and Trout

Control of early maturation of salmon and rainbow trout was a subject of study by several groups. Feminisation in both species by adding oestradiol to the diet of first feeding fry is successful in preventing male precocity. When salmon and trout are large enough surgical castration has been shown to be successful, to give excellent survival and be an economic proposition. Castration of salmon parr has also been achieved by using a vaccine containing gonad antigens.

The 1977 year has been marked by the occurrence of several either new diseases of farmed fish or diseases which have not been recorded before in Scotland. A serious pancreas disease of farmed first sea year salmon, confined to one sea pen site but occurring in two successive year classes, caused losses

in excess of 40%. The only pathological changes observed are confined to the acinar cells of the pancreas and the epithelium of the intestine but no infectious aetiology has yet been demonstrated. A significant outbreak of a disease caused by the fungus Dermocystidium has been found in one farm in salmon parr. No previous report of Dermocystidium infection has been recorded in this species. A serious outbreak of furunculosis occurred in 1st and 2nd sea year salmon in net pens, the first such recorded outbreak in sea water in Scotland.

A disease of unknown aetiology, which causes progressive thickening of the swim-bladder of young rainbow trout and eventually results in the death of many fish, has occurred in at least two farms. It has been experimentally demonstrated that a condition resembling renal calcinosis can be reproduced by an imbalance in dietary calcium, magnesium ratios as well as by elevated levels of carbon dioxide in the water.

#### Sole

In large scale rearing survival from the fertilised egg through to Artemia feeding was good. However, in the later stages of Lumbriculus feeding and during weaning and post weaning, survival was poor due to a disease condition causing a black ulceration on the skin.

Continuing progress has been achieved in the use of diets incorporating taste attractants, based on pure biochemicals, for O-group and larger fish.

#### Turbot

In large scale rearing egg viability was a continuing problem. Survival to weaning was variable with good survival in several groups. Survival to fully weaned fish was modest in comparison to previous years.

Inosine at low concentrations would appear to be the feeding stimulant controlling food intake in the turbot. Inosine is derived from breakdown of nucleotides in tissues and is present in variable amounts in fish meal, but is usually absent from many other protein preparations.

Eels

Commercial research has resulted in the setting up in 1977-8 of two pilot sized eel culture units both using heated industrial waste water. These are the first eel culture units in Scotland.

Shellfish

Experiments were continued in Loch Ardvar to compare the growth and fattening of Pacific oysters (Crassostrea gigas) on the shore and in cages suspended from a raft. Seasonal changes in the gonad and their effect on quality were studied, and organoleptic tests were carried out. The survival of seed of various sizes was studied.

Samples of molluscs and their seed for export and import were checked for freedom from pests and diseases.

The above projects will continue in 1978 and studies will be made of the settlement of commercially important bivalves and their competitors.

USA

(Arlene Longwell)

Reports on Aquaculture Potential in the United States

The National Academy of the U.S. has recently completed two studies, one directly on aquaculture, the other indirectly bearing on it in the context of the total world nutrition problem.

The 1977 Academy (Commission on International Relations) report, "World Food and Nutrition Study" included an aquaculture group as one of its fourteen study teams. Aquaculture was identified as one of twenty-two priority research areas. Nutrition, genetics and environmental stresses were identified in that order as highest priority approaches by discipline. It was concluded that aquaculture research in breeding, mass seed production and polyculture could raise potential aquaculture yields fivefold and double fish protein consumption by humans without increasing world catch. Particular note was made of the wide

range of ecologies within the borders of the U.S., including tropical and semi-tropical areas. Also generally noted was U.S. expertise in genetic manipulation. It was specifically recommended that there be a long-term research effort to improve the breed and seed stock of aquatic animals concentrating on tropical and semi-tropical localities with basic science support supplied elsewhere. Some of the U.S. experience in animal genetics and breeding could be applied to research on fish according to this report, which remarked that "the world has not begun to realize the potential inherent in the genetic manipulation of aquatic animals". In view of questions raised as to the direction U.S. aquaculture research ought to take, it is interesting to note that this study directed at U.S. food production in general recommended that more emphasis (in agriculture, presumably including aquaculture) be placed on fundamental research employing methods and approaches currently not employed in research on food production. This should be done without concomitantly reducing concern for applied research.

The 1978 study, "Aquaculture in the United States, Constraints and Opportunities", a report of the Committee on Aquaculture, Board on Agriculture and Renewable Resources", was undertaken at the request of the National Oceanic and Atmospheric Administration. To study aquaculture an interdisciplinary approach was used that included relevant aspects of the natural sciences, technology and the social sciences. The report concluded that aquaculture will have only a minor impact on food culture in the U.S. in the near term compared with other food production systems, but that aquaculture has the potential to contribute to increasing food production. It was further concluded that constraints on the orderly development of U.S. aquaculture appear to be political and administrative, rather than scientific. Sometimes dealing with a specific culture group, other times dealing with aquaculture generally, the status and aquaculture requirements were discussed separately for production systems, science and technology, economics and business, public law and administration. Noting that scientific knowledge has already made possible successful production systems for a few species, it was recommended that basic research be conducted naming in order, aquatic nutrient requirements, genetics, breeding for reproduction in mass culture, health maintenance, water quality

and behavior. The need was scored both for transfer of exotic species and for establishing appropriate proceedings for registering all exotic transfers and for effective quarantine.

The National Oceanic and Atmospheric Administration of the U.S. Department of Commerce has prepared an Aquaculture Plan (1977) stating what is believed to be realistically achievable with marine and estuarine species. This, too, describes the status of U.S. aquaculture and its potential. This plan calls for a national policy recognizing that aquaculture is of national interest, and for coordination of the activities of the various private and government groups currently involved in aquaculture, for example, the U.S. Departments of Commerce, Interior, and Agriculture, and numerous universities under the federal Sea Grant program administered by the National Oceanic and Atmospheric Administration, as well as by private laboratories and industry. Roles of the federal and state governments, universities and private sectors are discussed. In terms of national interests, this study identifies various aquaculture groups as high, medium and low priority or as being suitable for multi-species culture. Noteworthy was the earmarking of certain research disciplines regarded as cutting across culture groups and regarded of prime importance generally - intensive culture systems, polyculture, genetic improvement, disease constraints, nutrition and feeding.

The perspective and emphasis (also purpose) of all three of these studies, with input by individuals with different perspectives, are different, but the essence of any one report can be perceived as supporting the other two.

Aquaculture Subcommittee of the Federal Government Interagency Committee on Marine Sciences and Engineering

This group provides a medium for information exchange, encouragement of joint programs between government agencies, coordination of efforts and a review of national requirements and objectives. Through the cooperative effort of twenty federal agencies involved overall, the aquaculture group, among other problems, has been addressing itself to deficiencies of aquaculture statistics, utilization of waste effluent, and the impact of federal and state regulations affecting aquaculture development. The group is currently outlining a national aquaculture plan. Member agencies have pledged funds for a translation service for foreign aquaculture publications.

Cooperative NOAA/CNEXO Research

Scientists from the National Oceanic and Atmospheric Administration (of the U.S. Department of Commerce) and the Centre National pour l'Exploitation des Océans will participate in mutual shrimp research programs. Initial work will involve the National Marine Fisheries Service Galveston (Texas) Laboratory and Madame Laubier of CNEXO, Brest, France, in a study of shrimp maturation.

Aquaculture Panel of the U.S./Japan Cooperative Program in Natural Resources (U.S. State Department)

The Aquaculture Panel, one of the newest of several panels, serves as a medium for exchange of ideas between U.S. and Japanese aquaculture researchers. One of its initial purposes was to promote temporary exchange of scientists and literature between the two countries. In 1977 a geneticist from the National Pearl Research Institute spent a year in the genetics program at the Milford Laboratory of the National Marine Fisheries Service on a Japanese government fellowship. Initially organized about disciplines, the panel is now organized about culture types, one selection of which is the subject for study and meetings each year. In 1977 seaweed was the topic. This year finfish culture has been chosen as the focal point of a joint symposium to be held in Japan in October.

Shrimp, Finfish and Turtle Culture - National Marine Fisheries Service, Galveston (Texas) Laboratory

Systems for the intensive culture of shrimp and finfish are being designed and improved and culture procedures refined. Problems relating to maturation of penaeid shrimp are researched from the standpoint of nutrition and environmental manipulation. The molt cycle of shrimp is being studied biochemically, and fertilization is being studied in vitro. The major thrust of this program has been to rear shrimp for bait. In the future, now successful rearing of finfish in closed systems will be concentrated on the rearing of striped bass, redfish and snapper for release in the marine environment as juveniles in efforts at enhancing wild populations. Other studies are directed at the culture of marine red turtles, specifically loggerhead, for release to the wild of juveniles of this endangered species.

Nutritional Requirements of the Fresh-water Prawn Macrobrachium - National Marine Fisheries Service, College Park (Maryland) Laboratory

The nutritional requirements of the fresh-water prawn Macrobrachium are being determined in cooperation with the South Carolina Marine Resources Research Institute.

Salmon Culture and Technology - National Marine Fisheries Service, Seattle (Washington) Laboratory, Manchester Field Station

The major thrust of ongoing research has been oriented toward developing saltwater net-pens systems for the culture of Pacific salmon. This modest effort has resulted in a rapid increase in saltwater feed-lot farming with an annual commercial production in Puget Sound of 1,000,000 pounds of pan-size salmon. Research into development of marine culture systems for salmon in the northwest U.S. includes nutrition, physiology, disease and genetic studies. Diets containing alternate protein sources and color-producing additives are being evaluated. Also being evaluated are the effects of feeds on fertility and fecundity. The nutritional characteristics of potential feed components are characterized, and fundamental feeding studies conducted. Nutritional diseases are being researched. Immune mechanisms are under study, and prophylactic techniques and vaccine delivery are being developed. Various genetic stocks are presently being delineated for better management of mixed-stock fisheries. Growth and smoltification are being studied physiologically. The National Marine Fisheries Service presently funds the operation of twenty-one hatcheries on the Columbia River. The success of the massive release of juvenile salmon and steelhead depends on the status of smoltification of released juveniles and their ability to pass rapidly downstream into the sea. It appears that measurement of changes in gill-ATPase activity in hatchery stock may be a useful biochemical indicator of the parr-smolt transformation and optimum time for release. A three-year program is under way to assess fitness of artificially propagated salmon for the ocean environment using ATPase activity among other measures. Other short-term techniques for determining adaptability to sea water will be developed on select Columbia River stocks.

Ocean Ranching of Salmon - National Marine Fisheries Service, Auke Bay (Alaska) Laboratory

Ocean ranching of salmon in Alaska is being researched from several aspects. These include biological and management factors affecting marine survival, ocean migration patterns, and distribution of the juveniles. Brood stock development using endemic and transplant stock is under way. The interrelationships and interaction of wild and hatchery stock are being examined. Low-cost gravel and artificial-turf incubators are being developed and evaluated. The carrying capacity of streams, lakes and estuaries for carrying hatchery stock is under study.

Culture of Bay Scallops and Surf Clams - National Marine Fisheries Service, Milford (Connecticut) Laboratory

Most of the recent research effort with the bay scallop, Argopecten irradians, and the surf clam, Spisula solidissima, is centered on experiments with the growth of juveniles in the hatchery and in the tank farm. The spatial and nutritional requirements of young bay scallops in the hatchery were examined in tests in which the stocking densities and water flow rates were varied. The survival and growth of very small bay scallops and surf clams in an outdoor pumped raceway system were investigated in a series of experiments designed to determine the minimum-sized animal for successful transplantation to that system. A recent observational dive showed that a substantial number of hatchery-reared scallops planted last fall remain alive and growing at a rate comparable to that of nearby natural populations. Success in rearing bay scallops makes possible a give-away program that will allow other research groups to try this animal under various grow-out conditions. Surf clams spawned in November of 1976 have been reared to their projected market size of 50 mm (2 inches) in eight months. The effort represents the shortest period to date for raising clams from egg to marketable product.

Diseases of Mollusks - National Marine Fisheries Service, Milford (Connecticut) and Oxford (Maryland) Laboratories

Research is directed at larval shellfish disease as it occurs in the hatchery. Suspect bacterial pathogens are being monitored, isolated and identified and their pathology for the shellfish larvae characterized. Pathogen transmission, penetration and host specificity are all being examined. Bacterial metabolites toxic to oyster larvae have been identified. Ozone gas and ultraviolet light are explored as controls for pathogens and for inactivation of biotoxins. Immunological studies are following the development of a cell first appearing a few days after fertilization which, presumably, ends as a mature granular hemocyte capable of engulfing and digesting microorganisms.

As a service function, the Oxford (Maryland) Laboratory checks imported shellfish for diseases on request. Oxford personnel have recently developed a National Registry of Marine Pathology for cultured, as well as wild species.

Molluscan Genetics - National Marine Fisheries Service, Milford (Connecticut) Laboratory

For the purpose of providing information commercial and other hatcheries need to conduct breeding programs of their own, quantitative genetic studies are being conducted on the commercial American oyster, Crassostrea virginica. These include a fairly large-scale, three-way selection experiment (high, low, and control lines), also intended to serve as a breeding demonstration. This continuous experiment, expected to span many oyster generations, provides information on realized selection gains which are compared to the theoretical estimates of selection response simultaneously being made for growth (shell and meat) and other commercial characters. Eventually, the breeding studies will be expanded to include other shellfish. All results to date on the oyster indicate that a hatchery selection program for faster growth during larval and early juvenile stages would be successful. Inbreeding-outbreeding trials are under way on an experimental basis. Inter- and intra-species hybrids are evaluated as to their usefulness, either directly or in breeding programs aimed at achieving more vigorous hatchery stock. Experimental approaches are emphasized in the inbreeding-hybridization studies as in a current study on induced parthenogenesis. A more classic, quantitative

genetic-breeding approach is emphasized in the heritability estimates and selection experiment. Family selection, as an alternative to mass selection, for practical breeding programs is to be explored, and hybridization expanded to include Crassostrea oysters not previously test-crossed at least in this program. Considerable expertise exists in this program on cytogenetics of mollusks (recently expanded to finfish and to the lobster), which can be useful as a tool in some aspects of aquaculture-breeding research.

Molluscan Nutrition - National Marine Fisheries Service, Milford (Connecticut) Laboratory

Methods for mass culture of algae, developed at Milford Laboratory for the purpose of providing large quantities of food material for molluscan aquaculture, continue to provide a model for commercial aquaculture, as well as for academic researchers interested in algal mass culture for a variety of research studies. Harvests from the mass culture system provide food material on a consistent year-round basis for research conducted in other investigations at Milford Laboratory. A "Workshop on Algal Culture Techniques" was conducted at Milford Laboratory. Twelve invited participants from commercial hatcheries attended the 3-day workshop. A manual, "Laboratory Procedures for Marine Unicellular Algae", was prepared for this purpose.

A collection of axenic cultures of unicellular marine algae of about 100 strains is maintained on three types of growth media, in addition to which some strains are maintained on a paper medium support. Cultures in the collection provide a basis for the experimental and mass culture work. These cultures also provide a source of supply of pure culture strains for commercial aquaculture personnel who often have need for an axenic culture.

Recent studies on oyster larval feeding of algal cells have utilized a new technique for evaluating the response of larvae to algal foods. New information was found that explains some differences between "good" and "bad" algal foods. The autofluorescence of chlorophyll a in algae allows the uptake of food cells by the larvae to be observed microscopically. The lysis and digestion of the algae can also be monitored. Thus, it was observed that the "good" food organism, Monochrysis lutheri, was lysed and digested rapidly, while the "poor" food species, Chlorella, was not lysed or digested. A manuscript is in preparation that describes this work.