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Administrative Report

FISHERIES IMPROVEMENT COMMITTEE

1976

by P. Korringa

Belgium

(P. Hovart)

The studies on the effects of dumping of industrial waste along the Belgian coast on the stocks of fish and shrimp and invertebrates were continued.

The monitoring programme was carried out on two dumping areas for industrial wastes derived from titaniumdioxide processes.

In addition, the monitoring programme was also carried out on a dumping area for an industrial waste containing 1.5% of phenol.

The samples were taken on a two-monthly basis by means of a research vessel.

The two monitoring programmes on heavy metals in fish and shrimps were continued. In addition to this, a preliminary study was undertaken on fifteen species along the Belgian coast (Rhizostoma pulmo, Alloteuthis subulata, Macropipus holsatus, Asterias rubens, Engraulis encrasicholis, Clupea harengus, Trisopterus luscus, Ciliata mustela, Mullus surmuletus, Ammodytes lancea, Ammodytes lanceolatus, Eutrigla gurnardus, Trigla lucerna, Platichthys flesus, Limanda limanda).

Finally, a study was carried out on the evolution of mercury in Solea solea in the North Sea and the Irish Sea.

One toxicity test on an industrial pollutant containing gypsum was carried out in accordance with the Oslo Convention.

Canada

(E.G. Bligh)

Fish Culture

Several experiments conducted to study the nutrient requirements of Atlantic salmon grown in seawater have established minimum protein and dietary mineral requirements for Atlantic salmon in seawater. A study is now under way to characterise the genetic differences in the ascorbic acid requirements of various salmonids (brook trout, rainbow trout, lake trout, Atlantic salmon and Arctic char).

A study of the effects of alkylhydroxamic acids on blood parameters associated with respiration in trout has been completed.

The Fish Health Diagnostic and Control Unit was established in April, 1976 with a mandate to carry out the provisions of the Salmonids Import Regulations until such time as they should be superseded; to implement and operate the Fish Health Protection Regulations which were slated for introduction July 1, 1976; to investigate fish kills in the wild and to provide diagnostic and counselling service to government agencies and private industry.

Preliminary experiments to determine the efficacy of vaccination to control bacterial kidney disease in salmonids demonstrated uniform immunological competence of Atlantic salmon to the causative agent. Several vaccine administration procedures including injection, immersion and oral application are being investigated to assess their logistic feasibility and the conferred protective immunity against furunculosis and bacterial kidney disease. Sufficient results will not be available before next year to judge which method of applying the vaccine is the most effective and practical.

A new cell line has been developed from a marine fish (Cyclopterus lumpus). It was characterised as to chromosomal karyotype and shown to be susceptible to the amphibian virus LT-1 showing typical cytoplasmic inclusions. Thus adding a new cell line to the few marine lines available for diagnostic work.

The tissue culture bioassay system detected $CdCl_2$ at levels as low as 0.5 mg/l The metal at this level caused significant interruptions in normal mitosis.

As part of the continuing research effort to understand the host-pathogen interaction in fish, lipid synthesis in the liver and enzymes in the blood were followed in fish infected with Aeromonas salmonicida and compared with results for normal uninfected fish. The most significant changes in blood enzymes were the highly significant increases in aldolase, creatine phosphokinase and ornithine carbamyl transferase. Lipid synthesis in the livers of infected trout was 2 to 3 times more rapid than in the livers of non-infected control animals.

In an attempt to enhance genetic potential for survival, growth and salinity tolerance in cultured salmonids, all possible crosses were made between Atlantic salmon, rainbouw trout, brook trout, lake trout and Arctic char. Good survival was obtained in four of the hybrids. Growth rates averaged 2.14% net weight per day for all hybrids. Fastest growth (2.74%) was obtained with female brook and male char; slowest growth (1.63%) occurred in lake trout. Salmo species developed greater salinity tolerance at an earlier age than Salvelinus species.

A water reuse system designed and built has been under evaluation since March. At 95% reuse the system has proved capable of supporting fish loads well in excess of original estimated.

Post smolt Atlantic salmon were fed at different rates in salinities ranging from 0 to 30‰ and were found to grow fastest and have highest survival at intermediate salinities (12-13‰).

A study on relationship between ATP-ase and smoltification in Atlantic salmon indicates this enzyme can be used as an indicator of stage of smoltification.

The anabolic steroid 17 α-methyltestosterone was incorporated in the diet of Atlantic salmon to determine effects on somatic and reproductive growth. Salmon fed on 0.2 and 0.5 ppm grew significantly faster than controls, with best growth occurring on the lower dose. Information on gonads and tissue response is still being analysed.

Salmon eggs (60 000) were planted in selected gravel bars in the St Croix River in November 1975. Emergence success was about 5% for eggs planted within 24 hr of fertilisation, but less than 1% for eggs planted 24-48 hr after fertilisation. More eggs (62 000) were planted this fall for similar measurements next spring.

Atlantic salmon eggs and alevins were raised under conditions where the temperature was varied either at fertilisation, at the eyed-egg stage or at hatching. Response surfaces were calculated for time to hatching, and alevin size at hatching. In addition, growth rates and sizes at terminal yolk resorption were determined at various temperatures.

Radioimmunoassay analysis of sex hormones appears to be a feasible method for sexing immature salmonids.

The influence of gravel composition on emergence success of Atlantic salmon alevins is being investigated. Fine sand in greater than 15% total composition (by weight) reduces permeability of the gravel to nil, consequently no emergence occurs. Coarse sand at greater than 30% total composition, while still permeable, yields reduced numbers of emergent fry.

The saltwater salmonid project was continued on a limited basis near Halifax, Nova Scotia. During May and June, Atlantic salmon smolts, speckled trout yearlings, Rainbow trout fingerlings and Speckled trout sea-cross fingerlings were acclimated to sea water. Atlantic salmon smolts were also transferred directly to sea water without acclimation.

On 27 April, the Atlantic salmon one-year smolts averaged 45 g. On 14 November, they averaged 291 g. The rate of feed conversion was 1.8:1. These salmon will be over-wintered; their percentage survival and the overall size attained will be assessed in the spring. Their feed conversion rate was 1.6:1.

On 17 May, the Atlantic salmon two-year smolts averaged 76 g: on 12 November, they averaged 408 g. There was no significant difference in the growth rate of the acclimated two-year smolts that were transferred directly to sea water. Their rate of feed conversions was 1.6:1. These salmon will be overwintered also.

Shellfish Culture

The current investigation into the nutritional requirements of American lobsters (Homarus americanus) focused on on the dietary protein, lipid and essential amino acid needs of the animal. Cod fish protein was shown to be inferior to soybean or casein as a protein source, a marine oil source from cod livers produced superior growth to that obtained with corn oil.

Studdes on gaffkemia, the fatal bacterial infection of lobsters, continued but at a reduced rate. Attempts to develop a practical killed vaccine, for wide-spread use at a nominal cost and avoid the use of anti-biotics combined with liver pathogen, has resulted in partial success. An increased level of resistance was induced and was sufficiently high to warrant further work. The studies on bactericidin showed

that this factor, effective against most organisms except the Aerococcus viridans, is adsorbed by invading bacteria in the inactive form and can be activated on the bacterial surface by agents released from the hemocytes or apparently upon phagocytosis. Limited work was possible with the lobster agglutinin and its involvement in the efficacy of the inducible and non-inducible components bactericidialopsonic-phagocytic lobster defense system.

The organism isolated from diseased oysters in Malpeque Bay, PEI and believed to be the causative agent of Malpeque disease oysters, has been tentatively identified as Labyrinthula spp. It can now be grown in vitro; it exhibits vegetative and cyst-like stages and requires high salt environments for optimum growth. A fluorescent antibody technique for rapid and early detection of the organism in infected oysters was developed and works well.

Preliminary results of a shellfish depuration programme with oyster and soft-shelled clams showed that clams have a higher rate of uptake and release of virus than the oysters.

Lobsters in the normal environment have a seasonal cycle of molting which prevents growth during winter even if water temperature is maintained at 10°C. This phenomenon was considered a threat to lobster culture efforts that depend on continuous year-round growth. It was determined that the winter refractory period is thermally-coupled and is inactivated if the temperature is held at 20°C throughout the winter period.

Increased interest in lobster culture, eyestalk ablation and utilisation of thermal effluents prompted study of the effect of temperature on ablated lobsters. There is a direct relationship between temperature and time to ecdysis: about 65 days are required at 10°C and only about 25 days are required at 20°C. Thus, thermal effluent or solar energy could be utilised to provide substantially greater growth of ablated lobsters, as an increase of only 5°C can result in over 50% reduction in average time to molt.

Reports from the Halifax Laboratory indicated exceptional growth could be obtained in very small lobsters if eyestalks were ablated. This technique was tested on 5th stage lobsters to see if growth could be accelerated from start of settling stage. After four months in communal conditions survival was 0% and 15% for ablated and intact lobsters respectively, and for those held individually survival was 4% and 33% for ablated and intact. The surviving ablated lobsters were significantly larger than their intact counterparts, averaging 95% weight gain per molt as opposed to only 62% for intact lobsters, but their high mortality rate makes the technique economically unsound for this size lobster.

In a lobster culture experiment, the effectiveness of eyestalk ablation as a method for increasing the value of canner-size lobsters caught in the September-October fishery was evaluated. Results suggest this technique has considerable commercial potential. All ablated lobsters molted within four months and only six percent of intact lobsters molted in this same period. Weight gain at molt averaged 75% for ablated lobsters vs 40-50% for normal lobsters under optimum growth conditions. Formal flavor panel evaluation showed no difference in taste or texture between ablated and wild lobsters.

Preliminary work on extra-maternal hatching of lobsters looks promising. The large amount of space tied up in merely holding egg-bearing females represents a major expense for a lobster culture facility, and a technique for maintaining and hatching large numbers of unattached eggs would be extremely valuable. Disease-free maintenance and successful hatching for the final month of development was achieved and it is hoped to push this back to the time the eggs are extruded.

A lobster culture facility with a design capability of 545 kg/year was completed and has a current inventory of 2,400 lobsters. The system will serve as a vehicle for testing and evaluating new culture design concepts and techniques.

Juvenile lobsters reared communally for 2 months in oyster or clam shell habitats have demonstrated wide variation in growth rates between siblings. The largest lobster in a tank will routinely be 3-4 times the size of the smallest. A stocking density of $100/m^2$ at 5th stage will yield $13/m^2$ after two months, with average carapace lengths of 8.5 mm. If sorted by size and again stocked at $20/m^2$, density after two more months will once again be $13/m^2$ with average carapace length of 12.5 mm.

The effect of factors such as turbulence, salinity, etc. on the production to toxins in Gonyaulax excavata was studied. Chemical determination of the toxins was compared with the standard mouse bioassay.

In response to a herring kill in July 1976, the presence of the toxins in the stomachs of the dead fish was confirmed. Studies of the toxicity of these compounds to herring are in progress.

Moulting in lobsters can be induced upon demand by two injections of ecdysterone triacetate without use of oil suspensions. Over 80% of the animals moulted and survived.

Sea scallop spatfall collections were down from last year. Collection material and design is being studied along with larval settlement and survival to optimise collection.

Sea scallop culture is being studied with respect to depth and density in hanging culture. Bottom culture, less expensive than hanging culture is being studied to optimise transplant time and minimise predation.

A report was completed on the 1975 clam (Mya arenaria) depuration trials conducted in the Annapolis Basin of Nova Scotia and an operational protocol which would allow full-scale pilot commercial operation was developed. It is anticipated that operations will commence in the spring of 1977.

An assessment was begun into the potential for introduction of the bay scallop (Aequipecten irradians) into Maritime waters. A report is nearing completion. Should the potential appear high, any introduction implemented would be carried out under strict quarantine and supervision in order to protect existing shellfish resources from the potential introduction of pests or pathogens.

Oyster (Crassostrea virginica) spat collection areas in Cape Breton were managed, through collector quotas and space allocations, to ensure productivity and avoid damage to the resource. Quotas totalling 1 580 000 collectors were allocated.

Approximately 2.5 metric tons of adult oysters were planted as broodstock in the Ellerslie, Prince Edward Island spat collection area in order to maintain its productivity. This area is the most important commercial spat collection in Prince Edward Island.

Pollution

In contrast to the deleterious effects on hatchability, viability, and, induced enzyme levels observed in Pacific herring eggs incubated in 10 ppm Cd, lobster eggs incubated in this medium were unaffected.

As a result of an oil spill in the St John area and alleged mortality of impounded lobsters exposed to the resulting slick, the effect on continuous surface exposure of lobsters to light and heavy slicks of Iranian crude oil was evaluated. Even exposures of ten days to two weeks caused no mortality and only slight flavouring of the meat. Death of lobsters following the Canaport oil spill was probably due to poor holding practice in the commercial fishery rather than to toxicity of oil to which they were exposed.

Work completed on temperature selection of juvenile Atlantic salmon after exposure to various toxic substances indicated in general that substances which raise the preferred temperature are more toxic at low temperatures and vice-versa. Such shifts may be of potential, short-term, survival value to the fish.

The behaviour of herring in the presence of a sulfite pulp mill effluent and humic acid was studied. The fish avoided the effluent in concentrations above 2-3 mg/l (as sodium ligno-sulfonate). Model experiments indicate that the fish avoid lignosulfonates and humic acid rather than some more toxic compounds of the effluent.

The pattern of uptake and excretion of polybrominated biphenyls (PBB's) and isopropylated chlorobiphenyls (Chloroalkylene 12) by juvenile Atlantic salmon was determined (PBB's are used primarily as fire retardants, Chloroalkylene 12 is a potential substitute for PCB's).

Lower brominated biphenyls resemble closely the corresponding chlorobiphenyls, but the higher brominated ones behave differently. Some of them are accumulated from food, but not from water, and a debromination in the fish is a prominent degradation reaction.

The uptake and excretion patterns of isopropylated chlorobiphenyls are qualitatively similar to those of chlorobiphenyls, except that the degree of accumulation is lower and the excretion is faster, probably due to an oxidative degradation of the isopropyl groups.

In the pesticide field, synthetic analogs of pyrethrins are gaining importance and the toxicity of one such compound, permethrin (NRDC 143) to juvenile Atlantic salmon was determined. The lethal threshold of permethrin is in the vicinity of 9 µg/l, the compound is much more persistent than natural pyrethrins, and accumulates moderately in the fish.

In response to an alleged lobster kill by oil, the hepatopancreas of a number of lobsters were analysed for hydrocarbons.

Contamination of lobsters by the spilled oil could not be substantiated. A number of aromatic hydrocarbons was detected both in the sample and in control hepatopancreas. The presence of aromatic hydrocarbons in lobster

hepatopancreas deserves further attention. Some additives to plastics were also detected in laboratory-reared specimens. This brings the attention to another problem, deserving further studies - contaminants introduced by aquaculture techniques. Investigation of the toxicity of heavy metals and pesticides to lobster larvae and adults was continued. In addition, the toxicity of copper to a number of large invertebrates and a fish was studied to provide initial information on the comparative sensitivity of marine species to heavy metals in the water. Lobsters and sea cucumbers with lethal thresholds of 0.04-0.06 mg of copper /l and soft-shelled clams with a lethal threshold of 0.1 mg/l were the most sensitive animals of those tested. Rock crabs and winter flounder have lethal thresholds that are about one order of magnitude higher. Temperature had relatively little effect on the lethal threshold for these species, but at a particular lethal concentration of the toxicant, the resistance times were longer at the lower temperatures. The investigation of the toxicity of pyrethrins to lobsters has been initiated.

The interactions between various organochlorine insecticides and their effects on each other's metabolism by trout has been studied. A detailed study of the steps of p,p'-DDT degradation by trout has been completed. The effects of various organochlorine insecticides on mixed function oxidase activity in trout have been studied.

Studies of the behaviour and effects of stranded Bunker C oil from the 1970 "Arrow" spill in Chedabucto Bay have continued. Most of the oil remaining is associated with sediments in the area, and the effects on various benthic organisms such as Arenicola is being assessed. Laboratory studies have shown that clams (Mya) do not possess a mixed function oxidase enzyme system which can be induced by aromatic hydrocarbons.

Studies of the distribution of heavy metals in the Saguenay estuary and the Gulf of St Lawrence continue. These have allowed construction of a Hg budget for the area. The distribution of metals other than Hg is currently being investigated.

The dynamics of uptake and clearance of p,p'-DDT by copepods (Calanus) has been studied in the laboratory. These experimentally obtained data are being compared with field measurements of p,p'-DDT distribution in Georges Bay zooplankton.

Rapid methodology has been developed for the determination of arsenic and selenium in fisheries products utilising atomic absorption spectroscopy coupled with the graphite furnace. The method is based upon stabilisation of the arsenic or selenium in a simple nitric acid digest with nickel ion. This eliminated the necessity of internal standardisation typical of this type of instrument.

Work continues on identification of arsenic compounds present in West Atlantic Fisheries. Initial studies utilising high-pressure liquid chromatography suggest different forms of organoarsenicals occur in different species. The effects of cooking, mild acid and enzyme treatment upon these compounds are being investigated.

Analytical methodology was developed to selectively determine the tetraal kyl lead content of fisheries products and tissues. Initial studies indicated that from 10-80% of the total lead present was present as the tetraalkyl derivative.

Recently developed methodology for oil spill dispersants in sea water have shown that different dispersants degrade at markedly different rates, the polyethyleneglycol moiety appears environmentally stable.

Aryl hydroxylase, while occurring in several invertebrates is only inducible in fish. The usefulness of the enzyme induction monitor has been demonstrated in field studies.

Denmark

(A. Nielsen & E. Hoffmann)

Pollution

The investigations on the exchange of water and matter through the Danish Straits have been continued. (Agency of Environmental Protection).

The investigations on the content of DDT, dieldrin, lindane and PCB in fish used for human consumption in Denmark have been continued. (National Food Institute).

Aquaculture

Investigations on the feasibility of establishing aquaculture in thermal effluents have been carried out. A pilot experiment will be initiated in 1977. The fish species of interest are rainbow trout, turbot, dover sole and eel. Four commercial fish farms using net cages in sea water were established in 1976 (rainbow trout).

Greenland (P. Johansen)

Research of the impact on the marine environment of oil exploitation, mineral exploration and exploitation at West Greenland continued along the lines as described in the Administrative Report 1975. The results reported there have been confirmed by the studies carried out in 1976.

Finland

(P. Tuunainen & A. Voipio)

Fish Culture

Production of rainbow trout, Salmo gairdneri, in net cages in the SW archipelago of Finland has been carried out on the same level (200 t) as in previous years.

Experiments on rearing Baltic salmon, Salmo salar, smolts in brackish cooling water of an electric power plant for stocking purposes were continued. Comparisons between net cages and plastic basins for culture purposes as well as between brackish and fresh water were made. Oversaturation of dissolved nitrogen in cooling water caused some problems and increased the mortality rate of the fish. To avoid the damage caused by dissolved nitrogen, aeration was started in the autumn of 1976.

Marine Pollution

Pressure towards exploitation of marine sand and gravel resources is increasing and plans were made to increase sand and gravel extraction in the sea areas off Helsinki and Pori. Information on the production is still missing. The most important localities were the sea areas off Helsinki, Loviisa-Kotka and Pori.

During 1976 no high sea data could be collected, due to the reparation of the RV "Aranda". Therefore, the main activities have concerned the elaboration of earlier data in addition to studies carried out on the coast.

The distribution of several substances in the recent sediments (C, N, P, Fe, Mn, Cu, Zn, Pb, Hg, Cd, Cr, Co, Ni, Pu) has been studied together with the data by using $^{210}Po/^{210}Pb$ method.

The content of certain toxins (DDT, PCB, Hg, Cd) was determined in some organisms in connection with the ICES/SCOR and OECD studies.

Studies of nitrogen fixation by blue-green algae have been started.

Marine microbiological studies have been carried out in order to clarify the seasonal changes of different microbiological parameters in a coastal reference area.

The long-term investigation on primary production, chlorophyll a zooplankton and zoobenthos have continued along the earlier lines.

Investigations on the effects of effluents on coastal water have been carried out in the most heavily affected areas. Special attention has been paid to the heat exchange properties around the nuclear power plants off Lovisa (the Gulf of Finland), starting its operation in the beginning of 1977.

Ecophysiological laboraotry studies of the accumulation and excretion of heavy metals in Macoma baltica have been carried out together with some toxicity tests.

In addition to the bilateral cooperation with the USSR and Sweden, the Finnish scientists have actively participated in the scientific technological work carried out in the frame-work of the Helsinki Convention.

France

(Y. Thibaud)

1. Aquaculture

Les recherches entreprises antérieurement sur les mollusques et les crustacés ont été poursuivies.

Mollusques

Les expériences de captage de coquilles St Jacques (P. maximus) ont donné des résultats variables suivant les secteurs : les techniques de captage de Chlamys varia ont été améliorées et en Baie de Quiberon les fixations obtenues ont été importantes (plus de 2000 par collecteur). Pour 1977, le réalevinage des gisements naturels appauvris est envisagé.

Les essais d'élevage en surélévation sur terrain découvrant du Chlam (Mercenaria mercenaria) de la palourde rayée européenne (Ruditapes decussatus) et de la palourde japonaise (Venerupis japonicus) ont été poursuivis avec des résultats variables selon les secteurs.

Crustacés

Homards En 1976, le niveau de la production de post-larves de homards (Homarus gammarus) en vue du repeuplement des zones côtières s'est élevé à 200 000 (écloseries d'Yeu et de Houat).

Le programme 1977 comprend la poursuite des recherches sur la biologie du homard et les techniques de marquage des juvéniles.

Algues Les recherches ont été orientées principalement vers la biologie et la biochimie des algues rouges productrices des carragheenanes.

Les travaux sur Hypnea musciformis et H. spicifera entrepris en 1976 à la station biologique de Roscoff n'ont pas répondu aux espérances : si la croissance de l'espèce a pu être accélérée, les difficultés d'extraction des polysaccharides intéressants restent telles que la rentabilité de la culture est loin d'être assurée.

Des essais pour déterminer la possibilité de cultiver en eau de mer courante enrichie par des phosphates et des nitrates, les espèces Chondrus crispus, Gigartina stellata et Soliera sont en cours. Cette culture est basée sur la propriété de régéneration des frondes de ces espèces.

Les travaux entrepris par l'ISTPM en 1975 et poursuivis en 1976 sur l'acclimatation aux rivages de la Mer Rouge de l'algue indonésienne Euchema spinosum ont été menés a leur terme. Un rapport doit prochainement être publié dans une des revues éditées par cet organisme et une communication sera présentée au 9° symposium international des alques marines qui se tiendra à Santa Barbara à la fin d'août 1977. En résumé, l'acclimatation de l'Euchema spinosum à ce nouveau biotope est parfaite puisque les chercheurs ont noté une croissance 6 fois supérieure à celle du milieu d'origine (Indonésie); la reproduction s'effectue normalement, la qualité du carrangheenane extrait est remarquable. Une étude technique a permis de mettre au point la première unité de culture industrielle.

Les recherches sur les algues brunes ont surtout été effectuées au laboratoire de biologie cellulaire et de botanique de l'université de Caen. Les chercheurs de ce laboratoire s'efforcent de déterminer l'action des spores de laminaries.

l'équipe de l'Institut français du Pétrole qui travaille sur une algue microscopique riche en protéines : Spirulina maxima ont découvert une variété qui s'adapte au milieu marin. Des développements importants sont à attendre de cette découverte.

2. Sables et graviers (effets des extractions)

Les recherches pluri-disciplinaires, entreprises en collaboration avec plusieurs organismes (Centre national pour l'Exploitation des Océans, Commissariat à l'énergie atomique, Bureau des recherches géologiques et minières, Universités) sont de deux types:

- Etudes préalables des projets d'extraction. Environ 40 projets portant chacun sur plusieurs centaines de mètres cubes intéressent de nombreux secteurs du littoral. Ces études visent l'amélioration de nos connaissances des communautés benthiques et de ressources halieutiques, en particulier pour ce qui concerne les frayères et les nurseries.

- Etudes d'impact des extractions en cours. Après avoir observé les conséquences à court terme d'une extraction expérimentale en Baie de Seine, il est prévu d'étudier en détail les modalités d'exploitation et les conséquences sur l'environnement et la pêche des très nombreuses exploitations artisanales qui intéressent les côtes de Bretagne.

  A l'heure actuelle, l'effort principal est porté sur la réalisation des études préalables, conformément aux recommandations du Comité de l'Amélioration des pêches. Le but final recherché est la protection des zones d'intérêt et, notamment, des frayères et des nurseries de la bande littorale.

3. Pollution

Contamination par les micropolluants inorganiques

Les travaux commencés ces dernières années sur les niveaux de contamination en métaux lourds (Hg, Cu, Pb, Zn) ont été poursuivis en 1976.

Les métaux lourds, en particulier le mercure, ont été recherchés principalement sur les espèces situées en fin de chaîne alimentaire, notamment le thon rouge de Méditerranée.

Ils ont été aussi déterminés, comme en 1975, dans les graisses et les viscères de mammifères marins échoués sut les côtes françaises.

Un accent particulier a été mis en 1976 sur les techniques analytiques, notamment la mise au point de méthodes pour le dosage simultané dans les organismes marins de Pb, Cd, Cu et Zn.

Contamination par les polluants organiques

Une étude générale de la contamination des coquillages de l'Atlantique et de la Méditerranée comprenant moules, huîtres, patelles et coquilles St Jacques, pour les composés organochlorés, les hydrocarbures totaux et le mercure a été effectuée au cours de l'année. Les résultats font apparaître une assez bonne corrélation entre les teneurs en hydrocarbures totaux et composés organochlorés.

La surveillance des niveaux de contamination dans la faune côtière a été poursuivie.

Surveillance des zones sensibles

Le Résau National d'Observation s'est poursuivi en 1976 et sera étendu en 1977 au contrôle des teneurs en micropolluants dans les mollusques, crustacés et poissons.

Etudes diverses

Une étude microbiologique et chimique a été engagée pour tenter d'élucider les mécanismes responsables du développement des nécroses chez certains poissons pêchés sur nos côtes de la Mer du Nord.

Germany, Federal Republic of

(V. Dethlefsen)

Pollution.

Monitoring

The monitoring programme which had been started in 1975 was continued in 1976 and it was extended to 35 stations in the German Bight, where seawater samples, sediments and particulate matter were analysed for heavy metals and organohalogen compounds. In the Western Belt Sea, sea water was analysed from 18 stations and sediments were analysed from 28 stations at regular intervals. Also radioactivity of surface waters of the German Bight and the Western Belt Sea was continuously recorded by automatic sampling stations (Deutsches Hydrographisches Institut, Hamburg; Institut für Meereskunde, Kiel; Biologische Anstalt Helgoland, Hamburg; Institut für Meeresforschung, Bremerhaven).

Monitoring of levels of heavy metals and chlorinated hydrocarbons in marine organisms in the German Bight and the Western Belt Sea was extended to studies in estuaries and special attention was paid to the dumping areas for sewage sludge and industrial wastes (Staatliche Veterinäruntersuchungsämter, Cuxhaven und Bremerhaven; Institut für Küsten- und Binnenfischerei, Hamburg; Institut für Meereskunde Kiel, Institut für Meeresforschung, Bremerhaven).

Marine Chemistry

Investigations were carried out on the effects of residues of incineration of organochlorine compounds on sea water and on the development of sampling devices for sea water samples for subsequent analysis for organochlorines; neutron activation analysis was applied for the analysis of hydrocarbons in sea water, the effects of the influx of nutrients in sea water. Investigations were carried out on the formation of acute lack of oxygen in the Western Belt Sea, on the development of methods for analysis of radioisotopes in sea water, on the storage of radioactive wastes in the sea, on remote sensing of pollution by aeroplane in the German Bight and on the transport of particulate matter in the North Sea (Deutsches Hydrographisches Institut, Hamburg).

Investigations on the effects of pollutants on marine organisms

In situ studies

In situ studies were carried out on the effects of sewage dumping and dumping of wates of TiO_2-industry on water quality, structures of benthic communities and fish populations (Institut für Meeresforschung, Bremerhaven; Institut für Küsten- und Binnenfischerei, Hamburg; Deutsches Hydrographisches Institut, Hamburg), on the effects of crude oil on selected organisms in the sandy intertidal area of the mesohaline region of the Elbe estuary, on the effects of thermal pollution on the BOD of rivers and estuaries, on the influence of biocenotic processes on the population dynamics of vegetation ciliates in the mesohaline region of the Elbe estuary and on contamination of sediments and selected benthic organisms by radioactive isotopes (trace experiments) in the mesohaline intertidal zones in the Elbe estuary (Institut für Hydrobiologie und Fischereiwissenschaft, Universität Hamburg).

Laboratory Investigations

Heavy metals

Investigations were carried out on the effects of lead on bacteria in sediment and sea water in long-term constant flow cultures, on

the toxicity and accumulation of lead and cadmium by isolated marine bacteria (Institut für Meeresforschung, Bremerhaven), on the influence on Zn on the growth of marine plankton algae (Scippsiella faeroousae), Prorocentrum micans, Gymnodinium splendens, Schröderella schröderi, Talassiosira robula), on the effects of cadmium on the growth of Laminaria saccharina, in constant flow experiments, synergistic effects of heavy metals on populations of Harpacticides (Tisbe holothuriae), on the effects of cadmium on the ATP-metabolism of Crangon crangon (Biologische Anstalt Helgoland, Hamburg), on the accumulation of cadmium and lead by Crangon crangon in constant flow experiments (Institut für Küsten- und Binnenfischerei), on the effects of heavy metals on the reproduction of benthic polychaetes (Ophriotrocha, Dinophylus) and on sublethal long-term effects of cadmium on young stages of Pleuronectes platessa and Limanda limanda, in constant flow experiments, on the effects of cadmium, lead and mercury on the physiology and different blood parameters of eels (Anguilla anguilla) (Institut für Küsten- und Binnenfischerei, Hamburg).

Chlorinated hydrocarbons

Investigations were conducted on the accumulation and loss of lindane, dichloro- and pentachlorobiphenyl in annelides, pentachlorophenol, hexachlorcyclohexane, heptachlorepoxid, endrin, dieldrin, endosulfan in Mytilus edulis and lindane in Solea solea; on the bacterial degradation of organohalogen compounds and parathion (Institut für Meeresforschung, Bremerhaven), on the uptake and transfer of lindane in laboratory freshwater and marine food chains in constant flow experiments (Institut für Hydrobiologie und Fischereiwissenschaft, Hamburg), on the effects of organochlorine substances on species specific monosaccharides of marine organisms (Institut für Meeresforschung, Bremerhaven).

Fossile hydrocarbons

Effects of ^{14}C-labelled hydrocarbons on early life stages of marine fishes were investigated (Institut für Meereskunde, Kiel).

Other pollutants

The degradation of tensides in marine water and brackish water was investigated (Institut für Küsten- und Binnenfischerei, Hamburg). Studies were carried out on the evaluation of river pollution, on indicator species of mud flat vegetation and plankton on the turnover of the respiration and assimilation of a benthic community of the Elbe estuary (Institut für Hydrobiologie und Fischereiwissenschaft, Universität Hamburg).

Mariculture

Mytilus edulis

Feeding experiments were carried out with Mytilus edulis in raft cultures in power plant effluents in the Kiel Bight (Institut für Meereskunde, Kiel).

Crassostrea gigas

Experiments were conducted on the artificial reproduction of oysters (Crassostrea gigas)with special attention to the production of marine unicellular algae as food for the early life stages of oysters and on the growth of oysters in power plant effluents (Institut für Küsten- und Binnenfischerei, Hamburg).

Salmonids

Feeding experiments with salmonids in net cages at different locations of the German coast, especially in power plant effluents were continued with special attention to the development of food substitutes like krill and alkane yeast.

Other fishes

Growth experiments and experiments on rearing were continued with the species Anguilla anguilla, Siganides, Dicentrarchus labrax, Tilapia zilli, Tilapia mossambica (Institut für Küsten- und Binnenfischerei, Hamburg; Institut für Meereskunde, Kiel).

Recirculating seawater systems

Recirculating seawater systems were investigated with respect to activated sludge and ozonisation for the elimination and degradation of nitrogen by activated sludge (Institut für Küsten- und Binnenfischerei, Hamburg; Biologische Anstalt Helgoland, Hamburg).

Institut für Meereskunde, Kiel

In turnable globe-shaped net cages salomids (S. gairdneri, S. salar) were grown in different stocking densities in the thermal effluents of a power station at Kiel fjord.

In a specially designed experimental aquarium salmonids were raised using natural additives as krill and mussel meat to commercial dry food. A remarkable improvement of health and meat quality could be observed in rainbow trout.

An outdoor experiment has been started to measure the organic load of an intensive marine aquaculture on natural ecosystems in brackish water.

Iceland

(I. Hallgrímsson)

Pollution Studies

In 1976 a cooperative programme on the impact of municipal sewage in the inner part of Faxa Bay was continued and initial results prepared for reports.

Participation in the "IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring" was continued by visual observations of oil slicks and other floating pollutants.

Active participation was taken in the work of the ICES Working Group on Pollution Baseline and Monitoring Studies, e.g., in trace metal intercalibration exercises and the Fish Baseline Survey.

Mariculture

A Mytilus edulis rope culture experiment is in progress and will continue for a further year.

During the last few years experimental pen-rearing of salmon has been carried out in sea water. In 1976 two such experiments were in progress.

Ireland

(F.A. Gibson & M.J. Crowley)

Environment

1. An Aquatic Environment Unit was set up in late 1975 to handle all environmental matters.

2. ICES Pollution Baseline and Monitoring Studies. Fish samples from the ports of landing were analysed for heavy metals (Zn, Cd, Cn, Ph, Hg). The unit took part in the 1976 intercalibration exercise on analysis of heavy metals in sea water.

3. Estuarine studies. Water and sediment samples from several stations in four south coast estuaries were analysed for heavy metal content.

   A preliminary survey of the benthos of the lower reaches of the Suir estuary on the south coast of Ireland was undertaken.

4. Littoral and benthic surveys were carried out in Killala Bay, Co. Mayo, on Ireland's west coast, where a large artificial fibre factory is due to go into operation.

5. A biological and chemical survey of the benthos and sediments at an industrial waste dumping site off the south coast was carried out.

6. Toxicity testing. Acute toxicity tests were carried out on three effluents.

7. Twelve new applications for licences to discharge into estuarine or coastal waters have been examined.

Mariculture

Work on mariculture is presented in the Administrative Reports of the Shellfish and Benthos or Anadromous and Catadromous Fish Committees, as appropriate.

Netherlands

(P. Korringa & J. Duinker)

Work carried out by the Netherlands Institute for Fishery Investigations

Pollution by organohalogen compounds - notably PCB's, dieldrin and DDT-- remained the major environmental problem for the Dutch fisheries. During the year 1976 it became increasingly clear that sooner or later public health authorities will issue restrictive measures against the consumption of certain fishery products from the Southern Bight of the North Sea, like the heavily PCB contaminated cod livers.

PCB studies in 1976 and an evaluation of the 1972-1976 Dutch fishery monitoring programme showed the level of contamination of the Dutch coastal waters by PCB's to be more or less constant at a level around the 20 ppm on a fat weight basis. This level will mean a potential problem for fishery products containing more than 5% fat.

In order to get an insight into the amount of industrial pollution by chlorinated hydrocarbons a further study was made of the HCB contamination of the Western Scheldt esturay. Compared with the corresponding surveys of 1974 and 1975 a significant decrease in HCB level could be recorded. The present HCB levels in the Western Scheldt are about the same as the levels in the southern part of the North Sea.

Although the mercury contamination of the Rhine has been markedly reduced in the period 1972-1976, no indications of a corresponding decrease in the mercury level in fish could be detected in the monitoring programme.

The onset of the year 1976 was extremely dry and hence showed an extremely low fresh water run-off from land. This resulted in a temporary reduction of the eutrophication of the Dutch coastal water. The influence of the drought was also reflected by extremely high salinities (up to 34‰) in the Dutch Wadden Sea (normal values around 28‰).

Work carried out by the Netherlands Institute for Sea Research

Much effort was devoted to organising and realising a sampling cruise in the Wadden Sea area, including the Danish, German and Dutch sections. Trace metals and chlorinated hydrocarbons were sampled in solution and in suspended sediments in the major rivers influencing the Wadden Sea (Varde Å, Eider, Elbe, Weser, Ems and Rhine).

The results on the occurrence of different forms of a number of trace metals dissolved in sea water by the technique of differential pulsed anodic stripping voltametry have been offered for publication.

Within the Working Group on Marine Pollution at the Netherlands Institute for Sea Research, work has been initiated to study the possible sublethal effects of some selected chemical agents (trace metals and chlorinated hydrocarbons).

Norway

(G. Berge)

Pollution

1. Field Programmes

1.1 Investigations on the environmental qualities of selected Norwegian fjords from Oslofjord to Varangerfjord were carried out in November - December. The fjords were selected to represent different types of environmental conditions, fjords with expected industrial loads, domestic loads or "no" expected loads. Measurements were made of salinity, temperature, primary production indices, nutrients and oxygen distribution, turbidity and particulate matter (Institute of Marine Research).

1.2 The inter-institutional study of biological and other aspects of planned nuclear power plants in South Eastern Norway continued. A programme covering baseline studies of fish and shellfish productivity in the Oslofjord and adjacent coastal waters, experimental investigations on thermal effects on biological processes and possible utilisation of heated effluents for fish cultivation was carried

out by the Institute of Marine Research, Biological Station Flødevigen. The programme is planned to cover a 5 year's period ending in 1978. Seven cruises spread over the entire year were completed in 1976. Primary production, phytoplankton, zooplankton, fish larvae and the distribution of fish and shellfish were analysed.

1.3 Heavy metals in fish and shellfish. Stocks of commercial fish are continuously being analysed on mercury, cadmium, zinc, copper and lead at the official Norwegian Quality Control Institute for Canned Fish Products. Involved in this monitoring are also the Vitamin Institute of the Directorate of Fisheries. These results are made available to the Institute of Marine Research, and selected adequate observations are included in the Norwegian contribution to the ICES conjoint monitoring of fish and shellfish in the North Sea.

1.4 Environmental conditions in coastal sea water. This programme continued for the third season. The organic load of the Baltic Current is being investigated from the Øresund, through the Kattegat, Skagerrak and along the western Norwegian coast. Continuous measurements are made on particulate matter, organic components, nutrients and temperature, whereas primary production indices are measured at regular intervals (Institute of Marine Research).

1.5 Massfragmentographic analyses of petroleum hydrocarbons in Norwegian water have been carried out. The search has been concentrated on alkylated aromatic and sulfur-aromatic hydrocarbons. The following projects have been operated : 12 monthly samples from the section between Fedje and Shetland; a thorough investigation of the Fensfjord, a recipient of the waste water from a petroleum refinery; an investigation of the waters around the Ekofisk production platform; eight samples each of the month August and October from the prospected oil fields off northern Norway; a study of the effects of a spill of 2 000 tons of Iranian crude with respect to weathering of the oil and concentration of petroleum hydrocarbons in water and contaminated saithe (Institute of Marine Research).

1.6 Monitoring of shore and shallow water algal flora by aerial photography has been tried in two test areas. Diving and stereo-photography of fixed sites have been applied for monitoring of hard-bottom communities. (Norwegian Institute for Water Research).

1.7 Monitoring of the eutrophic state of the inner Oslofjord has continued (Norwegian Institute for Water Research).

1.8 Investigations on the use of brown seaweeds as indicator organisms for monitoring of heavy metals in the marine environment (Institute of Marine Biochemistry, University of Trondheim).

1.9 Studies of the exchange of heavy metals (Zn, Cu, Cd, Pb and Hg) in Ascophyllum nodosum in fjord waters to evaluate its use as an indicator of heavy metal pollution (Institute of Marine Biochemistry, University of Trondheim).

1.10 Monitoring of fjord waters with respect to heavy metals and hydrocarbons by means of dialysis cultures of phytoplankton (Institute of Marine Biochemistry, University of Trondheim).

1.11 Littoral algae as indicators of pollution (Zoological Dept., the Museum, University of Trondheim).

1.12 Heavy metals in sea water and mussels in polluted areas. Analysis of samples from selected fjords are being made on Fe, Zn, Cu, Cd, Pb and Hg at the University of Oslo, Institute for Marine Biology and Limnology. The programme is also part of the ICES Monitoring Programme for 1976.

1.13 A programme studying the influence of various concentrations of pollutants on the biology of Pleuronectes flesus was initiated in the Oslofjord in 1973. The programme is part of a joint Scandinavian effort aiming at development of an early warning system. The programme continues (University of Oslo, Institute of Marine Biology and Limnology).

1.14 Studies on cadmium uptake and excretion in flounder were initiated in the Oslofjord and compared with laboratory experiments, 1976. (University of Oslo, Institute of Marine Biology and Limnology).

1.15 Examination of the surface layer at 48 stations in the inner Oslofjord and part of the outer Oslofjord. At each station salinity and temperature, nitrate, nitrite, ammonia, silicate, phosphate, total phosphorus, dissolved and particulate trace metals (copper, lead, cadmium, nickel, zinc, iron and manganese) chlorophyll and plankton biomass (cell number and ATP) were measured (University of Oslo).

1.16 In addition to the surface layer, 40 other stations were studied along longitudinal sections and cross sections in the inner Oslofjord. The same parameters as previcusly described were observed. (University of Oslo, Institute of Marine Biology and Limnology).

1.17 In a special survey, studies have been carried out with the object to assess the chemical processes at the water sediment interface such as trace metal gradients and phosphorus loss to the sediments (University of Oslo, Institute of Marine Biology and Limnology).

2. Laboratory assays

2.1 Specific biological programmes related to thermal effects were carried out at the Institute of Marine Research, Biological Station Flødevigen. Mortality, growth, hatching success and temperature preferences were studied on commercially important fish and shellfish species.

2.2 A newly developed equipment for contiunous dosage of dissolved petroleum hydrocarbons was used in studying effects of petroleum on hatching, growth and mortality of fish larvae. Experiments with capelin larvae indicated traceable effects down to 25 ppb of dissolved hydrocarbons. Arrangements for increased engagement in similar studies on other species including other aspects of fish and shellfish behaviour towards petroleum were made at the Institute of Marine Research, Bergen, as well as the Biological Station in Flødevigen.

2.3 A large effort has been put into the refinement of analytical techniques. Weathering studies of oil on water in outdoor tanks. Development of a method of identification of oil spills by mass fragmentography. A study of tainting of saithe and salmon by organoleptic and mass fragmentographic analysis (Institute of Marine Research).

2.4 Utilisation of waste products from the fish industry. A process has been developed for preservation of fish and separation of protein from lipid by centrifugation. The process is now being introduced at an industrial scale in Norway. (University of Tromsø).

2.5 Belly bursting of capelin. One of the problems in using capelin for human consumption is the quick autolysis of the muscle tissue by enzymes which leak out from the digestive tract post mortem. The mechanism of tissue degradation by proteolytic and glycosidolytic enzymes is studied (University of Tromsø).

2.6 Lactic acid bacteria in fish. When saithe is starved, the numbers of lactobacilli in the alimentary tract increases. The biochemical properties of these bacteria are studied, in particular with the aims to find the optimum conditions of using these bacteria to preserve whole and minced fish (University of Tromsø).

2.7 Trimethylamin oxide in marine animals. Trimethylamin oxide (TMAO) is present in all marine animals. In putrefying fish it is reduced by bacteria to trimethylamin (TMA) which has the unpleasant smell of spoiled fish. The mechanism of enzymatic biosynthesis of TMAO in Calanus finmarchicus is studied (University of Tromsø).

3. Studies

3.1 Pollution load of degradable organics, nutrients and other pollutants has been calculated for several fjord recipients. (Norwegian Institute for Water Research).

3.2 A report evaluating environmental stress from different types of thermal power plants are under preparation (Norwegian Institute for Water Research).

3.3 A review of municipal waste water recirculation (cultivation of marine organisms) are under preparation. A report on general principles by monitoring of fjords and coastal areas was submitted to the Ministry of the Environment, and monitoring in selected pilot fjords will be carried out in 1977 (Norwegian Institute for Water Research).

3.4 A review of sources, levels and effects of polycyclic aromatic hydrocarbons in the aquatic environment has been prepared. A similar review on halogenated hydrocarbons are under preparation (Norwegian Institute for Water Research).

Diseases

No outbreaks of vibriosis in the young saithe population have been reported in 1976. Research has continued on the pathogenicity of Vibrio anguillarum strains, on the vaccination of farmed salmonids against vibriosis, on the oral treatment of salmonids against salmon lice (Lepeophtheirus salmonis) with organophosphor compounds, and on tumors in cod (Institute of Marine Research).

Vibriosis in fish. The project has been focused on the microbial ecology of the fish pathogen Vibrio anguillarum; conditions of pathogenicity; role of enzymes in the fish mucus in the defence; copper as an inducer of vibriosis. (University of Tromsø).

Aquaculture

The building of an annex comprising offices and auditorium, laboratories, a large hatchery and water cisterns at the field station "Fisk og Forsøk" in Matre was ended in 1976. The activities at the station were mostly a continuation of the activities from 1975, where the selective breeding programme was the most important.

A new field station at Austevoll close to Bergen has been planned in 1976 and will be built in 1977 and in use in 1978. The scientific work at the station will concentrate on hatching and rearing of marine organisms, studies on metabolism and population-genetics in fish.

1. Experiments with selective breeding of Atlantic salmon, rainbow trout, pink salmon and Arctic char continued at the field station at Matre and at the Svanøy foundation, 200 km north of Bergen. Growth, age at first maturation and early smoltification showed great variations between the groups. No correlation between size and early maturations were found, but fishes maturing a year later, $2\frac{1}{2}$ year totally for rainbow trout and $2\frac{1}{2}$ year in seawater for salmon, were found to be bigger than the unripe ones.

2. Feeding experiments were performed at Matre. Factors influencing feeding of swim-up fry, feeding frequency for rainbow trout in sea water and the effect of dietory carotenoid (astaxanthin) on muscle pigmentation of rainbow trout have been studied.

3. Tagged salmon were released into the Matre river, consisting of 5 000 Atlantic salmon smolts and 10 000 pink salmon, 5-10 cm long. Tagged Atlantic salmon smolts were also released into the river Opo in the inner part of the Hardangerfjord.

4. Growth of Atlantic salmon and rainbow trout has been studied at ten fish farms distributed along the coast from Bergen to Tromsø since 1973. The registered parameters were length, weight, age and size at maturation and the quantity of consumed food. Results showed that growth was best at the southern farms, but the northern farms were also economically profitable.

   In 1976 pink salmon were distributed to three of the ten farms and their development will be followed up to slaughtering (Institute of Marine Research).

5. A survey of localities suitable for aquaculture in West Finnmark started in 1975 and was ended in 1976. Data on water temperature, salinity and currents have been collected on four cruises. Continuous registration of temperature, salinity and currents have been continued in selected places.

   In the regional estimation West-Finnmark was divided into four zones: fjord, transition, coast and northern coast zone. The coast zone was the best for farming of salmonids. Here the physical parameters showed little variation. The fjord zone showed to be the less suitable. Short-time variations of the physical parameters could be great and in winter time some places were too cold for farming of salmonids. (Institute of Marine Research).

6. Respiratory metabolism of salmonids in sea water has been measured at the Institute of Marine Research. This work will in 1978 be continued at the new Station for Mariculture at Austevoll. The

experiments were performed with Atlantic salmon of 30-190 g and rainbow trout of 55-160 g (Institute of Marine Research).

The metabolism increased only to a lesser degree in rainbow trout after feeding and no marked rhythm was observed during day and night.

Growth and food consumption were less in Atlantic salmon compared to rainbow trout, but utilisation of the food was better in Atlantic salmon. The metabolism showed a marked rhythm during day and night with the highest activity during night and the lowest at noon (Institute of Marine Research).

7. The experiment to investigate the smoltification process in Atlantic salmon continued. The importance of day length and feeding time for growth and smoltification were studied. Best growth and most sea water adapted fishes were found within one year from hatching, when the fishes were fed day and night in continuous artificial day-light (Institute of Marine Research).

8. The experiment of feeding Atlantic salmon a diet with supplementary inorganic salts in order to induce salt water tolerance continued. Three different concentrations of salt in food were tested : 1.1%, 8.2% and 12.5%. The feeding period was 3/2-26/3. The results showed highest growth rate with 8.2% and lowest with 1.1% salt in the food. The utilisation of food (kcal/kg growth) was less at 8.2% and here we also found most sea water adapted fishes (Institute of Marine Research).

9. Observation of the behaviour of Atlantic salmon parr in aquaria with different stocking densities was started in 1975 and continued in 1976. The aim of the experiments is to study the relationship between aggressive behaviour, stocking density and growth.

   In densities of 120-878 salmon parr in 200 l aquaria the maximum number of aggressive actions per fish was found at the lowest density. One or several large fishes in each aquarium showed a kind of incomplete territorial defence. The gain in weight in percent of initial weight was greatest in the lowest density. The specific growth rate of large fish was about the same as for small fish (Institute of Marine Research).

10. An experiment to assess the effectiveness of several anti-fouling impregnants for net pens started in 1975 and continued in 1976. Up to now five different paints have been tested and of these were two much more effective than the other three. A new experimental series with five new anti-fouling impregnants was started in 1976 and will be ended in 1977 (Institute of Marine Research).

11. Research on genetic parameters in connection with semi-culture of flatfish (Biological Station, University of Trondheim) was carried out.

Poland

(J. Piechura)

In 1976 experimental farming of rainbow trout was initiated by the Sea Fisheries Institute of Gdynia. Two years old on the average, 170 g rainbow trouts were acclimatised in sea water cages and settled in Puck Bay (Baltic Sea) one mile from the Hel Penninsula. In 5 months they reached 800 g on the average. Cod, herring and sprat were used as food. Four percent losses during 5 months running of the experiment were observed.

Part of the fish is kept under ice. Some of them are ready to spawn and some have spawned in sea water. Experiments on survival of rainbow trout eggs and sperm in sea water were also carried out.

The experiments show good resistance and high survival of trout farmed under sea conditions.

Portugal

(M. J. de Figueiredo)

A survey on artisanal fish-farming and suitable spots for aquaculture enterprises along the Portuguese coast has been started in 1975 and continued during 1976. The southern and central part of the coastline, including estuaries, have already been covered and proved to assemble excellent conditions for the purpose, mainly due to the mild climate, great amount of sunshine, wind intensity and proper water quality. Among the finfish species growing under artisanal fish-farming conditions are the sea bass (Dicentrarchus labrax), the eel (Anguilla anguilla) the grey mullet (Mugil spp.) and the sea bream (Chrysophrys aurata).

In March 1976 a programme on monitoring the water quality, the primary and secondary productivity and the bacterial content of the water was started in an artisanal fish-farm situated in the estuary of the river Sado. Sampling is performed twice a month just before and immediately after the opening of the sluice gates for the entering of the water during the highest tides.

Spain

(A. Alvarez de Meneses)

Investigations by the Instituto Español de Ocenanografía

Laboratory of Baleares

Fish stock assessments by acoustic methods.
Application of production pattern to the main population of the Balearic Islands and other Mediterranean zones.
Study of the biological cycle of the red mullet (Mullus surmuletus) and the hake (Merlucius merluccius) on the Balearic platform.
Study of the biocoenosis of the continental slope north of Ibiza.

Laboratory of La Coruña

Research of cultures in the hatchery for bivalve molluscs.
Rearing the species Ostrea edulis, Venerupis pullastra, V. decussata and Pecten maximus as larvae and as juveniles on the sea bottom or in shallow waters up to commercial size.
Work on the culture of the crustacean Penaeus kerathurus and shrimps has been continued.
Culture of salmon (Oncorrhynchus kisutch) started in freshwater, thereafter they were removed to cages in seawater. Growth was satisfactory and almost no mortality was recorded.
A vigilance and monitoring network for observation on eutrophication, pollution and red tides in mussel culture areas has been set up.

Laboratory of Mar Menor (Murcia)

Research on the culture of the gilthead (Sparus auratus) in Mar Menor (SE Spain) has been continued. Reproduction was successful and at present the giltheads have reached an average size of 30 mm.

Laboratory of Santander

Studies on stock evaluation of shellfish and other molluscs were made in Marnay Park (Santander Bay).
Plans for laboratory cultures of crustaceans and fish are worked out.

Investigations by the Instituto de Investigaciones Pesqueras

Heavy metals

On the Biscay coast periodical determinations of Hg, Cd, Cu and Zn were made in the following species of fish : Trigla lucerna, Mullus surmuletus, Boops boops, Merlucius merluccius, Scylliohrinus canicula, Trachurus trachurus, and Coris julis. Only S. canicula appeared to contain a higher concentration of Hg than normal.

In the Mediterranean, the research proposal of the UNEP and CGPM, determination on Hg weremade in the following species : Fish - Mullus barbatus, M. surmuletus, Scomber scombrus, Sardina pilchardus, Macromesistius poutassou, Merlucius merluccius, Trachurus trachurus, Paracentopristis cabrilla, Conger conger and Boops boops. Mollusca - Octopus vulgaris, Mytilus edulis and Patella patella. Crustacean - Aristeus antennatus.

Biotests with toxic lethal and sublethal concentrations of Hg, Cu and Cd were carried out in some marine organisms. The first ones were made in Penaeus various, larvae of Penaeus kerathurus and young specimens of gilthead (Sparus auratus), the sublethal ones were made in adult gilthead (S. auratus) golden grey mullet (Mugil auratus) and the red bream Beryx didactilus. The accumulation of the heavy metals has been studied in different anatomical parts.

Hydrocarbons

The work on hydrocarbons in many places on the Spanish coast (Cádiz, Guipuzcoa, Castellón de la Plana, Pontevedra, Galician coast, South Atlantic coast) have been completed. The level of pollution appears to be higher in estuaries and similar places than in the open sea. 95% of the analysis gave less than 50 µg/l, whereas greater quantities were found in Pasajes and Cádiz.

Pesticides and organochlorines

Levels of PBB, DDT and derivates have been studied in coastal species in some zone off the Spanish coast. Crustacean : Carnicus mediterraneus. Mollusca : Mytilus edulis, Patella sp, Nucella lapillus. Fish : Mullus barbatus and Sardina pilchardus.

Studies on the interaction between phytoplankton and polychloride aromatic hydrocarbons were initiated. In the nuclear power plant of Vandellós (Tarragona) direction and diffusion of the refrigerator waste water as well as the repercussion of the biocides in the primary productivity have been studied.

Anionic detergents

Analyses of water samples from Cádiz Bay, Huelva coast and of water samples collected on a monthly basis from six stations NE of Bilbao have been made. The values recorded range between 0 and 60 ppb.

Plankton culture

Influence of light intensity on the growth of some phytoplankton species has been studied. When light intensity is 5 400 lux, Tetraselmis suecica, Carteria sp. Skeletonema costatum and Phaeodactylum tricornutum reach the maximum cellular concentration, whereas for Asterionella japonica the best intensity is of 2 000 lux.

The growth of some diatom species has been studied.

Fish culture

Sole (Solea solea)

Induced spawning by hormonal gonadotrope injection, introducing changes in the photoperiod and temperature has been successful. Metamorphosis of the larvae took place between the tenth and eleventh day after fertilisation. In 30 days juveniles of 18.7 mm length were obtained at concentrations of 6 000 to 10 000 specimens/m^2. Survival was 81%.

Gilthead (Sparus auratus)

Studies about behaviour and growth of larvae and juveniles of Sparus auratus were carried out, the first were fed with Artemia salina and meat of lamellibranch molluscs, the second on mussel and crab meat. Repeated spawning has been obtained by hormones PS, MG and GCH injections, increasingly applied in successive days.

Common bass (Morone labrax)

By applying the normal techniques to induce spawning, the females reacted positively. So was the simultaneous emmission of sperm by the males. When the vitellus was re-absorbed, experiences on feeding young larvae on phyto-plankton and Brachionus plicatilis were made. After eleven days, new-born nauplii of Artemia were added to the diet, inproving in this way the survival rate.

Other cultures

Complete culture of Sepia officinalis and Penaeus keraturus have also been made.

Sweden

(A. Sjöqvist)

1. With the assistance of Coast Guard Personnel and vessels, routine hydrographic observations are made along the coast of Sweden in a joint project of the National Environment Protection Board, the Swedish Board of Fisheries and the Swedish Meteorological and Hydrological Institute.

2. Since 1969 chemical and hydrographical observations are made by the National Board of Fisheries in order to study the stagnation of deep water of the Baltic. Research vessels visit the Baltic and the Kattegat four times a year. Data obtained for temperature, salinity, alkalinity, pH, oxygen, phosphate, total phosphorous nitrite, nitrate, ammonia, total N, silicate, absorption at 370 mm, hydrogen sulfide and occasionally chlorophyll, oil, urea-N, total organic carbon and tritium.

   In studies of the Gulf of Bothnia similar data are obtained twice a year.

   In addition to the above mentioned study hydrographical and hydrochemical investigations of the winter situation in the Gulf of Bothnia are carried out since 1974 with the help of ice-breakers, coast guard vessels and research vessels. Both chemical and plankton analyses are performed.

   At present 10 stations in the Kattegat along a section somewhat south of Göteborg - Frederikshaven are visited 20-30 times a year for hydro-chemical and plankton analyses. At two stations in this area currents, temperature and salinity are recorded automatically.

Hydro-chemical measurements are also more or less regularly made by vessels passing the southwest part of the Kattegat.

3. The Belt project is a joint Danish-Swedish study of the material balance and material transport through the inlets to the Baltic.

4. The water exchange in the Baltic has been studied by the Department of Oceanography at the University of Göteborg. The deep water flow into the Baltic is of special interest.

   Measurements of the circulation in the Skagerrak have also been made.

5. A two-dimensional numerical model of the time-dependent estuarine circulation in the Baltic has been developed in order to understand physical processes essential to the Baltic ecosystem. This model will be used in studies of the spring phytoplankton bloom.

   A model has also been made by the Stockholm Institute of Technology.

6. The quarternary geology of the sea bed in the eastern Skagerrak and the northern Kattegat is studied by the Department of Geology at the Chalmers University of Technology.

7. The Geological Survey of Sweden has finished its field investigations of sand and gravel extractions in the Øresund area, but the results are not ready for publication. A new investigation has been started near the island of Gotland.

   In connection with sand extractions off the town of Luleå geological, fishery biological and benthic investigations have been made.

   Geological and fishery biological studies are made also at other locations of sand extraction (the National Board of Fisheries).

8. The National Board of Fisheries determines both the primary production and the occurrence of fish eggs and larvae (especially herring, cod and plaice) in the Baltic.

9. The Askö Laboratory, south of Stockholm, has concentrated most of its work on dynamics and energy flow in the Baltic ecosystem. The biomass and production of phytal, pelagic and benthic organisms and of fish larvae have been studied. The findings are correlated with data on currents, temperature and chemical properties of the water. A similar investigation is made in the more coastal water of the Himmerfjärden. Some other projects are also carried out, for example an evaluation of air and satellite photos.

   Nitrogen fixation by blue-greenalgae is a project of the University of Uppsala.

10. At the west coast changes in the hard and soft bottom ecosystems are studied. (The Kristineberg Marine Biological Station).

11. Bacterial investigations of the bottom sediment of sandy beaches have shown that coliforms occur in high numbers in or around the water line (The University of Lund).

12. Observations of the effects on marine organisms of cooling water from nuclear power plants are made by the National Environment Protection Board.

There is also research on the growth of salmon and trout in the warm water outlet from a nuclear power plant.

13. An experiment with shellfish cultivation takes place in the province of Bohuslän at the northern part of the west coast. The project started in 1976 with the species Mytilus edulis, Ostrea edulis and Crassostrea gigas. Some information can also be obtained from 10 private cultures.

Pollution

14. Since 1972 routine analyses of the oil content of water from the Baltic, the Kattegat and the Skagerrak have been made by the National Board of Fisheries.

15. The DDT and PCB levels in seals are determined since 1969 by the Swedish Museum of Natural History in collaboration with the Special Analytical Laboratory of the National Environmental Protection Board, Herring, cod, and guillemot are analysed for DDT, PCB, mercury and cadmium.

Since 1967, the Swedish National Food Administration has determined the levels of DDT and its metabolites, PCB, dieldrin, BHC, lindane, hexachlorobenzene and pentachloroanisole in fish flesh, liver of cod and burbot, crayfish and canned fish products. A survey of methyl mercury levels in fish from Swedish waters started in 1966 and is still in progress.

16. The National Environment Protection Board is investigating the effect of heavy metals on ecosystems of soft bottoms. The influence of cadmium on the sexual maturation of Pontoporeia affinis has been studied.

17. The Department of Botany at the University of Lund has studied the bioaccumulation of heavy metals in algae.

18. Research on the exchange of phosphorus, nitrogen and silicone between bottom sediments and water and analyses of the content of heavy metals in sediments have been made (Dept. of Geology, University of Stockholm).

19. At several places along the coast studies of spreading and control of waste water outlets have been made.

United Kingdom

1. England and Wales

(A. Preston)

1. Fish Cultivation - Fisheries Laboratory, Lowestoft

Turbot

Further improvement was made on the techniques for rearing larval turbot. Addition of algae during the phase when larvae feed on Artemia was beneficial, possibly because the algae sustain the nutritional status of the Artemia nauplii or metanauplii. Weaning on to dry diets was accomplished with larvae from 0.6 cm to 1.7 cm in length. Survival was better for the larger larvae with individual batches reaching 70% survival to metamorphosis from the start of weaning. The need for partly grown Artemia was greatly reduced by the development of the weaning technique.

Biochemical analysis of rotifers fed on different algae showed that protein, lipid and carbohydrate levels were high whatever algal species was used and that the poor performance of larvae fed on rotifers which had been grown on Dunaliella could not be explained on simple nutritional grounds.

On growing trials with metamorphosed turbot showed that growth rate was not affected by stocking density over the range 70 to 390 fish/m^2. Fish were approximately 6 cm in length at the start and 15 cm - 16 cm in length after 25 weeks.

Sex control by the use of steroids incorporated into the food was accomplished with newly metamorphosed turbot. Macroscopic examination of gonads of treated fish suggests that although sex-reversal was apparent, a high proportion of the fish showed atypical gonad development. Dose-rates and timing require more study.

Spawning time manipulation by photoperiod was successful in turbot when performed on the basis of earlier experimental work with dab.

Sole

Methods were developed for weaning sole onto prepared foods. Fish of mean length of 1.6 cm were fed on high fat salmon starter diet by automatic feeder, with a small supplement of Artemia nauplii for the first 63 days. Survival to day 117 was 47%.

Cod

Initial attempts to feed cod larvae using the methods employed for turbot were successful. Good survival to a length of about 1 cm was achieved but it was not assessed precisely.

Rainbow trout

Collection of domesticated strains of trout continues. Genetic analysis suggests that some are inbred. Trials on the acclimatisation of young fish to salt water suggest that the minimum size for acclimatisation is in the range 20 to 40 g when transition to sea water takes place gradually over a period of three weeks. Some strains appear less well able to acclimatise than others.

2. Shellfish Cultivation - Fisheries Experimental Station, Conwy

Penaeid prawns

Breeding

Repeated spawning of P. monodon was obtained from females from which one eye had been removed but all were infertile. A laboratory population of P. merguiensis repeatedly spawned viable offspring.

Environment

Water from a 1 250 litre capacity recirculation system with a biological filter and stocked with 400 P. merguiensis was regularly analysed. One third of the water was replaced each week. Ammonia, nitrite and phosphate did not exceed levels thought to be toxic and at most were 0.4 mg NH_4-N/l, 0.7 mg NO_2-N/l and 7.0 mg PO_4-P/l. Levels of organic carbon however fluctuated erratically between 74 and 25 mg C/l. The weight of suspended matter retained on a GFC filter varied between 1.5 and 35.3 mg/l. These changes in clarity of recirculated water frequently occur in our culture systems and are thought to be due to the bloom and collapse of microbial populations.

The growth and survival of densely stocked P. merguiensis ($100/m^2$) in round and square tanks were compared over a 16 week period. The prawns apparently preferred the square tanks in which they grew to a larger size. Observations showed that they sort out shelter in the corners.

Nutrition

In previous work pelleted diets prepared from freeze-dried Mytilus edulis meal has resulted in reasonable growth response and excellent survival of the prawn Penaeus merguiensis. A more recent experiment confirmed that heat drying (60°C, 24 hours) adversely affected its potential for growth promotion. Therefore, in all subsequent experimental diets only the freeze-dried form was incorporated.

A series of experiments examined the requirements of P. merguiensis for major nutrients. The findings have shown the need for 3% vitamin and 7% mineral mix; the addition of cod liver oil to a diet containing 39% protein (mussel meal) did not increase growth, and growth declined as protein was decreased in an isocalorific diet.

In all experiments food ingestion rate tended to increase as dietary energy decreased. Excessive food consumption, poor food conversion and reduced protein efficiency was recorded at dietary energy levels below 2.8 K cal/gm. Available energy may, therefore, influence feeding rate, protein utilisation and growth. Abnormally high dietary energy could reduce protein intake while low levels may lead to diversion of protein for metabolic requirements.

Lobsters

Juvenile growth

Temperature and salinity. For the first six weeks of post-larval growth, the estimated optimum levels of these two factors are a temperature of 21°C combined with a salinity of 30 ppt. At the optimum salinity, 95% of the maximum theoretical yield should be obtained over a temperature range of 19-22°C. At the optimum temperature the respective salinity range is 27-33 ppt.

Container size. In the range of pot sizes tested (1"-6" diameter), both the growth rate and length increment at moult tended to increase with the size of container.

Shelter. In one experiment the mean dry weight after 12 weeks, and length increase at moult, were significantly greater in lobsters which were provided with semi-circular PVC shelters approximately $1\frac{1}{2}$ times their total length.

Feeding frequency. Feeding every two days did not produce significantly less growth than daily feeding. As a result of the lower absolute amounts of food consumed at the lower feeding levels, food conversion is better. The weight increase over a 31 day period of lobsters fed every two days was 11% less than for those fed daily, but 34% less food was eaten.

Bivalves

Larvae

The efficiency of production of oyster spat in large scale larval rearing has progressively improved since 1973. In 1976 efficiency in terms of C. gigas spat obtained per litre of sea water medium used throughout larval rearing was 77.6 compared with 43.3 in 1973. The values for O. edulis were 82.7 in 1974 and 119.9 in 1976. Improvements are largely attributed to the greater experience of staff and greater reliability in algal production.

The percentage of fertilised C. gigas eggs which develop to viable D-larvae in 24 h has been shown to be sensitive to variations in the quality of natural sea water. During the year a bioassay technique based on the proportion of fertilised eggs which developed into normal D-larvae was established. The assay utilises 30 ml samples, takes 24 hours, and the standard medium is a synthetic sea water.

The gross biochemical composition of Tetraselmis, Isochrysis and Chaetoceros has been altered by varying the amount of nitrate in the growth medium. Each species could be produced whether with a high proportion of protein together with low carbohydrate in high nitrate medium, or the reverse in low nitrate medium. These differences in proportional composition did not have a significant effect on the growth of C. gigas larvae. Spatfal was, however, significantly greater ($p < 0.05$) on a high protein Tetraselmis diet, although subsequent spat growth was reduced. In terms of food value to larvae Chaetoceros was superior to Tetraselmis, which in turn was better than Isochrysis. Differences in terms of gross biochemical composition between them do not explain differences in their relative food value.

Juveniles

The experiments have concentrated on methods of handling hatchery reared spat until they are large enough to lay on the sea bed. Trays and tubes (1m x 10 cm) made with 1 mm mesh allow 10 mg spat to grow to 100 mg in 6-8 weeks in the Menai Straits, with less than 20% mortality. The tubes can hold 2 000 spat and trays up to 12 spat/cm^2. At 100 mg the spat can be moved to a 6 mm mesh until they reach 1 g in weight. At this size oysters can be laid directly on the ground provided they are surrounded with a crab-proof fence.

The shore crab is abundant on our oyster ground. Monthly population estimates using mark-recapture methods, confirmed the 1975 seasonal pattern of abundance with fewest crabs onshore in January-February and peak numbers from May to August, apart from a temporary reduction in June due to moult and mating. During the peak months, average densities on the shore were 1-2 crabs/m^2 during high water compared to 1-3 m^2 in 1975.

Underwater television observations over a further six daylight tides showed from 57 to 130 crabs per metre width of shore moving upshore during neap and small spring tides from May to August 1976 (cf. 60-120/m for three tides in 1975).

3. Marine Pollution - Fisheries Laboratory, Burnham-on-Crouch

Monitoring Activities

Fish and Shellfish quality

1976 was the second year of a major survey effort which was designed to ensure sampling of all major fish and shellfish species landed in England and Wales from all fishing grounds of significant importance to the UK fishing fleet. Sampling success has been high and the programme is now being reduced to a surveillance effort with special attention being paid to a few potential hot spot areas and to the presence of particular pollutants. In the broad survey almost all samples were analysed for copper, zinc, lead, cadmium, mercury, PCBs and several of the more common organochlorine pesticides, e.g., dieldrin, HCH, DDT etc. In addition, a proportion is being analysed for arsenic. Work was completed on the preparation of a report covering the four years' work 1970-1973 and reports are now in the course of preparation for 1974/5. There has been no commitment to international programmes in the past year which it has not been possible to answer from the existing UK programme. International requirements have, however, involved the analytical chemistry group in several intercalibration exercises for both metals, pesticides and PCBs. In all cases where the results are available the performance of the laboratory vis-a-vis other participants has been good.

Monitoring of areas used for dumping of wastes

To supplement the statutory controls on the dumping of wastes at sea, under the Dumping at Sea Act 1974, monitoring of the areas used for the deposits of approved wastes continues.

The primary components of this monitoring programme, which is concentrated on areas receiving sewage sludge, and industrial wastes, are :

i) techniques to establish the dispersion paths and ultimate fate of the waste. Hydrographic investigations involving moored current meter emplacements, sea-bed drifter releases and 26 hr surface and bottom water current measurements are being carried out in several areas (off the River Humber, British Channel and off River Tyne). The dispersion of dumped sewage has also been followed successfully through tracing the sewage bacteria in sediments. Chemical analysis of sediments is also continuing, to indicate any sites of accumulation in sediments.

ii) Techniques to establish the biological effects on the benthos have been further developed (see ecological studies) and have been applied to areas used for sewage sludge disposal. The principal development is the analysis of the data by computer, using classification and ordination techniques, permitting a more objective and quantitative assessment of biological effects than was possible using earlier techniques. Baseline studies on two areas are likely to be complete during 1977.

iii) Ancillary field studies are also being undertaken to investigate the relationship between the metal levels in sediments and certain benthic species as well as the metal levels found in commercially exploited fish and shellfish.

Microbiological tracing of sewage sludge

Techniques for the estimation of coliforms and E.coli in bottom sediments have been successfully applied in the field to study the dispersion of sewage solids from dumped sewage sludge. The results obtained, using ship-board methods gave results comparable to earlier, more long-term drifter and radio-active tracer studies and enabled a comprehensive survey to be completed in under two days. Further development and extension of these and other methods is now in hand. Use of ^{14}C tracer techniques to study heterotrophic activity in sediments has been abandoned, since it did not give the degree of precision or reproducibility required. More direct methods using total plate counts on a variety of media are being evaluated at two sites, one of which is polluted by sewage.

Dinoflagellate toxicity

Monitoring of PSP toxin in mussels was again carried out on the north-east coast of England and between March and August 1976, 138 samples were examined. Although the summer period was exceptionally hot and dry, toxin was only detected sporadically at two stations. Hartlepool and Sunderland. Maximum values recorded were : 686 unit/100 g at Hartlepool (early June) and 896/100 g at Sunderland (late June). Detectable toxicity persisted at Sunderland until late August but no significant blooms of dinoflagellates were observed. The dinoflagellates Peridinium trochoideum and a small Exuviaella sp. were common in mussel gut contents when toxin was detected. No unusual biological events were reported in the area.

Vibrio parahaemolyticus

The cooperative survey to determine the distribution of this organism in sea-water, sediments and shellfish in British coastal waters was completed in 1976. The collected data have been summarised and a draft prepared for publication during 1977. Over 2 000 samples have been examined and although there was some seasonal variation in the incidence of Vibrio parahaemolyticus,

geographical differences were marked. The organism appears to be scarce or absent on north and east coasts but relatively common in south-east, south, south-west and western areas. Virtually all the recognised serotypes have been recorded during the survey although large numbers of untypeable strains were isolated. A few sucrose fermenting strains were also indicated (V. parahaemolyticus is normally sucrose negative) but all isolates were Kanagawa negative.

Ecological Studies

Sedimentological work

Most studies completed this year have been a part of the ongoing programme aimed at achieving a basic knowledge of the hydrography/sedimentology/benthic ecology of the fourteen major dumping grounds. This data will form a 'baseline' for future monitoring programmes.

Each sediment survey consists of seabed sampling (a net work of at least thirty stations) with a Day grab and/or box corer, observations of hydrographic/suspended sediment characteristics (26 hour hydrographic observations, continuous current-meter data, sea-bed drifter releases), and acoustic surveys (side/sector scans, echo sounding).

Seabed samples are analysed in the laboratory to determine particle-size characteristics, C/N and trace metal content - the latter (chemical) characteristics are determined on various size bacteria of the sediment. This data, together with the biological information, is fed into a data bank, from where statistical analyses can be performed.

Over the past year, the collection of necessary raw data from all of the dumping grounds has been completed. Surveys from Exeter, Plymouth and the north-east coast grounds (Blyth, Tyne, Wear) have been worked up, and reports are in preparation. A considerable amount of time has been spent in improving analytical techniques and documenting them, as reproducibility of results is of prime importance in baseline/monitoring programmes.

Using a combination of published data and MAFF survey data, it has been possible to obtain a reasonably detailed picture of the physical behaviour of sediments at each of the dumping sites, together with a clear description of the distribution of C, N, Hg, Cu, Cd, Cr, Zn, Ni, Pb associated with the sediments.

Benthic populations in dumping areas

Detailed benthic investigations of the major areas of waste disposal have continued. From these it is hoped to acquire a sufficiently clear understanding of benthic populations at each dumping ground to be able to revert to a lower level of monitoring in future years.

Draft reports have been prepared on benthic investigations conducted on the sewage sludge dumping grounds off Exeter and Plymouth, and in the outer Thames estuary, and on the dumping areas off the north-east coast of England. An appraisal of the results of various assessment techniques used in Liverpool Bay has also been made. Gross changes with severe impoverishment of species have been detected in a confined locality off Blyth (NE coast), where fly ash dumping causes physical blanketing off the seabed. In other areas, some effects attributable to the dumping of waste are discernable but not detrimental to the benthos.

Considerable effort has been applied to maximising data utilisation by the use of computer programmes. Eventually it is intended that by using classification and ordination techniques, a more objective and quantitative analysis of the benthic data can be achieved, particularly in terms of community structure. However, delays in computer programming have largely prevented the correlation/regression of biological characteristics with physical and chemical properties of the sediments. Consequently, for the time being the interpretation of such analyses, in terms of an assessment of effects, remains a basically subjective process.

Mineral Extraction

Investigations, by Lowestoft Laboratory staff, continue into the effects on, and subsequent recovery of, benthos, following marine gravel extraction off the east coast of England.

(No further Lithothamnium studies have been made or are planned).

Toxicological Studies

Laboratory tests of industrial wastes

Routine static tests to determine the acute toxicity of industrial wastes using Crangon and Agonus have been continued.

Dispersant and oil toxicity

New laboratory tests have been developed to determine the acute toxicity of oil dispersants, both as used at sea and on beaches. The sea test involves exposing Crangon to a 1:1 mix of oil and dispersant, maintained in suspension by agitation, for 100 minutes followed by a 24 hour recovery period in clean water. For the beach test, Patella, attached to 'Perspex' plates are sprayed with neat dispersant and exposed in air for six hours before being washed and given a 72 hour recovery period in a tidal seawater system. Development work on this test was backed by work in the field

Toxicity of pure compounds

Short-term tests in a flow through system are being used to determine the acute toxicity of pure compounds and other compounds likely to reach the marine environment (e.g., drilling muds, surfactants).

Sub-lethal studies

Long-term studies using Crepidula have continued with efforts aimed at identifying sensitive effect criteria. In addition to growth and reproduction rates the effect of stress on energy conversion parameters is being studied.

Petroleum Hydrocarbon Studies

Hydrocarbon surveys

A detailed investigation is being made of an estuary subjected to discharges from a refinery. Ecological surveys have been made and environmental samples (benthos, sediment and water) have been subjected to hydrocarbon analysis by TLC and GC/MS.

The distribution of non-biogenic hydrocarbon fractions in benthos and sediment shows no clear pattern attributable to the refinery discharge. Further water and sediment samples from selected sites are being analysed for indicator-compounds characteristic of the refinery discharge in an attempt to identify its area of influence.

Hydrocarbons in shellfish

Samples of oil-contaminated molluscs are being subjected to various procedures known to purify them of pathogenic bacteria and the effects on their tissue levels of selected polynuclear aromatic hydrocarbons followed. The factors governing tissue levels in the field at contaminated sites are also being studied.

Microbiology

Virology

Due to changes in staff and other commitments, the practical programme in this field has been delayed. However, a virology laboratory has been set up and tissue culture methods established. Priority will be given to the uptake and removal of poliovirus (run in parallel with similar studies using E. coli and bacteriophage) by molluscan shellfish and an evaluation of existing methods of shellfish purification in term of virus removal. Clearly there is also a need to look at the effects of heat processing on virus in shellfish.

Field Investigations

Studies in sewage polluted areas where there are existing or potential molluscan shellfisheries have continued. Much of this work has been directed towards assessing pollution problems in areas not previously used for shellfish cultivation. This has become relevant with more widespread culture of the Pacific oyster, Crassostrea gigas, and growing export trade in mussels (Mytilus edulis) and hard clams (Mercenaria mercenaria).

Public Health Aspects

A number of purification plants using ultra-violet light have been constructed during 1976; virtually all of these are of the high density tray type and a cheap, enclosed u/v source for use with them is now being manufactured.

Work carried out during 1975-76 on the processing of shellfish by steaming proved invaluable. In December 1976 more than 800 people were reported ill after consuming cockles (Cardium edule). The illness was characterised by diarrhoea and vomiting with an incubation period from 12 to 60 hours (average 36 hrs). All efforts to isolate recognised bacterial or viral pathogens from either cockles or human faecal samples, failed. Detailed and lengthy investigations suggest a pattern of events beginning with an outbreak of viral gastroenteritis in a community bordering the area of shellfish production. The agent of this outbreak, excreted by those affected, passing via sewage system to seawater where it was accumulated by the filter-feeding cockles. Inadequate heat treatment of the cockles, exaggerated by a period of very cold weather failed to remove the agent, which was then passed to the consumer. Evidence suggests that the causative agent was highly infectious and resistent to brining and acid vinegar treatment. Virus particles, of a type not previously described, have been identified by the Public Health Laboratory Service in electron microscope preparation of faecal samples, but not, as yet in any cockle samples. Laboratory and commercial processing trials have led to an improved cooking procedure using boiling rather than steaming. With general improvements in handling and hygiene the risks of similar outbreaks in future are generally reduced.

Analytical Chemistry

Instrumentation

Several new items of chemical analytical equipment have been added to those already available. The capability of the GC-MS purchased in 1975 has been greatly extended by the addition of a computer data system. A heated graphite

atomiser has been added to one of the atomic absorption spectrophotometers with a view to decreasing the detection levels of some elements, in particular lead and arsenic. A carbon, hydrogen and nitrogen analyser has been purchased for use on the analysis of C and N in sediments from dumping area surveys and for analysis of samples arising from the long-term bioassay work using Crepidula. Finally, with a view to extending the range of separation possibilities available, especially in relation to petroleum hydrocarbon work, a high pressure liquid chromatograph has been acquired.

Method development

Following an extended experimental programme, trace metal analysis using flame atomic absorption for zinc, copper, cadmium and lead and flameless atomic absorption spectrophotometry for mercury, is now carried out on a single common digest, This is derived from an acid oxidation procedure and the mercury determination stage has been fully automated.

Problems related to analysis of arsenic in marine fish and shellfish have now been traced to speciation of the element in fish tissues. Consequently, it has been possible to develop the methodology to a reliable stage though using a rather time-consuming digestion technique. It is hoped that attempts to simplify and automate the analysis using the heated graphite atomiser will be successful and thereby speed up the work. Similar improvements are expected in the determination of lead.

4. Marine Pollution - Fisheries Laboratory Lowestoft

Trace Metals

During 1976 the measurement of trace metals in water has continued in both the North Sea and the North Atlantic. Metals selected for analysis were mercury, zinc, copper, nickel and cadmium in both soluble and particulate phases. Some measurements of particulate iron and manganese were also made.

During January metals were measured on a section between the Thames Estuary and the Hook of Holland. An area off the north-east coast of England extending out to 2°E was surveyed during March-April. On the same occasion metals were measured in the Humber Estuary as part of the U.K contribution to the ICES sponsored investigation into the behaviour of pollutants across fresh water/marine boundary. During May-June an extensive area of the North Sea was surveyed between 51°30' and 61°N with an extension into the Kattegat. In addition to these North Sea observations, mercury was measured in the English Channel and Irish Sea during January.

During September and October trace metals were sampled in the North Atlantic on a section through the Norwegian Sea, across the north of Iceland and down through the Denmark Strait.

Samples were collected at a station in the Rockall Channel during May by the Scottish Marine Biological Association for analysis by the Lowestoft Laboratory. During July and August Lowestoft staff participated in a cruise of the Deutsches Hydrographisches Institut research vessel "Meteor". Samples of metal analysis were collected from an area west of Scotland extending to the edge of the continental shelf and from the Norwegian Sea extending northwards to 65°N.

Data from many of the above projects are still being processed, although preliminary indications do not show any increase in general metal levels compared with previous years. The mercury data are shortly to be submitted for publication.

During the year an intercalibration of trace metal standard solutions was conducted under the auspices of the ICES Working Group on Pollution Baseline and Monitoring Studies in the Oslo Commission and ICNAF Areas. A report on the project (Jones 1976) showed that 20% of the results were outside the ±10% of the expected values.

Nutrient salts

Nutrient salts were measured in the southern North Sea during January as part of an annual series of winter observations aimed at detecting trends towards conditions conducive to eutrophication. The phosphate level in coastal waters was similar to the previous year, but nitrate values were higher. Silicate remained relatively unchanged at the levels recorded during 1961 and 1962.

Nutrient salts were also measured at frequent intervals throughout the year off the coast of north-east England. Although the project was primarily concerned with a study of biological systems, the data provide information on the coastal levels of nutrient salts derived from terrestrial sources.

2. Scotland

(A.D. McIntyre)

1. Food Chain Investigations

The main effort in food chain investigations in 1976 was directed to our participation in FLEX, an international project designed to provide a better understanding of the physical and biological processes which control production. The field work is complete and data processing and evaluation is in progress.

Studies of the survival and growth of fish larvae in large plastic bags anchored in the sea have continued, with the aim of identifying the critical factors in this stage of the fishes' life history.

2. Shellfish Cultivation

Raft experiments on oyster culture were continued in west coast sea lochs. *Ostrea edulis* reached commercial size (ca. 50 g) after 3½ years. *Crassostrea gigas* grew much more quickly reaching commercial size in 1½ years. Flesh condition was better after a further season's growth. Conditions declined during the winter but no unpleasant taste or odours were detected. *C. gigas* was grown in stacks of cages on the shore in Loch Ardvar. Growth was better at a low level in relation to tide, but was also improved by keeping the animals off the bottom.

Newly settled *Chlamys opercularis* were kept in cages held off the bottom. They spawned in October - one year after settlement. No extension of the known distribution of shellfish pests and diseases in Scottish water was recorded during the year.

3. Fish Farming - Disease and Parasite Studies

Infectious pancreatic necrosis (IPN) virus is currently known to be present in 8 Scottish rainbow trout farms. A continuing survey of wild fish for IPN virus in the vicinity of a farm known to have had virus for 6 years has shown no change from the situation reported last year. Examination of spawning salmon from 11 major river systems where salmon eggs are reared to the eyed stage did not show the presence of virus. Investigations of serum neutralising ability of brown and rainbow trout and in salmon against IPN virus has shown a biomodal distribution, the upper mode correlation with the presence of virus. The overlap between the two modes is considerable, however, and it appears other disease conditions may elevate the titre of the lower mode.

A swimbladder tumor, classified as a fibrosarcoma and often of considerable dimensions, has been found in several farmed salmon held in sea pens. Electron microscopy has shown numerous virus-like particles. The budding of several of the virus-like particles from the cytoplasmic membrane is similar to the method of replication of RNA tumor producing viruses. The tumor has been found in salmon in two sea farms some of whose stock of smolts came from a common freshwater source.

The development of the humoral and cell mediated responses were studied in conjunction with the histogenesis of the lymphoid system in salmon and trout embryos and larvae. The results show that lymphocytes appeared first in the thymus at an early stage of development but a lymphoid element in the kidney was not recognisable until close to hatching. As measured by the presence of surface immunoglobulins and a positive mixed leukocyte reaction pre-feeding fry do not possess specific immune mechanisms to protect against infection, but in some manner feeding was a stimulus to full maturation of the immune system.

An in vitro method of propagating Ichthyophonus was developed. Varied morphological forms indicate a complex life cycle. Cultures have remained viable for 12 months and infectious for fish. Immunofluorescent antibody techniques have shown a humoral response in infected plaice in 3 weeks and by the gel diffusion method within 5 weeks.

A survey of the dissolved gas content of sub surface fresh water supplies in six fish farms has shown a considerable variation in the levels of oxygen, nitrogen, and carbon dioxide. Oxygen values vary from 15-80% of saturation, nitrogen from 109-132% of saturation, and carbon dioxide from 8-40 mg/l. Investigation of the amount of aeration necessary to raise oxygen to acceptable levels as an indicator of removal of the other gases is continuing.

The salmon louse, Lepenophtheirus salmonis, caused severe damage to cultured salmon in a marine site in 1976. Laboratory studies have shown that a copepodid stage infective to fish can develop within 3 days of hatching from the eggs at 12°C. Hatching and subsequent development of the free-living stages occurred at salinities above 25‰ . A second caligoid copepod, Caligus sp. has been observed in large numbers on cultured salmon but its pathogenicity, if any, is unknown at present. Large scale invasion of salmon occurred between September and December but only a small proportion of the parasite population apparently developed to maturity during this period.

4. Pollution - Shellfish and Public Health

The service for advice on purification and for analysis of shellfish and water for selected pollution indicators was maintained.

Sewage input

Evaluation was made of new dumping grounds for sewage sludge and monitoring of existing grounds continued. Studies of the effects of untreated sewage in coastal areas have been made, and experimental investigations in tanks and in situ, of the effects of sewage sludge in the benthos are underway.

Heavy metals

Routine monitoring of certain heavy metals in selected species of commercial importance has continued, and regular measurements were made of the input of metals to the Firth of Forth from the atmosphere. Earlier experiments on a benthos-based food chain in tanks were extended to include a food chain based on plankton-eating fish, and copper effects were studied. Large plastic bags moored in the sea were used to investigate the transfer of mercury from the water column to the sediments.

Oil

Studies of oil in the North Sea in collaboration with Torry Research Station included general monitoring of environmental levels between the Firth of Forth and the Forties Field, as well as site-specific investigations particularly at Sullom Voe. The effects of water soluble fractions of North Sea crude oil on plaice larvae are being examined, and the plastic bags were used to study the process of oil transfer from the water columns to the bottom.

Work at Pitlochry Laboratory.

The analysis of marine fish and plankton for organochlorine residues was continued during 1976. The twice-yearly samplings of cod, whiting, plaice and herring from the Clyde, Moray Firth, Firth of Forth and Ling Bank has been maintained, in view of the increased interest in the trends in PCB contamination. Although a major discharge of PCBs to the Firth of Clyde ceased in 1972, the concentrations in the fish sampled in this area have not shown any significant decline, and recent samples suggest an increase, particularly in cod liver. The Clyde remains the area most polluted by organochlorines in Scottish waters. The concentrations of α and γ-HCH and of HCB in the muscle tissue of the four fish species sampled in Scottish waters are, however, all very low, and usually less than 0.01.mg/kg.

To investigate the fluctuations which occur in organochlorine levels within one species in one area, and relate them to physiological changes, herring have been sampled approximately monthly in the Clyde, three-year-old males being selected for analysis. The results of this study will be reported in 1977.

Further analyses of marine zooplankton samples from the Firth of Clyde to Ocean Weather Station "India" were completed, and the data obtained were compared with those already published from earlier surveys. The area of the sludge dumping ground in the Firth of Clyde remains the most heavily contaminated zone, buth there was some evidence of a decrease in general organochlorine contamination up to 1974.

The study of organochlorine deposition in atmospheric precipitation which previously examined the quantities of various compounds deposited along the east coast of the United Kingdom, has now been restricted to a number of Scottish sites, including two on the west coast. It is hoped to show whether there is a significant increase in deposition from west to east across Scotland, and to assess the proportion of the substances deposited which may have originated in North America. A few analyses of sea water from the Firth of Clyde were made in April 1976, the samples being taken at 10m depth. Concentrations of PCBs were mostly below 1 ng/l, total DDT (mainly DDE) less than 0.1 ng/l, total HCH almost 1 ng/l and dieldrin mostly below 0.5 ng/l. Samples from the Firth of Forth contained similar concentrations. The PCB concentrations were lower than those reported by American Workers for the North Atlantic, and the accuracy of PCB analyses at these very low concentrations is still questionable.

U.S.A.

(C.J. Sindermann & D.W. Menzel)

1. Marine Pollution

A brief summary of experimental and survey work related to ocean pollution in the U.S. was presented in last year's Committee report. All of the described programmes have been continued through 1976-77. In addition, within the past two years the U.S. Department of Interior through its Bureau of Land Management has initiated intensive chemical and biological benchmark, geological and physical oceanographic studies of defined areas in anticipation of exploratory oil drilling and perhaps production. The long-range objective of these studies is : 1) To define geological hazards within areas where leasing for oil exploration is likely. 2) To develop trajectory models which would allow prediction of the transport of pollutants in the event of chronic leakage or accidents. 3) To determine the ranges of high molecular weight (HMW) hydrocarbons (operationally defined throughout as greater than or equal to $^{C}14$) and selected trace metal concentrations in the sediments and selected macrofauna species preceding oil and gas development against which possible man-induced chemical change can be assessed in the future. 4) To delimit the major chemotopes, lithotopes, and biotopes for the study area, and characterise each with respect to natural seasonal variability and interrelationships. 5) To characterise the existing health of selected benthic macrofauna preceding oil and gas development, and establish a historical data base that can serve as a reference for later comparisons. 6) To describe dominant microbes in sediments and in the upper water layers and evaluate their "potential" and possible importance in the degradation of oil. 7) To describe the HMW hydrocarbon and selected trace metal concentrations in the water column. 8) Identify and describe unique or fragile/endangered areas. 9) Collect other data supportive of the above objectives.

Studies with the same objectives and with internal consistency in sampling and analytical procedures are being conducted on the New England Continental Shelf including George's Bank (40-43°W and 71-65°W), the mid-Atlantic Continental Shelf off Delaware and the Southeast Continental Shelf off the Carolinas, Georgia and Florida (29.5-34°N), the Continental Shelf of the Gulf of Mexico between Mississippi and Florida, and in separate studies off Texas, the Southern California Bight and the Gulf of Alaska and Bering Sea.

More than 80 % of all ocean dumping in the United States occurs in the New York Bight - offshore of New York State and New Jersey. A large-scale investigation on the effects of such dumping (sewer sludge, contaminated dredge spoil, construction rubble, and acid wastes) on the coastal ecosystem has been carried out since 1973. Localised impacts on benthos and demersal fish have been documented and a large volume containing many summary papers was published in 1976 by the American Society of Limnology and Oceanography. The intensive phase of the study being funded and directed by the National Oceanic and Atmospheric Administration, will continue until 1981, when it will be replaced by a monitoring programme.

A major zone of oxygen depletion developed and persisted in the bottom waters of the Middle Atlantic Bight from July to October 1976. Mortalities of shellfish occurred - the most significant being the loss of an estimated one-half of the surf clam (Spisula solidissima) stocks off the New Jersey coast. Lesser effects were seen in other shellfish populations. Seasonal migratory patterns of a number of pelagic fish species were disrupted and demersal fish seemed able to avoid the anoxic zone as it developed (except for certain reef inhabitants). The zone of oxygen depletion covered approximately 3 000 square miles from Long Island, N.Y. to Delaware, in a corridor roughly 60 miles wide. Unusual hydrographic events (early runoff and early onset of the thermocline) combined with massive phytoplankton (Ceratium tripos) bloom, all in a stressed coastal area, were felt to be contributing factors.

2. Marine Aquaculture

Attempts to culture Pacific (coho) salmon in coastal waters of north-eastern United States have been conducted for the past decade. Several small commercial ventures, using floating net pens, have endured, and some limited success has been achieved with ocean ranching (hatching, early rearing, and release of yearlings, and harvest of returning adults). Evidence exists that ocean ranching success depends on source of eggs and size at release. Several year classes of coho salmon have been released and returned to spawn; these fish are being used now as a source of eggs for future releases. Annual increases in survival rates suggest successful adaptation to the Atlantic coastal environment.

Aquaculture is receiving more attention by the Federal Government to determine the potential of such ventures in the United States. For example, the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce has prepared a National Aquaculture Plan (mentioned in last year's report) which should be available in its final version this spring. It (NOAA) has also commissioned the National Academy of Science to conduct an aquaculture study. Four panels will compile information on the science, technology, economics and administration/law as it involves aquaculture. The results of this study should indicate whether or not there should be a National Aquaculture Programme. In addition, the Interagency Committee of Marine Science and Technology of the Federal Council for Science and Technology has established a subcommittee on Aquaculture. It is composed of representatives from government agencies conducting programmes in aquaculture or involved in related activites. Its purpose is to coordinate activities in the area of aquaculture. This group has met three times in the past year and has organised study panels to consider such issues as the translation of scientific papers, aquaculture statistics and thermal effluents.

These efforts should provide a more integrated approach to determining the potential for aquaculture in this country and indicate the probable roles and responsibilities of federal and state governments as well as academic institutions and industry.

The following are examples of on-going aquaculture projects in different parts of the country :

University of Alaska, Institute of Marine Science - Seward Station

A model aquaculture and pond system has been developed to test the possibility of using artificial upwelling to enhance primary productivity in Alaskan impoundments. Conclusions from the study so far indicate that artificial upwelling can be used in aquaculture systems in Alaska. Chum salmon fry were successfully reared in one of the artificially upwelled ponds, utilising a food web composed of Chaetoceros sp. and Acartia clausi Pinto abalones (Haliotis kamtschatkana)and mussels (Mytilus edulis)have also been successfully reared on commonly occurring species of algae.

In addition, a chemical assay for paralytic shellfish poison is in the final stages of development. Two scientists and four graduate students are involved in these research efforts.

California, Bodega Bay Marine Laboratory

Several areas of interest are being looked at simultaneously to provide information on the economic potential for commercial culture of the American lobster and other crustacean (dungeness crab, spot prawn, Macrobrachium), For example, nutritional experiments are being conducted to determine the nutritional requirements of each species to develop economical artificial diets. Genetic experiments have characterised and measured the genetic variation within and between populations of the American lobster. Thus, genetic markers could be used for tagging hatchery reared fry for release and recapture field studies. Disease experiments have led to the recognition of disease and isolation of disease agents

in egg, larval and juvenile stages of crustaceans. And Malachite green has been used to control and remove infectious disease organisms which occur on crustaceans.

The economic systems analysis programme has developed a model to define optimal operation of a culture facility, project costs of each component of a culture facility and determine research priorities.

San Diego State University

The major aquaculture effort at this laboratory is accelerating lobster growth by using thermal effluent, which appears to be free of heavy metal and chlorinated hydrocarbon contamination. Recent accomplishments in this lobster research include 38 controlled matings, and reducing the molt-mate-extrude-hatch cycle to 8 months. American and European lobsters have been hybridised and the offspring are growing well.

In addition, a nutritive supplement has been developed for commercially produced shrimp foods so these inexpensive diets can be used in lobster culture with some success. And several new culture systems for intensive lobster farming have been developed. Ten scientists and five M.S. graduate students are working on this research project.

University of Delaware, College of Marine Studies

A recirculating system is being used to produce adult bivalves (oysters, clams, mussels) from animals hatched and grown to maturity in the laboratory.

Oysters are being grown to marketable size in 36 weeks and have twice as much meat as naturally grown oysters of the same size. And clams are being grown to marketable size three to five times faster than in nature. High growing rates for algae have been achieved and certain species of diatoms and flagellates have been identified as promoting the fastest growth for each species of bivalves.

In addition, research is being conducted on the detection and control of potentially harmful bacteria. And trace metals, which are added to the system as algal nutrients, are being studied to determine which ones build up in the culture system and where. Techniques are also being developed to mass produce algae on an economic basis. This research is being conducted by eight scientists with a support staff of twenty.

New York Ocean Sciences Laboratory, Department of Ichthyology

This laboratory is involved in finfish aquaculture, which includes an evaluation of candidate species (striped bass, northern blowfish, yellow perch, winter flounder) from the mid-Atlantic region. Also, netpen culture in the Atlantic, and genetic manipulation such as induced gynogenesis and polyploidy. Another area of interest is the evaluation of the lobster resource and recruitment in Eastern Long Island Sound. The staff is composed of a senior research scientist, five research and graduate assistants and several college interns.

South Carolina Wildlife and Marine Resources Department, Marine Resource Research Institute

The major aquaculture research at this laboratory is focused on Macrobracium rosenbergii with special emphasis on intensive culture in recirculating systems, alternate rations, lipid and essential fatty acid nutrition and cost analysis of production. Work is also being done on the development of crab and subtidal oyster cultures. The scientifc staff is comprised of 15 scientists, forty-nine support personnel, plus summer aides and graduate students.

University of Texas, St Croix "Artificial Upwelling" Project

Phytoplankton cultures can be produced continuously in unsupplemented deep-seawater. Twenty-two species can be grown simultaneously so that a large variety of diets can be

provided for the different species of shellfish. Tapes japonica ("semidicussada"), Crassostrea gigas and its Kumamoto variety have been spawned, and nutritional experiments on the larvae are underway to improve survival and shorten the larval stages. Research is also being conducted on the genetic improvement of these species.

Hypnea musciformis, a carrageenan producing seaweed is being cultured and has attained its best growth in the effluent from a shellfish tank.

An economic analysis of this project is also underway. The staff is comprised of five scientists and technicians and thirteen support personnel.

Tallman Island "Effluent Aquaculture" Project, Queens, N.Y.

The purpose of this project is to provide tertiary treatment for sewage by a biological method prior to its discharge into the estuary. In the system nutrients are stripped from secondarily treated sewage by phytoplankton, which, in turn, are filtered from the effluent by shellfish. Shellfish excretory products and any remaining nutrients from the secondary effluent are stripped by racks of agar and carrageenan-producing seaweeds, Mytilus edulis is the shellfish most suited to the system.

Two scientists and seven supporting personnel are conducting this research.

Woods Hole Oceanographic Institution, Environmental Systems Laboratory

During the past year, research has continued on the development, testing and evaluation of a combined waste-recycling marine polyculture system. A study has recently been initiated on the "Cultivation of Macroscopic Marine Algae for Energy Conversion, Hydrocoloid Production and Advanced Wastewater Treatment". The research team consists of fifteen scientists and technical staff, and five students.

U.S.S.R

(P.A. Moiseev)

In 1976 All Union Research Institute of Marine Fisheries and Oceanography (VNIRO) and the Polar Research Institute of Fisheries and Oceanography (PINRO) continued investigations on pink salmon acclimatised in the Barents and White Seas. Downstream migration of young pink salmon of natural reproduction was studied in a number of rivers of the Kola Peninsula. Downstream migration began in the first decade of June and ended in early July at the water temperature of 3-18°C. The period of downstream migration on the Barents Sea coast was longer than on the White Sea coast. The length of downstream migrants varied from 26 to 49 mm, the weight varied from 0.1 to 0.7g. Considerable differences in length and weight of downstream migrants by days were recorded. This fact allows the assumption that downstream migrants were not homogeneous. In 1976 the magnitude of downstream migration was nearly equal to that in 1974 and 1972. A comparatively important mass return of pink salmon, according to local standards, may be expected in 1977 (the level of 1973 and 1975). In recent years, pink salmon returning to the rivers of the Kola Peninsula to spawn in odd years supplied stable and high catches in accordance with local standards. This fact allows for the supposition that pink salmon of odd years acclimatised themselves to local conditions.

The abundance of pink salmon returning to spawn in even years was low. It was observed that the spawning of pink salmon in even years always occurred later than the spawning of pink salmon in odd years. Later spawning caused the development of eggs under low water temperature and probably low survival rate of the young.

Recently it has been observed that acclimatised pink salmon penetrated to the west up to the mouth of Yenisei.

In the Baltic Sea, watershed experimental deliveries of eggs were continued, but no substantial returns have been observed so far. Natural reproduction of pink salmon acclimatised in the Baltic Sea may probably be impossible in the USSR, and this is the reason why a truly commercial effect could be obtained with the aid of a hatchery.

Experiments on commercial rearing of the following valuable commercial species were carried out : Atlantic salmon and coho salmon (the White and the Barents Sea watershed - Polar Research Institute of Fisheries and Oceanography); trout, sea trout, steelhead, pollan, coho salmon bester (the Baltic Sea watershed - All Union Institute of Marine Fisheries and Oceanography, Baltic Research Institute of Marine Fisheries). Average increase in weight of fish reared in cages was, per cage, as follows: trout yearlings - to 140 g, three-year old trout to 350 g, four-year old trout to 1 200 g, coho salmon fingerlings to 15 g, coho salmon yearlings to 45-85 g, bester fingerlings to 100 g, yearlings and two-year old bester to 700 g.

In future work the commercial rearing in cages will be continued. In the nearest future a sharp increase in the volume of commercial production from cage rearing is expected. Experiments on rearing of mussels were begun in the Barents Sea.

No publications relative to the interests of the Committee appeared in 1976.

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