

BIOLOGICAL OCEANOGRAPHY COMMITTEE

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by

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BELGIUM

(C. Heip & R. De Clerck)



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Several biological oceanography cruises were organised with the R.V. Belgica in 1986 in the North Sea and the Channel. The primary aim of this, the only Belgian vessel, is public service (monitoring and fisheries research) but some time is allocated to fundamental research in which primarily research teams from the universities are involved.

Studies of macro- and meiobenthos by the State University of Gent were continued. These studies aim at an understanding of the structure and the trophic role (mainly production) of the benthos in the area, the study of long-term fluctuations and the impact of pollution on these structures and processes. These studies were extended to include gobies and juvenile fish and their interactions with the infauna and the hyperbenthos. R.V. Belgica also participated in the North Sea Benthos Survey, covering about twenty stations in the Southern Bight.

The University of Leuven participated in several programmes. Studies were done on hormonal regulation of metabolism, reproduction and migration of fish. Preliminary work in collaboration with the Biologische Anstalt Helgoland was done on the German vessel 'Friedrich Heincke' in October-November 1986 on the recruitment of leptocephali of Anquilla anquilla. Samples were taken on the European continental slope (Bay of Biscayne) in order to evaluate the decrease of migrating leptocephali.

The Flemish Free University of Brussels organized a large cruise covering the entire North Sea in June 1986 in which the influence of vertical and horizontal structuration of the water masses on planktonic production was studied. Scientists of other universities also participated in this cruise. Other programmes include the transport and accumulation of stable pollutants (together with the University of Liege) and studies of fluxes between sediments and the water column and the relationship with biochemical processes in the sediments.

The French Free University of Brussels continued its studies on the effects of eutrophication on phytoplankton dynamics (Phaeocystis-blooms) and bacterial activity in the benthos after sedimentation of phytoplanktonic material.

At the University of Liege a programme was continued on elaboration of an ecotiochemical model of chitin and the production (as well from a biochemical as from an ecological point of view) and degradation and early diagenesis (by microbiological activity) of chitonoproteic complexes in the marine environment. In another programme the impact of microorganisms on the alteration of the physical properties of sediments was studied. Processes such as the microbial precipitation and neogenesis of carbonates, the concentration of traces in skeletall tests in connection with sulphate reduction etc. were studied.

#### CANADA

M. Sinclair

The following is a summary of some of the relevant activities in Canada; for further details, please consult the individuals named in each section.

#### DEPARTMENT OF FISHERIES AND OCEANS

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Operations were carried out on the Scotian Shelf (three cruises), in the Gulf of St. Lawrence, on the Newfoundland Grand Banks, in Hudson's Bay and Hudson's Strait, the eastern Arctic (from ice camps), and in the Gulf Stream. These cruises have continued to add to the Laboratory's archives of comparative data on primary and secondary production processes. Strong emphasis was placed on the interaction between biological and physical processes.

An analysis of water-column data from Georges Bank revealed a strong temperature-NO<sub>3</sub>-correlation. This correlation has been used to calculate a nitrate flux onto Georges Bank using the temperature and velocity signals from current meters moored at the front between the well-mixed and stratified waters at the edge of the Bank in summer. This computed flux was shown to be consistent with levels of primary productivity found in the frontal region. In addition, vertical profiles of turbulent eddy dissipation were taken at various locations on Georges Bank, and these are being analysed so that vertical fluxes of nutrients can be calculated.

During spring studies in Resolute (NWT), further experiments on the relationship between tidal intensity and organism distribution were carried out. Six diel studies, each about 32-h long, were timed so as to compare the effects of springs and neaps on the pelagic ecosystem just beneath the ice. While tidal energy probably was important, the most striking result was the strong migratory signal shown by *Pseudocalanus* on each sampling date regardless of the environmental conditions. On several dates phytoplankton was abundant, apparently advected into the area from open water a few nautical miles away in Barrow Strait; but on other occasions it was as low as in earlier years. Physical measurements of near-ice boundary conditions suggested that exudation by ice algae could affect drag. Epontic algae were also found to have high nitrate-reductase capabilities

despite high ammonia levels in the interstitial water associated with the proximal ice in contrast to the pelagic realm where ammonia generally suppresses nitrate reduction and utilization. Dead ice-algae, such as might occur from exposure to light and freezing temperatures if ice were overturned during ice breaking, inhibited feeding by copepods in the near-ice zone and reduced their metabolic and excretory rates. The normal scenario suggested a gradual increase in metabolic rate over the spring period as the epontic and plankton blooms developed.

A laser-based flow cytometer was used to study the abundance of autofluorescent microorganisms in the Bedford Basin. Plankton samples were characterized by histograms correlating low-angle light scatter, fluorescence emission greater than 630 nm, and fluorescence emission greater than 530 nm and 590 nm. These measurements are being analyzed with a view to discrimination among the major taxonomic groups of the phytoplankton.

BIONESS sampling combined with the observations by the multiple-frequency acoustic system were carried out during September in the region of the Emerald Basin with the purpose of determining the biomass and exact vertical position of the various components of the zooplankton and microekton communities relative to one another and to the other biological and physical features of the water column.

Process-oriented ichthyoplankton/recruitment studies have continued on the southwestern Scotian Shelf, targetted at the egg-to-juvenile stages of cod and haddock. Several cruises were conducted between April and July. The most exciting result was the enormous number of post-yolksac haddock larvae collected over a broad area along the northwestern edge of Browns Bank and further to the north of the Bank.

The average density of haddock larvae was 100 to 1,000 times greater than the density recorded during 1985, and commonly exceeded  $1/m^3$  at many stations. This density exceeded any previously recorded on Georges Bank or the Scotian Shelf. Large numbers of late larvae and pelagic juvenile haddock were evident in June, so the potential for the formation of a strong year class is excellent.

The larvae of cod and plaice were also abundant relative to their 1983-85 densities, and their centers of abundance were the same as those of the haddock. However, for the late-stage larvae and pelagic juvenile cod and haddock collected during June, there was no coincidence of distribution pattern over the region. An important difference in the ontogeny of the two species must occur when they are about 15-20 mm long. The end result is that young cod become associated with the nearshore waters off southwestern Nova Scotia while young haddock remain further offshore.

On the Grand Banks, detailed information on the vertical and horizontal distribution of capelin larvae relative to hydrographic features was studied in the region of the Southwest Shoal. Prior to this study in September, a concurrent physical oceanographic program was in place from May to October, thus providing the necessary background information to link the age structure and spatial distribution of capelin larvae to physical processes.

Ichthyoplankton tows were taken during the summer in St. George's Bay, Nova Scotia (southeastern Gulf of St. Lawrence) to assess the mackerel spawning population and the larval mortality rates. In the autumn, collaborative work with DFO Moncton was carried out in the Fisherman's Bank region of the eastern Northumberland Strait, to survey a herring spawning bed, ascertain the duration and pattern of egg deposition, estimate egg mortality, and collect adult and larval herring. A large part of this work was to test the herring-spawning wave hypothesis.

As a continuation of the investigation of the role of freshwater outflow from Hudson Bay in stimulating fish production, a cruise to Hudson Strait and Ungava Bay was undertaken in September. Studies were made of the role of tidal mixing and local freshwater runoff on the water properties of Ungava Bay. CTD data were collected, and the observed density stratification will be compared with predictions from a numerical tidal model, to identify regions of intense tidal mixing. In the Hudson Strait a current meter and tide gauge array were deployed along the southern coast. It is scheduled to be recovered in late summer 1987, and will help test the hypothesis that the strength of the outflowing current is related to freshwater fluxes from local ice melt and Hudson Bay freshwater runoff.

As part of the international study coordinated by NAFO on the larval and early juvenile phases of the squid Illex illecebrosus, a joint cruise to the Gulf Stream/Slope waters between Florida and Cape Hatteras was conducted by the Scotia-Fundy Region of DFO and the Marine Ecology Laboratory. Although the spawning location is yet to be firmly established, it is clear that the Gulf Stream system plays a key role in determining the geographic distribution of Illex during the early life history. Catch statistics, and size-frequency distribution, point to the area of Cape Canaveral, on the shoreward side of the high-velocity core of the Gulf Stream, as one place where major spawning is probably occurring. Entrainment in the shoreward edge of the Gulf Stream would result in the rapid advection of larvae and juveniles northward. Downstream of Cape Hatteras the formation of warm-core eddies ejects large quantities of Gulf Stream water into the Slope water area south of the Scotian Shelf and the Grand Banks, with eddy duration time typically of several months. Although as yet speculative, recruitment success or failure may be critically dependent on the timing, location, and number of Gulf Stream frontal eddies and warm-core eddies developing when larvae and juveniles are present.

The ECOLOG acoustic fish counting system was deployed on Browns Bank, while at the same time video cameras were deployed on the BRUTIV underwater towed vehicle. Individual haddock were successfully recorded in the bottom few meters of the water column at night. In daylight, no fish were observed by video, in spite of acoustic records indicating their presence. This may have been due to avoidance reactions by the fish during daylight. A June cruise in the northern Gulf of St. Lawrence employed ECOLOG alongside a Biosonics dual-beam system to count cod and capelin. The two kinds of equipment gave similar basic acoustic results, but the ECOLOG system appeared to have higher sensitivity and superior size and abundance discrimination, resulting from a much higher efficiency of data utilization. On this same cruise evidence was collected confirming the hypothesis of McGill University scientists that the north and westward migration of cod is strongly influenced by a cold-water layer at intermediate depths.

Two ecosystem modelling projects have been brought to completion - one for the Grand Banks and the other for the Cumberland Basin, an estuary in the upper Bay of Fundy. Both models are holistic in nature and simulate the flow of carbon through major ecosystem components (detritus to fish). Their development stimulated much interdisciplinary discussion and identified important data gaps. They represent valuable quantitative tools which can be used to examine ecological hypotheses and determine critical environmental processes. Plans call for this kind of modelling to be applied to the Scotian Shelf.

Toxicological studies have continued, using the indication of mixed-function oxidase enzymes as an indication of sublethal stress by contaminants. Response of hepatic detoxification enzymes in winter flounder was studied to define mechanisms of enzyme induction in fish. Studies were initiated with mussels (Mytilus) stressed by organic pollutants.

Studies of the distribution of contaminants in environmental samples from the eastern Atlantic coast of Canada and from the shelf region of the Arctic Ocean were continued. Organochlorines in seals were quantified to document levels of DDT and PCB contamination geographically and over time. Organochlorines in atmosphere, snow, ice, plankton, suspended particles, sediments, and bottom fauna were measured from the Canadian Ice Island off Ellesmere Island in the Arctic Ocean. This is the first comprehensive survey of the distribution of organochlorines in all compartments of an Arctic ecosystem. Investigations have continued of the fate, metabolism, and effects of petroleum hydrocarbons in coastal marine sediments, and their transfer to marine organisms. Mutagenesis in bacteria was used to demonstrate that water-soluble hydrocarbons typical of concentrations observed in oiled sediments can cause changes in microbial populations under conditions of long-term chronic-oil pollution. A new project was initiated to measure the uptake, loss, and physiological stress in juvenile Atlantic salmon exposed to a range of concentrations of petroleum in water.

Ecological studies in the deep sea have focussed on the role of biological activity in transferring material within abyssal food webs. This is relevant to proposals for the disposal of high-level radioactive waste by burial in deep-sea sediments. Microelectrodes and nutrient flux measurements across gradients at the sediment surface have been used to assess the effects of microbial colonization and organic enrichment on material transfer across the sediment-water interface.

The Canadian contribution to a site description of the South Nares Abyssal Plain was compiled in 1986. This reviews available data on primary production, sedimentation, biomass distribution (pelagic and benthic overall size ranges), and benthic respiration. The contribution will be part of the Nuclear Energy Agency site description documents for a feasibility study of nuclear waste placement in abyssal sediments.

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La division d'océanographie biologique a continué ses recherches visant à étudier les processus de production primaire et secondaire dans l'estuaire et le golfe du Saint-Laurent ainsi que dans les baies d'Hudson et de Frobisher.

**Bactérioplancton:** La répartition et les processus de contrôle de l'abondance des bactéries dans l'estuaire du Saint-Laurent ont été décrits et analysés, afin de développer un modèle général de la dynamique des bactéries dans les estuaires. Ce modèle a été conçu de façon à être applicable à d'autres systèmes estuariens. D'autres études ont également été effectuées pour étudier la survie et la croissance des bactéries de part et d'autre de la transition saline dans l'estuaire du Saint-Laurent. La connaissance du sort des bactéries dans le système de l'estuaire du Saint-Laurent revêt un intérêt particulier si l'on veut dire et prédire ce qui arrive aux bactéries et aux autres contaminants contenus dans les eaux usées qui sont rejetées en grande quantité dans ce système.

Par ailleurs, les travaux pour étudier les microhétérotrophes, principalement les bactéries, dans la colonne d'eau et la glace dans la baie de Frobisher se sont poursuivis. Des mesures de carbone particulaire et dissous ont été effectuées ainsi que des mesures de biomasse, d'activité et de production bactérienne. Des difficultés rencontrées dans le calcul de la résolues par des mesures microscopiques de façon à en estimer indirectement la biomasse carbonique. Par ailleurs, les méthodes de filtration sélective et d'inhibiteurs métaboliques pour séparer les diverses activités microhétérotrophiques ont été évaluées. L'existence de microconsommateurs de bactéries a été démontrée et des mesures indirectes de leur activité ont été effectuées. Un effort considérable a été consacré cette dernière année pour tenter de relier la production primaire et la production bactérienne.

**Phytoplancton:** Un projet a été entrepris pour tenter de vérifier l'existence d'un mécanisme de photoadaptation rapide ("sun glass effect") chez les populations phytoplanctoniques estuariennes. Les trois hypothèses testées sont que ce mécanisme ne se retrouve que chez les espèces incapables de contrôler leur régime lumineux, que le temps de réponse des cellules aux changements des conditions lumineuses soit un facteur important pour la succession des espèces et, que des variations endogènes cycliques de la réponse phytoplanctonique soit en phase avec les événements dominants de l'environnement. Plusieurs expériences en laboratoire et sur le terrain ont été réalisées et l'analyse des données se poursuivra en 1987-88.

L'étude de la dynamique des éléments nutritifs et de la production primaire dans une région frontale et dans une zone d'upwelling du Saint-Laurent pour déterminer l'impact de telles régions sur la production phytoplanctonique et sur la survie larvaire de différentes espèces de poissons pélagiques s'est poursuivie par la réalisation de plusieurs missions d'échantillonnage en 1986. L'utilisation d'un véhicule onduant (V-Fin) a permis d'obtenir

des images quasi-synoptiques de la répartition de la température, de la salinité, de la turbidité et de la fluorescence dans ces régions, en même temps que l'échantillonnage sur transects de diverses variables biologiques (assimilation de sels nutritifs, chlorophylle, POC, PON, protéines, etc.). Ces régions sont soupçonnées constituer des aires d'alimentation privilégiées pour plusieurs espèces de larves de poisson. Comme l'alimentation de ces larves repose essentiellement sur la production phytoplanctonique, la compréhension de la dynamique de la production primaire dans ces régions est indispensable à la connaissance globale des processus régissant le transfert d'énergie vers les maillons supérieurs de la chaîne trophique.

Le projet d'étude de la production biologique dans la colonne d'eau et les glaces de la baie d'Hudson en était à sa dernière et plus importante année d'échantillonnage sur le terrain. Ces études visaient: 1) à estimer les échanges entre les différentes composantes des interfaces glace/eau/sédiments; 2) à comprendre l'impact de ces échanges sur l'écosystème, avant et après la fonte des glaces; 3) à comprendre les adaptations physiologiques des organismes qui vivent dans ces milieux, sous des conditions extrêmes de température et de lumière à l'interface glace/eau; et finalement 4) à évaluer l'influence des changements dans la circulation côtière et de la stratification sur les phénomènes mentionnés. Au cours de 1986, plusieurs projets différents ont été réalisés, impliquant la collaboration de nombreux chercheurs gouvernementaux et universitaires, ainsi qu'une équipe importante composée d'étudiants gradués, de techniciens et de plongeurs sous-marins. Des mesures de chlorophylle, de cellules, d'éléments nutritifs, de CHN, de CO<sub>2</sub>, d'assimilation du N<sup>15</sup> et du C<sup>14</sup>, du taux de sédimentation, du taux de sédimentation, du zooplancton, de courant, de lumière, etc., ont été réalisées au cours de 1986. Les résultats sont présentement en cours d'analyse. D'autres études sur les plantes marines ont été réalisées dans la Baie de Frobisher. Celles-ci ont examiné la composition spécifique, la distribution, la biomasse et le taux de production du phytoplancton et des algues de glace à différentes périodes de l'année. Des études sur l'influence de la lumière et de la température sur la production relative de lipides, protéines et carbohydrates par la flore planctonique et celle de glace ont également été effectuées.

Un projet sur l'écologie et la dynamique de population de l'algue *Protogonyaulax tamarensis*, un dinoflagellé marin responsable de l'empoisonnement toxique paralysant des mollusques dans l'estuaire du Saint-Laurent, s'est également poursuivi en 1986. Des cultures de cette algue ont été réalisées pour analyser les variations dans leur toxicité. Par ailleurs, des échantillonnages de terrain ont été effectués pour analyser la répartition des cystes de *Protogonyaulax* dans l'Estuaire et pour déterminer leur rôle dans le processus de déclenchement des "blooms." Un des objectifs de cette étude vise à développer et mettre en application une méthode de remplacement (HPLC et Autoanalyser) pour la méthode conventionnelle de bioessais sur des souris pour la détermination de la toxicité des mollusques.

Enfin, l'étude sur les mécanismes de synchronisation de la ponte de plusieurs invertébrés marins en relation avec le "bloom" printanier du phytoplancton s'est poursuivie. Il a été déterminé que la substance

Zooplankton et ichtyoplancton: Une étude a été réalisée pour déterminer les mécanismes qui sont responsables de la rétention et de l'accumulation des euphausiides au niveau de la pente du Chenal Laurentien dans l'estuaire du Saint-Laurent. Cette étude a démontré que ces accumulations résultaient de l'interaction entre la circulation, caractérisée par des remontées d'eau le long des pentes de la côte nord du Saint-Laurent, et le comportement d'évitement de la lumière du jour par ces organismes. Un modèle schématique a été proposé pour expliquer ce processus au niveau des pentes côtières.

Des programmes d'échantillonnage concernant trois projets sur la survie larvaire ont été réalisés au cours de l'été 1986. Un premier projet visait à étudier l'importance sur la production, la survie larvaire et le recrutement des zones frontales présentes dans l'estuaire. Le deuxième projet visait à vérifier la théorie des stocks de Illes et Sinclair dans le cas particulier de la zone de rétention des stades larvaires de hareng dans l'estuaire moyen du Saint-Laurent. Finalement, le troisième projet visait à étudier la dynamique des stades larvaires de poissons entraînés dans le courant de Gaspé. La mise au point et l'utilisation d'un véhicule sous-marin ondulant pour effectuer des mesures physiques a permis de réaliser des échantillonnages spatiaux à haute résolution et d'établir que les structures frontales sont importantes pour la disponibilité des proies. La survie et la croissance de plusieurs espèces de larves pourrait en dépendre. Plusieurs missions en mer ont été réalisées au cours de l'été 1986 et les résultats sont en cours d'analyse.

Dans un autre volet, un projet a été mis sur pied pour étudier les composantes fondamentales de la prédation et de l'alimentation chez les stades larvaires de certaines espèces de poissons. Il est possible, en effet, que la prédation soit largement responsable des fluctuations de la mortalité naturelle de l'ichtyoplancton. Au cours de 1986, des études écophysiologiques ont été effectuées sur certaines espèces de larves de poisson. De même l'existence de couches anti-réfléchissantes a-t-elle été mise en évidence pour plusieurs espèces de larves. L'importance de ces couches en ce qui concerne les problèmes de visibilité en regard avec la prédation est présentement étudiée.

Un autre projet visait à déterminer l'effet d'une variable comme les panaches d'eau douce sur la composition et l'abondance de la flore des glaces. Les résultats ont démontré que les panaches de rivière exercent une forte influence sur l'abondance et la variabilité de la faune zooplanctonique affectée. Ainsi donc, les changements dans la localisation et l'étendue du panache pourront avoir un effet majeur sur la chaîne trophique basée sur la faune des glaces. Les études se sont continuées à la baie de Frobisher pour déterminer les relations trophiques entre les organismes sous la glace et dans la communauté planctonique. Des observations sur la répartition verticale du zooplankton indiquent des mouvements verticaux marqués dans les eaux côtières semblables aux migrations verticales mieux connues en milieu océanique. Le cycle de vie du copépode cyclopoïde récemment découvert Arctocyclopina pagonasta a également été étudié en milieu naturel et en culture.



Un dernier projet visait à étudier l'écophysiologie de plusieurs invertébrés marins provenant du milieu nordique de la baie de Frobisher. Ce projet comportait des études sur le terrain et en laboratoire et visait à mieux comprendre les adaptations physiologiques variées utilisées par des organismes tels les amphipodes pour en arriver à supporter les oscillations saisonnières extrêmes des milieux nordiques. La biologie de reproduction et l'énergétique de plusieurs espèces de crevettes benthiques ont aussi été étudiés dans la région de Killiniq dans la baie d'Ungava.

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Field and laboratory studies concerning the ecology of early life-history stages of gadids off southwestern Nova Scotia and in the Gulf of Maine made substantial progress during 1986. Analyses of samples collected in 1985 from tidally mixed and stratified waters of Georges Bank (NAFO Division 5Ze) indicate the diel vertical distributions of juvenile (0-group) cod and haddock differ depending on the quantity and type of zooplankton prey available. In the mixed water mass where prey were abundant, juvenile cod and haddock both occurred deep in the water column and preferred the same type of prey. In the thermally stratified water mass where prey were less abundant, juvenile cod and haddock differed in their prey preferences and occupied separate portions of the water column (haddock being shallower than cod), reflecting the vertical distributions of their preferred prey items. These results have substantial implications for the design of surveys for juvenile gadids. Analysis of these samples also indicated an important interaction between juvenile gadids and the copepod ectoparasite Caligus sp. It was found that juveniles of both cod and haddock were heavily infested with this ectoparasite. However, infestation on haddock was predominantly about the head region, suggesting that Caligus sp. ectoparasitism may be a source of mortality for young haddock. Caligus sp. were also found to be a significant component of the fishes' diet, particularly for cod at the stratified site where zooplankton were less abundant. Considering the importance being placed on predation as a major contributor to recruitment variability, this study indicates that parasitism may also play an important role.

Three programs involving juvenile gadids were conducted in 1986. The first was a cooperative experiment with USA scientists (National Marine Fisheries Service) on Georges Bank to compare the abilities of the International Young Gadoid Pelagic Trawl and the MOCNESS sampler to collect pelagic Stage 0-group cod and haddock, and to determine potential avoidance reactions to these gears. This experiment also examined the mesoscale distributions of temperature, salinity, nutrients, chlorophyll, zooplankton, 0-group cod and haddock, and potential predators (dogfish) across a tidal front on the southern flank of Georges Bank. The second field program involved further joint Canada-USA research on juvenile cod and haddock on Georges Bank, but used a submersible to make in situ observations of gadid abundance and behavior. Preliminary results indicate visual observations of abundance were often much higher than estimates derived from research trawls, and that 0-group cod were distributed very close to the bottom during daylight, but made forays off the bottom at night. These cooperative studies are planned to continue in 1987. The

third field program involved the annual cooperative Canada-USSR autumn survey for juvenile silver hake on the Scotian Shelf. This survey included expanded coverage from the central core area. A general study was also completed examining the use of juvenile fish surveys for obtaining year-class strengths and recruitment estimates, based on surveys for cod, haddock, silver hake, and herring. Changes in availability to survey gear due to diel or ontogenetic vertical migrations pose particular problems for the development of abundance estimates. It was concluded that midwater trawl surveys should be used with caution for estimates of abundance, but are necessary for studies of distribution, behavior, and stock structure.

Laboratory studies of gadid ecology involved examination of larval cod condition when exposed to various prey densities. The weight/length<sup>3</sup> index was not correlated with prey density for early larvae, while body height standardized for length appeared to be a more sensitive index of larval condition. The ability of a larva to avoid a simulated predator was positively correlated with rearing prey density. The results of a buoyancy experiment indicated poorly fed larvae may occur nearer the water surface, and thus be more vulnerable to predation or cause a sampling bias in ichthyoplankton studies. Further techniques such as energy release, RNA/DNA ratios, and histological examination are now being used to assess condition of larval cod and haddock reared under various feeding regimes. Two of these techniques have not previously been applied to these species.

Growth rates of adult Gulf of St. Lawrence cod over the period 1957-73 were examined in relation to temperature, river discharge, population biomass, stomach fullness, and diet composition. Changes in growth were not related to temperature, biomass, or stomach fullness, but were positively correlated with the fraction of fish that occurred in the diet. The increase in consumption of fish during the period of accelerated growth of cod (1964-68) was attributed to predation on capelin.

Information on the distribution and timing of appearance of flatfish eggs on the Scotian Shelf, obtained during the Scotian Shelf ichthyoplankton program, was used with other data to examine whether existing management boundaries adequately reflect stock structures of these fishes. Preliminary results indicate the present management units are less than optimal. Larvae of winter flounder were sampled during spring and summer from an estuary adjacent to the mouth of the Bay of Fundy to examine their horizontal distribution and feeding relationships relative to the numerous but transient riverine fronts that occur in this area. An investigation of the potential for regular exchange of ichthyoplankton between Georges and Browns Banks has also been initiated, with particular application to stock structure and recruitment problems in these two regions.

The annual fall Bay of Fundy and southwestern Nova Scotia larval herring survey completed its standard grid of 163 stations. Additional sampling for chlorophyll and water clarity was made at several stations for comparison with satellite sea-surface temperature and color images. In addition, a new cooperative program was begun with scientists from the USA Maine Department of Marine Resources to investigate the transboundary nature of the herring population in coastal waters of eastern Maine and southwestern New Brunswick. Three surveys were conducted (early September, late September, late October) to locate major herring spawning sites in the

Bay of Fundy and central coastal Gulf of Maine, and to examine the subsequent dispersal of larvae. Detailed hydrographic information and samples of potential larval food organisms were also collected.

Further studies on herring included: analysis of southwestern Scotian Shelf and Bay of Fundy larval herring survey data from 1972-85 to determine its reliability and precision as an indicator of parent stock abundance, and for comparison with similar data for the eastern Atlantic; theoretical studies on stock concepts in marine teleosts and stock structures in Atlantic herring; studies on the use of the terms "passive drift," "migration," and "retention" in relation to the distribution of plankton; and stock-recruitment relationships in Atlantic herring.

During 1986, all programs associated with the Southwest Nova Scotia Fisheries Ecology Project, with focusses on all life-history stages of haddock, had entered the data analysis phase. Presentation of results and syntheses of findings are expected in 1987. However, new hypotheses resulting from this project are already being investigated. One such study in 1986 was an inshore survey of southwestern Nova Scotia to examine cod distribution and recruitment. Recently settled cod were located in the inshore region. Otolith microstructure examination of these juveniles is being used to determine the period during which these fish were in the pelagic stage.

The spatial and temporal patterns of groundfish distributions sampled from research surveys on the Scotian Shelf and in the Bay of Fundy were examined using cluster analysis and discriminant analysis. Species groupings were strongly aligned with the physical environment and consistent through time. A joint project with the fishing industry was also initiated to examine relationships between commercial catch rates and oceanographic features. The relationship of bottom temperature with silver hake catch rates by USSR commercial vessels on the Scotian Shelf was also examined, particularly to determine its influence on silver hake spawning migrations. However, regression analysis could determine no relationship, based on the limited data available.

Further surveys were conducted along the edge of the continental shelf and in adjacent oceanic regions to examine the distribution and ecology of mid-water and non-commercial fish species. This project also explores the interrelationships of neritic and oceanic systems.

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Annual blooms of the toxic marine dinoflagellate *Gonyaulax excavata* are responsible for paralytic shellfish poisoning (PSP) and occasional fish kills in the Bay of Fundy. Persistent levels of paralytic shellfish toxins above the public health safety threshold have resulted in a year-round harvesting closure of many prime shellfish areas in the southwestern Bay of Fundy. Research on the anatomical distribution of the toxins in soft-shell clams from one of the problem areas indicates a high percentage of the toxin load is confined to a small portion of the viscera in the vicinity of

the brown gland. Toxin content has been determined by both mouse bioassay and high-performance liquid chromatography (HPLC).

Analysis of five years of distribution and abundance data on toxic dinoflagellates in the Bay of Fundy has revealed several areas of high *G. excavata* accumulations in frontal zones which has been found for other dinoflagellate species in other locations. This frontal phenomenon may explain some of the seasonal inconsistencies in PSP levels such as that which occurred along the Nova Scotia coast of the Bay of Fundy in 1986. High concentrations of *G. excavata* detected from a fall cruise sampling of the southern Bay of Fundy frontal region predicted a PSP hazard. Reinstatement of shellfish monitoring that had ceased on the basis of normal seasonal PSP patterns resulted in a subsequent shellfish harvesting closure of the area.

The influence of heavy organic loading on the L'Etang Inlet, Bay of Fundy, was monitored in 1986 to determine the extent of pulp mill pollution as well as the possible problems resulting from fecal and waste food disposal in the vicinity of salmonid sea-cage culture sites. Hydrographic and sediment sampling of the area showed no obvious changes from a similar survey conducted in 1985.

Observations on the behavior of giant scallops, *Placopecten magellanicus*, placed in bottom culture were carried out using time-lapse photography. Scallop swimming behavior as affected by density and predation was tested in four experiments.

Experiments on the effect of flow velocity on scallop feeding were undertaken in a Blaxka respirometer. The results suggest that ambient flows influence feeding, causing inhibition at flows greater than  $10-16 \text{ cm}^{-1} \text{ sec}^{-1}$ . The mechanism is thought to involve interference of the scallop ciliary pump, which becomes inefficient at higher velocities, resulting in full or partial mantle closure. Growth experiments in controlled velocities in a flume confirm this inhibitory effect on feeding at greater than  $10 \text{ cm}^{-1} \text{ sec}^{-1}$ .

Estimates of benthic macrofauna production on Browns Bank, southwestern Scotian Shelf, and the composition, distribution, and utilization of the suprabenthos by groundfish have been developed as a part of the Fisheries Ecology Program.

Northwest Atlantic Fisheries Center, Biological Sciences Branch,  
P.O. Box 5667, St. John's, Newfoundland, A1C 5X1  
(M.C. Mercer, Regional Director)

An examination of factors affecting catch in the inshore cod fishery of Labrador and eastern Newfoundland was published in August 1986 (Can. Tech. Rep. Fish. Aquat. Sci. 1469). The study consolidates biological and oceanographic information during 1975-84 and uses principal component analysis to determine the interrelationships of these factors and their contribution to short- and long-term variability on the inshore fixed-gear fisheries for cod. Several hypotheses to explain variability are discussed and recommendations presented for future research.

A synopsis of research relevant to cod and redfish recruitment on the Flemish Cap was prepared for presentation at the NAFO Special Session on Recruitment Studies held in September 1986. This paper reviews the history of the project (since the late 1970's), the hypotheses posed and investigated, and progress in testing these hypotheses. Other papers presented dealt with recruitment variability in marine fish, a study designed to identify and measure certain sources of error in ichthyoplankton surveys, a numerical model of water movement on the Flemish Cap, abundance and growth rate of juvenile redfish on the Flemish Cap, 1978-85, size/number/weight of juvenile redfish of Ages 1 to 4 in stomachs of cod caught during Canadian surveys in 1978-84, a histological analysis of female cod caught during the prespawning period, data on fecundity, gonad weight and maturity of cod caught during the winters of 1978-85, condition factor of cod, and relationships between recruitment and either spawning stock size or temperature and salinity.

A new data base stock-recruitment projection method has been developed. The Rice/Evans method uses raw stock and recruit data for detection of a stock effect; the method has been applied in projecting the population size of the 2J3KL cod stock and seeking evidence of environmental effects on its recruitment.

Investigations have commenced (May 1986) on the consequences of interactions between components of the environment (e.g. food abundance and temperature) on the dynamics of marine organisms. The project focusses primarily on the variability of environmental conditions which may influence growth and mortality during the larval and early-juvenile stages of the life cycle of marine fish and potential consequences of such influence on their exploitation.

A research team has been identified to document changes in fish distribution and community structure that have taken place on the fishing banks of Newfoundland and Labrador, and analyse these changes in light of fishery and ocean climate effects in an attempt to gain insights into the processes involved. The group will avail of the extensive research vessel data base that has accrued since 1946.

Analysis of the recruitment dynamics of the major spring-spawning herring stock in the northwestern Atlantic demonstrated that environmental parameters were the major determinants of recruitment variability. Removal of the environmental variability revealed generic dome-shaped stock-recruit curves which were characterized by a high degree of compensatory density dependence in recruitment.

The Southeast Shoal (Grand Bank) larval yellowtail study will terminate in 1987. A primary manuscript on plankton and oceanographic data collected from the area appeared in the December 1986 issue of the Journal of Plankton Research.

The increasing importance of ocean climate in relation to resource availability and stock migration and distribution was especially evident this past year. Data on ocean climate were particularly integral to research vis-à-vis cod-capelin interactions and 2J3KL cod migrations.

Gulf Region, Biological Sciences Branch, P.O. Box 5030, Moncton, New Brunswick, E1C 9B6  
(J.S. Campbell, A/Regional Director)

#### 1. Inshore Surveys:

A time series of inshore surveys using small vessels was begun in 1984. To date, although detailed analysis has not been attempted, it appears that certain areas of the southeastern coast of Prince Edward Island have a predominance of small fish - both small species such as smelt, cunner, etc., and juveniles of larger species such as cod, white hake, plaice, etc.

High-density sampling in a bay of about 800 km<sup>2</sup> has identified a micro-distribution of various flatfish species that is missed at the normal level of sampling carried out in our research surveys.

#### 2. Herring Spawning Bed Surveys:

Spawning bed surveys of Atlantic herring (*Clupea harengus*) in the southern Gulf of St. Lawrence (NAFO Div. 4T) were continued in the fall of 1986. An underwater video camera was used to assist the SCUBA divers in locating and delineating the spawning bed. On September 2, schools of spawning herring were observed and monitored. On September 4, a spawning bed of an area 1.1 km<sup>2</sup> on Fisherman's Bank over a depth of 15 m was found. SCUBA divers collected samples of eggs to estimate egg density and spawning biomass. Samples of fish predators were also collected.

For the first time, we recorded Atlantic mackerel (*Scomber scombrus*) feeding heavily on herring eggs. The mean number of eggs per stomach was 3,900. Winter flounder (*Pseudopleuronectes americanus*) was another major predator, with a mean number of 7,600 eggs per stomach. The estimated egg mortality due to predation was 30% of the initial spawn. The egg density was estimated at 3,800,000 eggs/m<sup>2</sup>. The number of spawners was estimated at 58,200,000, comprising a spawning biomass of approximately 17,000 t.

#### UNIVERSITÉ DU QUÉBEC À RIMOUSKI

Département d'océanographie, 310 avenue des Ursulines, Rimouski, Province de Québec, G5L 3A1  
(B. Marinier, directeur)

Les travaux en océanographie biologique et en biologie marine se sont poursuivis sous quatre thèmes de recherche en 1986.

Le premier thème regroupe les travaux en dynamique des populations benthiques. L'objectif global de ces recherches est d'étudier les mécanismes d'adaptation des espèces à leur environnement. Dans un premier projet, la communauté à *Macoma balthica* de l'estuaire maritime du Saint-Laurent a été choisie pour mettre en évidence les facteurs et mécanismes qui interviennent dans la dynamique des populations benthiques des

substrats meubles intertidaux et pour analyser la valeur adaptative des stratégies démographiques en fonction des diverses pressions sélectives. Les travaux se sont poursuivis (G. Desrosiers et B. Vincent) en vue de connaître le cycle de développement de l'espèce, les variations inter- et intra-population, de vérifier la correspondance tactique/facteurs extrinsèques avec les modèles démographiques et de juger de l'importance des facteurs abiotiques.

En relation avec ce projet, une étude a été effectuée par J.-C. Brêthes et A. Mauviel sur les caractéristiques de la colonne d'eau en zone intertidale. On s'est intéressé aux variations de ces caractéristiques au cours d'une saison et au cours de cycles de marée. Une étude sur les taux de sédimentation et sur la nature du matériel sédimenté dans un tel environnement a également été réalisée.

Le projet de recherche sur l'écologie et la dynamique du crabe des neiges (*Chionectes opilio*) s'est poursuivi sous la responsabilité de J.-C. Brêthes en collaboration avec le Ministère de l'agriculture, des pêcheries, et de l'alimentation du Québec. On a étudié plus spécifiquement les déplacements à court terme (quelques jours) et à moyen terme (migrations saisonnières et annuelles) ainsi que les phénomènes de compétitions alimentaires intraspécifiques (jeunes/adultes, mâles/femelles) et interspécifiques entre les diverses espèces de crabes présents sur les mêmes fonds.

Le deuxième thème de recherche porte sur l'identification des unités de stock de hareng et à leur contamination dans le golfe Saint-Laurent. L'équipe de recherche qui poursuivait ces travaux a subi un dur coup en 1986 suite au décès d'Alcide C. Horth qui s'occupait de l'identification des protéines de certains tissus de hareng afin de connaître le bagage génétique de cette espèce. Le projet a subi en conséquence un retard important et a été repris et réorienté par Michel Bourassa. La caractérisation physico-chimique des protéines est désormais dirigée sur un nombre restreint de protéines des cristallins afin d'évaluer cette technique comme outil d'évaluation génétique des populations de hareng. Les études de contamination des stocks (M. Arnac et M. Khalil) se sont poursuivies.

Le troisième thème vise l'étude des relations entre le recrutement larvaire et les processus physiques dans le sud-ouest du golfe Saint-Laurent. M. El-Sabh en collaboration avec B. Côté de l'INRS-Océanologie ont poursuivi leurs travaux normalement sur ce projet. On étudie en détail les conditions physiologiques des oeufs et des larves et leur condition de vie en fonction des caractéristiques du milieu telles que la température, les tourbillons, les courants, etc.

La biologie du développement des invertébrés marins constitue un nouveau thème de recherche qui a débuté à l'automne 1985 avec l'arrivée à l'UQAR de François Dubé et Louise Dufresne respectivement chercheur-boursier et attaché de recherche du CRSNG. On sait d'une part que les invertébrés marins constituent un matériel de choix qui a été abondamment utilisé pour des études sur le développement embryonnaire. Chez les organismes à fécondation externe, la probabilité relativement faible de produire des larves venant à terme est compensée par une production très importante

d'ovules ou ovocytes. D'autre part, la compréhension des mécanismes fondamentaux régissant le début du développement des invertébrés marins a des retombées potentielles très diverses dans les domaines de la productivité biologique en milieu marin et dans l'identification de cibles physiologiques particulièrement sensibles aux agents polluants.

Les travaux se concentrent principalement sur le développement des oeufs d'oursin (Echinoderme) mais s'étendront sous peu à d'autres invertébrés marins, notamment les Mollusques bivalves. Les axes majeurs de cette recherche sont: 1) l'identification des processus ioniques responsables de l'accélération du métabolisme intracellulaire suite à la fécondation, principalement les effets de variations du pH intracellulaire mais aussi des fluctuations en ions calcium, sodium, et potassium; 2) l'analyse des effets de ces variations ioniques sur l'état de polymérisation d'une protéine du cytosquelette, l'actine et sur l'activité de synthèse protéique; et 3) l'identification des protéines dont la synthèse est essentielle au déclenchement et au déroulement normal de la mitose.

McGILL UNIVERSITY

Institute of Oceanography, 3620 University Street, Montreal, Province of Québec, H3A 2B2  
(J.B. Lewis, Director)

J.B. Lewis continued his work on the cryptofauna of reef corals and demersal reef zooplankton with P. Snelgrove and J. Boers. Life history strategies of several species of shallow water corals were examined and investigations of nutrient loading by ground water onto coral reefs in Barbados was initiated. Spatial and temporal variations in ground-water discharge have been observed, and significant discharge of nitrates and phosphates is occurring onto the reefs.

M.J. Dunbar, with M. de Sève, will be completing the study of the ice biota in the Magdalen Islands region in the Gulf of St. Lawrence this summer. The ice biota research carried out in northern Baffin Island (C. Rymes) is completed and will be published in due course. Work is continuing on cycles of abundance and environmental factors in the sea. A conference on polynyas, with special reference to the North Water polynya in northern Baffin Bay, will be held at McGill University in October 1987.

H.M. Reiswig began laying a foundation for a review of the Hexactinellida (glass sponges) of North America by survey of the institution holdings of the West Coast of the U.S.A. from San Diego, California to northern Oregon. Museums, universities, marine laboratories and other institutions were visited to determine the size and status of collections of this class. Specimens were photographed, and where possible, fragments were obtained for development of a catalogue centre at McGill's Redpath Museum. Survey of the East Coast institutions, where many of the type specimens are located, is planned for 1987, with European collections to be inspected the following year. The long range plan is development of extensive distribution maps for use in specimen identification in photographic and video surveys of the continental borderlands of North America.



B.M. Marcotte -Quantified the effects of diet and social interactions on learning and memory in juvenile Atlantic salmon. Established the functional morphology of evolving prehensile oral appendages in harpacticoid copepods. Described the naupliar development of two cyclopoid and one harpacticoid species living in Arctic sea-ice. Quantified the distribution and reproduction of Arctic shrimp. Quantified the distribution and ecological physiology of two Arctic amphipods.

DENMARK

(Vagn Hansen)

1. University of Copenhagen  
Institut for Sporeplanter (thallophytes)
  - 1.1. Plankton, unicellular algae.
    - 1.1.1. Taxonomy and ultrastructure of marine nanoplankton, especially prasinophytes (Ø. Moestrup).
    - 1.1.2. Taxonomy, fine structure and ecology of the potentially toxic dinoflagellate *Gonyaulax excavata* from Denmark and the Faroe Islands (Ø. Moestrup).
    - 1.1.3. Taxonomy and distribution of benthic euglenoids and dinoflagellates (J. Larsen).
    - 1.1.4. Marine nanoplankton, especially haptophytes and choanoflagellates, taxonomy, ultrastructure and biogeography (H. Thomsen).
    - 1.1.5. Ultrastructure and pigment composition of *Gymnodinium nagasakiense* from Australia (J. Larsen).
    - 1.1.6. Taxonomy of unarmoured dinoflagellates from the Bass Strait, Australia (J. Larsen).
  - 1.2. Benthic macroalgae.
    - 1.2.1. Experimental studies on the effect of temperature on growth and reproduction in various populations of the brown alga, *Scytosiphon* (Aa. Kristiansen and P.M. Pedersen).
    - 1.2.2. Culture studies on life history and taxonomy in brown algae from Lanzarote and the North American Pacific coast (P.M. Pedersen)
    - 1.2.3. Culture studies on life histories and taxonomy of small epi- and endophytic/-zoic green algae from Canada, New Zealand and Finland (R. Nielsen).
2. University of Odense  
Institute of Biology
  - 2.1. Biochemistry/Physiology
    - 2.1.1. Gluconeogenesis in *Arenicola marina*: Purification and regulatory properties of fructose 1,6-biphosphatase (T. Mustafa).

- 2.1.2. Comparative biochemical and physiological studies of vitellogenesis in various teleosts (B. Korsgaard).
- 2.1.3. Transport and turnover of low molecular compounds in context to maternal-fetal metabolic relationships in lower vertebrates (B. Korsgaard).
- 2.1.4. Blood adaptations to high-speed swimming in the Pacific gamefish, blue marlin (Maikara nigricans), striped marlin (Tetraterus angustirostris) and short-billed spearfish (T. audax) (R.E. Weber)
- 2.1.5. Adaptation in hemoglobin function to deep sea habitats in the teleost Coryphaenoides acrolepis (R.E. Weber)
- 2.1.6. Blood adaptations to water temperature, salinity and cadmium concentration in the hermit crab, Pagurus bernhardus (R.E. Weber)
- 2.2. Ecology
  - 2.2.1. Deposit feeding and carbon budget in marine invertebrates (L.H. Kofoed)
  - 2.2.2. Microbial symbiosis in the digestive tract of marine invertebrates (L.H. Kofoed).
  - 2.2.3. A comparison of oxygen microgradients, oxygen flux rates and electron transport system activity in coastal marine sediments (F.Ø. Andersen)
  - 2.2.4. An experimental approach to quantify biologically mediated enhancement of dissolved silicate transport at the sediment-water interface (F.Ø. Andersen)
  - 2.2.5. Influence of macrofauna on photosynthesis and mineralization in coastal marine sediments (F.Ø. Andersen & E. Kristensen)
  - 2.2.6. The fate of organic carbon and nitrogen in experimental marine sediment systems: Influence of bioturbation and anoxia (E. Kristensen)
  - 2.2.7. Determination of organic carbon in marine sediments: Comparison of two CHN-analyzer methods (E. Kristensen & F.Ø. Andersen)
  - 2.2.8. Direct measurements of denitrification and total nitrate reduction in polychaete burrows (E. Kristensen)
  - 2.2.9. Measurement of pumping rates in Mytilus edulis by means of a new method for determination of "pump-characteristics" and influence of laterofrontal cirri in particle retention (H.U. Riisgård).

### 3.3. Toxicology

3.3.1. Assessment of biomagnification of mercury in marine foodchains by measuring uptake, turnover and elimination of organic and inorganic mercury in fish and mussels (H.U. Riisgård)

3.3.2. Effect of cadmium exposure on Arenicola marina. 1. changes in body weight through coelomic fluid losses (T. Mustafa) & P. Bjerregaard). 2. changes in burrowing ability, ventilation, O<sub>2</sub> uptake and CO<sub>2</sub> production (T. Mustafa & E. Kristensen)

3.3.3. Uptake and effects of heavy metals on marine invertebrates, with special emphasis on the effects of selenium on cadmium uptake (P. Bjerregaard)

### 4. Greenland Fisheries and Environment Research Institute

#### 4.1. Zoo- and ichthyoplankton.

On the June/July cruise along Western Greenland from Nuuk to Disko zoo- and ichthyoplankton were sampled with a Bongo net in connection with hydrographical work.

### 5. Danish Institute for Fisheries and Marine Research Copenhagen

The Department of Fish Ecology continued, in 1986, to concentrate research efforts on field and laboratory studies of herring larvae. Two cruises were carried out in the western and central North Sea with the goal of mapping herring larvae distributions (both vertical and horizontal) in relation to hydrography, primary and secondary production. In addition, current meter measurements were carried out from Sept. to Nov. near the herring spawning grounds in the Buchan Area. In the laboratory, studies were carried out on herring larvae respiration as a function of biomass and feeding regime as well as on digestion processes in herring larvae. Other projects carried out in the Department include: hydrographic and plankton studies along the Danish west coast and in the northern Kattegat as well as laboratory studies of copepod (Acartia tonsa) bioenergetics and grazing. Efforts to culture Calanus finmarchicus were also initiated.

Danish Institute for Fisheries and Marine Research  
Hirtshals.

- 6.1. An immunoassay is being developed in cooperation with the State Serum Institute with the purpose of detecting predator/prey relations in larval fish.
- 6.2. Mesocosm studies are conducted on phytoplankton/zooplankton production and growth and survival of larval turbot.
- 6.3. In-situ determination of growth rates of North Sea herring larvae using drifting Buoys.
- 6.4. Development of procedures for calculating production of larvae of North Sea Herring.

FINLAND  
(J.M. Leppänen)

Finnish Institute of Marine Research

Studies on long-term fluctuations and population dynamics of phyto- and zooplankton as well as macrozoobenthos, started in 1961, were continued in the entire Baltic Sea including the Baltic Monitoring Programme of the Helsinki Commission.

Studies on the cycling of organic matter, with the aim of quantification of the main energy and elemental fluxes in the food web of the open Baltic were continued. This involved investigations on primary and secondary production and on the decomposition at different trophic levels as well as on sinking of particulate matter. An essential purpose of the study was to elucidate the interaction between the benthic and pelagic systems.

The studies on the role of planktivory in the functioning of the pelagic ecosystem were directed to the feeding strategies of the Baltic herring and to the importance of gelatinous predatory zooplankton.

National Board of Waters, Water Research Office, Helsinki

Phytoplankton primary production, chlorophyll *a*, and phytoplankton were measured at coastal monitoring stations in both polluted and unpolluted areas. At four stations the sampling frequency was high. Special investigations were performed off several residential areas.

Studies on the influence of industrial pollution on the composition of benthic macrofauna were continued at several localities along the coast of Finland.

Finnish Centre for Radiation and Nuclear Safety, Helsinki

Environmental radioactivity monitoring and radioecological studies on selected species were carried out in the vicinities of two nuclear power plants, one situated on the coast of the Gulf of Finland, and the other one on the coast of the Bothnian Sea.

Studies on phytoplankton, primary production, and zoobenthos were continued in the sea areas around the two nuclear power plants.

Tvärminne Zoological Station, University of Helsinki

The research carried out at the station includes a broad spectrum of studies on brackish water ecology, basic physiology of brackish water animals, population genetics of Baltic molluscs, and effects of pollutants on selected coastal species.

The most extensive project deals with the pelagic system: phytoplankton/bacterial relationships, coupling of autotrophy and heterotrophy, and diurnal dynamics of biological interactions. The studies on the different processes are carried out with long-term measurements in the Baltic Sea as a background. Nutrient cycling is being analyzed and coupled with the dynamics of the metabolism of the microbiota. Enclosure experiments are used to evaluate the effects of variations in biotic and abiotic factors on the community metabolism.

#### Husö Biological Station, Åbo Akademi

Monitoring studies were continued at fixed stations in the Åland archipelago for long-term fluctuations (natural reference areas for the northern Baltic Sea) and pollution control (municipal effluents, food industry, fish farming, oil pollution). The nearshore monitoring was combined with monitoring of zoobenthos at the open sea in collaboration with the Finnish Institute of Marine Research.

Ecological studies were carried out on phyto-benthos (Fucus vesiculosus community) in relation to seasonality and exposure to wave action (including the ecology of rock pools) in NW Åland archipelago. Interactions on shallow softbottoms in the archipelago were studied experimentally in the field and laboratory, including studies on biotic interrelationships and structuring mechanisms in zoobenthos and fish. Investigations on zoobenthos recovery potential and colonizing strategies were continued.

#### Archipelago Research Institute, University of Turku

The work at the station included basic research on the ecosystem of archipelago waters, eg. production ecology of zooplankton and population dynamics of typical coastal species. Examples of applied research were studies on fouling, man-induced changes of biocenoses, and effects of waves caused by ferry traffic on fisheries. Studies on the effects of aquaculture on the environment were continued.

#### Perämeri Research Station, University of Oulu

Studies on the population density of near-bottom fish have been continued in three areas representing different types of exposition and pollution load.

Studies on the population dynamics of benthic macrofauna were continued.

An ecosystem research project in the Bay of Liminganlahti was continued. It includes investigations on nutrients, phyto- and zooplankton, benthic flora and fauna as well as waterfowl and input of water and organic matter from rivers.

Germany, Federal Republic of

(J. Lenz)

INSTITUT FOR MEERESKUNDE AN DER UNIVERSITÄT KIEL

The institute with its 5 biological departments covering botany, zoology, microbiology, planktology and fisheries biology is engaged in a great number of activities falling within the scope of biological oceanography. The following enumeration of recent and current research activities is conventionally subdivided into planktological and benthological projects, though the interaction of biological processes between both ecological zones in shallow sea ecosystems forms the main topic of interest in a number of projects.

Planktological investigations

In addition to monthly sampling of the monitoring stations for HELCOM in Kiel Bight, the water column at the Institute's pier was sampled two times a week in order to follow short-term changes in water chemistry and plankton composition.

Within the framework of a research project on eutrophication in the Baltic, oxygen consumption rates were measured in water samples under in situ conditions during the course of the year in order to follow the regular development of oxygen deficiency in deeper parts of Kiel Bight and Kiel Fjord during summer and autumn.

The occurrence and abundance of phytoplankton resting stages in sediment traps and on the sea bottom in Kiel Bight was investigated. A pronounced seasonal cycle was detected mirroring the predominant plankton blooms in spring and autumn.

Natural fluorescence of phytoplankton algae was modelled on the basis of field and laboratory data. The results show an inverse relationship with chlorophyll concentration in the water column and a considerable variation according to irradiance and, probably, physiological stage of the algae.

In a joint study with the Institute of Oceanology of the Polish Academy of Sciences in Sopot, experiments on wave-induced sunlight flashes on primary

production of phytoplankton were carried out in Kiel.

A newly developed turbulence incubator for measuring primary production of phytoplankton under the natural conditions of the mixed surface layer was tested and first results obtained.

A number of tank experiments were carried out under various conditions in order to study nutrient cycles, phytoplankton growth in dependence of light supply and the grazing and faecal pellet production by copepods.

Within a new project on particle flux in the North Atlantic, a new type of sediment trap was tested during cruise No. 1 of the new RV 'METEOR'; samples of phytoplankton and particulate matter were collected and analyzed.

Work on phyto- and zooplankton distribution in the Norwegian and Greenland Sea was continued with special emphasis on grazing and faecal pellet production by copepods.

Intensive studies on the abundance of eggs and larvae of cod and sprat in the Baltic, of herring in the North Sea and adjacent waters and of mackerel in the Bay of Biscay and the Celtic Sea were continued and their fine-scale distribution analyzed.

#### Benthological investigations

Experiments on metabolism of microphytobenthos of soft-bottom communities were started.

A study on nutrient supply in macroalgae communities in Kiel Bight showed that there is apparently no limitation during the summer months. Particulate matter originating from macrophytes is transported into deeper parts of Kiel Bight. This could be documented by under-water television and the analysis of algal pigments.

1986 was the official start of the benthic monitoring programme according to HELCOM recommendations. A strong oxygen deficiency was observed again as in former years below the 20 m depth in Kiel Bight and a fish kill in Kiel Fjord in autumn.

A study on macrozoobenthos distribution and abundance with a sampling grid of 15 stations in Kiel Bight over a 5-year period (1981-85) was completed.

Small-scale variability in the occurrence of macrozoobenthic organisms was studied in the field and laboratory. Preliminary results show an antagonistical distribution pattern between the two dominant species Arenicola

marina and Pygospio elegans.

Seasonal changes in the biochemical composition of the sponge Halichondria panicea were followed through the year. Respiration rates were apparently influenced by epiphytic or symbiotic algae within the sponge tissue.

The seasonal flux of carbon and organic matter in the upper sediment layers was measured along a section through the western part of Kiel Bight.

A new type of water sampler for the boundary layer water/sediment was developed and successfully employed.

Laboratory experiments on the energy flux within the benthos community confirmed field observations by simulating the sedimentation of a spring and autumn phytoplankton bloom. The organisms reacted within hours to the sedimentation event and their increased activity could be followed down to 7 cm into the ground. Energy conversion from freshly sedimented material to body tissue reached 50 - 60 % at the sediment surface and 30 - 40 % in the deeper parts of the sediment.

A symbiosis between the bivalve Limantula subauriculata and chemoautotrophic bacteria was investigated and a similar symbiosis in Halicryptus spinolosus.

The tube system of macrofauna with their inhabiting meiofauna was intensely studied in sedimented samples from deeper parts of the Norwegian Sea.

A newly developed multiple in situ calorimeter with a high sensitivity enabled the measurement of benthic activity even at a bottom water temperature of -0.5° C in the Norwegian Sea. Sedimentation of the spring bloom led to a marked increase of metabolism of the bottom organisms.

Population dynamics and food selection of Ophiura albida and Dyastylis rathkei were studied in Kiel Bight.

Investigations on the nutrition of pogonophora were continued. In the Skagerrak the newly described species Siboglinum poseidoni apparently occurs in the vicinity of so-called pockmarks where methane rises from the bottom. This is a further indication that its symbiotic methane oxidizing bacteria depend on this energy source.



ZOOLOGISCHES INSTITUT DER UNIVERSITÄT KIEL

Benthic investigations in the highly polluted Flensburg Fjord were continued with recolonization experiments on seasonal larval settling patterns. Changes in benthic structure as a response to artificially organically enriched sediments are being studied in another submarine experiment. Recolonization analysis of 3-year series of bottom samples from defaunated areas in the deeper parts of the fjord continues.

Experimental work on the biology and behaviour of socially living amphipoda was summarized by producing a film on Dulichia porrecta in collaboration with the IWS (Institut für den wissenschaftlichen Film) Göttingen.

Investigations on the sensitivity of an intertidal flat to oil pollution with special reference to meiofauna were continued.

A preliminary report on a restricted area of about 700 km<sup>2</sup> was finished.

Based on field experiments on intertidal flats, other ecological studies deal with the influence of macroinfauna on nutrient concentrations in pore waters and the role of Nereis diversicolor on the establishment of a benthic community. By means of laboratory experiments burrow structures and sediment reworking by polychaetes and molluscs were studied.

Investigations on intertidal hard-bottom communities (Island of Helgoland) are still running with special reference to development, persistence, maintenance and organization. Furthermore the influence of predation, grazing and interspecies competition is being observed. Using experimental field techniques, ecology of intertidal gastropoda (e.g. Littorina spp.) is being studied, especially their preference for different algae of hard-bottom substrata.

Further hard-bottom investigations focus on the black zone in the supralittoral fringe of artificial rocky shores. Faunal composition and adaptation to varying abiotic factors are under study.

The long-term investigations on harpacticoidea in the Western European Deep Sea (47° N, 20° W) were continued. Further samples were taken from 3700 m to 4500 m water depth during 'METEOR'-cruise 3 in July/August 1986. The material is under examination from taxonomic and ecological viewpoints.

INSTITUT FÜR HYDROBIOLOGIE UND FISCHEREIWISSENSCHAFT DER UNIVERSITÄT HAMBURG

North Sea studies

Our investigations concerned:

- the small-scale distribution of the benthic fauna in order to develop an optimal sampling strategy;
- the concentration of heavy metals in and by several macrofaunal species in littoral and sublittoral regions;
- determinations of the concentrations of chloroplastic pigments and proteins in the sediment surface, in cooperation with the 1986 survey of the ICES Benthos Group;
- the distribution of larger epifauna (trawl fauna) throughout the North Sea in cooperation with the ZISCH-Projekt of the University of Hamburg in order to study the spatial distribution of heavy metals in organisms;
- the development of benthic stock after industrial disturbances;
- community development in an artificial marine lake with distorted tides;
- the development of bivalve populations after severe winters;
- the influences of artificial seagrass substrates on the benthos.

Deep-Sea Research

The BIOTRANS-Projekt has been continued. At 47°00' - 47°30' N and 19°00' - 20°00' W an intensive study on all benthic organism groups, on the near-bottom plankton and on benthopelagic organisms has been carried out. The project aims at the measurement of biological activities and transports in the deep ocean. During 'METEOR' cruise 3, microbial studies were conducted under in situ pressure and in pressure vessels on board the ship. Respiration was measured for the first time in situ by a free fall system at a depth of 4500 m. The discovery of phytodetritus on the sediment surface, even in this high oceanic deep-sea region, has been of great interest.

BIOLOGISCHE ANSTALT HELGOLAND

Routine measurements of hydrographical, chemical and biological parameters have been continued at Helgoland Roads (54°11,3' N, 07°54,0' E). Five

times a week, temperature, salinity, nutrients ( $PO_4$ ,  $NO_3$ ,  $NO_2$ ,  $NH_4$ ,  $SiO_2$ ), yellow substances ('Gelbstoff'), and biomass as organic carbon, derived from microscopic counts (inverted microscope), were measured.

In addition once a week, bacterial numbers (pour plate method) in the surface film and at a depth of 1 m were determined and BOD and surface tension measured. In the 1 m samples also yeasts and oil-degrading microorganisms were counted.

Monthly cruises from Helgoland to the estuaries of the Elbe River, the Eider River, and the Weser River for hydrographical, chemical, and biological investigations have been continued.

The annual cruise to the eastern Wadden Sea with hydrographical, chemical and biological investigations has been continued.

The long-term ecological studies on temporal and spatial distribution of Noctiluca miliaris in the German Bight have been continued. Seasonal fluctuations and annual abundance of this dominant dinoflagellate have now continuously been recorded over a period of 21 years at Helgoland Roads.

A survey investigating causes and effects of oxygen deficiency in the south-eastern North Sea (east of  $6^{\circ}20'$  E, south of  $57^{\circ}00'$  N) was continued. Seston and its organic carbon and nitrogen content, phytoplankton concentrations, dissolved oxygen, micronutrients, salinity and temperature were measured. Sampling was carried out in vertical series of water samples on a grid of stations 12.5 nautical miles apart from each other during four cruises in April, June, August and October with R.V. 'FRIEDRICH HEINCKE'.

The ecological studies in the northern Wadden Sea of Sylt (German Bight) were carried on. 64 times a year the following parameters were measured at four different stations (depending on the weather-conditions):

Phytoplankton, mesozooplankton, seston components, temperature, salinity, pH, oxygen and phytoplankton nutrients ( $NH_4$ ,  $NO_2$ ,  $NO_3$ ,  $SiO_3$ ,  $PO_4$ ).

#### ALFRED-WEGENER-INSTITUT FOR POLAR- UND MEERESFORSCHUNG, BREMERHAVEN

##### Planktological investigations

The study of the relationship between hydrographic fronts and horizontal distribution of chemical and biological properties of water masses is being

terminated in the southern German Bight. Further work on plankton and marine microorganisms is being conducted almost exclusively in Antarctic waters.

#### Benthological investigations

In April 1986, RV 'VICTOR HENSEN' took part in a synoptic benthos survey within the framework of an ICES programme including 9 European institutes and 7 research vessels. Samples of sediments, pigments and protein as well as of meio-, meso- and macrofauna were taken as far as 57° N, and are presently being analysed.

Monitoring of macrobenthos communities in the German Bight was continued, and sampling of macrobenthos communities in the central North Sea was also carried out for comparison.

The study on initial colonization and succession of soft-bottom macrobenthos at the North Sea Research Platform was completed, and part of the data have been analysed. Both in 1985 and 1986 densities and species numbers increased during summer, but there were differences in the kind of colonizers and in the period the newcomers were able to maintain a dominant position within the community.

Another investigation using the 'Bremerhaven Caissons' was started in the Wadden Sea. The main objective is to quantify the 'small food web', i.e. the impact of the O-Group of herbivorous macrobenthos, testing the hypothesis that a major pathway of energy flux might go this way.

Meiofauna laboratory investigations indicate that free-living marine nematodes might use acetate as a food source. In another study a special nematode fauna as found in 'green detritus' freshly sedimented to a 4500 m deep Atlantic deep-sea bottom.

#### FORSCHUNGSMUSEUM SENCKENBERG, WILHELMSHAVEN

Within the framework of the ICES Working Group on North Sea Benthos, sediment and benthos samples were taken from the German, Dutch and British economic zones and analyzed for drawing distribution maps and estimating biomass production.

Within an interdisciplinary cooperation programme, sediment cores from the

southern and northern Dogger Bank were studied for their sedimentological characteristics and content of botanical (pollen) and zoological remnants. Preliminary results reveal the history of this area in the early Holocene and oscillations in sea level and its rise during the past 8000 years.

Benthos investigations carried out during the international COST-647 Project devoted to fluctuations of littoral communities along European coasts were continued off the island of Norderney. The results presented at an international symposium in Brussels show not only annual fluctuations but point to long-term changes on the species level and standing stock of benthic communities.

A pilot study on the sensitivity of benthic communities to pollution by hydrocarbons was completed in the Wadden Sea between Cuxhaven and Bremerhaven and a new study started in the area between the East Frisian islands and the mainland.

Studies on population dynamics and productivity of selected species living in the eu- and sublittoral zones were continued in order to gather information on standing stock development, growth rates and generation times.

Investigations on anthropogenic impacts on the epibenthos in the Jade Bight and on the endobenthos of the marine-terrestrial transition zone at the island of Mellum were also continued.

ICELAND

(O.S. Astthorsson & Th. Thórdardóttir)

**Phytoplankton (Th. Thórdardóttir)**

During the annual hydrobiological spring survey (20.5.-10.6.) of the waters around Iceland, routine measurements of primary production (0, 10, 20 and 30 m) and Chl a were made at fixed hydrographic stations. More detailed studies were carried out in specific areas. Simultaneous measurements of primary production *in situ* and in incubator were made 5 times during a 24 hour period in the Arctic waters northeast of Iceland (pos. 68°00'N 12°40'W). Primary production, Chl a (depth range 0-75m), PvsI curves and C:N ratio of phytoplankton were obtained in Atlantic, Arctic and mixed waters off the southeast coast of Iceland.

In July measurements of primary production *in situ* and in incubator at light saturation were compared several times at a location in Faxabai near Reykjavik (pos. 64°14'N 22°03'W).

**Zooplankton (O. S. Astthorsson)**

Long term studies on the densities and composition of zooplankton in the Icelandic shelf area during spring were continued. Similarly, the distribution and composition of zooplankton was investigated in connection with the survey of 0-group distribution in the autumn.

Work has continued on the predation of euphausiids by cod in the subarctic shelf waters north-west, north-east and south-east of Iceland.

Studies on the biology and ecology of shallow water mysids in Skerjafjord (on the south-west coast near Reykjavik) are in progress.

The Institute for Marine Environmental Research in Plymouth has been assisted in the running of their Continuous Plankton Recorders between Iceland and Scotland, and Iceland and the U.S.A.

IRELAND

(R. Grainger)

The Fisheries Research Centre has conducted surveys for herring larvae in ICES Divisions VIa and VIIb each year during October and November since 1981. A mackerel egg survey in Divisions VIa and VIIb was also undertaken in May 1986 in conjunction with the fishing industry.

The University College, Galway is involved in ichthyoplankton research off the west coast of Ireland and, in particular, Galway Bay. This work is mainly descriptive but vertical and horizontal distributions are examined in relation to physical and chemical oceanographic data collected concurrently. This university is also involved in community mapping and population studies of benthos in Irish coastal waters and in the Celtic Sea.

The Irish Phytoplankton Research Group in conjunction with the Fisheries Research Centre conducts research into various aspects of marine phytoplankton ecology with most of the emphasis on "red tide" organisms.

The Shellfish Research Laboratory is investigating primary production in various Irish estuaries to gain information on their carrying capacities for mariculture and the potential growth of shellfish.

Trinity College, Dublin carries out research into benthic community structure and dynamics in Dublin Bay.

## NETHERLANDS

(N. Daan & J.J. Zijlstra)

### Netherlands Institute for Sea Research, Texel (J.J. Zijlstra)

Studies in coastal waters as the Wadden Sea concerned a.o. the role of oil pollution on a tidal flat ecosystem (mesocosm study) and the effect of eutrophication were continued. Both short and long-term effects of oil pollution on benthic macrofauna were found. Effects on the fauna were enhanced by the use of detergents. The effect of eutrophication on the intertidal macrofauna, which was reported last year, appears to be mainly numerical, that is the numbers of individuals are increasing because of an improved recruitment. However, in the species *Macoma balthica* both recruitment and growth increased. Studies on the recruitment of macrobenthic species is continued.

In the North Sea the synoptic mapping project, an international exercise to study distribution and abundance of the benthic fauna was carried out successfully. The effort of the Netherlands mainly concerned parts of the southern and central North Sea, in which some 300-400 boxcore samples were collected, together with 59 trawl-catches. Most of the sorting of the material is finished, in part of the benthic animals contamination levels have been determined.

During early summer (May-June) a special study was made of a transitional area between mixed and stratified waters north of the Dutch coast. The study on this frontal zone, which at the time was developing, included physical studies on both small-scale turbulence and large-scale water movement (current meter moorings). In addition, studies were made on nutrient dynamics, phyto- and zooplankton development, and distribution and activity of pelagic predators. Also, the benthic fauna and the mesoplankton in the area were investigated.

### Netherlands Institute for Fishery Investigations, IJmuiden (N. Daan)

#### Stomach sampling studies

Stomach sampling of cod and whiting in the first quarter and third quarter was continued in 1986.

#### Phytoplankton studies

Monitoring of exceptional algal blooms with potential toxic effects upon consumers of shellfish was continued. In the North Sea a bloom of *Dinophysis* spec. (with a large component of *D. acuminata*) has been observed medio September. Peaks of more than 5000 cells per L have been recorded 20 km offshore.

Also in the Dutch Waddensea *D. acuminata* was observed, firstly in one station on 1 September. During September they spread over the mussel sites in an average concentration of ca. 100 cells per L. D.S.P. levels in mussels increased gradually during the month.

#### Energy budgets

In the ongoing study of the energetics of reproduction and growth of North Sea plaice, fish samples have been taken in the first quarter to determine energy loss during the spawning period of both sexes. In addition, a maturity survey has been conducted to study the spatial distribution of plaice as a function of length, age and stage of maturity.



NORWAY

(H. R. Skjoldal)

1. Institute of Marine Research, (IMR) Bergen  
Biological Station Flødevigen, (BSF) Arendal.

1.1 Phytoplankton

1.1.1 Studies on the phytoplankton ecology in the Barents Sea continued. A cruise with icegoing Coast guard vessels permitted to investigate the early spring bloom phase both in ice covered and ice free ocean water. This study is part of an interdisciplinary program designed to investigate the biological production system in this important fishing area (IMR) and is integrated with the Norwegian Research Program for Marine Arctic Ecology (PRO MARE).

1.1.2 A long-term programme on the environmental conditions of the Norwegian fjords was continued. In November-December 30 fjords were surveyed and analysis of nutrients, oxygen, salinity and temperature were made.

1.1.3 The spring phytoplankton development in the Lofoten area (Northern Norway) was again studied. Once to twice a week during March and April nutrients, chlorophyll and species composition were analysed. (Integrated with 1.2.3).

1.1.4 Samples for nutrient, chlorophyll and phytoplankton species composition were obtained at cruises off the Western Norwegian coast as a part of an interdisciplinary program studying fish eggs- and larvae distribution. (Integrated with the Institute's program on fish eggs and larvae).

1.1.5 Monitoring of toxic phytoplankton in the Skagerrak and along the southern coast of Norway.

1.1.6 The distribution and ecology of toxic phytoplankton in the Skagerrak and along the southern coast of Norway was studied, Biological Station, Flødevigen (BSF).

## 1.2 Zooplankton

1.2.1 A programme on acoustic estimation of zooplankton by means of multiplefrequency sonar systems continued. Results were compared with observations with conventional gears (Juday nets, Gulf III, and Tucker nets).

1.2.2 A study of the zooplankton at the ice edge in the Barents Sea continued. (Integrated with 1.1.1)

1.2.3 An interdisciplinary programme on the spawning success and the survival of cod larvae continued in 1986 with emphasis on the feeding conditions for the larvae. Mocness 1m<sup>2</sup> and a plankton pump were used to study the cod larvae and the zooplankton distributions.

## 1.3 Ichthyoplankton

1.3.1 Investigations on the distribution of herring larvae in order to localize the spawning grounds along the coast continued. Eggs and larvae of other species were also recorded.

1.3.2 Post larvae surveys (since 1977) continued with the aim of establishing indices for the abundance of different species, with emphasis on cod.

1.3.3 Investigations on mackerel eggs in the North Sea continued.

Based upon intensive egg surveys, one aims at establishing the abundance of the North Sea mackerel spawning stock.

1.3.4 Investigations on cod eggs and larvae continued in the

Lofoten area (see 1.2.3). In 1986 egg surveys were conducted during the spawning season covering the total spawning area in order to estimate the abundance of the spawning stock of Arcto-Norwegian cod.

1.3.5 A study of the coastal cod stock in the Møre region continued, including surveys on the eggs and larvae distribution.

1.3.6 Investigations on the distribution and abundance of capelin larvae continued in cooperation with the USSR.

1.3.7 Investigations on eggs and larvae of sprat were carried out to determine the state of spawning in the Ryfylke and Nordfjord areas of western Norway (BSF).

2. University of Bergen

Department of Marine Biology

2.1 Studies on the biology of the food-species of young cod in a fjord (Masfjorden) where large amounts of artificially reared cod are to be set out. (In cooperation with IMR, Bergen).

2.2 Studies on the plankton productivity in Masfjorden, where especially the relationship between allochthonous (plankton biomass brought into the fjord by advection), and autochthonous production is studied.

2.3 Studies on the biology and productivity of planctonic ciliates in the Barents Sea. (Part of the interdisciplinary Pro Mare project).

- 2.4 Investigation on the effect of nutrient-rich deep-water (artificial upwelling) on the productivity of the surface water.
- 2.5 Investigations on the composition of the near-bottom fauna (suprafauna) in Norwegian fjords, on the shelf, and in the Norwegian Sea. With special emphasis on plankton-benthos interactions and food-selection of demersal fish.
- 2.6 Effects of organic pollution on benthic communities.

### 3 Norwegian Institute for Water Research NIVA, Oslo

#### 3.1 Phytoplankton

Within the framework of the State Pollution Monitoring Programme, levels of Chlorophyll a is used to indicate the degree of eutrophication in several polluted fjords. Aerospace Remote Sensing is included in these studies along with quantitative phytoplankton samples, nutrients and hydrographical measurements.

#### 3.2 Benthic communities

Registration of shore and shallow water communities by diving is routinely applied in recipient studies. The lower limit of benthic algal growth was used to characterize the mean light conditions. Stereophotography at fixed sites down to 30m has also been applied.

Structure of soft bottom fauna was studied at several localities under the State Pollution Monitoring Programme. A model for pollution impact on soft bottom fauna has been developed on the basis of (1) diversity ("rarefaction") curves from about 150 fjord stations, and (2), occurrence of opportunistic vs. intolerant species ("species indicator index").

- 4. University of Oslo  
Department of Biology
- 4.1 Marine Botany
- 4.1.1 Pico- & nanoplankton flagellates from Arctic and Mediterranean waters. (J. Thronsen.)
- 4.1.2 Diatoms related to ice in the Arctic Part of Pro Mare Project. (G. R. Hasle.)
- 4.1.3 Nitrogen turnover in coastal and Arctic waters. <sup>15</sup>N investigations. Part of Pro Mare Project. (S. Kristiansen.)
- 4.1.4 Sea ice algae in the Barents Sea. Part of Pro Mare Project. (E. E. Syvertsen.)
- 4.1.5 Experimental studies on taxonomy, life histories and environmental control of growth and reproduction in red algae. (J. Ruess, S. Fredriksen.)
- 4.1.6 Bioactive secondary metabolites (brominated organic compounds) from the red alga Bonnemaia hamifera. (J. Ruess, F. E. Moy.)
- 4.2 Marine Zoology
- 4.2.1 Studies in population genetics of Antarctic krill (Euphausia superba). (S. Fevolden.)
- 4.2.2 Comparison of genetic structure in populations of Atlantic Halibut (Hippoglossus hippoglossus) in the North Atlantic. (S. Fevolden.)
- 4.2.3 Population field studies of littoral fish in the Oslofjord. (K. I. Ugland.)
- 4.2.4 The Ringed Seal (Pusa hispida) as part of the Arctic ecosystem. Field studies. (Experimental studies planned.) Part of Pro Mare Project. (K. I. Ugland.)
- 4.2.5 Studies of excretion rates in the mussel Nucula tenuis in experimental tanks. (O.-A. Follum.)
- 4.2.6 Studies on the influence of oil contamination on recruitment, growth and mortality of the mussel (Mytilus edulis). P. Thoms, M. Waay.)
- 4.2.7 Experimental tank studies of biological and chemical responses to the settling of plankton and suspended oil drill cuttings on soft bottom. (J. A. Berge, M. Schaanning.)
- 4.2.8 Studies on recolonization, particularly by endobenthos, of oil contaminated sublittoral sediment. (J. A. Berge.)
- 4.2.9 Experimental studies on variation in genetic structure of populations of mussel (Mytilus edulis), periwinkle (Littorina littorea) and barnacle (Balanus balanoides) in oil contaminated water. (S. Fevolden.)
- 4.2.10 Classification of soft bottom animal communities in inner Oslofjord and their relation to the state of pollution. (A. M. Skallerud, M. Aschan.)
- 4.2.11 On the relation between a local concentration of the Common Seal (Phoca vitulina) in the Oslofjord and the occurrence of the nematode Pseudoterranova decipiens in various species of fish. (K. I. Ugland.)

University of Tromsø

Tromsø Museum

5.1. Zoobenthos

5.1.1 Monitoring of hard-bottom communities along the northern coast of Norway (Troms, Finnmark) and Svalbard (B. Gulliksen).

5.1.2 Succession of hard-bottom communities on volcanic rock after the volcanic outbreak at Jan Mayen in 1970 (B.Gulliksen).

5.2. Pelagic fauna

5.2.1 Ecology of sympagic fauna (under ice fauna) in the Arctic and the Antarctica (B.Gulliksen).

5.3. Fish

5.3.1 Biology and ecology of Arctic fish (T. Haug, B.Gulliksen, I.-B. Falk-Petersen, V. Frivoll, W. Vader).

5.3.2 Migration and recruitment mechanisms of Greenland halibut, Reinhardtius hippoglossoides, in the Svalbard area (T. Haug, O.R. Godø, B. Gulliksen).

5.3.3 Biology, ecology and the possible use of the Atlantichalibut Hippoglossus hippoglossus, in aquaculture (T. Haug, B. Gulliksen E. Kjørsvik, P. Solemdal, S.E. Fevolden).

5.4 Birds

5.4.1 Mapping and population surveillance of seabirds in Northern Norway (W.Vader, R. Barrett, K.-B. Strann).

5.4.2 The food and breeding ecology of breeding seabirds in Northern Norway and Svalbard (W. Vader, R. Barrett, B. Gulliksen).

Institute of Biology and Geology

5.5 Phytoplankton

5.5.1 Marine ecological research in the arctic: Phytoplankton (a component project of Pro Mare, the Norwegian Research Program for Marine Arctic Ecology) is focused upon the growth physiology of arctic diatoms and Phaeocystis pouchetii, and interactions between phytoplankton and herbivorous zooplankton (H.C. Eilertsen, J.P. Taasen).

5.5.2 Quantifications of seasonal variations in numerical abundance and production of phytoplankton in fjords and coastal waters of northern Norway (J.P. Taasen, H.C. Eilertsen).

5.6. Zooplankton

5.6.1 Ecological investigations of the zooplankton community of Balsfjorden have concentrated on quantifying condition, growth and production (based on proximate composition) in copepods and krill (C.C.E. Hopkins, K.S. Tande, S. Grønvik).

5.6.2 Calanus finmarchicus and C. glacialis in the Barents Sea: Growth strategy and ecological importance. The project (part of Pro Mare) analyses the interaction between phytoplankton production and production ecology of these two dominant calanoid copepods in the Norwegian arctic (K.S. Tande, C.C.E. Hopkins).

5.6.3 Research has been continued comparing phytoplankton and zooplankton ecology and community structure in the fjords of Spitzbergen (C.C.E. Hopkins, K.S. Tande, H.C. Eilertsen, J.P. Taasen).

5.7. Phytobenthos

5.7.1 Quantitative studies of algal communities in the littoral zone (J.R. Hansen).

5.3 Zoobenthos

- 5.8.1 Population dynamics and production of the prawn Pandalus borealis in north Norwegian fjords, the Barents Sea and west Spitzbergen. The importance of prawns in the diet of cod (Gadus morhua) (C.C.E. Hopkins, E.M. Nilssen and collaborators).
- 5.8.2 Investigations of the bottom fauna of the Barents Sea and the Spitzbergen area (E. Oug).
- 5.8.3 Population dynamics and production of Macoma calcaria (E. Oug, K.E. Langseth)
- 5.8.4 Intertidal distribution and zonation (E. Oug).
- 5.8.5 Systematics and zoogeography of the Terrebellomorpha (T. Holthe).
- 5.8.6 Deep sea fauna of the Norwegian Sea (T. Holthe).
- 5.8.7 Zoogeography of the echinoderms of northern Norway (T. Holthe, H.P. Mannvik).
- 5.8.8 Systematics of Oweniidae (T. Holthe, R. Nilsen).
- 5.8.9 Reproduction and larval development of echinoderms, particularly starfish (I.B. Falk-Petersen)
- 5.8.10 Effects of hydrocarbons on sea urchin embryos (I.B. Falk-Petersen).
- 5.9 Fish
- 5.9.1 Fertilization and development of marine fishes studied by morphological (including EM), physiological and genetical methods (E. Kjørsvik, I.B. Falk-Petersen).
- 5.9.2 Effects of hydrocarbons on fish embryos and larvae (I.B. Falk-Petersen, E. Kjørsvik).



PORTUGAL

(T. Neto)

One project implemented in 1985 included studies concerning planktonic production cycles in relation to small pelagic fishes, food availability, spawning areas, and seasons in relation to sardine (*Sardina pilchardus*) on the of the most relevant fishery resources in Portugal. Four cruises with the N.E. "NORUEGA" were carried out along the Portuguese coast (August and November 1985, January and March/April 1986), and since October 1986 monthly sampling of four transects (five days) localized in the main sardine spawning grounds and seasons were performed by the INIP research vessels "NORUEGA" and "MESTRE COSTEIRO".

The project will be developed in two different phases. In 1987, experience with methods and data requirements for the application of the "Egg Production Method" will be acquired. During 1988, field data will be collected during the first half of the year; analysis and data treatment will be carried out in the second half.

A Portuguese/Spanish workshop was held in Vigo, July 1986, where it was agreed that the "E.P.M." should be implemented in Portuguese and Spanish waters (bearing in mind that the sardine stock is not limited to Portuguese waters). The offshore limits of the spawning area will be described simultaneously by both countries.

These projects involve two Portuguese colleagues, one from "Laboratorio Marítimo da Guia - Faculdade de Ciências de Lisboa," and another from "Instituto Hidrografico".

SPAIN

(E. López-Jamar)

A) PHYTOPLANKTON

1) Instituto Español de Oceanografía, La Coruña Laboratory

The study of temporal variability of phytoplankton in relation to upwelling in the Galician shelf was continued. Temporal changes closely follow the water mass dynamics, and the population structure may drastically change within 1 or 2 days.

2) Instituto de Investigaciones Marinas, Vigo

Phytoplankton counts and chlorophyll determinations were performed in the Galician continental shelf from the Miño River to Cape Peñas (NW Spain), as well as in the Rias of Vigo, Muros, Corcubión, Laxe, Betanzos, Ortigueira and Viveiro. Oceanographic parameters (temperature, salinity, nutrients, particulated and dissolved organic matter) were also determined.

3) Departamento de Biología de Organismos y Sistemas, Universidad de Oviedo

A program on the hydrography, plankton and benthos of the Asturias coast started in 1986. A first sampling was carried out in October. The phytoplankton research will deal with taxonomy, abundance, chlorophyll and carotenoids content, primary production and spatial distribution.

4) Servicio de Investigación Oceanográfica del Gobierno Vasco

Hydrography and plankton studies are being carried out in the Ría del Bidasoa and Ría del Nervión, and off San Sebastián.

B) ZOOPLANKTON

1) Instituto Español de Oceanografía, La Coruña and Vigo Laboratories

Zooplankton studies in relation to upwelling conditions are being conducted in the Galician shelf. Pelagic fisheries in this upwelling area depend very much on the availability and composition of zooplankton. Standing crop and filtration rates of mesozooplankton were estimated, as well as the composition and abundance of microzooplankton. These studies were carried out during the spring bloom.

2) Departamento de Biología de Organismos y Sistemas, Universidad de Oviedo

A study of the zooplankton of the Asturias coast has started in October 1986. The main objectives are to investigate: (1) the annual cycle of populations; (2) the vertical and horizontal distribution; (3) the diel migrations.

C) ICHTHYOPLANKTON

1) Instituto Español de Oceanografía, La Coruña Laboratory

The spatial distribution of the eggs of sardine (S. pilchardus) and of the dominant fish larvae was studied in relation to upwelling and non upwelling conditions off the Galician coast.

D) BENTHOS

1) Instituto Español de Oceanografía, La Coruña Laboratory

A three-year study on growth and production of the bivalve Thyasira flexuosa of Ría de La Coruña has been completed. The temporal variation of two subtidal benthic communities, dominated respectively by Thyasira flexuosa and Paradoneis armata was continued, as well as the dynamics of the dominant species.

Benthic studies have been continued during 1986 in the continental shelf off Galicia, in relation to coastal upwelling and organic enrichment from the Rías. Polychaete feeding guilds were related to environmental characteristics, and preliminary results suggest a dominance of pioneering species (mainly Spionidae) in the Northern area, enriched principally by upwelling, in contrast to the dominance of large deep deposit feeders in the Southern part, enriched mainly by organic "outwelling" from the Rías. Benthic megafauna is also being studied in this area. It is largely dominated by the decapod Polydora henslowii, and consequently, feeding, reproductive biology and growth of this species is being investigated.

2) Universidad del País Vasco, Departamento de Biología.

Several taxonomic studies on holothurians, polychaetes, molluscs, and sipunculids are being carried out in the Bask coast. Benthic communities off Bermeo have also been studied in collaboration with the Servicio de Investigación del Gobierno Vasco.

3) Sociedad Cultural de Investigación Submarina, San Sebastián

Studies on the soft-bottom benthic fauna in relation to wave energy and pollution are being conducted in several sites of the Bask coast.

The dynamics and reproductive biology of the dominant species of the rocky intertidal habitat are also being investigated.

4) Departamento de Biología de Organismos y Sistemas, Universidad de Oviedo

The effect of herbivores on the structure of Chondrus crispus and Gelidium latifolium communities was investigated, including feeding selectivity and feeding rates of the dominant herbivores. The reproductive biology and growth of Paracentrotus lividus, as well as its effect on the macroalgae of the Asturias coast was also studied.

5) Servicio de Investigación Oceanográfica del Gobierno Vasco

The biology of the swimming velvet crab, Liocarcinus puber is being studied. Several studies related to the biology of Gelidium sesquipedale are being carried out in the Cantabrian Sea.

6) Departamento de Biología Animal, Universidad de Alcalá de Henares, Madrid

Intertidal benthic studies are being carried out in the Lapaman Beach, Ría de Pontevedra (NW Spain). The seasonal variation of the dominant species is being followed. A particular study on the taxonomic problems of Scolecopsis squamata and S. mesnili was performed. The benthic intertidal habitats on Ría de Foz (NW Spain) were studied, including the dynamics of the dominant species.

UNITED KINGDOM

1. England

(K. Brander)

A. Ministry of Agriculture Fisheries and Food Lowestoft

1. Herring larvae surveys

The English participation in the international surveys of herring larvae production south of 62°N continued with surveys of the southern North Sea and eastern Channel in January and the central North Sea in October. Larvae production in the southern North Sea and Channel continued to increase as the stock in that area recovers from its low level in recent years. The recovery of the spawning stock in the central North Sea has continued but there are indications of a levelling off or slight-decrease in larvae production in 1986. One notable feature in this area has been the re-occupation of spawning grounds along the western edge of the Dogger Bank which were abandoned some twenty years ago.

Concurrent ecological studies continued in both surveys areas. These included an examination of discrete layer sampling systems for studies of the vertical distribution of herring larvae and their prey; and use of the Isaacs Kidd Methot trawl for sampling large herring larvae (>20 mm) and their predators. Some studies on the feeding status of herring larvae were made in both areas using histological examination of organ development, lipid analyses and analysis of RNA/DNA ratios in the tissues.

A small plankton survey of the herring spawning area south east of the Isle of Man was conducted in September. This single survey has confirmed the position and density of spawning in that area and has been used to give an estimate of larvae production there.

2. Mackerel egg surveys

The effort put into the international egg survey of the western stock was stratified both spatially and temporally. The English effort was concentrated into a single cruise at peak spawning time (May) and was confined mainly to the central zone in the Celtic Sea. The data from this survey and those by other countries were presented to the mackerel egg workshop in November. (Anon, 1987).

3. Flatfish recruitment studies

The annual inshore surveys of parts of the English east and south coasts are now used to study the variability in flatfish recruitment in addition to their input to stock assessment. First results from the juvenile sole mortality studies support the belief in variable natural mortality. For this species the data suggests that the determination of year class size may be altered after the onset of the '0' group phase at metamorphosis.

B. Institute for Marine Environmental Research Plymouth

The Continuous Plankton Recorder Survey 1986

The CPR Survey was maintained on the same basis as in previous years (Fig. 1) to give a time series of 39 years, collected at monthly intervals in the seas around the British Isles. During 1986, Recorders were towed over 70,000 miles by ships of seven nations (Denmark, France, Iceland, Germany, Norway, Republic of Ireland and the United Kingdom). Route 'J' was dropped and a new route added to the survey IB. Following discussions with MAFF, Lowestoft we have withdrawn all the north-east Atlantic routes for the 1987 survey, with the exception of the 'X' route which will be separately funded. Routes to be dropped from our 1987 survey will be, GC, GB, G, D, SB, Z and possibly the V.

One of the main features of the results from the CPR survey has been the downward trend in the abundance of the plankton, which has lasted for at least three decades. The data for 1986 show, for both phytoplankton and zooplankton, a continuation of the increase in abundance which started in about 1980.

A full annual report will be supplied on application to the Director, Institute for Marine Environmental Research, Prospect Place, The Hoe, Plymouth, PL1 3DH, England.

C. Marine Biological Association - Plymouth

1. Space-time dynamics of plankton and benthos (Long-term changes)

The standing crop of macroplankton at the routine stations (L4, L5, E1) was again low in 1986 continuing the trend reported in 1985. Eggs of pilchard were again quite abundant, confirming the impression that this fish is switching to spring spawning such as was found in the 'warm years' from 1935 to 1970. However, apparently as a consequence of the cold spell in February, all seasonal trends were later than

usual and considerable numbers of young fish were still present late in July.

2. Interdisciplinary studies at the shelf-break

Interdisciplinary studies relating biological productivity at the shelf edge to physical processes in this region were developed further during the GA Reay cruise in June. Internal waves and tides propagating both on-shelf across the Celtic Sea, and off-shelf, were studied with particular emphasis being placed on mixing of nutrients to the surface by internal waves and barotropic tides. The proposal that physical mixing creates a favourable environment for phytoplankton growth in this region by mixing up inorganic nutrients from below the seasonal thermocline was supported by this work.

3. Remote Sensing

Analysis of Coastal Zone Colour Scanner (CZCS) and NOAA AVHRR Channel 1 (visible) data has continued in support of both the 1986 cruise programme. The last images from the CZCS were received at the end of June, and it appears that no comparable colour scanner will be in orbit until the early 1990's.

Good CZCS and AVHRR (sea temperature) images were obtained during the RRS Charles Darwin cruise in the Southern Bight (30 April-15 May). Selected CZCS images have been atmospherically and geometrically corrected, and show the development of the Phaeocystis bloom off the Dutch coast.

A study of coccolithophore blooms in the south western approaches has shown that reflectance is also detected by the AVHRR Channel 1 (570-680 nm) with about 11% of the sensitivity of the CZCS Channel 3 (540-560 nm).

D. Institute of Oceanographic Sciences - Godalming, Surrey

The work of the Department has been dominated by the analysis of material collected in 1985 in order to make a biological assessment of an abyssal station some 300 miles west of Madeira. The total water column (5540 m) had been sampled using opening/closing nets. The total water column standing-crop of plankton and micronekton only amounted to 2g wet weight/m<sup>2</sup>, a highly oligotrophic region. Pyrosoma was dominant in terms of biomass and undertook diel vertical migrations of 800m. Pelagic biomass

showed an exponential decline with depth which when log transformed had an identical slope to similar regressions calculated at three other NE Atlantic stations. Vertical profiles of taxa at both group and species level have proved to be consistent with previous observations.

Similarly the benthic samples collected with an epibenthic sledge and a semi-balloon trawl, contain very little biomass and were not rich in species. There was an impoverished carnivore/scavenger population and sediment feeders tended to dominate. Fish populations were dominated by infaunal species rather than the epipelagic species which dominate abyssal plains in the Biscayan region. There is a large element of taxonomic novelty in some but not all the taxonomic groups examined. The benthic biomass standing-crop fitted an extrapolation of the regression against depth derived from sampling in the Porcupine Seabight region. Such consistent trends have major implications to the flows of carbon through oceanic ecosystems which is the main thrust of the Global Ocean Flux Study (GOFS) initiated in the States to which the Department plans to make a major input towards a UK contribution.

One important element in this contribution will be modelling and exploration of flow analysis techniques to epipelagic communities has provided indications of the importance of the picoplankton/microbial loop. A collaborative cruise with IMER to the Celtic Sea endeavoured to parameterise some of the key variables with a modicum of success.

Submersible studies on gelatinous organisms conducted on the Johnson-Sea-Link in collaboration with WHOI, continued to provide embarrassing evidence of the inadequacy of net-sampling for these organisms. Species which were observed to be extremely abundant in well-sampled water proved to be either poorly-known or even novel. Such forms are likely to be just as important in shelf seas as oceanic seas.

The Department also contributed to the formation of the Oceanic Biology Advisory Group (OBAG) which aims to develop consensus views about priorities in research for deep-water studies in the UK.

E. School of Ocean Sciences - UCNW Menai Bridge

Mr Beaumont has continued his work on the anti-fouling agent, tributyl tin, and the genetics of the scallop, Pecten maximus. He has been involved in lectures and seminars dealing with tributyl tin at the Department of the



Environment, the Shellfish Association and the Marine Conservation Society. He read a paper at the 2nd Genetics in Aquaculture Symposium, held at Davis, California, USA, and whilst in the US, visited a number of marine laboratories on the east and west coasts.

Dr D A Jones has continued research into nutrition and feeding of penaeid shrimp larvae on encapsulated feeds. This work has expanded to consider bivalve spat and maturation of adult bivalves on encapsulated diets. Frippak Ltd and Unilever Ltd are continuing to support these programmes. Research contracts on isopod taxonomy (Red Sea and Arabian Gulf) have been initiated for the period 1986-87. Results from the research into the use of thematic mapping by satellites to identify marine habitats demonstrate that, at least in shallow tropical waters, over 80% accuracy may be achieved. In the course of these activities he has visited a number of Institutions: the River State University of Science and Technology as a visiting professor under the auspices of the Royal Society, a number of Gulf States (Bahrain, Kuwait and Qatar), and the Watamu and Malindi Marine Parks in Kenya to discuss with and advise research and management staff. He was also invited as the keynote speaker, to the ROPME Symposium on the Arabian Gulf and the Coasts of Oman.

Dr Tett has brought his work on the numerical modelling of marine microplankton to UCNW, which strengthens the links between the physical and biological parts of the future School of Ocean Sciences. He was involved in the setting up of the NW Shelf Seas Study Group and as part of the programme participated, along with two of our MSc students, in a research cruise on the Scottish shelf.

Mr Rees has been involved in a number of collaborative activities with external organisations. The contract with British Gas, for the environmental study of Morecambe Bay gas field, has been renewed for a further year. He has participated in joint cruises with both the MAFF (Burnham on Crouch) and the SMBA. The lobster stock enhancement project of the Lancashire and Western Sea Fisheries which is based at the Marine Science Laboratories and with which Mr Rees is involved, is half way through its five year programme. During this year 5000 tagged lobsters were released on experimental sites in Cardigan Bay.

Dr Floodgate has been awarded a joint DTI/SERC Grant via MarineTech Northwest for a two year study on microbiological fouling in relation to

the operating efficiency of Ocean Thermal Energy Conservation heat exchanger systems. He has just completed a two year term of office on the Ecology Committee of the Society for General Microbiology.

Dr Dorsett has continued his research on the Neurobiology of marine organisms and has been invited to chair the session on "Central and Peripheral Actions of Neurochemical Messages" at the SYMON Conference in Amsterdam this summer. He has completed a four year term as Secretary of the Society for Experimental Biology.

Dr Yule has sustained a number of research lines on the behaviour and physiology of marine invertebrates. He has followed the settlement of barnacle larvae in well defined velocity gradients and the activity spectrum of con- and allo-specific barnacle extracts in promoting settlement. He has also continued to study the feeding mechanism of small zooplankton and their growth in fluctuating food environments. He gave a lecture on Adhesion in Nature at the Biotech '86 Conference.

Dr Mills delivered a lecture on "Benthic microalgae around estuarine industrial outfalls" to the British Phycological Society at Bristol in January, and was a contributor to the 1985-86 extra-mural course in Marine Biology at Criccieth. He has continued research into the nutrient metabolism of microalgae. Dr Lucas has been on a one year sabbatical leave at the CSIRO Labs, Hobart, where he is providing assistance in setting up an electron microscope facility.

Professor Williams has continued his research interest in the study of the rate of planktonic metabolism and organised a field study at Asko in Sweden and participated in a major US research cruise in the Central Pacific Ocean. The latter was the culmination of four years' development and planning. He was co-organiser of the American Society for Limnology and Oceanography Symposium on Oceanic Productivity, in Minneapolis in June, and also organised and participated in a course on Carbon and Carbon Flux in the Marine Environment, held at the University of Gothenburg.

Scotland

(J.C. Gamble)

1 Marine Laboratory, Aberdeen

Herring Larvae Patch Studies 1986

In 1984 a programme was initiated on the dispersion and biological characteristics of herring larvae (*Clupea harengus harengus*) hatched from autumn spawners off the west and north coasts of Scotland. In 1984 a patch was followed for 7 days off the Outer Hebrides while in 1985 similar investigations were carried out off the north coast of Scotland between Cape Wrath and the Orkney Isles during late August and early September. In this case the patch, estimated to be approximately 14 days old when located off Cape Wrath, was tracked for 13 days as it moved eastwards towards the Orkney Isles. The movement of the patches of larvae in both localities was consistent with Eulerian current meter measurements and the distribution patterns could be defined within identifiable water masses.

The 1986 study followed on from the observations made in the previous year. A patch was located in mid-September and followed over a two week period as it drifted up the west side of the Orkney Isles through the Fair Isle Channel into the North Sea. The drift rate varied from day to day (maximum approximately 15 km/d) and there was some evidence that variation was associated with particular weather patterns. A more intensive programme was carried out than in previous years including Lagrangian studies on vertical distribution of the larvae, of plankton and of physico-chemical parameters of the water column. A greater emphasis was put on measuring the growth rates of larvae and possible environmental determinants. Rate measurements were also made on primary and secondary production in the vicinity of the patch.

The work in 1985 and 1986 indicated that the majority of the herring larvae spawned off the north coast of Scotland become entrained in the coastal current which, in most circumstances, flows through the Fair Isle Channel into the North Sea. However hydrographic observations from moored current meters and from a satellite-tracked drifting buoy suggest that in certain weather conditions the flow through the Fair Isle Channel is blocked and the coastal current is directed northwards up the west coast of Shetland. The consequences of this eventuality for entrained herring larvae is as yet unknown.

North Sea Benthos Survey

In an attempt to describe the characteristics of North Sea bottom sediments as an environment for benthic fauna, a total of 273 stations covering the sector from 56.00N to 61.00N were sampled between 1980-1985. The sediments were analysed for particle size, organic C, photosynthetic pigments and heavy metals (Cd, Pb, Zn, Ni, Co, Cu). A few of the stations were also sampled for redox potential, pH and organo-chloride pesticides. This data has been written up in 1986.

In the offshore northern sector 76 stations have been analysed in order to describe the infauna. The overall epifauna population has been described from 152 Agassiz trawl and TV stations.

Loch Ewe Enclosure Experiments 1986

a) Predation on herring larvae

The multiple 5 m<sup>3</sup> enclosure system was used during two experimental periods in 1986. In the spring an investigation was made on the relationship between predation by the jellyfish *Aurelia aurita* and the degree of starvation of the larval prey. The results indicated that the larvae had to be starved for a considerable period, well beyond recovery, before there was a noticeable effect on predation rate.

In the autumn a preliminary investigation of the predation by O-group fish, also herring, on herring larvae was carried out. Again the interaction of starvation was investigated. In this case no noticeable effect was detected with increasing starvation but it also felt that the enclosure design needed to be modified on the future so as to accommodate the greater predatory capability of fish when compared to jellyfish.

b) Early nutrition of cod larvae

A further attempt was made to establish the origin of the green material seen in the guts of first feeding cod larvae reared on natural plankton in a 300 m<sup>3</sup> enclosure. As in 1985 pigment analysis indicated that the source was phytoplanktonic although the remains in the gut were unrecognisable. The green material in the gut had a very close resemblance to copepod faecal pellets. Enzymatic and microbiological examination of the larvae gave no indication of high activities of enzymes associated with the breakdown of herbivorous material.

A mass mortality of cod larvae coincident with the time of first feeding was closely associated with an increase in *Vibrio* infection.

2 Scottish Marine Biological Association, Dunstaffnage, Oban

a) Pelagic production in relation to hydrography on the south-western Scottish shelf and adjacent coastal waters.

Little information is available about primary and secondary production on the western Scottish shelf, although theoretical considerations suggest that it might be higher than many other areas around the British Isles. An interdisciplinary study was initiated in 1986 to quantify productivity in this region and investigate the role of advection and mixing in the control of the distribution and production of phytoplankton and zooplankton in the Firths of Clyde and Lorn and on the Malin Shelf. Phytoplankton studies have concentrated on the determination of seasonal patterns of chlorophyll distribution and primary productivity and the characterisation by size fractionation of biomass and 14-C assimilation, of phytoplankton assemblages from hydrographically different regions of the study area. Quantification and characterisation of zooplankton within the area has been carried out and preliminary investigation of zooplankton grazing pressure within the area has started. In association with the School of Ocean Sciences, Menai Bridge; Department of Agriculture and Fisheries, Scotland; and the Universities Reactor Centre, East Kilbride, investigations of water exchange between the Firths and their adjacent shelf regions and water transport on the inner shelf have been carried out.

b) Deep-sea studies to the west of the British Isles

Analysis has continued of the unique time-series of samples of deep-sea demersal fish, mid-water plankton and micronekton and deep-sea benthos collected from the Rockall Trough and adjacent areas between 1973 and the present. Rates of growth and reproduction of individuals and populations are being investigated.

USSR

(A. A. Elizarov)

Barents and Norwegian Seas

In 1986 to evaluate feeding conditions of commercial fishes, a winter assessment of euphausiid stocks - prey of cod - was carried out, peculiarities of development and distribution of zooplankton were determined in drift routes of larval cod, migrational routes of blue whiting and in feeding areas of capelin in the Barents and Norwegian Seas. A series of stations occupied for many days was completed in order to determine diets of cod in relation to different food objects - euphausiids, capelin, shrimps.

In the first half-year spring development of *Calanus* and euphausiid in the southern Barents Sea was observed two weeks later compared to long-term dates and was slow, because of negative water temperature anomalies. Due to this the *Calanus* were distributed pelagically longer than usual. Yearly maximum of biomass was recorded only in late June in southern areas, in July - early August in the south-east and in September in the north. The biomass was at an average level, because of much poorer, against 1985, massive development of plankton predators - medusa and ctenophore.

A delay in spawning and development of euphausiids resulted in later formation of summer post-spawning aggregations in southern shallows, their length was half as much as the norm.

A strong relationship between abundance of larval cod and that of copepod nauplii in the south-western Barents Sea in spring is found.

With a trawl-attached net were collected 254 phyto-, 2822 zooplankton and 247 euphausiid samples. A quantitative - weight analysis of food in 325 capelin and 425 blue whiting was made.

In 1987 investigations of plankton in the Barents and Norwegian Seas will be continued in accord with the programme previously adopted.

White Sea

A survey to evaluate plankton and feeding conditions of herring was conducted. These data showed strong trophic relations of adult

herring and coldwater plankton complex, the representatives of which inhabited deep cold layers. In the White Sea herring stucked to surface water warmed in summer. Areas of intensive feeding on coldwater plankton organism coincided with the upwelling of deep water layers.

#### Baltic Sea

Zooplankton. In 1986 zooplankton samples were taken in divisions 26, 28 and 29 of the Baltic Sea and the Gulf of Riga in February, May, August and October and early November. 500 samples were taken by Juday net 37/50 the mesh size of 0.16 mm in the filtering cone.

Ichthyoplankton. In 1986 ichthyoplankton samples were taken monthly from March to July in divisions 25, 26, 28, 29, 32, in the coastal area from May to July. 815 ichthyoplankton samples were taken by I-80 net with mesh size of 0.5 mm in the filtering cone and 10-foot Isaaks-Kidd trawl with mesh size of 0.5 mm in the codend.

Zoobenthos (macrofauna). In 1986 zoobenthos samples were taken in divisions 26 and 28 of the Baltic Sea in May, July and November. 260 samples were taken by Van-Vin bottom grab (0.1 m<sup>2</sup>) and dredge "Baltika".

Feeding of fish. In 1986 data on feeding of herring and sprat were taken in divisions 26 and 28 of the Baltic Sea in January, March-May, July and September. 2700 digestive tracts were taken, including 1500 ones of herring and 1200 of sprat.