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FIFTH REPORT OF THE BENTHOS ECOLOGY WORKING GROUP

Ostende, 12-15 May 1986

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1. OPENING OF MEETING

The Benthos Ecology Working Group met in Ostende from 12-15 May 1986. A list of participants is given in Annex 1.

1.1 TERMS OF REFERENCE

There was approval for the Working Group's amended title which now reflected the broader range of interests in benthic studies. The Group was asked to consider the results of the intersessional activities outlined in Annex 2 of the fourth report (Doc. CM 1985/L:33), and in particular the following:

(i) activities of interest in ICES and other organisations;

(ii) comparative efficiencies of different sampling devices and methods;

(iii) standard methods;

(iv) cooperative studies - North Sea benthos survey
- intercalibration of ash-free dry weight measurements
- further cooperative regional studies;

(v) the use of benthic communities in monitoring the impact of point source inputs of wastes (ACMP);

(vi) contributions to the 'benthos/demersal fish trophic interactions' theme session;

(vii) future requirements;

(viii) any other business.

2. ACTIVITIES OF INTEREST IN ICES AND OTHER ORGANISATIONS

2.1 SHELF SEAS HYDROGRAPHY WORKING GROUP

An ad hoc working group chaired by G. A. Becker met at ICES Headquarters in December 1985 to develop the SCAPINS project dealing with the circulation in the North Sea in summer and its transition into autumn, including its effects on the autumnal plankton bloom. There should be a period of intensive study from 15 August to 30 September 1987 and the project should engage physical, chemical and biological oceanographers.

2.2 COST 647 EEC (COASTAL BENTHIC ECOLOGY)

Since last year this group has organised a successful symposium in December 1985 in Brussels, the results of which will be published in Hydrobiologia and Developments in Hydrobiology. Coastal benthic ecology will remain an important item in CEC research dealing with the environment. This group is currently discussing extending its field of work into the Mediterranean, focusing primarily on the seagrass communities of Posidonia.

The work being done in the COST 647 project remains highly interesting to the WG; since several informal links exist between the WG and COST 647 it was not felt necessary to establish contacts beyond these, except for intercalibration exercises and taxonomic workshops (point 5.3.2).

2.3 COUNCIL OF EUROPE

At a meeting in Lisbon in December 1985 the European Association of Marine Sciences and Technology was established under the chairmanship of Prof Vigneaux of Bordeaux, France. This Association will act to stimulate the creation of networks in oceanography. One of these networks concerns the spatial distribution and ecodynamics of benthic communities on the European continental shelf and is chaired by Prof Saldanha (Lisbon) and Prof Stromberg (Stockholm). The North Sea Benthos Survey has been mentioned at that meeting as being a possible example of a network. The Chairman will contact Saldanha and Stromberg to investigate possible collaboration.

3. COMPARATIVE EFFICIENCIES OF DIFFERENT SAMPLING DEVICES AND METHODS

3.1 COMPARISON BETWEEN A VAN VEEN GRAB AND DIVER-OPERATED BOX CORER

Dr Brey presented a paper comparing the performance of the above two sampling devices (Annex 4). The grab could seriously underestimate the biomass of deep-burrowing species; divers needed to avoid creating unnecessary turbulence prior to sampling, and a pre-planned sampling design was desirable to avoid bias in visual selection of sites.

4. STANDARD METHODS

4.1 EFFECTS OF NARCOTISATION WITH BENZOCAIN ON BIOMASS/LENGTH MEASURES

Dr Künitzer (for Dr Rachor) explained that no progress had been possible as Dr Dittmer had now left the Bremerhaven Institute.

4.2 EFFECTS OF FORMALIN, DOWICIL AND KOHRSOLIN ON WEIGHT CHANGES IN TWO BIVALVE MOLLUSCS

In a summary of work already published (Sonderdruck aus Bd., 31, H.1, 52-57, 1986) Dr Brey drew attention to the stabilisation of weight with time after fixing of *Arctica islandica* and *Macoma balthica* - a minimum of 100 days before determination was recommended though this would not preclude counting and identifying of sample contents in the meantime. Further, dowicil was expensive, and therefore not suitable for routine use in quantity. There was little difference between use of formalin and kohrsolin - the latter was preferable on grounds of safety as no formaldehyde gas was released. Processes affecting weight change, amounting to some 20% over 200 days, were uncertain.

4.3 A COMPILATION OF BIOMETRIC CONVERSION FACTORS FOR BALTIC INVERTEBRATES

A report with the above title will shortly be published by the Baltic Marine Biologists Group (authors: H. Rumohr, T. Brey and S. Ankar). Wt/wt, wt/energy, length/wt conversions are included for a wide range of species and groups of species, extracted mainly from Baltic and North Sea literature and unpublished work. The degree of variability in conversion factors, depending on geographical location, season, sex and age, limited the scope for widespread application to new data, especially with respect to length-weight relationships. However, wt/wt conversion factors for major taxonomic groups such as polychaetes, crustaceans and molluscs were less variable, and the averages given in Annex 5a, b are suitable for application to North Sea survey data.

This work did not separately address the influence on AFDW of organic content of molluscan shells, though this was believed to be generally small.

4.4 MONITORING PROCEDURES AT NORTH SEA OIL AND GAS PLATFORMS

A survey by Dr Brattegard of information extracted from accounts of surveys of North Sea oil and gas fields is given at Annex 6. It was evident that a sampling design based on radiating transects was not always suitable - this was especially true for mixed sediment areas to the north. In such cases, there would be merit in stratification according to sediment type, following a pilot survey. Recommendations on standardisation of monitoring approaches was required, covering not only sampling device, minimum number of replicates, sieve mesh size and staining, but also presentation of results and archiving of raw data.

4.5 TAXONOMY (LARVAE AND JUVENILES OF MARINE MACROBENTHOS)

A literature survey compiled by Dr Bosselman was circulated and will in due course be published. This contribution was valued by WG members.

Those interested in producing taxonomic keys should be aware of the opportunity to publish in the long-standing ICES series of identification leaflets.

5. COOPERATIVE STUDIES

5.1 NORTH SEA BENTHOS SURVEY

The survey (now endorsed by ICES) was completed in early 1986 through the commitment of several marine institutes.

A summary of progress is given in Annex 7. The objectives of core and grab sampling were successfully met despite local problems caused by bad weather, and difficulties in sampling on coarse ground. Dredge sampling was less successful; there was doubt as to the suitability of the lightweight apparatus for North Sea-wide deployment.

5.1.1 Plans for work-up of North Sea survey samples

A list of determinands is given on p.24 of WG Report 4 (CM 1985/L:33). The time required for completion of sample processing will depend in a number of cases on the future allocation of funds for contract staff, though it was anticipated that macrofauna samples would be finished within two years. Availability of expertise on meiofauna was more limited, and so results may take longer to generate.

The Dutch Rijkswaterstaat (RWS) had fulfilled their commitment to sampling the English north-east coast region; samples will be processed by Dr Kingston and Dr Dewarumez.

A non-citable introductory report will be prepared for submission as an ICES paper in 1987, with special emphasis on methods. Reference will also be made to preliminary results of individual institutes, who will each be responsible for detailed reporting of work in their sampling sector. A synoptic map of sediments will be prepared as an illustration of the type of results which will in due course be forthcoming.

5.1.2 North Sea data base

A format for storage and retrieval will initially be similar to that outlined in WG Report 4 (p.17), and will be further developed within the framework of wider ICES objectives in this area. Dr Heip will provide a standard format for initial recording of data. Stations sampled during the North Sea benthos survey will be numbered according to Dr Künitzer's system, to be prefixed by IBS (= ICES Benthos Survey), and suffixed by a two-letter code for the institute responsible for sample collection, e.g. IBS 43(x,y).

5.1.3 A protocol for the sampling and analysis of North Sea benthos

In view of the importance which the WG attached to the need for standardised approaches to field sampling and laboratory processing in cooperative studies, it was felt that experience gained from the North Sea benthos survey could provide a framework for a series of recommendations on methodology for this sea area. The initial aim would be to establish a protocol for those engaged in North Sea studies of soft sediments. Though the report would undoubtedly find a wider readership, it was not the intention to compete with existing manuals - such as the IBP Handbook - which already provided a 'global' perspective on benthic sampling methods.

In preliminary discussion on this topic, it was accepted that coring devices offered the most efficient means for field sampling, but where their deployment was not feasible, a Van Veen-type grab appeared to be most suitable. A specification based on the design of grab in use by Heriot-Watt University (Dr Kingston), with the addition of mesh doors (Kiel) will be prepared.

Concerning laboratory processing, a finer mesh sieve than used in the field should be employed during sample extraction. With the use of a graded series of sieves, the addition of a vital stain was only necessary for the fine fraction. Local knowledge may occasionally dictate against use of a stain, e.g. where reference to natural colour of certain animal groups was required in identification. Following extraction of animals, records such as shell content of residual material could be useful in inferring the history and stability of sediments in the area sampled.

Both round and square mesh sieves were commonly used in North Sea studies, and no firm preference was established. It was standard practice to use 4% buffered formalin for initial preservation of benthic samples; recommendations could not yet be offered on alternatives, though investigations were proceeding (see item 4.2).

5.2 REPORTS ON OTHER RECENT STUDIES OF NORTH SEA BENTHOS

5.2.1 Northern North Sea (DAFS)

Dr Eleftheriou presented results of analyses of sediments taken from a grid of stations between latitude 56° and 61°; results for median grain size are given at Annex 8 by way of illustration. These, along with benthos data, will be published later. Elevation in, for example, carbon, chlorophyll and certain heavy metals, could be linked with depositional areas such as the Fladen Ground and Norwegian Deeps. There were a number of unexpected features, e.g. redox values were lower than average, and lead levels higher in the south east of the survey area, while cadmium values off the Orkney and Shetland Islands were elevated.

5.2.2 Norwegian Trough

Dr Brattegard gave results of sledge samples taken along a transect running into the Norwegian Trough, where abundant populations of mysids, cumaceans, amphipods and decapods occurred. There was a 10-fold increase in biomass of mysids from shallower to deeper water; this trend may be linked with increased food supply through sedimentation, though no data are presently available. The general area is under investigation with respect to fish stock recruitment, physical oceanography and oil operations.

5.2.3 Dogger Bank

Dr Duineveld noted that an intensive sampling study of this area had been conducted earlier in 1986 by NIOZ, using a benthic corer; certain samples could if necessary be processed in order to meet requirements of the North Sea benthos survey.

5.2.4 Belgian coast

Dr Redant summarised Belgian studies on demersal fish/brown shrimp distributions, which were coordinated on a half-yearly basis with similar programmes by Denmark, Germany, Holland and (in future) France. 'By-catches' which include several epibenthic species have been recorded for many years; recent data may be useful in connection with synoptic mapping of North Sea survey results.

5.2.5 French coast

Dr Dewarumez outlined recent benthic studies along the northern French coast and offshore, as far as the Belgian border. Faunal communities, ranging from Modiolus on coarse gravel, to Abra in inshore mud, had been mapped from an initial grid of sampling stations. Human influences in the coastal zone included a power station cooling water discharge, sewage and industrial waste discharges, and dredged spoil disposal. Follow-up work in areas of interest was in progress.

5.3 INTERCALIBRATION EXERCISES

5.3.1 Intercalibration of ash-free dry weight measurements

There was much variability in methodology employed by different workers. This could lead to inconsistencies in results as evidenced in data presented by Dr Heip from a recent intercalibration exercise (see 4th WG report, CM 1985/L:33) in which a 50% difference was found between the lowest and highest of three estimations of AFDW of a standard-sized bivalve.

The following standards for weight determination were agreed:

(i) a minimum of 3 months to elapse following addition of formalin to field samples, in order to allow for stabilisation of weight loss (see item 4.2);

(ii) dry weight to be determined at 60°C until constant weight is achieved; mollusc shells to be opened, and echinoderms crushed;

(iii) AFDW - a minimum of 6 h for determination of ash content, at a temperature of 520°C (temperatures above this were likely to induce weight loss associated with the inorganic fractions of mollusc shells or echinoderm tests).

Dr Duineveld agreed to coordinate an intercalibration exercise between WG members, involving determination of dry weight and AFDW of a series of samples of *Cerastoderma* from the same locality.

5.3.2 Intercalibration: taxonomy and enumeration

Dr Heip reviewed other findings of the Texel intercalibration exercise, the results of which will soon be published. There were systematic differences between participating institutes concerning the taxonomy of certain groups, e.g. Lumbrinereidae and *Bathyporeia*. Deeper penetrating core samplers were generally preferable to grabs for estimating numbers and biomass.

There was a need to improve links between institutes engaged in marine taxonomy; there would also be merit in organising workshops to deal with intractable groups. To this end, Dr Heip will contact COST 647 organisers in order to widen participation. Mention was made of annual workshops organised by the Estuarine and Brackish Water Sciences Association. Dr Brattegard referred to a forthcoming review article on European molluscs, with up-to-date nomenclature and descriptions, to be published in Sarsia. This will be followed by a comparable review on echinoderms.

5.4 FURTHER COOPERATIVE REGIONAL STUDIES

The WG had necessarily concentrated on progress of the 1986 North Sea Benthos Survey. A number of proposals for cooperative work arising from completion of the first phase of this programme could be anticipated; however it was felt that detailed discussion would at this stage be premature. The WG recognised the importance of its role in fostering collaborative studies both within and beyond the confines of the North Sea.

6. BENTHIC COMMUNITIES IN MONITORING THE IMPACT OF POINT-SOURCE INPUTS OF WASTES (ACMP)

ICES had been requested by the Oslo and Paris Commissions to report on the usefulness of benthic studies in point-source monitoring (dumping from ships, pipeline discharges), and as a consequence of this the Advisory Committee on Marine Pollution (ACMP) had identified the Benthos Ecology Working Group as an appropriate source of advice. Members endorsed this addition to the Working Group's terms of reference.

ACMP had isolated four particular areas on which advice was being sought, namely:

(a) the types of inputs that might elicit a response from the benthos and the nature of the response(s),

(b) the time scales of these responses,

(c) the types of benthic community response that would lend themselves to sufficiently accurate and precise measurement to identify spatial and temporal trends in impact waters,

(d) the degree to which benthic community responses can be evaluated in terms of effects on the components of the marine environment, in particular in terms of effects on fish stocks.

Additionally, ACMP had referred to the outcome of an ICES study group on biological effects techniques (ICES Doc. CM 1985/E:48), which had used an amended version of the GESAMP strategy as a framework for discussion:

Phase I	(a)	identification
	(b)	quantification
Phase II	causation (of observed effect)	
Phase III	evaluation (of consequences to marine resources).	

There was constructive exchange of ideas on these topics, though it soon became clear that a detailed submission would not be forthcoming, within the limited time available. The WG isolated a range of measures of community structure and function which were appropriate for assessment of pollutant impact (Annex 9). There was also recognition of the need for both qualitative and quantitative models of pollution-induced changes. A report on this topic will be prepared for discussion at the next meeting.

7. CONTRIBUTIONS TO BENTHOS/DEMERSAL FISH INTERACTIONS

Dr Heip had received written communications from two Working Group members. Dr Lilly (Canada) had outlined his interest in benthic feeding habits of cod, plaice and flounder, exemplified by a paper to be submitted to the 1986 ICES theme session on benthos/demersal fish trophic interactions ('Propeller clam (Cyrtodaria siliqua) from stomachs of Atlantic cod (Gadus morhua) on the southern Grand Bank (NAFO Div. 3NO): natural prey or an instance of net feeding?'). Dr Cranmer (UK) would be reporting on stomach analyses of some 5000 North Sea haddock, and the relationship between prey organisms and the known distribution of benthic communities ('The food of the haddock (Melanogrammus aeglefinus) in the North Sea').

Investigations into the life-history, food consumption and food resource partitioning in two sympatric gobies inhabiting Belgian coastal waters were reported by Dr Hamerlynck. Pomatoschistus minutus and the smaller P. lozanoi sampled by beam trawl were present in densities of respectively 80 and 40 individuals per 1000 m^2; consumption (AFDW) was estimated at about 1 g and 0.25 g m^{-2} yr^{-1}. The food of P. minutus was composed predominantly of a wide range of benthic and epibenthic species, while that of P. lozanoi was predominantly epibenthic and pelagic, and represented by fewer species. Length frequency distributions showed that in 1984 recruitment of P. minutus took place in July, while P. lozanoi recruited in August. Only during August, at a time when the size distributions of both species were similar, was there a significant shift in feeding habits of P. lozanoi to benthic polychaetes, which could be connected with spawning behaviour (Table 1).

Smaller-sized P. minutus fed extensively on pelagic copepods in October, but the latter were abundant at this time, and therefore not limiting as a food source.

Concerning categorisation of prey species, Dr Brattegard suggested that there would be merit in distinguishing between benthic, hyperbenthic and pelagic animals, especially as mysids - which formed a significant component of the diet of P. lozanoi - were not strictly epibenthic in habit.

Dr Creutzberg and Dr Duineveld reported on studies of populations of the lesser weaver Trachinus vipera in sandy areas of the southern North Sea. Production was calculated at 0.02-0.08 g AFDW m^{-2} yr^{-1}. Some 85% of the diet consisted of fish, of which about 90% were Pomatoschistus. Assuming a 10% conversion efficiency, calculated consumption was 0.6 g AFDW m^{-2} yr^{-1}. Since this in turn suggested a consumption of 6 g AFDW m^{-2} yr^{-1} for gobies, which could not be sustained by benthic production in this area, it was inferred that plankton would form a major component of their diet. (In support of this, Dr Hamerlynck believed it was probable that the species in question was P. lozanoi.)

In contrast to the lesser weaver, populations of dab Limanda limanda on muddy areas could be supported exclusively through benthic feeding, notably on Amphiura filiformis. This was present in high densities in the survey area, and it was estimated that one in five would lose an arm every year through predation. In population studies of Amphiura, Dr Duineveld had identified 0-group recruitment to a 200 micron sieve at densities exceeding 10 000 m^{-2}. Growth of this cohort was fast and mortality high compared with adult populations, so that only about 1% remained after about 6 months. The modal size of these survivors soon became indistinguishable from older animals. Use of a 1 mm mesh sieve could therefore lead to erroneous conclusions concerning recruitment and growth.

Using published data, Dr Brattegard highlighted the importance of crustaceans to the diet of pelagic and demersal fish. This was also true for demersal fish only, irrespective of depth (0-> 400 m). Other fish were prominent in the diet at intermediate depth (100-199 m); in water deeper then 100 m, there was a trend towards an increase in consumption of echinoderms and cephalopods, and a reduction in polychaetes and bivalves.

		Benthic	Epibenthic	Pelagic
P. minutus				
May n = 37	50-59 mm	40	51	9
July n = 84	30-39 mm	54	18	28
August n = 30	45-49 mm	86	9	5
September n = 89	35-49 mm	24	18	58
September n = 178	35-64 mm	32	28	40
October n = 30	35-39 mm	19	3	79
P. lozanoi				
May n = 51	45-54 mm	1	41	57
July n = 60	40-49 mm	2	5	93
August n = 30	45-49 mm	96	4	0
September n = 84	35-49 mm	1	3	96
October n = 30	35-39 mm	1	2	96

Table 1 Percentage ash-free dry weights of prey in food niche categories.

Dr Eleftheriou summarised studies on feeding of plaice *Pleuronectes platessa* in north-west Scottish waters. There was evidence for density-dependent growth, though sampling of the infauna and hyperbenthos did not suggest food limitation. This could be explained by the lack of availability of certain infauna species (e.g. deeper burrowing forms) and the feeding activities of other vertebrate and invertebrate predators. Such factors - though difficult to quantify - could have an important bearing on budget studies.

Dr Creutzberg noted that temperature was the key factor controlling age class success in tidal flats of the Dutch Wadden Sea. At low temperatures, predation pressures on planktonic eggs and larvae in the water column were reduced. Growth in the first year was dependent on the timing of settlement which was delayed at lower temperature, but was independent of density and therefore of food supply.

Dr Brattegard commented on the transport of deep-water hypoplankton into the northern North Sea via inflowing Atlantic water. Downward migration in the somewhat shallower waters led to daily concentration at the sea bed, so providing a significant food source for demersal fish. This, together with observations that N-levels were higher in inflowing than outflowing waters, was taken as further evidence that the richness of the North Sea was based partly on Atlantic influx.

Production of Pontophilus - an important fish food organism - was determined at a standard site in Norwegian waters; using data from this site as a model, 'potential production' could be calculated from single samples at sites elsewhere, by extrapolating from size frequency distributions. Such information could be of practical value to fish biologists. Other work in this region included estimates of production for major decapod and mysid species, and an investigation into the 'carrying capacity' of a fjord in relation to proposed cod ranching.

8. FUTURE REQUIREMENTS

There was lengthy discussion on this topic. The following is a synthesis of the views expressed by WG members.

In applying the concept of carrying capacity, e.g. to a plaice feeding ground, there was an historical tendency to ignore the role of other vertebrate and invertebrate predators. Their inclusion could have significant implications for resource management. Also, clearly, not all benthic biomass is available as food, e.g. deep-burrowing species, though this would not be immediately apparent from grab sampling studies.

There was a need for up-to-date estimates of assimilation efficiencies of fish, which paid heed to differences in age, season and the nature of the food supply. There was a view that conventionally applied ratios from the literature tended to underestimate the true efficiencies.

Regarding the benthos, further research was required in order to identify the role of dissolved organic matter as a direct source of food, and the capacity of individual species to alter their feeding mode in response to changes in the nature of available food.

The 'hyperbenthos' - free-swimming animals such as mysids and amphipods living near to the sea bed - had not been widely studied, due to a combination of difficulties in quantitative sampling associated with patchiness in the distribution of species, and more fundamentally in defining the boundaries of the habitat. More work on this group was required, especially as many hyperbenthic species were important in the diet of fish.

Information on production of benthic communities - as distinct from individual species - was sparse. Also, such work rarely took into account sublethal predation, e.g. cropping of bivalve siphons by fish, which in some areas could lead to significant underestimation of true production.

Finally, the significance of meiofauna, especially nematodes, as fish food may be underrated as these organisms rapidly disintegrate in fish stomachs and so are not commonly recorded. Further, P:B ratios for meiofauna may range between 4 and 60, depending on locality: this was far greater than previous work had suggested.

9. ANY OTHER BUSINESS

Workshops on sampling design and data treatment were being organised within the framework of the EEC COST 647 programme; the ICES Benthos Ecology Working Group could make a useful contribution based on North Sea survey experience.

It was proposed that members should circulate reprints of published papers, to others in the Group.

Dr Heip undertook to write to the chairman of the Working Group on Marine Sediments in Relation to Pollution, as there appeared to be scope for collaboration in areas of common interest such as sampling methodology, bioturbation and seabed mapping.

Dr Brattegard referred to the 'Norwegian Remote Sensing Centre', which would be operational from 1987, with the purpose of retrieving and disseminating information from satellites concerning the Atlantic and North Sea.

Dr Duineveld referred to Dutch participation in the 'Friesen Front Project' - a study of exchange processes in a tidal front area in the vicinity of the Oyster Ground, southern North Sea.

Dr Eleftheriou drew attention to recent work by DAFS, firstly on effects of scallop dredging on the benthic fauna, and secondly on feeding relationships in artificially baited areas, with the aid of underwater TV.

10. DATE OF NEXT MEETING

The Working Group proposes that it meets from 27 April to 1 May 1987 at Heriot-Watt University, Edinburgh to consider the results of the intersessional work requested (see Annex 2 and 3).

ANNEX 1

LIST OF PARTICIPANTS

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ANNEX 2

ACTION LIST

1. The following participants in the 1986 North Sea Benthos Survey to individually compile progress reports for each sector: Drs Dorjes, Kröncke, Künitzer, Rumohr, de Wilde, Heip, Kingston/Dewarumez.

2. (a) Dr Heip to lead on preparation of an introductory paper on the 1986 North Sea Benthos Survey for the ICES Statutory Meeting, 1987;

   (b) under the guidance of Dr Creutzberg, participants to work up sediment sub-samples for grain size and loss on ignition as a priority, for inclusion in this paper.

3. Dr Eleftheriou to report on results from the DAFS northern North Sea benthic survey.

4. Dr Brattegard to report on the hyperbenthos of the northern North Sea at sites corresponding with certain DAFS infauna stations.

5. Dr Lopez-Jamar to present results of a survey on benthos of the Galician continental shelf.

6. Dr Thiel to provide a map on the distribution of chlorophyll equivalent pigment in sediment samples from the North Sea Benthos Survey.

7. Dr Duineveld to coordinate an intercalibration exercise involving determination of dry weight and ash-free dry weight of a benthic bivalve by WG members.

8. Dr Heip to compile a review on meiofauna production studies.

9. Dr Brey to compile a review on macrofauna production studies.

10. Dr Redant to compile a review on mobile epifauna production studies.

11. Dr Rumohr to compile a list of recommended procedures to be used in the study of benthic communities in the North Sea.

12. Dr Brattegard and Dr Kingston to report on standardisation of benthic monitoring procedures at North Sea oil and gas platforms.

13. Dr Dewarumez to produce a report on effects on benthos of dredged spoil disposal and coastal engineering works (French coast).

14. Dr Rees to prepare a report on the use of benthic communities in monitoring point source discharges.

15. Dr Heip to present a report on the outcome of the 1986 ICES theme session on benthos/demersal fish trophic interactions.

16. Dr Heip to provide a standard format for the recording of data from the North Sea Benthos Survey, and to discuss future requirements for input to an ICES environmental data base.

17. Dr Eleftheriou to provide a list of taxonomic groups which present particular identification problems.

18. Dr Redant to produce a bibliography on effects of bottom fishing gear on benthic organisms.

ANNEX 3

RECOMMENDATIONS

1. The Benthos Ecology Working Group recommends that it meets from 27 April to 1 May 1987 in Edinburgh in order to:

   (a) consider the results of the North Sea Benthos Survey and prepare the first cooperative report according to an agreed format;

   (b) consider future cooperative studies in the North Sea and other areas;

   (c) consider the results of an intercalibration exercise on ash-free dry weight and dry weight determination;

   (d) review and evaluate existing data on production of benthic species and communities;

   (e) compile a list of recommended procedures to be used in the study of benthic communities in the North Sea;

   (f) prepare a report on the use of benthic communities in monitoring the impact of point source pollution (request from ACMP);

   (g) consider the results of the theme session organised by ICES on benthos/demersal fish trophic interactions.

2. The BEWG recommends that the programme of comparative studies between different types of sampling gear (beam and Agassiz trawls, underwater camera) be continued.

ANNEX 4

COMPARISON BETWEEN A VAN VEEN GRAB AND DIVER-OPERATED BOX CORER

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Abstract

The comparison between a 0.1 m^2 VanVeen grab and a diver-operated box corer with 0.0192 m^2 sampling area at a shallow, sandy site in Kiel Bay showed that

(a) the biomass of deep burrowing species is seriously underestimated by the VanVeen grab;

(b) water turbulence produced by the divers may reduce the abundance of small surface-living species.

Methods

At a shallow (6 m water depth) station with fine sandy sediment (mean grain diameter < 0.250 mm) in Kiel Bay five samples were taken by a 0.1 m^2 VanVeen grab (weight 60 kg) and ten samples taken by 0.0192 m^2 diver-operated box corers (according to Rumohr and Arntz 1982).

From the volume of the sediment contained by the VanVeen grab the 'initial penetration depth' was calculated according to Ankar (1977); the penetration depth of the box corers was 10 cm.

The samples were sieved through 1 mm mesh size and stored in 4% formaldehyde solution buffered with borax.

Ash-free dry weight (AFDW) was determined at 85°C (dry)/520°C (ash).

Abundance and biomass of the dominant species were calculated to 1 m^2 and tested on significant differences by the U-test (not normal distributed data) and the Weir-test (normal distributed data) respectively; both tests are quoted from Sachs (1978).

Results

Table 1 (overpage) shows the results of the comparison for the dominant species.

Discussion

It is evident that the biomass of deep burrowing species like Mya arenaria, Arenicola marina, Capitella capitata (and, however not significantly, Macoma balthica) is much higher in the box corer samples than in the VanVeen grab samples.

This is directly correlated with the different penetration depth of the two samplers. The VanVeen grab penetrated the sediment to about 5 cm depth, whereas the box corers were pressed into the sediment to about 10 cm depth.

Table 1 Comparison of 5 VanVeen grabs (VV) and 10 diver-operated box corers (Box). Abundance and biomass (AFDW) per m^2. '<' and '>' indicate significant differences at the 5% level

Species	Abundance			Biomass		
	VV		Box	VV		Box
Cardium edule	972	>	729	26.034		20.031
Macoma balthica	1411		1443	1.467		2.141
Mya arenaria	3238	>	2453	11.232	<	19.323
Hydrobia spp.	8835	>	4052	3.718	>	1.757
Arenicola marina	0	<	31	0	<	1.627
Capitella capitata	28	<	141	0.007	<	0.030
Pygospio elegans	8764	>	5901	1.030	>	0.803
Scoloplos armiger	853		828	0.730		0.876

The second phenomenon shown in Table 1 is hard to explain. The abundance of small or juvenile animals living on or just below the sediment surface (e.g. *Cardium edule*, *Mya arenaria*, *Hydrobia* spp. and *Pygospio elegans*) is significantly lower in the box corer samples than in the VanVeen grab samples.

The most likely explanation is water turbulence caused by the divers, which blew away these small animals. This turbulence may be caused by the fins of the divers or by the shock wave in front of the box corer, when the corer strikes the sediment.

Another explanation may be non-objective sampling by the divers, i.e. that they search for a 'clean' spot to take the sample.

Conclusion

With respect to deep burrowing species, the diver-operated box corer is superior to the VanVeen grab. However, the divers operating the box corers should be carefully instructed to avoid any unnecessary turbulence, especially before the sampling procedure. Additionally, a grid with previously marked cells to be sampled should be used to avoid non-objective sampling.

References

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ANNEX 5a

MEAN CONVERSION FACTORS FOR MAIN MACROBENTHIC TAXA. WEIGHT TO WEIGHT

WW: wet weight
DW: dry weight
SFDW: shell free dry weight
AFDW: ash free dry weight
[1]AFDW%WW is calculated from the other factors

Taxon	Type	Factor %	95% conf. interval	Number values	Number species	References*
Gastropoda	SFDW%WW	8.7	1.3	28	15	9,39
	AFDW%DW	23.5	7.3	8	6	10,25
	AFDW%SFDW	85.5	2.3	30	15	13,27
	AFDW%WW	7.4[1]	-	-	-	-
Bivalvia (except *Arctica islandica* and *Astarte* spp.)						
	SFDW%WW	8.4	2.0	28	18	2,4,9,39
	AFDW%DW	14.7	1.6	24	18	10,25,26,32,43
	AFDW%SFDW	84.3	2.4	24	15	13,39
	AFDW%WW	7.1[1]	-	-	-	-
Crustacea (except Balanomorpha, large Decapoda, juvenile stages)						
	DW%WW	21.9	1.4	39	30	2,4,9,25,26,30,32,39,40,43
	AFDW%DW	75.8	4.1	29	26	8,10,11,25,26,28,30,39
	AFDW%WW	16.6[1]	-	-	-	-
Polychaeta	DW%WW	18.3	1.0	59	52	2,4,9,11,25,26,32,35,39
	AFDW%DW	75.9	4.5	44	40	10,11,12,25,26,28,39
	AFDW%WW	13.9[1]	-	-	-	-

*Refer to: Rumohr, H., Brey, T. and Ankar, S. (in press), "A compilation of biometric conversion factors for Baltic invertebrates".

ANNEX 5b

MEAN CONVERSION FACTORS FOR MAIN MACROBENTHIC TAXA. WEIGHT TO ENERGY CONTENT

WW: wet weight
DW: dry weight
SFDW: shell free dry weight
AFDW: ash free dry weight
[1] value in brackets: weighted mean (weights: no. of single values or combustions per species and author)
[2] value in brackets: total number of single values or combustions given by all authors

Taxon	Weight type	Joule/mg	95% conf. interval	Number values	Number species	References*
Gastropoda	DW	12.90	2.14	17	17	16,32
	SFDW	18.11	0.96	33	16	16,28,33,39
	AFDW	23.23 (23.10)[1]	1.05	27 (169)[2]	26	28,33, 39
Bivalvia	DW	16.45	4.56	7	7	23,33
	SFDW	19.28	0.58	41	33	9,11,16,23,28,33,39,40
	AFDW	21.88 (21.71)[1]	3.50	31 (219)[2]	25	11,13,17,18,22,23,28,32,33,39
Crustacea (except Balanomorpha, large Decapoda, juvenile stages)						
	DW	16.32	0.84	108	57	8,9,11,16,22,23,28,32,33, 39,40
	AFDW	22.39 (21.92)[1]	1.16	47 (191)[2]	36	8,11,22,23,28,32,39,40
Polychaeta	DW	16.26	1.41	32	30	8,9,11,16,23,28,32,39,40
	AFDW	23.60 (23.13)[1]	1.24	13 (80)[2]	12	8,11,13,28,33,39
All taxa	AFDW	22.58 (22.32)[1]	1.00	118 (659)[2]	99	8,11,13,17,18,22, 23,28, 32,33,34,39,40

*Refer to: Rumohr, H., Brey, T. and Ankar, S. (in press), "A compilation of biometric conversion factors for Baltic invertebrates".

ANNEX 6

DATA ON INVESTIGATIONS OF BENTHOS AT GAS AND OIL FIELDS IN THE NORWEGIAN SECTOR OF THE NORTH SEA

compiled by

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Table A Investigations of benthos at oil and gas fields in the Norwegian sector of the North Sea. A = number of stations; B = number of replicates per station; C = mesh size of sieve; D = staining of organisms

Field	Year	Made by	Station pattern	A	Main gear	B	C	D
Statfjord	1980	IMR	4 rad. trans.*	20	Day 0.1	16 x 1 4 x 5	1	-
	1982	MP	4 rad. trans.	44	Van Veen 0.1	36 x 1 6 x 5	?	-
	1984	IOE	3 trans.	28	Van Veen 0.1	28 x 5	0.5	+
Gullfaks	1984	MP	4 rad. trans.	31	Shipek 0.04	19 x 1 10 x 5 2 x 10	?	-
	1986	NIVA	?	?	Shipek/Day	?	?	-
Oseberg	1984	?	Grid	?	?	?	?	?
	1986	IKU	4 rad. trans.	?	Van Veen 0.2	x 5	1	?
Odin	1985	NIVA	4 rad. trans.	9	Van Veen 0.2	x 3	1	-
Frigg	1986	IKU	4 rad. trans.	10	Van Veen 0.1	x 2?	1	?
Heimdal	1986	IKU	4 rad. trans.	10	Van Veen 0.1	x 2?	1	?
Ekofisk	1973	OPRU	5 rad. trans.	24	Day 0.1	24 x 10	1	+
	1975	OPRU	5 rad. trans.	24	Day 0.1	24 x 10	1	+
	1977	OPRU	5 rad. trans.	27	Day 0.1	24 x 10 3 x 3	1	+
Valhall	1985	IMB	4 rad. trans.	9	Van Veen 0.2	9 x 5	1	-

IKU = Continental Shelf and Petroleum Technology Research Institute, Trondheim
IMB = Department of Marine Biology, Bergen
IMR = Institute of Marine Research, Bergen
IOE = Institute of Offshore Engineering, Edinburgh, UK
MP = A/S Miljøplan, Oslo
NIVA = Norwegian Institute for Water Research, Oslo
OPRU = Oil Pollution Research Unit, Pembroke, UK
*Radiating transects

Table B Investigation of benthos at gas and oil fields in the Norwegian sector of the North Sea. I = main component of sediment: S sand, mS medium sand, Sm mixed sand, FS fine sand; II = % organic material in sediment; III = radium (m) of affected area; columns S, N, H' and n/m^2 concern unaffected areas and stand for number of species, number of individuals and Shannon-Wiener diversity index per station, and N/m^2 is N extrapolated to 1 square metre

Field	Year	I	II	III	S	N	H'	N/m^2
Statfjord	1980	S	?	A: 2000	85	877	?	1754
61°17'N 01°50'E	1982							
	1984	mS	0.8	A: 1000	161	2922	5.8	5844
			0.7	B: 500	177	3110	5.7	6220
			0.5	C: <250	161	2981	5.6	5962
Gullfaks 61°10'N 02°10'E	1984	Sm	1.4	no effect	76	496	4.9	2480
Oseberg	1984	S	?	?	?	?	?	?
60°37'N 02°50'E	1986	S	-	-	-	-	-	-
Odin 60°07"N 02°10'E	1984	?	?	<100	53	105	5.4	350
Frigg 59°55'N 02°10'E	1986	?	-	-	-	-	-	-
Heimdal 59°33'N 02°13'E	1986	?	-	-	-	-	-	-
Ekofisk	1973	FS	0.5	no effect	45	3223	-	3223
56°33'N 03°20'E	1975	FS	?	<2000	?	?	?	?
	1977	FS	-	<3000	68	2537	-	2537
Valhall 56°17'N 03°30'E	1985	FS	0.6	3000	35	134	4.2	264

Table C Investigations of benthos at oil and gas fields in the Norwegian sector of the North Sea. The three top-ranked species among the polychaetes, crustaceans, bivalves and echinoderms

Statfjord A		1984	1980
	POL	Glyphanostomum macroglos.	Myriochele oculata
		Exogone verugera	Owenia fusiformis
		Glycera capitata	Eclysippe vanelli
	CRU	Tmetonyx cicada	Menigratopsis sp.
		Paraphoxus oculatus	Cirolana borealis
		Cirolana borealis	-
	BIV	Venus ovata	Parvicardium minimum
		Lima spp. juv.	Thyasira spp.
		Yoldiella tomlini	Venus ovata
	ECH	Ophiura affinis juv.	Ophiura affinis
		Echinus sp. juv.	Echinocardium sp. juv.
		Brissopsis lyrifera juv.	Ophiura carnea
Statfjord B		1984	
	POL	Exogene verugera	
		Glycera capitata	
		Owenia fusiformis	
	CRU	Hippomedon denticulatus	
		Praniza	
		Cirolana borealis	
	BIV	Lima subauriculata	
		Venus ovata	
		Yoldiella tomlini	
	ECH	Ophiura affinis juv.	
		Brissopsis lyrifera juv.	
		Echinus sp. juv.	
Statfjord C		1984	
	POL	Exogone hebes	
		Exogone verugera	
		Aonides paucibranchiata	
	CRU	Praniza	
		Cirolana borealis	
		Cythereis mucronata	
	BIV	Lima subauriculata	
		Modiolus phaseolinus juv.	
		Venus ovata	
	ECH	Ophiura affinis juv.	
		Brissopsis lyrifera juv.	
		Echinocyamus pusillus	
Odin		1985	
	POL	Owenia fusiformis	
		Nephtys caeca	
		Onuphis conchylega	
	CRU	Harpinia pectinata	
		Ampelisca typica	
		Anapagurus laevis	
	BIV	Astarte sulcata	
		Venus ovata	
		-	
	ECH	Echinocyamus pusillus	
		-	
		-	

Ekofisk		1973	1977
	POL	Myriochele heeri	Myriochele oculata
		Goniada maculata	Goniada maculata
		Owenia fusiformis	Owenia fusiformis
	CRU	Tryphosites longipes	(lysianassid)
		Hippomedon denticulatus	(cumaceans)
		Ampelisca gibba	Ampelisca sp.
	BIV	Cultellus pellucidus	Arctica islandica
		Montacuta ferruginosa	Abra prismatica
		-	Montacuta substriata
	ECH	Amphiura filiformis	(ophiurids juv.)
		-	Amphiura filiformis
		-	Ophiura affinis
Valhall		1985	
	POL	Nephtys ciliata	
		Goniada maculata	
		Sthenelais limicola	
	CRU	Eudorellopsis deformis	
		-	
		-	
	BIV	Abra prismatica	
		-	
		-	
	ECH	Amphiura filiformis	
		Echinocardium cordatum	
		Echinocardium flavescens	

ANNEX 7

1986 NORTH SEA BENTHOS SURVEY: PROGRESS IN FIELD SAMPLING

Institute/ship	Number of station in survey sector	Number of samples			Dates	°Beauf.
		Corer	Van Veen	Dredge or beam trawl		
RUG/BELGICA	3	1	-	-	08/04/86	7-10
RUG/BELGICA	4	2	1	-	02/04/86	
RUG/BELGICA	6	1	3	-	08/04/86	7-10
RUG/BELGICA	7	3	1	-	01/04/86	
NIOZ/TYRO	7	5	-	-	17/04/86	0
RUG/BELGICA	8	1	3	-	08/04/86	7-10
RUG/BELGICA	9	1	3	-	29/04/86	
NIOZ/TYRO	9	5	-	1	18/04/86	1
RUG/BELGICA	10	2	1	-		7-10
NIOZ/TYRO	10	5	-	1	17/04/86	2
RUG/BELGICA	11	2	-	-	08/04/86	7-10
RUG/BELGICA	12	1	3	-	29/04/86	
NIOZ/TYRO	12	5	-	-	18/04/86	2
RUG/BELGICA	13	-	5	-	10/04/86	7-10
NIOZ/TYRO	13	5	-	1	17/04/86	5
RUG/BELGICA	14	1	3	-	08/04/86	7-10
NIOZ/TYRO	14	5	-	-	18/04/86	2
RUG/BELGICA	15	1	3	-	30/04/86	
NIOZ/TYRO	15	5	-	-	17/04/86	2
RUG/BELGICA	16	-	-	-	08/04/86	7-10
RUG/BELGICA	17	1	3	-	29/04/86	
NIOZ/TYRO	17	5	-	-	18/04/86	3
RUG/BELGICA	18	1	3	-	30/04/86	
RWS/HOLLAND	18	2	1	1	02/05/86	
NIOZ/TYRO	18	5	-	1	17/04/86	3
NIOZ/TYRO	19	5	-	-	19/04/86	3
RUG/BELGICA	19	1	3	-	30/04/86	
RWS/HOLLAND	19	2	1	1	02/05/86	
RUG/BELGICA	20	-	5	-	09/04/86	7-10
NIOZ/TYRO	20	5	-	1	17/04/86	2
RUG/BELGICA	21	-	-	-	-	
NIOZ/TYRO	21	5	-	1	16/04/86	3
RUG/BELGICA	22	-	-	-	-	
RUG/BELGICA	23	-	5	-	09/04/86	7-10
NIOZ/TYRO	23	5	-	-	19/04/86	4
RUG/BELGICA	24	-	5	-	09/04/86	7-10
NIOZ/TYRO	24	5	-	1	19/04/86	3
NIOZ/TYRO	25	5	-	1	16/04/86	4
NIOZ/TYRO	26	-	-	-		
RUG/BELGICA	27	-	-	-		
RUG/BELGICA	28	-	5	-	09/04/86	7-10
RUG/BELGICA	29	-	5	-	09/04/86	7-10
NIOZ/TYRO	29	5	-	1	19/04/86	3
NIOZ/TYRO	30	5	-	1	19-20 "	3
NIOZ/TYRO	31	5	-	-	01/05/86	2
RUG/BELGICA	32	-	2	-	09/04/86	7-10

ANNEX 7 continued

Institute/ship	Number of station in survey sector	Number of samples			Dates	°Beauf.
		Corer	Van Veen	Dredge or beam trawl		
RUG/BELGICA	33	-	5	-	09/04/86	7-10
NIOZ/TYRO	33	2	3	-	21/04/86	3
NIOZ/TYRO	34	5	-	1	20/04/86	6
NIOZ/TYRO	35	5	-	1	20/04/86	2
NIOZ/TYRO	36	5	-	1	01/05/86	1
NIOZ/TYRO	37	5	-	1	30/04/86	0
RWS/HOLLAND	39	2	1	-	22/04/86	
RWS/HOLLAND	40	2	1	1	01/05/86	1
NIOZ/TYRO	41	-	-	-	20/04/86	3
NIOZ/TYRO	42	5	-	1	20/04/86	5
NIOZ/TYRO	43	5	-	1	01/05/86	3
NIOZ/TYRO	44	5	-	1	30/04/86	2
NIOZ/TYRO	45	5	-	1	30/04/86	2
Wilhelmshaven/SENCKENBERG	45	3	-	1	21/04/86	6
Wilhelmshaven/SENCKENBERG	46	3	-	1	24/04/86	4
RWS/HOLLAND	47	2	1	-	22/04/86	5
RWS/HOLLAND	48	2	1	1	01/05/86	1
NIOZ/TYRO	49	5	-	1	21/04/86	3
NIOZ/TYRO	50	5	-	-	21/04/86	6
NIOZ/TYRO	51	2	-	1	22/04/86	8
NIOZ/TYRO	52	5	-	1	30/04/86	2
NIOZ/TYRO	53	5	-	1	29/04/86	3
Wilhelmshaven/SENCKENBERG	53	3	-	-	21/04/86	6
Wilhelmshaven/SENCKENBERG	54	3	-	-	21/04/86	6
Bremerhaven/VICT. HENSEN	55	3	1	-	25/04/86	
RWS/HOLLAND	56	2	1	-	22/04/86	3
RWS/HOLLAND	57	2	1	1	01/05/86	1
NIOZ/TYRO	58	5	-	1	21/04/86	3
NIOZ/TYRO	59	5	-	1	21/04/86	5
NIOZ/TYRO	60	-	-	-	22/04/86	8
NIOZ/TYRO	60	5	-	1	01/05/86	3
NIOZ/TYRO	61	5	-	1	29/04/86	3
Wilhelmshaven/SENCKENBERG	61	3	-	1	21/04/86	6
NIOZ/TYRO	62	5	-	1	29/04/86	0
Wilhelmshaven/SENCKENBERG	62	3	-	1	21/04/86	6
Bremerhaven/VICT. HENSEN	63	3	1	x	25/04/86	
Hamburg/FRIED. HEINCKE	64	-	-	-	-	
RWS/HOLLAND	65	2	1	-	22/04/86	3
RWS/HOLLAND	66	2	1	1	01/05/86	1
NIOZ/TYRO	67	5	-	1	23/04/86	3
NIOZ/TYRO	68	5	-	1	23/04/86	4
NIOZ/TYRO	69	5	-	1	22/04/86	6
NIOZ/TYRO	70	5	-	1	22/04/86	3
Wilhelmshaven/SENCKENBERG	70	3	-	-	21/04/86	6
NIOZ/TYRO	71	5	-	1	29/04/86	1
Wilhelmshaven/SENCKENBERG	71	3	-	-	23/04/86	4
Bremerhaven/VICT. HENSEN	72	-	3	-	25/04/86	

ANNEX 7 continued

Institute/ship	Number of station in survey sector	Number of samples: Corer	Van Veen	Dredge or beam trawl	Dates	°Beauf.
Hamburg/FRIED. HEINCKE	73	2	1	1	13/04/86	
RWS/HOLLAND	74	2	1	-	23/04/86	2-3
RWS/HOLLAND	75	2	1	1	01/05/86	1
RWS/HOLLAND	76	2	1	1	01/05/86	1
NIOZ/TYRO	77	5	-	1	23/04/86	3
NIOZ/TYRO	78	5	-	1	23/04/86	3
NIOZ/TYRO	79	-	-	-	22/04/86	7
NIOZ/TYRO	79	5	-	1	24/04/86	3
Wilhelmshaven/SENCKENBERG	79	-	-	-	23/04/86	
NIOZ/TYRO	80	5	-	1	28/04/86	3
Wilhelmshaven/SENCKENBERG	80	3	-	1	23/04/86	4
Bremerhaven/VICT. HENSEN	81	3	1	x	25/04/86	
Hamburg/FRIED. HEINCKE	82	1-2	3	1	15/04/86	
RWS/HOLLAND	83	2	1	-	23/04/86	2-3
Wilhelmshaven/SENCKENBERG	84	3	-	-	19/04/86	
Wilhelmshaven/SENCKENBERG	85	3	-	-	19/04/86	4
Wilhelmshaven/SENCKENBERG	86	3	-	-	20/04/86	5
NIOZ/TYRO	86	5	-	1	23/04/86	3
Wilhelmshaven/SENCKENBERG	87	3	-	-	20/04/86	6
NIOZ/TYRO	87	5	-	1	24/04/86	4
Wilhelmshaven/SENCKENBERG	88	3	-	-	20/04/86	6
NIOZ/TYRO	88	5	-	1	24/04/86	3
Wilhelmshaven/SENCKENBERG	89	3	-	-	23/04/86	4
NIOZ/TYRO	89	5	-	1	28/04/86	3
Bremerhaven/VICT. HENSEN	90	-	3	-	25/04/86	
Hamburg/FRIED. HEINCKE	91	2	3	1	15/04/86	
Hamburg/FRIED. HEINCKE	92	2	3	1	15/04/86	
RWS/HOLLAND	93	2	1	-	23/04/86	2-3
Wilhelmshaven/SENCKENBERG	94	3	-	1	19/04/86	4
Wilhelmshaven/SENCKENBERG	95	3	-	1	20/04/86	5
Wilhelmshaven/SENCKENBERG	96	3	-	1	20/04/86	5
NIOZ/TYRO	96	5	-	1	24/04/86	3
Wilhelmshaven/SENCKENBERG	97	3	-	-	18/04/86	2
NIOZ/TYRO	97	5	-	1	24/04/86	3
Wilhelmshaven/SENCKENBERG	98	3	-	1	23/04/86	4
NIOZ/TYRO	98	5	-	1	25/04/86	3
NIOZ/TYRO	99	5	-	1	28/04/86	2
Bremerhaven/VICT. HENSEN	99	-	3	2	25/04/86	
Bremerhaven/VICT. HENSEN	100	3	1	x	19/04/86	
Hamburg/FRIED. HEINCKE	101	2	3	1	16/04/86	
Hamburg/FRIED. HEINCKE	102	-	-	-	-	
RWS/HOLLAND	103	2	1	-	23/04/86	3
Wilhelmshaven/SENCKENBERG	104	3	-	-	19/04/86	
Wilhelmshaven/SENCKENBERG	105	3	-	-	19/04/86	4
Wilhelmshaven/SENCKENBERG	106	3	-	-	19/04/86	2
NIOZ/TYRO	106	5	-	1	26/04/86	1
Wilhelmshaven/SENCKENBERG	107	3	-	-	18/04/86	2
NIOZ/TYRO	107	5	-	-	25/04/86	1
Wilhelmshaven/SENCKENBERG	108	3	-	-	18/04/86	2

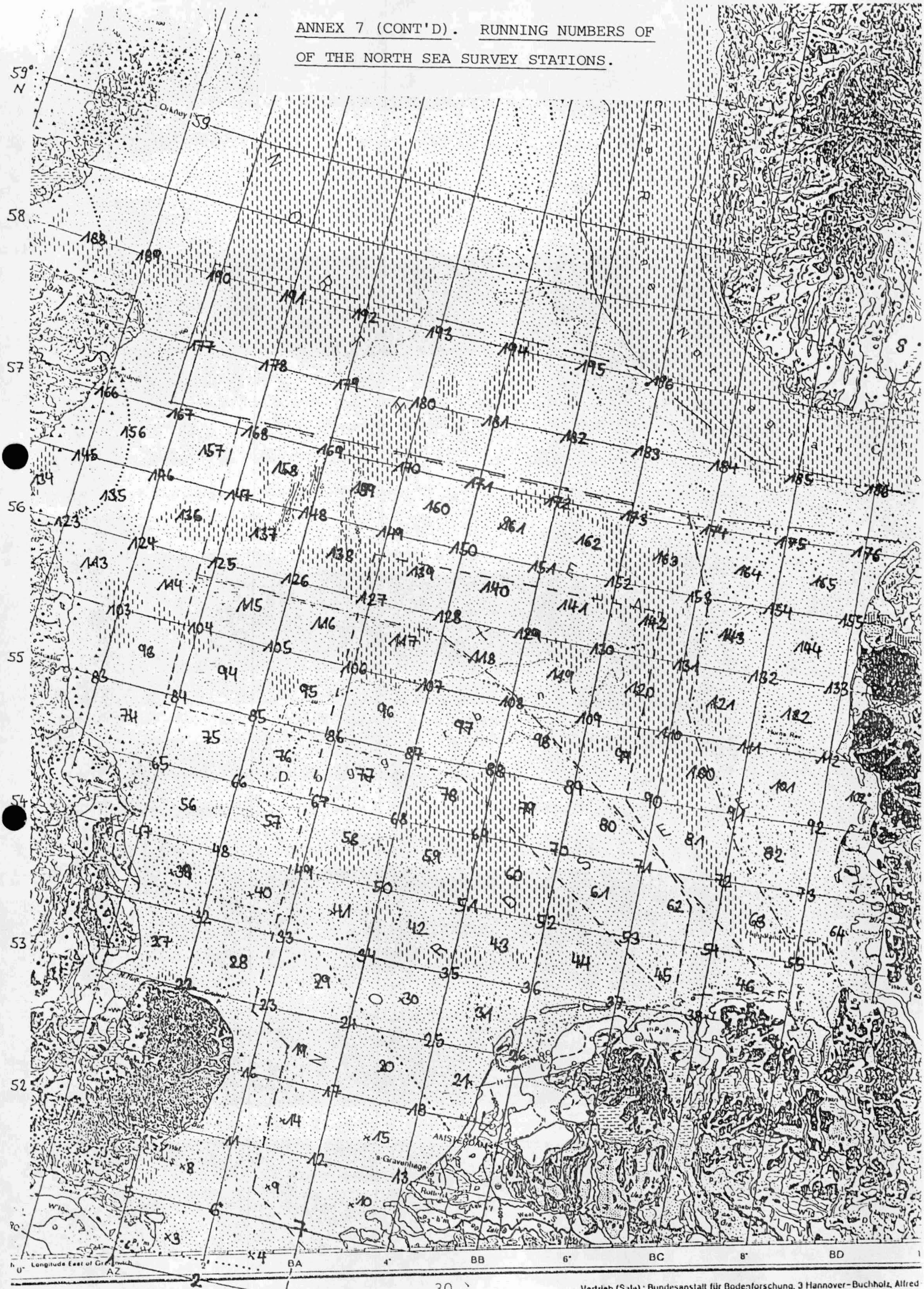
ANNEX 7 continued

Institute/ship	Number of station in survey sector	Number of samples: Corer	Van Veen	Dredge or beam trawl	Dates	°Beauf.
NIOZ/TYRO	108	5	–	1	25/04/86	3
NIOZ/TYRO	109	5	–	1	28/04/86	2
Bremerhaven/VICT. HENSEN	109	–	3	–	25/04/86	
Bremerhaven/VICT. HENSEN	110	3	1	–	19/04/86	
Hamburg/FRIED. HEINCKE	111	2	3	1	17/04/86	
Hamburg/FRIED. HEINCKE	112	2	3	1	17/04/86	
RWS/HOLLAND	113	2	1	–	23/04/86	2
RWS/HOLLAND	114	2	1	1	29/04/86	1
Wilhelmshaven/SENCKENBERG	115	3	–	1	19/04/86	4
Wilhelmshaven/SENCKENBERG	116	3	–	1	19/04/86	4
Wilhelmshaven/SENCKENBERG	117	3	–	1	18/04/86	2
NIOZ/TYRO	117	5	–	1	25/04/86	0
NIOZ/TYRO	118	5	–	1	25/04/86	3
Bremerhaven/VICT. HENSEN	118	–	3	x	24/04/86	
NIOZ/TYRO	119	5	–	1	25/04/86	3
Bremerhaven/VICT. HENSEN	119	–	3	x	24/04/86	
NIOZ/TYRO	120	5	–	1	28/04/86	0
Bremerhaven/VICT. HENSEN	120	3	1	x	19/04/86	
Hamburg/FRIED. HEINCKE	121	2	3	1	18/04/86	
Hamburg/FRIED. HEINCKE	122	2	3	1	18/04/86	
RWS/HOLLAND	123	2	1	–	23/04/86	1
RWS/HOLLAND	124	2	1	1	29/04/86	1
Bremerhaven/VICT. HENSEN	125	3	1	–	23/04/86	
Bremerhaven/VICT. HENSEN	126	–	3	–	23/04/86	
Bremerhaven/VICT. HENSEN	127	3	1	–	23/04/86	
NIOZ/TYRO	127	5	–	1	26/04/86	3
Bremerhaven/VICT. HENSEN	128	–	3	–	24/04/86	
NIOZ/TYRO	128	5	–	1	26/04/86	1
Bremerhaven/VICT. HENSEN	129	–	3	–	24/04/86	
NIOZ/TYRO	129	5	–	1	27/04/86	3
Bremerhaven/VICT. HENSEN	130	–	3	–	24/04/86	
NIOZ/TYRO	130	5	–	1	27/04/86	4
Bremerhaven/VICT. HENSEN	131	3	1	–	19/04/86	
Hamburg/FRIED. HEINCKE	132	2	3	1	18/04/86	
Hamburg/FRIED. HEINCKE	133	2	3	1	18/04/86	
RWS/HOLLAND	134	2	1	1	23/04/86	1
RWS/HOLLAND	135	2	1	–	23/04/86	1
RWS/HOLLAND	136	2	1	1	30/04/86	1
Bremerhaven/VICT. HENSEN	137	3	1	x	23/04/86	
Bremerhaven/VICT. HENSEN	138	–	3	x	23/04/86	
Bremerhaven/VICT. HENSEN	139	–	3	x	24/04/86	
NIOZ/TYRO	139	5	–	1	26/04/86	2
Bremerhaven/VICT. HENSEN	140	–	4	x	24/04/86	
NIOZ/TYRO	140	5	–	1	27/04/86	3
Bremerhaven/VICT. HENSEN	141	–	3	x	24/04/86	
NIOZ/TYRO	141	5	–	1	27/04/86	3
NIOZ/TYRO	142	5	–	1	27/04/86	2
Bremerhaven/VICT. HENSEN	142	3	1	x	19/04/86	
Hamburg/FRIED. HEINCKE	143	2	3	1	19/04/86	

ANNEX 7 continued

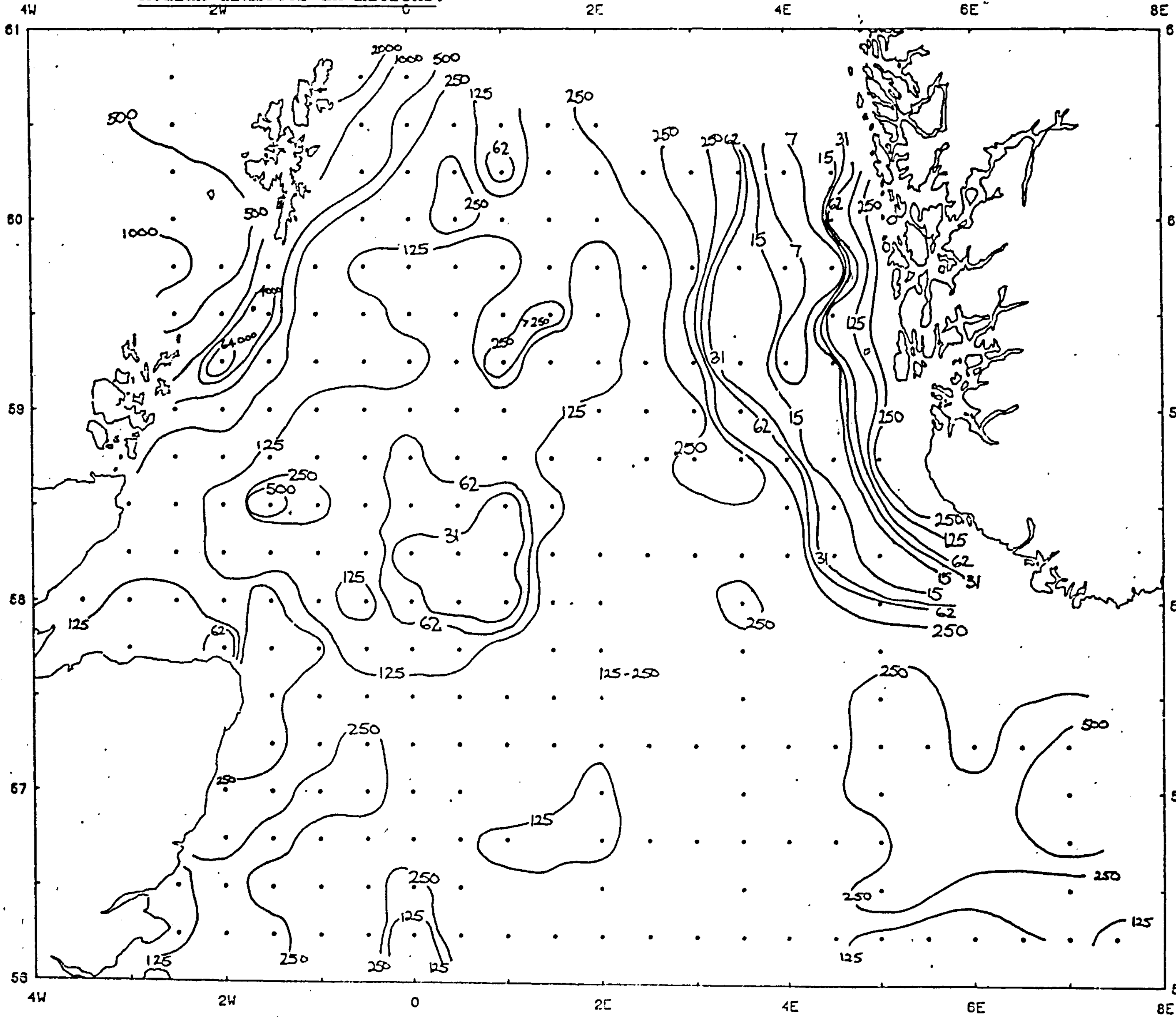
Institute/ship	Number of station in survey sector	Number of samples			Dates	°Beauf.
		Corer	Van Veen	Dredge or beam trawl		
Hamburg/FRIED. HEINCKE	144	2	3	1	19/04/86	
RWS/HOLLAND	145	2	1	1	23/04/86	1
RWS/HOLLAND	146	2	1	1	24/04/86	1
Bremerhaven/VICT. HENSEN	147	-	3	-	23/04/86	
Bremerhaven/VICT. HENSEN	148	-	3	-	22/04/86	
Bremerhaven/VICT. HENSEN	149	-	3	-	21/04/86	
Bremerhaven/VICT. HENSEN	150	-	3	-	21/04/86	
Bremerhaven/VICT. HENSEN	151	-	3	-	20/04/86	
Bremerhaven/VICT. HENSEN	152	3	1	-	20/04/86	
Hamburg/FRIED. HEINCKE	153	2	3	1	20/04/86	
Bremerhaven/VICT. HENSEN	153	3	1	-	20/04/86	
Hamburg/FRIED. HEINCKE	154	2	3	1	20/04/86	
Hamburg/FRIED. HEINCKE	155	2	3	1	19/04/86	
RWS/HOLLAND	156	2	1	1	24/04/86	1
RWS/HOLLAND	157	2	1	1	24/04/86	1
Bremerhaven/VICT. HENSEN	158	-	4	x	23/04/86	
Bremerhaven/VICT. HENSEN	159	-	3	x	22/04/86	
Bremerhaven/VICT. HENSEN	160	-	3	x	21/04/86	
Bremerhaven/VICT. HENSEN	161	-	3	x	21/04/86	
Bremerhaven/VICT. HENSEN	162	-	3	(2)	20/04/86	
Bremerhaven/VICT. HENSEN	163	3	1	x	20/04/86	
Hamburg/FRIED. HEINCKE	164	-	3	1	20/04/86	
Hamburg/FRIED. HEINCKE	165	-	3	1	20/04/86	
RWS/HOLLAND	166	2	1	1	24/04/86	1
RWS/HOLLAND	167	2	1	1	24/04/86	
Bremerhaven/VICT. HENSEN	168	-	4	-	23/04/86	
Bremerhaven/VICT. HENSEN	169	-	3	-	22/04/86	
Bremerhaven/VICT. HENSEN	170	-	3	-	22/04/86	
Bremerhaven/VICT. HENSEN	171	-	3	-	21/04/86	
Bremerhaven/VICT. HENSEN	172	-	3	-	21/04/86	
Bremerhaven/VICT. HENSEN	173	3	1	-	20/04/86	
Hamburg/FRIED. HEINCKE	174	-	2	-	21/04/86	
Hamburg/FRIED. HEINCKE	175	2	3	1	21/04/86	
Hamburg/FRIED. HEINCKE	176	-	2	1	21/04/86	
Kiel/LITTORINA	177	3	1	1	16/05/86	
Kiel/LITTORINA	177a	-	-	1	16/05/86	
Kiel/LITTORINA	178	-	3	1	19/05/86	
Kiel/LITTORINA	179	-	3	1	20/05/86	
Kiel/LITTORINA	180	-	3	1	20/05/86	
Kiel/LITTORINA	181	3	1	1	20/05/86	
Kiel/LITTORINA	182	3	1	1	20/05/86	
Kiel/LITTORINA	183	-	-	-		
Kiel/LITTORINA	184	3	1	1	14/05/86	
Kiel/LITTORINA	185	3	1	1	14/05/86	
Kiel/LITTORINA	186	3	1	1	14/05/86	
Kiel/LITTORINA	187	3	1	1	14/05/86	
Kiel/LITTORINA	188-193	-	-	-		
Kiel/LITTORINA	194	3	1	1	20/05/86	
Kiel/LITTORINA	195	3	1	1	20/05/86	
Kiel/LITTORINA	196	-	4	1	15/05/86	

ANNEX 7 (CONT'D). RUNNING NUMBERS OF OF THE NORTH SEA SURVEY STATIONS.



ANNEX 8. NORTH SEA PHYSICAL DATA (DAFS SURVEY).

Median diameter in microns.



ANNEX 9

SUMMARY OF MEASURES FOR ASSESSING THE POINT SOURCE IMPACT OF WASTES ON BENTHIC COMMUNITIES

a. Types of input

Shallow water to c. 300 m:

i mixed inputs of unknown composition
ii sewage and organic matter; sewage sludge
iii industrial waste of known origin
iv dredged spoil
v drilling activity
vi oil (shipwrecks/tank washings/pipeline)
vii coastal engineering works

Deep sea:

i radioactive waste
ii sewage sludge
iii industrial waste of known origin
iv polymetal nodule mining

b. Time-scales of response

i	Biochemical		hours
ii	Physiological)	individual	days
iii	Behavioural)		minutes-days
iv	Population		generation times (weeks-months)
v	Community		seasons-years

c. Types of community response for precise and accurate measurement of spatial and temporal trends

(Advantages of direct measures of community changes may be offset by imprecise definition of subtle effects.)

i density
ii diversity - species richness; higher taxa
iii trophic diversity - feeding strategy, enzyme systems, morphological characters
iv size spectra - exhaustive sampling required
v life-cycle strategies - r, k
vi community composition - interstitial fauna/infauna/epifauna; vertical distribution
vii biomass
viii community metabolism - R, O_2-uptake, etc.

Precision and accuracy depend on:

- i previous knowledge of the area: sediments, communities, other human impacts (e.g. fishing)
- ii hydrography
- iii sampling strategy: design, effort
- iv sampling gear: grabs, dredges, corers, navigation aids, etc.
- v standardisation of methods
- vi taxonomic and other individual expertise
- vii data treatment

d. Wider consequences of benthic changes

- i fish - numbers and biomass of suitable food species (effects on eggs, larvae, juvenile and adult fish requires separate study)
- ii nutrient regeneration/community metabolism (role of benthic bacteria?)
- iii direct exploitation - e.g. crustaceans, molluscs, worms as bait
- iv physical effects on benthic boundary layer - e.g. mussel beds: change in exchange pattern
- v benthic larvae in pelagic systems

e. General remarks

- i both qualitative and quantitative models for benthic community responses to pollution are required
- ii large gaps exist in basic knowledge of the benthic fauna, especially concerning the biology of individual species, and interactions between species
- iii no single measure of community change has yet been derived which can adequately account for the full range of pollutant impact; assessment of effects therefore requires a combination of approaches, each measuring different properties of community structure and/or function.