Advisory Committee on Fishery Management ICES CM 1997/E:4

REPORT OF THE

WORKING GROUP ON THE EFFECTS OF EXTRACTION OF MARINE SEDIMENT ON THE MARINE ECOSYSTEM

Copenhagen, Denmark
15–18 April 1997

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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April 1997

1 INTRODUCTION

The Working Group was welcomed to Copenhagen and to the National Forest and Nature Agency, Ministry of Environment and Energy by Miss Anne Rasmussen (Head of the Raw Materials Division) and by Poul Eric Nielsen. Miss Rasmussen stressed the importance of the work of the Group and noted the ever increasing concern for the environment when aggregate extraction projects were discussed. Poul Eric Nielsen outlined arrangements for the week. The meeting was opened by the Chairman, Dr S J de Groot, who welcomed all the participants. Dr de Groot provided new participants with a brief overview of the ICES request that the Working Group consider extraction activities and effects in the Baltic Sea, and of attempting to conclude work on the Cooperative Research Report. The Terms of Reference were confirmed (see Section 2 below) and the Agenda adopted (Annex 1). The participants appointed Dr Jonathan Side as Rapporteur.

2 TERMS OF REFERENCE

The Terms of Reference of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (Chairman: Dr S J de Groot, Netherlands) were set out by ICES Council Resolution (C.Res 1996/2:28) as:-

a) provide information on the effects of extraction of marine sand and gravel on the Baltic ecosystem, including the extent and volume of such extractions, and known impacts on, e.g. benthos, diving seabirds, and bottom-spawning fish and invertebrates [HELCOM 1996/11];

b) complete work on the update of the ICES Cooperative Research Report No 182 with the aim of finalising a revised edition at this meeting, including:

   i) approaches to Environmental Impact Assessments, relative to marine extraction operations;
   ii) the evaluation of the effects of marine sediment extraction activities on benthos and fisheries, in particular, the development of concerted approaches to critical habitat mapping and classification.

3 REVIEW OF NATIONAL MARINE AGGREGATE EXTRACTION ACTIVITIES

3.1 Belgium

In 1996, 1,443,629 m³ sand was extracted from extraction zone 2 on the Belgian continental shelf (Figure 5.1, Section 5), which is somewhat less than in 1995. Twelve licence holders are currently involved. As in the previous years, most of the sand was extracted at the northern part of the Kwintebank.

At the beginning of 1997 a new licence was granted for a three-year trial period. One of the licences which existed in 1996 has been suspended from January 1st 1997 on request of the licence holder.

Two new applications for temporary licences are under consideration. The first is to provide 1,575,000m³ sand and gravel for the Interconnector gas pipeline, currently under construction. The other application is to provide 400,000 m³ sand and gravel as cover for the NORFRA gas pipeline. This project will start in May-June 1997.

It is likely that licences for both projects will be granted.

3.2 Canada

As of April 1997, marine mining is not permitted in the Canadian offshore. Industry continues to express interest in marine mining for placers and aggregates, but the lack of a legislative framework and detailed mapping of resources, particularly in the nearshore, are the main deterrents to further investment and investigation. Marine mining assessment projects are in final stages of preparation for areas of the Scotian Shelf and the Grand Banks of Newfoundland off the east coast of Canada. These have been sponsored by the federal government and the provincial governments of Nova Scotia and Newfoundland.

The Geological Survey of Canada has conducted both large and small vessel surveys in the nearshore and on the outer continental shelf to map and collect large volume samples of marine aggregate. These samples have been tested to determine their characteristics for a wide variety of asphalt, concrete and other applications. Preliminary reports on this testing have been released as Geological Survey of Canada publications. The density, diversity and dominance of the benthic macrofauna has been included in the assessment. Final synthesis reports and maps are in progress and aggregate genesis models will be produced. Of particular importance to models of the genesis of aggregates has been a study of the sea-level history of the continental shelf, which to a large degree is the dominant control the distribution of suitable aggregate materials.

Considerable volumes of sand and gravel occur offshore that could be used in aggregate applications. Not including areas of the seabed where fishing is extensive and mining would be difficult to approve, the Scotian Shelf has an area of 90,000 square kilometres covered by sand and gravel for potential use in aggregate applications. An area of high potential, where bottom fishing is limited, occurs on Middle Bank. It contains approximately 700 million cubic metres of coarse sand and gravel. Additionally, a large sand ridge on Eastern Shoal, Banquereau, approximately 20 km in length, contains 99% pure silica sand with high economic potential.

3.3 Denmark

Production of sand and gravel in Denmark.

The extraction of marine sand and gravel represent 10-13 % of the total production of materials for construction and reclamation in Denmark. The amount of materials dredged for construction has been slightly increasing since 1992. The dredging of sand for land reclamation has increased markedly over the last 10 years caused by several large construction works in coastal areas.

From 1989 to 1993 more than 9 x 10^6 m^3 of sand fill and till have been dredged for the construction of the Great Belt bridge and tunnel project.

Table 3.1: Marine sediment extraction in Denmark

Year	Sand O-2 mm	Gravel 0-20 mm	Gravel/ Stones (6-300 mm)	Sand fill	Misc. (Till)
1990	1.0 x 10^6 m^3	0.2 x 10^6 m^3	0.6 x 10^6 m^3	3.9 x 10^6 m^3	0.1 x 10^6 m^3
1991	1.1 x 10^6 m^3	0.5 x 10^6 m^3	0.9 x 10^6 m^3	4.4 x 10^6 m^3	1.0 x 10^6 m^3
1992	0.7 x 10^6 m^3	0.5 x 10^6 m^3	0.9 x 10^6 m^3	1.2 x 10^6 m^3	0.8 x 10^6 m^3
1993	0.9 x 10^6 m^3	0.2 x 10^6 m^3	1.1 x 10^6 m	2.1 x 10^6 m^3	
1994	1.1 x 10^6 m^3	0.2 x 10^6 m^3	1.3 x 10^6 m^3	2.6 x 10^6 m^3	
1995	1.1 x 10^6 m^3	0.2 x 10^6 m^3	1.2 x 10^6 m^3	2.8 x 10^6 m^3	0.3 x 10^6 m^3
*1996	1.0 x 10^6 m^3	0.2 x 10^6 m^3	1.1 x 10^6 m^3	4.0 x 10^6 m^3	2.2 x 10^6 m^3

* The figures for 1996 are preliminary.

In 1995 the majority of the sand fill (2.6 x 10^6 m^3) was used for beach nourishment on the west coast of Jutland.

During the construction of the fixed link between Denmark and Sweden 3 x 10^6 m^3 of sand will be dredged from the Kriegers Flak in the Baltic. The dredging started in January 1996 and is expected to last 4 years. To date, some 350,000 m^3 have been dredged. In the period of the project up to 7 x 10^6 m^3 dredged materials of glacial till and limestone will be used for reclamation and as hydraulic fill in ramps for the bridge and tunnel.

No detailed forecast for the future extraction has been prepared but it is expected that the exploitation of marine sand and gravel will increase with a corresponding reduction in exploitation of land-based materials. This is mainly a result of the future termination of a number of licences on land and increasing environmental conflicts in potential extraction areas on land.

The National Forest and Nature Agency has commissioned the Geological Survey to undertake an evaluation of the total reserve volume of sand and gravel in Danish Waters based on all existing data collected since 1979. The calculation of the reserve volume is based on known technical limitations (i.e. overburden) and present environmental restrictions. To date the southern Kattegat and part of the Baltic have been evaluated. The rest of the Inner Danish Waters will be evaluated during 1997. The present knowledge of the resources and the environmental conditions in the North Sea is very incomplete and will only allow an evaluation of selected areas.

3.4 France

In 1994, about 4 million tonnes (2.6 million m^3) of siliceous material and gravel were extracted from the French seabed. In the same year, 0.68 million of tonnes (0.5 million m^3) of calcareous material (shelly sand and *Lithothamnion*) was produced. There are eleven locations at which siliceous deposits are exploited; calcareous deposits are exploited at 10 locations, principally in Brittany (see Maps in Annex V)

Production has been very stable in France from 1990 to 1995, being 3.92, 3.99, 3.70, 3.45, 3.67, and 3.66 x10^6 tonnes respectively. Production from calcareous deposits is about one fifth that of siliceous aggregates.

3.5 Finland

The volume of sand and gravel extraction varies from year to year and there are no official statistics available. The annual average extraction of sand and gravel is, however, estimated to be less than 500,000 tonnes. The principal areas where extraction operations have occurred in recent years are in coastal areas off the cities of Helsinki, Kotka, and Pori (in the Gulf of Bothnia).

3.6 Germany

North Sea

The data presented below are incomplete as it is not possible to report on all activities.

In the Ems and Jade estuary, the commercial aggregate sites are in or alongside the shipping channels which are maintained by dredging. Maintenance dredged sand is also used for commercial purposes and the amount of commercially dredged sand is a fraction (10%) of the total sand removed. Table 3.2 shows the amount of sand extracted (commercially) in the Ems and Jade estuary and varies from year to year from 0.6 to 2.5 million m^3.

In the North Frisian area all extraction is commercial extraction. Most of the sand is extracted near the island of Sylt with the greatest extraction site west of the city Westerland. The year 1994 was an exception, when most of the sediment was extracted between the islands south of Sylt.

Table 3.2: Commercial extraction in estuaries and the North Sea [m^3] (Map Annex V)

Year	Ems and North Sea	Jade	North Frisian Coast
1991	1,916,916	0	2,000,000
1992	294,273	300,000	2,652,500
1993	404,080	165,000	2,285,000
1994	2,469,795	0	1,910,000
1995	487,687	120,000	1,547,500
1996			1,285,000
1991 - 1995	5,572,751	585,000	10,395,000

Baltic Sea

Within the western Baltic there are only 4,000 to 15,000 m^3 per year extracted commercially as part of the maintenance dredging within the area around Luebeck. In the past and at present there are 17 areas used for sediment extraction. There have been no data available on the amount of already extracted sediments in the Mecklenburg Bight and around the island of Ruegen.

Use of Sediments

Within the North Frisian area and the Jade Bay nearly all of the extracted sand is used for coastal protection or beach nourishment. For the Ems estuary the sediments are partly used for coastal protection, beach nourishment or road construction and similar activities (data for Table 3.2 are not yet complete).

Further reasons for sediment extraction in the marine environment are maintenance (see Table 3.3) or capital dredging within the waterways.

Table 3.3: Maintenance dredging within federal waterways [m³] (Leuchs and Nehring 1996)

Year	Ems	Jade	Weser	Elbe	Kiel Canal
1991	6,300,000	10,200,000	1,700,000	16,400,000	7,700,000
1992	7,000,000	10,300,000	1,700,000	10,500,000	7,600,000
1993	8,200,000	14,500,000	1,800,000	15,800,000	9,400,000
1994	10,600,000	13,600,000	1,300,000	13,300,000	7,600,000
1995	9,200,000	11,000,000	1,600,000	11,700,000	7,100,000
1991 - 1995	41,300,000	59,600,000	8,100,000	67,700,000	39,400,000

3.7 The Netherlands

The amount of sand extracted from the North Sea in 1996 was as follows:

Euro-/Maas access-channel to Rotterdam 10.0 x $10^6 m^3$
IJ-access-channel to Amsterdam 4.8 x $10^6 m^3$
Dutch Continental Shelf 8.4 x $10^6 m^3$
Total sand extraction in 1996 23.2 x $10^6 m^3$

The main applications of the extracted sand are for the beach nourishment programme and for land uses. In 1996 approximately 7.7 x $10^6 m^3$ was used for beach nourishment and approximately 15.5 x $10^6 m^3$ was used mainly for land fill.

For the Policy on Extraction of Surface Materials, the Dutch Government has made a Structure Plan for Surface Minerals. This document (June 1995) shows the central government's position on the extraction of surface minerals on land and on the Dutch Continental Shelf of the North Sea by zoning as follows:

- Zone 1: No extraction permitted in principle
- Zone 2: Extraction permitted on certain conditions
- Zone 3: Extraction permitted in principle

A desk study has been undertaken in order to make an evaluation of "The Total Demand for sand out of the North Sea for the period 1996 to 2030". The draft study report shows a need of minimum 173 and a maximum of 953 x $10^6 m^3$ during this period. The final report on this research is to expected soon.

Gravel extraction in 1996

In 1996, no extraction of gravel took place in the Dutch part of the North Sea. Due to the Dutch policy on extraction of surface minerals as written down in Structure Plan for Surface Minerals, extraction on the Cleaver Bank will not be permitted before the termination of the gravel extraction carried out in conjunction with the lowering of the winter bed of the River Maas. This policy is part of the expected peak in the extraction of gravel in the south-east of the Netherlands (Limburg) as a result of the implementation of the Delta Plan for the Major Rivers. The effects of this Plan will lead to a production of relatively high quantities of gravel in a short space of time (period up to 2005). The total available quantities will increase from 35 to 60 million tonnes, due to these works.

Shell extraction in 1996

Because of the low density of shells in deeper water (>20m), shell extractions in the Dutch waters are limited to the coastal waters of the Waddensea and adjacent tidal inlets, and the Delta Area. The extraction policy is based on the principle of ecological and economical sustainability. In this case defined as: the yearly amount of extracted shells must be equal or be less than the average yearly amount of new shells that become available for extraction (Busschbach *et al.*,1997).

In 1996 new calculations were made to establish the natural production of shells in the Waddensea. These calculations are based on a 28 year time series of shell production in a study area of 50 km^2, and on observations over 7 years in the whole Waddensea. The results of these calculations confirm the maximum allowed amounts of shell extractions that had been permitted in previous years. So a change in permitted extraction volume is not to be expected. The maximum amount for the Waddensea is 140,000 m^3 and for the areas outside the tidal inlets 60,000 m^3.

Also for the Delta area maximum amounts will be defined. The calculations of natural production in this area are less clear, because of the lack of long time series of observed shell production. Due to the licence for shell extraction for the period 1998-2000 an Environmental Impact Assessment study for the shell extraction in Dutch waters will be carried out in 1997.

3.8 Norway

Little sand and gravel exploitation has taken place during 1996, partly due to the easy available resources on land, and partly due to quality requirements, e.g. salt content. The small quantities are extracted in fjord deltas along the Norwegian coast.

Carbonate sand extraction has increased by 10-15 % from 1994-1995, from 127,000 tonnes to 155,000 tonnes. 80 % of the volume is extracted and utilised in the counties of Rogaland, Hordaland and Vest-Agder in southwest Norway.

3.9 Poland

Aggregate resouces

During the last 30 years geological prospecting and reconnaissance surveys carried out by the Branch of Marine Geology of the Polish Geological Institute has resulted in locating concentrations of various mineral products on the seabed of the Polish part of the Baltic Sea. In some cases they are of potential economic significance. Natural aggregate, i.e. gravel, sandy gravel and gravelly sand, which form deposits on the seabed are the most thoroughly investigated mineral resources in the Southern Baltic. To date, three deposits have been documented.

The "Slupsk Bank" deposit lies at depths between 16 and 20m. The deposit comprises eight fields of aggregate within sandy deposits in the middle and eastern part of the bank, or on a washed out surface of till – in the western part of the bank. The areas of the fields are between 0.8 and 10.5 km^2 and total about 31.0 km^2. The thickness of the deposit layer is between 0.3 and 2.0 m, with an average of about 1.0 m. The average content of grains with diameter below 2.0 mm (sand) is 64%. Geologically documented resources are 64.5 x 10^6 tonnes.

The "Southern Middle Bank" deposit lies at a depth of between 16 and 30 m. The aggregate occurs in the form of irregular patches of varying thickness, resting on sandy substratum, and in the south-western part also on till. Nine deposit fields have been documented with areas ranging from 0.53 to 16.9 km^2 (totally about 26.0 km^2). The thickness of the deposit layer is between 0.3 to 5.0 m, with an average of 0.92 m. The average content of grains with diameter below 2.0 mm (sand) is 56.3%. Geologically documented resources are 57.1 x 10^6 tonnes.

The "Koszalin Bay" deposit is in the shallow-water zone at depth 10.0 - 25.0 m. Seventeen deposit fields occur in the form of isolated patches lying on a sandy substratum, or in the south-western part, on till. The area of fields range between 0.3 to 3.6 km^2 (totally about 21.0 km^2). The thickness of the deposit layer is between 0.3 to 1.8 m, with an average of 0.9 m. The average content of grains with diameter below 2.0 mm (sand) is 60.1 %. Geologically documented resources are 37.7 x 10^6 tonnes.

Laboratory and technical investigations of the aggregates from the Southern Baltic deposits showed their very high quality. The aggregates are ideally suited for production of concrete including high strength concrete. The most important advantageous properties of the marine aggregate are their:

- petrographic composition, with predominance of resistant crystalline rock fragments,
- nearly complete lack of contaminants,
- very high crushing strength,
- lack of alkali - aggregate reactivity

Sand resources for beach nourishment

The Hel Peninsula is one of the most popular recreation regions on the Polish coast. The western part of the spit (which forms the Peninsula) is strongly affected by erosion. The sand for beach nourishment is excavated by dredgers from the adjacent open sea bottom and also by a bypassing system from the Puck Lagoon.

Between 1991-1996 there were documented four areas of sands for beach nourishment; three on the open sea bottom and one large area in the Puck Lagoon.

The first area documented in 1991 is located north-east of Jastarnia on the Hel Peninsula, in a distance of 2.5 - 4 km from the shore, at a water depth of 14-20 m. The area consists of two fields of medium sands with available resources for exploitation of 3,496,750 m^3.

The second area documented in 1992 is located north-east from Cape Rozewie and north from Wladyslawowo about 4-10 km from the shoreline at a water depth of 15-20 m. The area consists of 11,250,000 m^3 of medium and coarse sand.

The third area documented in 1996 is located to the east of Wladyslawowo, 3-5 km from the shore, at a water depth of 14-18 m. Similarly like the first area, it consists of two fields of medium sands with total resources of 103,000 m^3.

In the Puck Lagoon seven fields of sands were recognised, which are suitable for beach nourishment and land reclamation. Four fields contain fine sand, totalling about 12,000,000 m^3. The fifth field in the Puck Lagoon contains about 3,500.000 m^3 of fine sand mixed with medium sand. The sixth and seventh fields contain medium sand, totalling about 3,000,000 m^3.

All recognised fields in the Puck Lagoon are located about 0.6-2.5 km from the shoreline and at a water depth of 1-3 m. The fields of fine sands are in the north-western part of the lagoon. The fields of medium sand occur on the submerged barrier forming the southeastern margin of the Puck Lagoon.

Potential areas of sand and gravel accumulation

Gravel, sandy gravel and gravelly sand

Apart from the deposits described above with proven resources, there are also in the Polish EEZ other prospective regions with aggregate accumulations. The most prospective areas are on the north and north-western slope of Slupsk Bank and several smaller fields lying in the Pomeranian Bay, and in the shallow-water area between Dziwnów and Kolobrzeg. There are also a few prospective fields in the area to the north of Leba.

Sand enriched with heavy minerals

Accumulations of sand enriched with heavy minerals are well investigated on the Odra Bank. In this area, highest concentrations of heavy minerals occur at the seabed surface in the form of small isolated fields or elongated belts. The layer with high heavy mineral content rarely exceeds 40 cm (mostly 15–20 cm), and is composed of 0.2–1.0 cm thick laminae alternately rich and poor in heavy minerals. As a rule, the enriched sand contains over 80% fine sand (0.25–0.063 mm) and is well to very-well sorted. As a result of documenting surveys on the north and north-eastern part of the Odra Bank, nine deposit fields of 9.0 km^2 total area have been located and investigated. The average thickness of the deposit layers is 0.55

m, and the average heavy mineral content is 4.64% by weight. There are over 7.0 x 10^6 tonnes of sand enriched with heavy minerals, in which there are about 0.5 x 10^6 tonnes of heavy minerals; garnet, zircon, rutile, ilmenite, magnetite, monazite and others.

Two prospective areas with heavy minerals have also been found on the Slupsk Bank. On this bank, fine sand with high heavy mineral content is present adjacent to the natural aggregate fields. Percentage of heavy minerals varies from 0.75 to 45.0% by weight. Mean percentage of heavy minerals is 13.1 on the first field, and 3.1 on the second. According to preliminary assessments, an average content of ilmenite is about 40 kg/t and 12 kg/t of sand, zircon, rutile and monazite — about 3.5 kg/t and 2.5 kg/t, and garnet — 3.0 kg/t and 9.5 kg/t of sand, respectively.

Sands for beach nourishment and other purposes

Areas of medium and coarse grained sand accumulations are expected in the shallow-water zone (between 10 and 30 m water depth) to the north of Jaroslawiec, Ustka and north-west of Lebsko Lake – on Czolpino Shoal, north-east of Leba, north-west and north-east of Rozewie, and in the Gulf of Gdansk. Preliminary evaluation of medium and coarse sand areas in the Rozewie region, which could be used for nourishment of the Hel Peninsula beaches, is about 240 km^2. Thickness of the sand layer is between 1 and 5 m.

The largest potential areas of fine sand accumulation are in the Pomeranian Bay and on the Odra Bank. Such areas are also in the Ustka and Leba regions, to the north-west of Rozewie and in the Gulf of Gdansk. Because of their chemical composition and physical properties fine sands may be used for industrial applications. The best quality are the well sorted fine sands of the Odra Bank, which can be used as raw material for the steel (moulding) and glass industries and as construction sands.

Use of construction aggregates for concrete in Poland

Manne aggregates have been exploited from the "Slupsk Bank" deposit. About 1,400,000 tonnes of aggregate, were dredged between 1985-1989 using suction hopper dredgers. In 1990 ceased because of economic reasons.

Exploitation from the "Southern Middle Bank" and "Koszalin Bay" deposits was carried out as a trial in the years 1987-1989. About 4,000 - 6,000 tonnes was dredged from each deposit.

Use of marine sediments for coastal protection

A 1 km^2 sand extraction field located 4 km north-east of Jastarnia on the Hel Peninsula was used in 1993 and 1995 for beach nourishment needs (total amount of extracted sand was ca. 200,000 m^3). Sand is currently extracted in a 5 km^2 area north-east of Cape Rozewie for the needs of artificial beach nourishment. It has been dredged since 1995 at a rate of 100,000 m^3/year.

Since 1989 sand has been extracted at four sites in the Puck Lagoon for sand nourishment on the Hel Peninsula. Since 1993 two sites have been closed. From the remaining two areas sand is presently extracted at a rate of 150,000 - 300,000 m^3/year, but this is planned to be (except in instances of coastal catastrophy caused by storm activity) stopped by 1998. The total amount of sand extracted from the Puck Lagoon is about 6,000,000 m^3.

Sand is also extracted from approach channels to ports and from sand traps at ports within operation of artificial sand by-pass systems; such extraction has taken place since about 1990 at the ports of Kolobrzeg ca.60,000 m^3/year), Darlowo (ca. 80,000 m^3/year), Ustka (80,000 m^3/year), Leba (30,000 m^3/year), Wladyslawowo (ca. 200,000 m^3/year).

3.10 United Kingdom

Production in the UK in 1996 rose to 26.6 x 10^6 tonnes from 26.1 x 10^6 tonnes in 1995. Regional summaries are shown in Table 3.4:-

Table 3.4: Marine Aggregate Extraction in 1996

Dredging Area	Actual Removal 1996 (tonnes)
Humber	1,903,678.00
East Coast	9,306,920.00
Thames Estuary	1,115,597.00
South Coast	4,738,401.77
South West	2,019,304.50
North West	287,251.00
Rivers and Miscellaneous	21,783.50

Licences specifically for fill contracts and beach replenishments were as follows:-

England	7,220,642.70
Total	**26,613,578.47**

In 1996, 13 x 10^6 tonnes were used by the construction industry mainly for concrete. A further 7.22 x 10^5 tonnes were used for beach recharge and reclamation and 7.5 x 10^6 tonnes went for export primarily to the Netherlands and Belgium with smaller quantities to France and Germany. A summary of port statistics for material exported is shown in Table 3.5:-

Table 3.5: UK Exports of Marine Sand and Gravel 1996 to 1997

Port	Tonnage
Amsterdam	2,171,208.00
Antwerp	755,970.00
Brest	16,515.00
Brugge	333,080.00
Calais	132,215.00
Dunkirk	689,563.00
Fecamp	48,072.46
Flushing	987,017.00
Hamburg	137,732.00
Harlingen	322,779.00
Nieuwpoort	281,325.00
Oostende	347,218.00
Roscoff	48,835.00
St Sampson	5,039.00
Terneuzen	9,133.00
Treguier	34,326.00
Zeebrugge	343,812.00
Total	**6,695,843.46**

The dredging industry experienced an upturn in activity during 1994 although market demand remained fragile during 1995 due to cuts in government infrastructure funding and reduced house sales which had a dampening effect on the industry, delaying any reinvestment. The potential lack of future spare infrastructure capacity will be accentuated by the emergence of increased demand (up to 48%) for beach

nourishment material over the next few years. The limited uplift in production in 1995 of building material reinforced the approach of caution and consolidation adopted by industry, as predicted limited increase in demand occurred in 1996.

Marine derived aggregates/sand continued to supply about 15% of the total demand in Great Britain during 1996, the main areas of use being concentrated in the South East principally London and the Thames Estuary and South West.

There was no calcareous seaweed extracted from Crown Estate land in 1996 although a limited amount of extraction did take place in the Falmouth Estuary under the ownership of the local Harbour Commissioners the year before. A limited amount of waste coal was extracted. Very small quantities of marine sand and gravel were extracted from non-Crown land.

Increasingly there is a tendency for individual wharves to be supplied by sand and gravel from a variety of licensed areas also, an increase in the number of joint ventures due to the variations in quality and gravel concentration in material. Companies are now husbanding good quality/high concentration gravel reserves by blending it with lesser quality material at as many wharves as possible so that an acceptable material is available for the widest possible market. The blending of high and low quality material from gravel areas is likely to become more complex in the future especially when consideration is given to the commercial implications of increasing screening times necessary to produce acceptable cargoes.

The aggregate demand forecast for England in the fifteen year period 1992 to 2006 inclusive is given in MPG6 (Mineral Planning Guidelines, No 6), published by the DOE in April 1994. For marine sand and gravel the demand in England (excluding coast protection and exports) only averages 21 million tonnes per year for the fifteen years. Over the first five year period, 1992 to 1996 inclusive, the average demand is forecast as 18 million tonnes per year.

In the first three years of this period actual supply to ports of landing in England was 11.1 million tonnes (1992), 10 million tonnes (1993), and 12.5 million tonnes (1994). Thus, at the end of 1994 actual supply was only 70% of the demand forecast and at the current rate of increase will only reach the forecasted annual average at the end of the first five year period.

The corresponding DOE average forecast demand for the fifteen year period for land won crushed rock and land won sand and gravel is 127 million tonnes and 80 million tonnes per year respectively. These actual tonnages were both 80% of the average fifteen year demand (the corresponding marine 1992 supply/fifteen year forecast demand ratio was close to 50%). This demonstrates the greater effect that the recession has had on marine aggregate with its concentration on the South East market where the recession is greatest, although the worst effects of the UK's downturn have been cushioned by increasing European markets and coast protection schemes.

Current Licence Position Summary UK - Summary

- 346 million tonnes total reserve of sand and gravel within UK dredging licences.
- 310 million tonnes in the Government View Procedure.
- 115 million tonnes of possible sources identified by prospecting.
- 19 current prospecting licences.
- 33 applications currently in the Government View Procedure.
- 78 areas licensed by the Crown Estate for marine aggregate dredging.

Scotland

There has been some recent interest in aggregate prospecting in Scotland, but at the present time there is little activity. There are 2 licences in Scottish waters, one in Spey Bay where there are no current extraction operations and another in the River Tay/Tay Estuary where very small volumes are extracted.

There has, however, been a licence to extract maerl in Orkney. This licence, which is for 4000 m^3 per annum, has been issued subject to the condition that the extraction volume is sustainable given the availability of the natural resource and its slow growth rates. Extraction operations are limited to a small area where it seems that accretion of dead maerl material is occurring and to certain months of the year. The operators plan to provide material for use in specialised chemical and biological filtration applications rather than for general agricultural use.

3.11 United States

Marine mining continues at a low level. The only continuing commercial operation is run in the waters of the State of New Jersey by Amboy Aggregates, an affiliate of Great Lakes Dock and Dredge Co. The extraction is from the main shipping channel into New York Harbour. In 1996 between 1.3 and 1.4 million m^3 were mined. Most of this was supplied to the regional Department of Transportation for roadways and infrastructure construction. When necessary the marine sand was mixed with crushed rock to provide the appropriate grade. The activity is licensed by the US Army Corps of Engineers and extraction reports and bathymetric surveys are required. Weekly monitoring of the levels of dissolved oxygen is also required since there is public concern of hypoxia as the channel becomes over-deepened. The company has requested that the US Minerals Management Service undertake an Environmental Impact Assessment to allow a lease sale for sand and gravel mining on the shelf offshore New York and New Jersey. No decision has been made.

Along the coast offshore sand is periodically extracted for beach renourishment. The largest projects in 1996 relocated 2.4 million cubic yards and 2.3 million cubic yards onto Rockaway Beach, New York and the beaches of New Jersey, respectively. Several smaller projects, each about 100,000 m^3 were undertaken in more southern states.

Along the entire coast of the United States the total amount of sediment dredged in 1996 was 48 million m^3. This includes the amount of sand mined but the major part of this was maintenance dredging of navigation channels.

4 REVIEW OF NATIONAL SEABED RESOURCE MAPPING PROGRAMMES

4.1 Belgium

No new information to report

4.2 Canada

Marine mapping remains the responsibility of the Geological Survey of Canada, with projects on the Atlantic, Pacific and Arctic coasts. Surveys are conducted in the nearshore, on the continental shelf and slope. Reductions in staff, implemented by the Canadian government over the past several years, have restricted programmes of seabed resource assessment and regional mapping in northern areas. Mapping programmes in the future will focus in southern areas of Canada where societal pressures are the greatest.

Federal and provincial co-operative efforts in preliminary aggregate and placer gold assessment in offshore Atlantic Canada are in the final stages of completion. As a result of these studies, vast quantities of aggregate have been delineated at a reconnaissance level on the shallow offshore banks and in other areas of the inner, central and outer Scotian Shelf. Their suitability for varied industrial uses is not known.

The collection of multibeam bathymetric data is viewed as the most important first step in seabed resource mapping. Cooperative survey efforts are in place with the Canadian Hydrographic Service to apply this new technology. These systems have provided an enhanced insight into subtle aspects of deposition and erosion of shallow water seabed sediments. Backscatter acoustic data are extracted from the multibeam signals and maps of calibrated seabed type (texture) are produced. The future approach will be to integrate bathymetric and backscatter attributes using statistical approaches. During 1996, new areas of the continental shelf including Browns Bank, areas of the Bay of Fundy, off Cape Breton Island and the south coast of Newfoundland, were surveyed with multibeam bathymetric systems. Additional surveys are planned for 1997.

Developments in habitat mapping

The Geological Survey of Canada has initiating a new research programme in marine mapping entitled "high-resolution seafloor characterisation". A spin off application project in habitat mapping has also been formulated. The seafloor characterisation project will be divided into two phases. The first is the calibration and enhancement of existing survey tools for remote, high-resolution sensing of seabed sediment characteristics and morphology. This will involve the maximisation of resolution of existing 500 kHz sidescan sonars and high-resolution seismic reflection profilers to portray seafloor characteristics of grain size, patchiness, particle shape, porosity, roughness, relief and sub-bottom stratigraphy. The second phase of the project will be to extract quantitative sediment data from the acoustic signals of multibeam, sonar and seismic reflection systems. The Department of Fisheries and Oceans is supporting this research as it relates to lobster, clam and shrimp habitat classification and the impact of fishing operations on the seabed.

4.3 Denmark

Mapping of the sea bed is an integrated part of the systematic reconnaissance resource mapping programme in Danish Waters.

The mapping programme continues and is concentrated in The North Sea, Kattegat and The Baltic. Since 1991 mapping programs have been carried out on Jutland Bank and Horns Reef in The North Sea and in Femer Baelt, Adler Ground, Rønne Banke and Kriegers Flak in The Baltic. Maps in scale 1:100.000 of surface sediments, Quaternary geology and sand and gravel resources have been prepared. At present, between 80 % and 90 % of potential resource areas in the Inner Danish Waters have been mapped.

In 1996 a reconnaissance mapping has been carried out on greater water depths in the central part of Kattegat and in the North Sea.

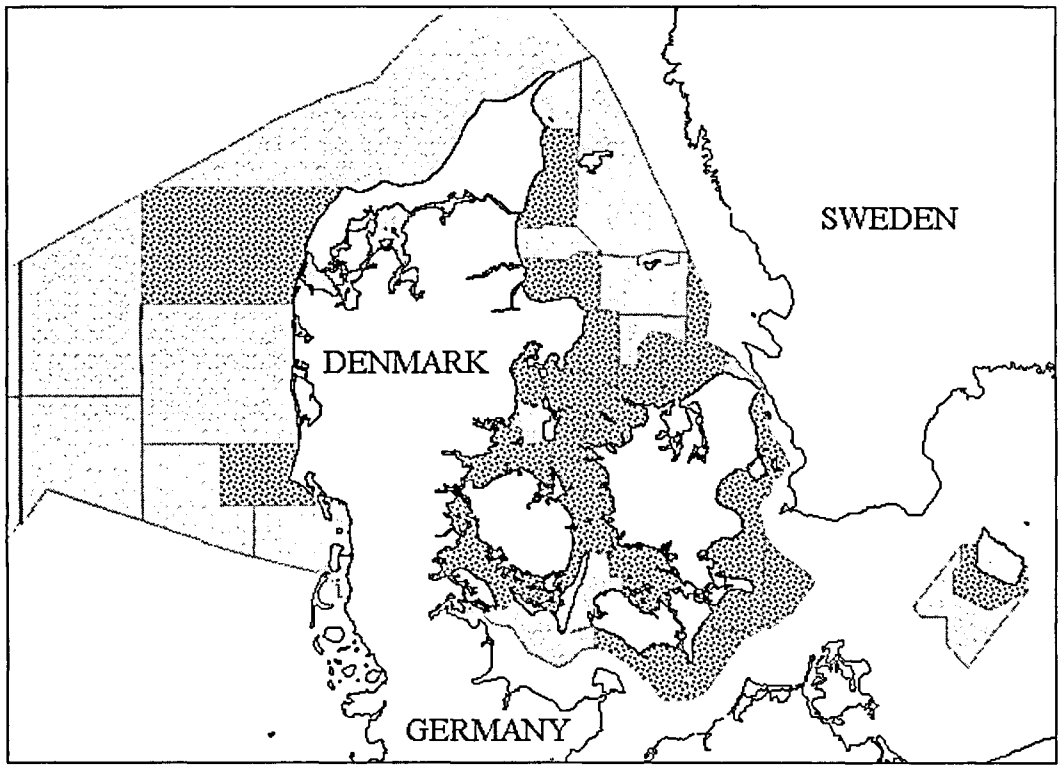

Figure 4.1 Mapping programme in Danish Waters. Dark shaded areas indicate where surface sediment maps have been prepared during the reconnaissance mapping programme (unpublished and published data).

Detailed resource mapping programmes have been carried out in some regional extraction areas with materials of high quality and in areas licensed for bridge and tunnel projects.

A map of the surface sediments in the Danish part of the Sound in scale 1:100.000 was published in 1990.

An overview map of the bottom sediments around Denmark and western Sweden in scale 1:500.000 has been published in 1992 in a co-operation between The National Forest and Nature Agency, The Geological Survey of Denmark and The Geological Survey of Sweden.

A detailed map of the Flensborg Fjord area has been published during 1994 by the Geological Survey of Denmark.

Surface sediment map from the Femer Baelt - Arkona Basin in scale 1:200.000 has been published in 1996 by the Geological Survey.

Surface sediment map from Jytland Bank, North Sea will be published in 1997.

Some of the most important stone reefs in Danish waters have been mapped 1990-1996 using shallow seismic equipment, side scan sonar, SCUBA-diving and sampling. The project is a co-operation between The National Forest and Nature Agency, The Geological Survey of Denmark and University of Copenhagen. Two reports have been published which include surface sediment maps, gravel and stone concentration maps and descriptions of the biology in the areas.

4.4 France

The IFREMER seabed mapping programme, is now being undertaken in French West Indies (Martinique).

The following reports were published in 1996:

- an atlas of 10 environmental parameters (morphology, currents and waves, sedimentology, bedrock, fishing activities, benthic populations etc.) in Bay de Saint-Brieuc (North Brittany) with maps at scale of 1/100 000 (see Annex V),
- a surficial sediment map of the Groix area (South Brittany, scale 1/20 000) (see Annex V).

The edition of this atlas was supported by local authorities to provide a synthesis of environmental data to ensure good management of Lithothamnion exploitation in the bay.

At the same time, GIS are being developed for these areas.

4.5 Finland

There was no new information reported.

4.6 Germany

Resources of sediments of commercial interest in the Baltic areas have been surveyed. The results (Gosselck *et al.* 1996) are shown in Table 3, with locations shown on the Map in Annex V.

Table 4.1: Sediment extraction in the Baltic - calculated resources (Gosselck *et al.* 1996)

place	type of sediment	calculated total capacity Lange *et al.* [x10^6t]
Outer Wismar Bight	sandy gravel, sand	5.4
Sea area of Kuehlungsborn	sandy gravel, gravel	7.0
Sea area of Markgrafenheide	sandy gravel, sand	6.9
Plantagenetgrund	sandy gravel, gravel	9.1
Sea area north of Ruegen	sandy gravel, sand, pebbles	?
Tromper Wiek	sandy gravel, sand	4.1
Landtief/Osttief	sandy gravel, sand	2.4
Greifswalder Bodden	sandy gravel	3.1
Sea area of Usedom	sandy gravel, sand	4.7
Adlergrund	sandy gravel, sand	> 20.0
Total amount		**> 62.7**

4.7 The Netherlands

Resource mapping is within the responsibility of the Geological Survey of the Netherlands. The Survey is becoming part of the national applied science and technology conglomerate TNO. Its new name is 'Netherlands Institute of Applied Geoscience TNO, national geological survey'

A review of the progress in the field of seabed resource mapping in 1996/7 is presented below.

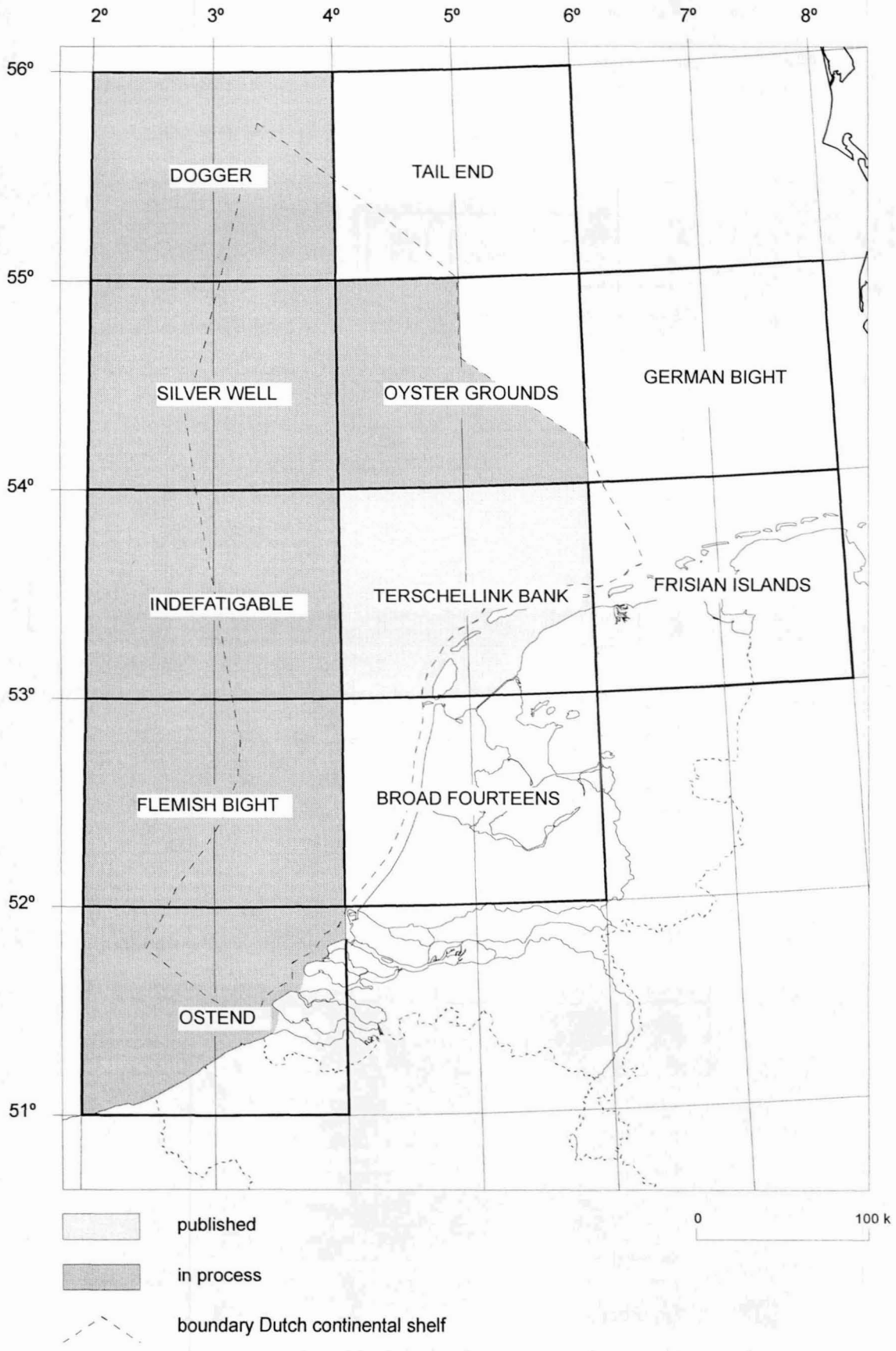

Figure 4.2: Geographical reconnaissance map series for the Dutch Continental Shelf

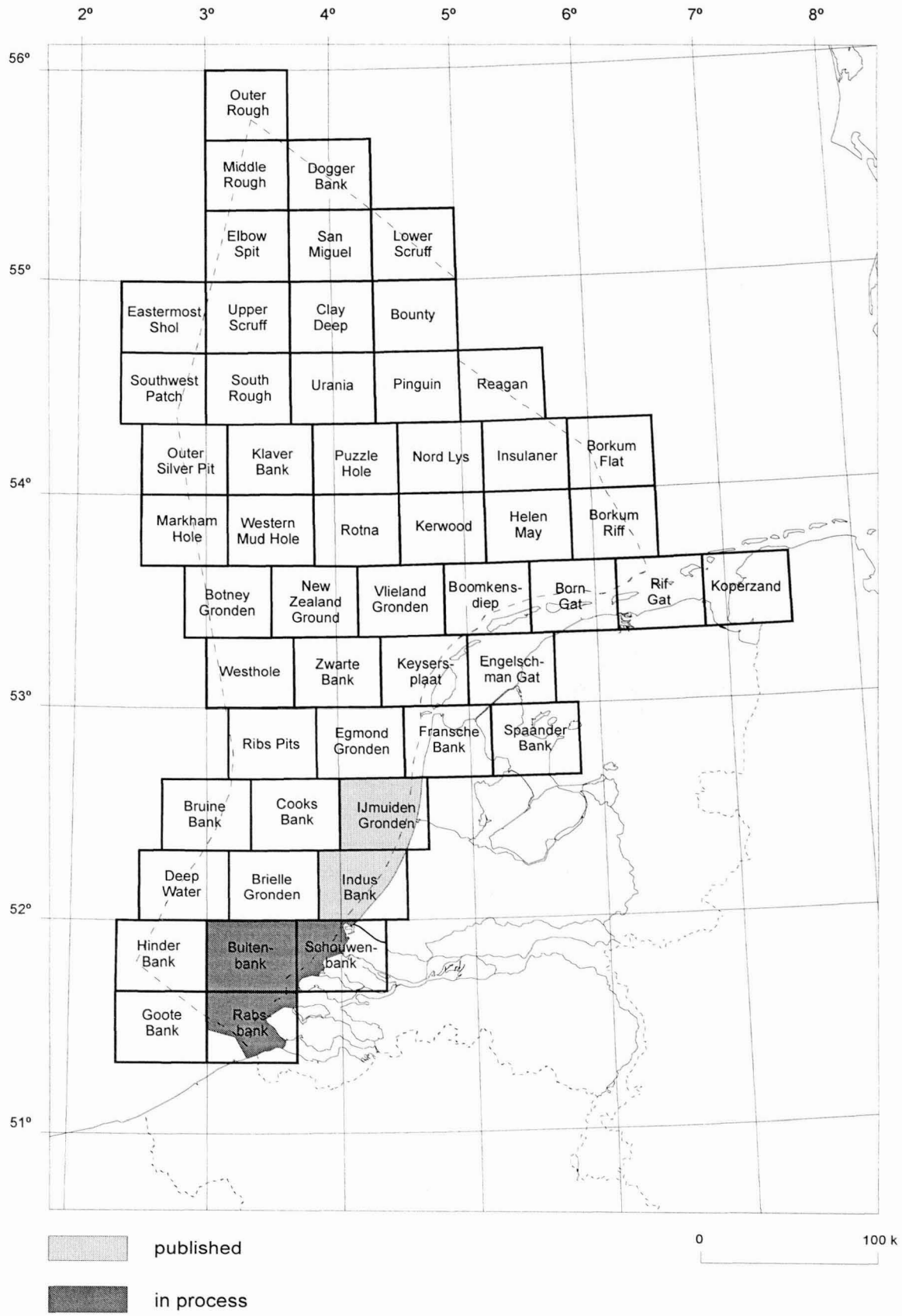

Figure 4.3: Geology and resource maps for the Dutch Continental Shelf

1:250,000 geological reconnaissance map series

This map series comprises *inter alia* surface geology (sea bed sediments) sheet which includes a main map in UTM on scale 1:250,000 showing the uppermost 10 cm of the seabed following the Folk classification system and various subsidiary maps. These subsidiary maps on scale 1:100,000 include the seismic line grid, thickness of Holocene sediments, depth to the base of the Holocene sediments, distribution of (older) Holocene formations, mean grain size, biogenic and lithic gravel content and/or carbonate content of sand fraction, lead content of surface sediments, a key to colours and symbols and a short description.

In 1995 the seabed sediment map of Oyster Grounds (54-55°N, 4-6°E) was printed. A similar map of Terschelling Bank (53-54°N, 4-6°E) is in preparation. All 6 printed maps are now also available in digital format.

1:100,000 geology & resource map series

This map series consists of map sheets with geological information on one side and resource information on the other side.

The geological side depicts a fence diagram with the geological structure of the younger layers (1:100,000), a bathymetric map on 1:150,000, 1:250,000 maps on geomorphology, on the occurrence of Holocene formations, on thickness of Holocene and of Pleistocene deposits, a fence diagram of older sediments, nature and depth of the top Pleistocene and of the top Tertiary and a short description a/o. of the stratigraphic units.

The resource side shows a map of the mean grain size and mud content of the uppermost metre on 1:100,000, a similar map of the metre below on scale 1:150,000 and 1:250,000 maps on the carbonate content in the first and the second metre, on lithic and biogenic gravel contents in the first and second metre, and on interfering (clayey) layers in the first and in the second metre and a short note on methodology, sediment classification and on the availability of further information.

The map sheet Buitenbanken (51° 40'-52°N, 3-3° 40'E) was printed in 1996. Schouwenbank (51° 40'-52°N, 3° 40'-4° 30'E) is now digitally available while the Indusbank (52-52° 20'N, 3° 50'-4° 30'E) and IJmuiden Ground (52° 20'-52° 40'N, 4-4° 40'E) sheets are in progress.

Applied geological investigations in 1996/7

As in previous years various beach nourishment schemes led to extraction site surveys and surveys for intermediate storage pit sites.

Continuous demand for the latest information on offshore sand resources necessitated the update of existing syntheses on nature and suitability of sands down to 1 m and to 2 m below seabed in a 50 km wide belt off the Netherlands coast.

Also some attention was given to an improved selection of offshore dredged material dump sites off Rotterdam harbour and to contaminated dredged material disposal sites in inland waters.

Geochemical maps

Geochemical distribution maps of surface sediments, as outlined in the previous ICES progress report, are being prepared for the 1:250,000 Terschelling Bank sheet. Moreover, to facilitate correlations with existing BGS work samples for geochemical analyses have been taken along the UK/NL median line.

Reports

Ebbing, J.H.J., 1996. Voorstudie naar geschikte zandvoorkomens in het onderzoeksgebied Maasvlakte II, (preliminary study of suitable sand resources in the Maasvlakte II area), Rept BP 3110000 (in Dutch).

Janus, R.G., 1996. Vergelijking geo-electrische methoden versus geofysisch onderzoek op zee, (comparison of geo-electric and seismic methods in potential sand extraction areas), Rept MK 3130001 (in Dutch)

Klugt, P.C.M., van der, 1996. De lithologie van drie boringen t.b.v. de aanleg van een winput nabij Wijk aan Zee, (lithology of 3 boreholes dug for the construction of a temporary storage pit near Wijk aan Zee), Rept. MK 300244 (in Dutch).

Klugt, P.C.M., van der, 1996. De lithologie van twee boringen t.b.v. de aanleg van een winput nabij Ameland, (lithology of 2 boreholes dug for the construction of a temporary storage pit near Ameland), Rept MK 300245 (in Dutch).

Klugt, P.C.M., van der, 1997. Onderzoek zeezandwingebied nabij Ameland Blok M8/M9, (sand extraction area survey near Ameland), Rept. NITG 97-20-B (in Dutch).

Zwanenburg-Nederlof, H.P., 1996. Geologisch onderzoek 27 tijdelijke putten Noordzee, (geological survey of 27 temporary sand storage pit sites in the North Sea, Rept MK 300553 (in Dutch).

4.8 Norway

Digital maps from the Skagerrak area are published in various scales, covering topics such as bedrock and Quaternary geology, seabed sediments, sediment accumulation rates, physical and chemical parameters etc.

4.9 Poland

General Information about Polish Geological Institute

The Polish Geological Institute is under the Ministry of Environmental Protection, Natural Resources and Forestry and performs many functions of state geological survey. The Institute is involved in the exploration of the geological structure of Poland and evaluations of mineral resources, evaluation of reserves and quality of the ground waters as well as investigation of pollution of the lithosphere. The Institute is also responsible for geological mapping of the country and publishing of various types of maps. The Polish Geological Institute, has its headquarters in Warsaw, and six Regional Branches.

The Branch of Marine Geology is located in Sopot and is responsible for the geology of the Polish Exclusive Economical Zone of the Baltic Sea, eastern part of Polish coast and northern part of Poland. The main subject of the Marine Geology Branch's works are geological and geochemical mapping of the seafloor, detailed geological, geomorphological and geodynamical investigation of the coastal zone. The main purposes inland is detailed geological and hydrogeological mapping (1:50 000) and ground water monitoring. The Branch of Marine Geology of the Polish Geological Institute has a permanent staff of thirty eight persons (twenty six postgraduate geologists with different specialisations, eight technicians, and four administrations)

There is in the Branch of Marine Geology of the Polish Geological Institute a regional department of the Central Geological Archives which collects results of sea and coastal zone investigations as well as data concerning the economy of mineral raw materials and data on the ground water resources inland.

Published Maps

Geological Map of the Baltic Sea Bottom, 1 : 200,000 (published: 1989 - 1994)

The Polish EEZ (30 532 km^2) has been mapped geologically at a scale of 1 : 200,000. During 1976-1990 approximately 30,000 km of echo-sounding profiles and ca. 7,000 km of shallow seismic (EG&G Boomer) lines were carried out and 6051 samples of surface bottom deposits and 827 cores were taken, also 23 boreholes were made. Sampling was done using a Van-Veen grab sampler and 6 m vibro and gravity corers. Also borings to ca.30 m were done. For navigation the following systems were used: 1976-1982 DECCA, 1982-1990 Hi-Fix 6 and Syledis.

Standard laboratory investigations were carried out; including 8850 analysis of grain size distributions (sedimentation balance and set of sieves with 1 phi unit spacing), ca. 3570 content of heavy minerals, ca. 2150 composition of heavy minerals. Also 14C, thermoluminescence, pollen, diatomological and macro and micro fauna analysis were carried out.

Results of the survey and laboratory work are presented on 12 sheets of colour printed maps, which contain: the map of bottom sediments 1:200 000 (Shepard's 1954 classification, developed additionally for sands) on a background of bathymetry with isobaths every 5 m, geological cross-sections, geological profiles, and maps 1:500 000 of geomorphology, lithodynamics, sediments 1 m below the bottom surface, and mineral resources (legends are in Polish and English). There is also an explanatory booklet for each sheet of the Map (only in Polish). Results of cruises and laboratory investigations are stored in a computer database (Fox-Pro, 20.1 megabytes), only echograms and shallow seismic records are in hard copies

Geochemical Atlas of the Southern Baltic, 1 : 500,000 (published: 1994)

During 1991-1993 cores of bottom sediments were taken at 368 stations in a regular grid (10x10 km), covering the 30 532 km^2 of the Polish Exclusive Economical Zone. GPS was used for navigation. Muddy deposits were sampled by Niemisto corer. The tops of cores (0-6 cm layer) were sliced into 1 cm sections and deposits from 6-20 cm depth into 2 cm samples. The samples of sands were taken from the top 0-5 cm seabed layer using Van-Veen grab sampler. All samples were placed into airtight plastic boxes, frozen and stored at - 20°C.

Granulometric analysis was carried out on 498 samples using a laser particle sizer Analysette 22 for muds and a set of sieves with 1 phi unit spacing for sand. Chemical analyses were undertaken with digestion in HNO3 1+1 in a MDS-81D microwave device, and ICP techniques with emission spectrometer PV8060 for determination of elements, Culomat 702 for determination of total organic carbon. Chemical investigations were made on 924 samples, comprising the determination of TOC, Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, Mn, Ni, P, Pb, S, Sr, V, Zn. The analyses were made on the < 0.2 mm size fraction separated by nylon sieve. For 6 selected cores the rate of sedimentation was determined using the 210Pb method. All analyses were done in the Central Chemical Laboratory of the Polish Geological Institute using international reference samples for analytical accuracy and through interlaboratory comparisons carried out at Warsaw University and at the Institute of Oceanology of Polish Academy of Sciences.

Analytical results and measurements are stored in a data base using Fox-Pro system, and the distribution of elements in the surface (0-1 cm) layer and vertical distribution in selected cores are presented in maps. The printed atlas consists of 19 colour maps (documentation map + 18 monoelement maps printed on a background of bathymetry and granulometric type of sediments) and explanatory booklet (Polish and English). All information on maps was digitised using the PC ARC/INFO. Digital data is availabe from the data base (Fox-Pro, 0.6 megabytes) and maps (PC ARC/INFO, 2.5 megabytes)

Geological Atlas of the Southern Baltic, 1 : 500,000 (published: 1995)

The objective of this work was to summarise the knowledge about the geological structure of the southern Baltic and about the evolution of this part of the Baltic basin which was gained during:

- realisation by the Polish Geological Institute of the serial 1:200 000 Geological Map of the Baltic Sea Bottom, which was finished in 1994,
- previously carried out geological investigations aimed at obtaining knowledge about the deeper structure of the southern Baltic area,
- investigations in the Polish coastal zone,

- investigations of selected problems of the geology of the southern Baltic in a broad sense (resource problems, geochemistry of deposits, etc.).

Additionally, during the production of this Atlas several special and new studies of the southern Baltic area were undertaken. For example the distribution on the seafloor of selected species of fauna were examined, the dynamics of bottom sediments were investigated and the surfaces of quartz grains in deposits of various ages were analysed in order to obtain new criteria for determination of the genesis and later transformation of the deposits.

The Atlas contains 34 colour printed plates (with Polish and English explanations), text (Polish and English), and a list of references. The first plate presents the bathymetry and Polish and English physiographic names in the Baltic area. A significant number of the plates presents the geological structure, from the map of the surface of the crystalline basement to the map of present-day bottom sediments. These maps are accompanied by geological cross-sections and profiles of selected well documented boreholes. The text forms a commentary to all the tables, and synthesises the development of the southern Baltic's geological structure.

Geochemical Atlas of the Vistula Lagoon, 1:150 000 (published:1996)

During June and July 1994 the Polish part of the Vistula Lagoon (328 km2) was geologically and geochemically mapped. Samples of bottom sediments were taken at 100 sampling stations in a regular grid of 2x2 km. The 20 cm length cores of muddy deposits taken by Kajak corer were sliced into 2 cm samples. The samples of sands were taken from the surface 0 - 5 cm layer by Pettersen sampler. All samples were placed into airtight plastic boxes, frozen and stored at -20°C. For navigation the differential GPS was used.

Results of the investigations are presented in the colour printed atlas which contains: documentary map, bathymetric map with isobaths every 1 m, map of bottom sediments in Shepard's (1954) classification, 24 monoelement maps with vertical distributions of elements in selected cores (on inserts) and maps of As/Al, Cd/Al, Cr/Al, Cu/Al, Hg/Al, Ni/Al, Pb/Al, Zn/Al ratios, as well as explanatory text in Polish and English. Results of analyses are stored in Fox-Pro data base, and maps were digitised (PC ARC/INO) and prepared for printing using CorelDraw software (digital form on hard disk, 10.8 megabytes).

CURRENT MAPPING PROGRAMMES

Detailed geological - geodynamical map of the coastal zone

The aim of this project is to recognise the geological background of the coastal zone evolution. The first stage of the project started in 1993 and will be finished in 1997, and covers the coastal zone, 1 km inland and 1.5 km offshore), between Dziwnów and Sarbinowo (ca. 80 km in the western part of Polish coast) and between Leba and Gdynia (ca. 100 km in central-eastern part of the Polish coast)

The objective of the survey is to determine the Quaternary geological structure - lithology, origin and age of deposits both inland and on the sea bed, bathymetry, coastal erosion hazards, land use, land cover, water quality, soils, forests protected areas, etc. The basic topography map is at a scale of 1 : 10 000

The survey methods include: geological and environmental mapping, sub-bottom profiling, side scan sonar profiling (ca. 400 km), 70 boreholes of depth (inland and on sea) from 10 to 30 m, 44 vibrocores (at sea) up to 3 m, ca. 200 drillings on the beach up to 5 m depth. Survey methods utilised differential GPS offshore and classic geodesy onshore.

The laboratory methodology utilised: grain size distribution by sieving and laser particle sizer, mineralogical-petrographic composition, C14 and TL datings, pollen, diatom micro and macrofauna analysis

Databasing and map production utilised: FOX PRO for Windows for field and laboratory data and ARC INFO for maps and cross-sections development.

Geological Map of the Baltic Sea Bottom (pre-Quaternary deposits)

The project started in 1996 and should be finished in 1999. The aim of the map is to recognise the pre-Quaternary deposits up to ca. 300-600 m below the sea bottom in the Polish EEZ.

It is planned to execute ca. 6,000-7,000 km of seismic profiles with the multi-channel equipment and reinterpretation of previously carried out geological investigations of the deeper structure of the southern Baltic area.

The map will consist of 12 colour printed sheets in scale 1 : 200,000 presenting general lithology, stratigraphy, tectonics and relief of the top of pre-Quaternary formations, as well as geological cross-sections. The fully digital (ARC INFO) version of the map will be also available.

Further information and maps are available at the: Polish Geological Institute, (c/o Branch Director) Branch of Marine Geology, st. Polna 62, 81-740 Sopot, tel/fax +48 58 512387

4.10 Sweden

The Geological Survey of Sweden (SGU), Division of marine Geology, has a permanent staff of twelve persons (seven marine geologists, one computer-system engineer, two sea captains, two chiefs) and an annual budget of about 11.8 million SEK in 1997 (including the capital costs of the survey vessel). As a consequence of a government decision in 1988 the rate of mapping has increased, so the Swedish EEZ will be mapped at a scale of 1:100 000 by the year 2060, *i.e.* one map per year. The marine geological mapping programme also comprises a special geochemical subprogram concentrating on natural and anthropogenic substances (c. 60 inorganic elements and c. 50 organic micro-pollutants are studied).

Equipment: the SGU has a twin-hull, sandwich constructed survey vessel, S/V Ocean Surveyor, of 509 brt, 38 m long and 12 m wide. The vessel has 6 winches A-frame, moon-pool, sediment laboratory, photo laboratory and a special survey-room for data processing. The division and vessel are equipped as follows:

- dynamic positioning system and HPR
- Doppler
- satellite navigator, DGPS, Syledis positioning systems including survey computer
- seven work-stations and 14 PC
- shallow seismic system (boomer, sparker, sleve gun)
- 50, 100, 500 kHz and 100 kHz chirp side scan sonars
- 3.5/7 kHz and 8 kHz chirp pingers
- echo sounders
- CTD-sond including processing software
- vibro-hammer corer (6 m)
- piston corers (3/6 m)
- gemini corer and gravity corers including subsampling devices
- grabs
- under-water video, sea-floor camera
- radiometer including processing software

Map content: Maps are published by the Geological Survey of Sweden (SGU) at a scale of 1:100 000 and show the distribution of the surficial Quaternary deposits according to character and genesis. Each map sheet covers an area of 2500 km² and is accompanied by a subsidiary map at the same scale showing the stratigraphy of selected geological sections of the mapped area. These two maps are accompanied by a description including photos, diagrams and thematic maps. These maps are produced mainly at a scale of 1:200 000 and show, within the map area, the distribution of pre-Quaternary rocks, till, glaciofluvial deposits, sand volumes, thickness of postglacial and glacial clays, c. 60 inorganic elements and c. 50

organic micro-pollutants of environmental interest, coring sites, surface sample sites, and tracklines. The maps are projected in Gauss with both the Swedish grid net 2,5c°W, 1938 and the longitude and latitude system (Swedish datum).

Published maps: Currently Sweden has mapped 12 % of the Swedish EEZ (see outline map, Figure X). The results are published in five maps from the Sounds at a scale of 1:50 000 (SGU Rapporter & Meddelanden, no. 13), three maps from the northern Gotland area in the Baltic Sea (SGU Serie Am, no. 1-3) and three maps from the Kattegat (SGU Serie Am, no 4-6) at a scale of 1:100 000. The Stockholm Archipelago will now be mapped in 5 sheets. The first were to be published in 1998 (SGU Serie Am, no 7). Field work has been completed within two map areas in the south-western Baltic Sea south of Scania.

An outline map of the solid geology of the Swedish EEZ at a scale of 1:1 000,000 (SGU Rapporter & Meddelanden, no 47) was published in 1986. In co-operation with the National Forest and Nature Agency of Denmark and the Geological Survey of Denmark a map at a scale of 1:500 000 showing the bottom sediments around Denmark and western Sweden was published in 1992 (SGU Serie Ba, no 48). In the National Atlas of Sweden outline sedimentary and bedrock maps at a scale of 1:2 500 000 over the Baltic Sea, the Kattegat and the Skagerrak were published in 1992 (volume "Sea and Coast") and 1994 (volume "Geology").

Ordering: Maps, with description and English summary, can be ordered from: Geological Survey of Sweden, Box 670, S-751 28 Uppsala, Sweden. Tel. +46 18 179 000, Fax +46 18 179 210, E-mail: kundservice@sgu.se

Information: Geological Survey of Sweden, Division of Marine Geology, Box 670, S-751 28 Uppsala, Sweden. Tel. +46 18 179 000, Fax +46 18 179 420, E-mail: icato@sgu.se

4.11 United Kingdom

Since the completion of the **regional mapping programme** of the UK Continental Shelf in 1992 the British Geological Survey (BGS) has produced a series of eleven offshore geological reports, giving a general account of the geology of the UK sector of the north-west European continental shelf.

A series of **marine aggregate resources** desk studies which summarise BGS data, supplemented by available dredging industry prospecting survey data, are also available. The reports summarise seabed sediments and geology and indicate the approximate location and quality of potential sand and gravel resources. Four studies have been completed, the reports are:

Marine Aggregate Survey Phase 1: Southern North Sea
Marine Aggregate Survey Phase 2: South Coast
Marine Aggregate Survey Phase 3: East Coast
Marine Aggregate Survey Phase 4: Irish Sea

A fifth (confidential) report covering the Thames Estuary has been produced for the Crown Estates. Three more detailed resource assessment studies are available (the marine sand and gravel resources off Great Yarmouth, off the Isle of Wight and Beachy Head and off the Humber).

BGS also contributed to the MAST III proposal '**MAX**' (Effect of Marine Aggregate Extraction on the Biodiversity of Sand and Gravel Deposits) which has not at this stage been successful in attracting support from the European Commission.

BGS in association with CIRIA (Construction Industry Research and Information Association) is also developing a proposal to evaluate long term demands and the wider resource inventory of **marine sand and gravel in North West Europe.** Partners may include RGD, DGU and BRGM/IFREMER.

4.12 United States

There is no comprehensive effort at offshore mapping of sand and gravel resources. The CONMAP programme has been discontinued. The US Geological Survey sediment texture database can be accessed on the World Wide Web at site ORACLE.ER.USGS.GOV/SEDIMENT. Three states, Maryland, Delaware and New Jersey are collecting offshore information to search for borrow sites further than 3 miles from the shore for beach renourishment. Vibracores are being taken but the results are not yet available.

The US Geological Survey has side-scan sonar mosaics for selected areas of interest. (These were not necessarily undertaken for the purposes of sand and gravel mapping). Sites were in Boston Harbour, Stellwagen Bank (Massachusetts), Georges Bank, New York Bight, Little Egg Inlet (New Jersey), Wrightsville Beach (North Carolina) and the Gray's Reef National Marine Sanctuary (Georgia). These can be reviewed on the WWW site KAI.ER.USGS.GOV/SURVEYS/USMAP.HTML.

5 REVIEW OF APPROACHES TO ENVIRONMENTAL IMPACT ASSESSMENT AND RELATED ENVIRONMENTAL RESEARCH

5.1 Belgium

There is no legal requirement for the execution of environmental impact assessment in respect of seabed aggretate extraction. Nevertheless the Ministry of the Environment (Management Unit of the North Sea Mathematical Models, MUMM), as part of its role as an advisory body, always requires an environmental impact assessment when a new application is introduced based upon Article 182 of United Nations Law of the Sea Convention 1982.

Two environmental impact assessments are currently under preparation (cf. Section 3.1): one for the Interconnector pipeline and one for the NORFRA pipeline.

Two new pipelines crossing the Belgian continental shelf gave rise to new sampling and monitoring programmes. The Interconnector will cross from the United Kingdom to Zeebrugge in Belgium. Monitoring of macrobenthos and demersal fishes is planned along the pipeline track. A considerable amount of sand and gravel (up to 1.6 x10^6 m^3) will be used to cover the pipeline south of the Goote Bank. Yearly sand extraction from extraction Zone 1 so far, has been of the same order of magnitude (around 1.7 x10^6 m^3). The extraction zones will be monitored before and after extraction. NORFRA (NORway-FRAnce) will cross from Norway to France. A study similar to the one for Interconnector will be carried out. The map (Figure 5.1) shows the two planned pipelines, old and new sampling stations, and relevant sand banks.

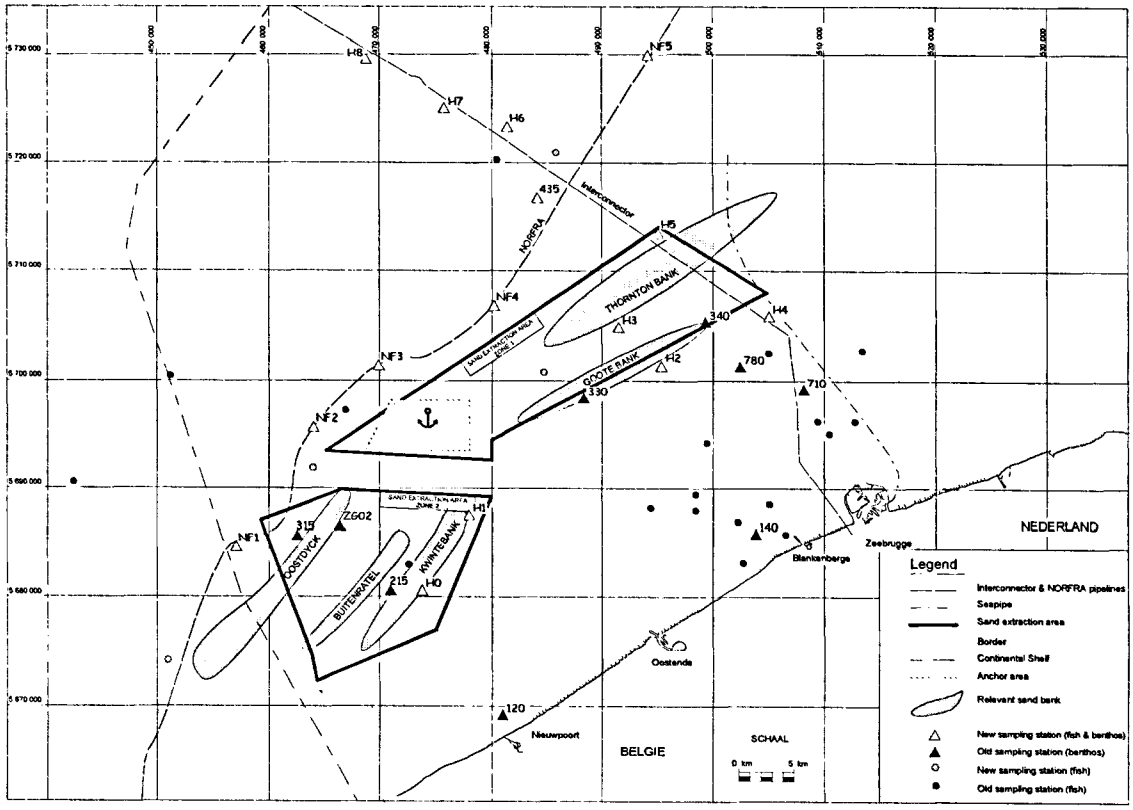

Figure 5.1 Map showing pipelines and sampling stations on the Belgium Continental Shelf.

5.2 Canada

Multibeam bathymetric data are being used increasingly in the study of placers and aggregates to delineate and characterise bedforms of varying sizes and former submerged sea level positions. The quantitative interactive aspects of this emerging technology are applied routinely to marine sediment mapping. Canada has expanded the collection of multibeam bathymetry in the coastal zone with the acquisition of Simrad EM 3000 systems, mounted on coastal survey vessels, for operations from the beach to depths of 80 m. These systems have been tested and trialed during field seasons in 1996, and are now considered operational systems. The images produced have decimetre resolution.

A co-operative study of the effects of bottom fishing gear on the sediments and marine ecosystem has entered a new phase for areas of the Scotian Shelf. A five year programme, which began in 1996, is investigating selected areas of the continental shelf where fishing has been prohibited for several years. Experimental fishing will take place in these areas, followed by a series of investigations to assess the disturbance on the sedimentology and benthic communities. The investigations will evaluate the temporal and spatial recovery of the seabed. This research has direct applications to potential mining of mineral resources on the seabed, as several of the bottom fishing techniques disturb the substrate in a similar fashion to seabed mining.

In 1997, the fishing gear effects project will be expanded to investigate a clam fishery on Banquereau, a large bank on the eastern Scotian Shelf. Hydraulic clam dredging equipment is used to fluidize the sediments in the fishing operation. A preliminary assessment, based on 1996 surveys, shows that the seabed is disturbed for a distance of twice the width of swath of the clam dredge and shallow troughs are formed which are up to 20 cm in depth and many kilometres in length.

Other seabed habitat characterisation projects are planned for Browns Bank to define and understand scallop habitat. The fishing community has embraced the seafloor mapping technologies developed and refined over the last few years as essential tools for sustainable fishery management and to maximise their operations for efficient and safe fishing practices.

5.3 Denmark

In Denmark the National Forest and Nature Agency is responsible for administration of marine aggregate dredging.

All new licensed areas are subjected to a Government View Procedure including public and private consultation.

Recent Environmental Impact Studies

Øresund Link

In the Sound between Denmark and Sweden impact assessments have being carried out prior to the initiation of the tunnel and bridge project. Especially the consequences of dredging in till and chalk have been studied in detail.

In order to assess the environmental impact, monitoring programmes have been established by the contractor, the Owner (Øresundskonsortiet) and the environmental authorities. The monitoring programmes are expected to be the most comprehensive and detailed in the world so far. The programmes include monitoring of sediment spreading and sedimentation, water quality, eelgrass, algae, benthos, migrating fish (herring), birds and coastal morphology.

A statement of the condition of the environment is published biannually by the Danish and Swedish authorities.

The management of the dredging operations is based on a feed-back monitoring programme run by the Owner. The programme is based on modelling and mapping of sediment spreading and a newly-developed eelgrass growth model.

Until now, only minor effects have been demonstrated. The effects are in accordance with the forecasts and are within the accepted limits.

Sediment spill during dredging in glacial till and Limestone with a large dipper dredger was about 4 % on average. The spill from backhoe dredger is presently 4 - 6 % and the spill from cutter suction dredging 4.5 % on average.

A detailed resource assessment and an environmental impact assessment of dredging of sandfill has been carried out on Kriegers Flak in the Baltic by the Øresund Consortium. The assessment has been prepared in accordance with the EC Directive 85/337.

Preliminary results from the spill monitoring program on Kriegers Flak indicate that the spill rates are strongly depending on the type of dredger to be used. Spill rates range from 0,7 % to 4,8 %. The release of fines and nutrients is very low. Bottom fauna have been resampled in autumn 1996. Preliminary results indicate, in accordance with the EIA, that there is no detectable environmental impact outside 1000 m from the dredging area.

Research projects.

In 1994, The Forest and Nature Agency has initiated a 3-year research project on the consequences of marine dredging in co-operation with the Geological Survey of Denmark and the National Environmental Research Institute. The project includes studies of fines in potential resources, computer models for studies of sediment spreading, development of ecological models and field tests. One of the aims of the project is to establish a decision framework (computer-aided Expert System) to evaluate the environmental consequences of existing and future dredging projects. This system will be based on content of fines in the resource, hydrography, spreading of fines and ecological models.

Results from analyses of a very large number of samples from marine resources have shown that the content of fines, i.e. silt and clay, only exceeded 5% in a few samples. Although the figures are general they give a natural framework for the evaluation of aggregate dredging. A report has been published in 1995 (in Danish).

A detailed study of the ecological consequences of dredging in coarse sediments was started in may 1996. In particular the effects on the benthic flora and fauna on surrounding stone reefs will be evaluated.

The environmental effects of dredging in gravel deposits have been studied in details in a highly dynamic area north of Laesoe in Kattegat. Here, a dredging operation carried out with a stationary suction hopper dredger was closely monitored including pre and post-video inspection of the sea bed and algal reefs, spill measurements onboard the dredger, current measurements and water sampling. The material dredged was screened onboard, and the initial spill from the dredger was measured to between 70 % and 90 %. Most of the spill was sand while only 3 % was in the silt and clay fraction. Spreading of the sediments was modelled with a program developed by the National Environmental Research Institute (NERI). Most of the spill was sedimented very close to the dredger, where the vegetation was partly buried, and despite the large initial spill, only 5 % was still in suspension 500 m from the dredger. This was in accordance with the video inspections where a thin layer of sand was seen on the leaves of the algae in some distance from the dredger. It is expected the sand will be removed by current activity.

The Forest and Nature Agency and the Coastal Protection Agency have initiated a monitoring programme off the west coast of Jutland to study the effects of dredging of sand for coastal protection. The study is based on a new sampling concept. Instead of taking several samples on a few stations, samples are spread in a 200 m grid covering the area of potential impact.

A study of the environmental impact of gravel dredging in the Limfjord area is currently being carried out by the Forest and Nature Agency. During dredging the sediments are screened and sand and finer particles are returned to the sea. Detailed spill measurements have shown that the spill rates vary between 60 % and 90 %. Analysis of the spill has shown that most of the material is sand and less than 5 % consist of silt and clay. The spreading of sediments have been evaluated by the hydrographic model MIKE 21 and the spreading module PARTICLE developed by DHI. The tests have shown that despite the large spill rates the spreading of sand is restricted to the dredging area and sedimentation of fines outside the area is very limited.

5.4 Finland

At the Helsinki extraction site an environmental survey was undertaken prior to the extraction. There are areas close to this site which support recreational activity.

The Kotka sand extraction area is situated inside the Eastern Gulf of Finland National Park areas though the Park itself includes only the land areas of the islands. Studies made in connection with this extraction site which were conducted in the 1980s (available only in Finnish) concluded that the principal effects of the extraction operation were:-

- the greatest harmful effect was that of erosion of coastal areas and islands in the vicinity of the extraction sites;
- nursery and spawning areas of certain fish species were studied (Baltic herring, and white fish species - both of which are commercially important in this region). Fishing activities tend to be made more difficult owing to the changes caused to the topography of the seabed at these extraction sites;
- in the sea areas where silt and/or clay layers cover the sand, suspended solids make the water turbid. In such areas avoidance behaviour by the fish may occur. Ecologically important *Fucus* belts and eelgrass meadows may also be damaged or destroyed. Potential changes in local fish stock populations and bird population may also take place.

5.5 France

Baie de Seine

Four of the nine companies asking for licences in the Baie de Seine area (cf. map in the Working Group Report 1996) were asked by the administration to gather together to get a single licence for dredging the new experimental site; its surface has been limited to 0.6 km² and the annual authorised amount to 500,000 tonnes.

Duration of investigation of the application (administrative consultation, public inquiry) will postpone the beginning of the experimentation up to 1999, instead of late 1997. This application takes into account the document entitled "Recommendations for the exploitation of a new experimental dredging site in Baie de Seine" which was elaborated by the GEMEL in 1995 (cf. Working Group Report 1996) with the collaboration of IFREMER and the Ministry of Industry, and which is based on the ICES *Coop. Res. Report* No 182.

Discussions are in progress between the dredging companies, fishermen and administration (Ministries of the Sea and of the Industry) about :

- the constitution of a survey committee of dredging activities ;
- the way to manage the million francs which will be annually paid by dredging companies to finance the environmental monitoring procedures ;
- the elaboration and diffusion to fishermen of a synthetic document explaining the experimental project, in order to get their opinion and possible complementary expectations ;
- the extension in 1997 and 1998 of the fisheries baseline survey, to get at least four years of data.

Dieppe

A study is presently in progress to analyse the potential impact of marine aggregate extraction on coastal erosion processes ; it consists of :

- a summary of the bibliography on these processes in the particular case of chalk cliffs ;
- a calculation of the influence of lowering the sea-bottom on the wave amplitude and frequency and on the modification of their refraction pattern.

ENVIRONMENTAL IMPACT ASSESSMENT

Baie de Seine

The final report of the recent prospecting of the former CNEXO experimental dredging site was published by the GEMEL in July 1996. Comparison of the physical and biological characteristics of ten stations located inside and outside this site (Map in Annex V) gave the following results (Figure 5.2 & Table 5.1), 15 years after the cessation of dredging activity :

- the natural filling-up of the dredging site is limited and its intensity is linked to the morphology of the bottom : in the deepest and narrowest part of the site, canalised tidal currents have prevented any sedimentation, whereas in the larger and shallower part fine sediments could deposit ;
- these fine sediments are 5 times more silty than in the adjacent reference area ;
- their community is from 2 to 3 times richer for the number of species, abundance and biomass ;
- mud-dwelling species are dominant inside the site whereas the reference area is dominated by sand-dwelling species ;
- dominant groups for density and biomass are respectively Amphipods and sea-urchins within the site and Polychaetes and Holothurians outside ;
- the community of the site is linked to the muddy fine sand community with *Abra alba* and *Pectinaria koreni* ; in the reference area, it is intermediate between the medium clean sand community and the muddy fina sand one ;
- 20 years ago, the site was located in medium sands with *Ophelia* ; since the cessation of dredging activity, the evolution of substratum has been more rapid within the site than outside and its new community is more stable, explaining that it is 2 to 3 times richer than in the adjacent area.

	Depth (m)	Silts (%)	Specific richness	Abundance $m^{-2}.10^{-2}$	Biomass ($g.m^{-2}$)
OUTER AREA	17.2	0.6	12	5.38	8.8
INNER AREA	21.7	3.2	30	15.10	17.5

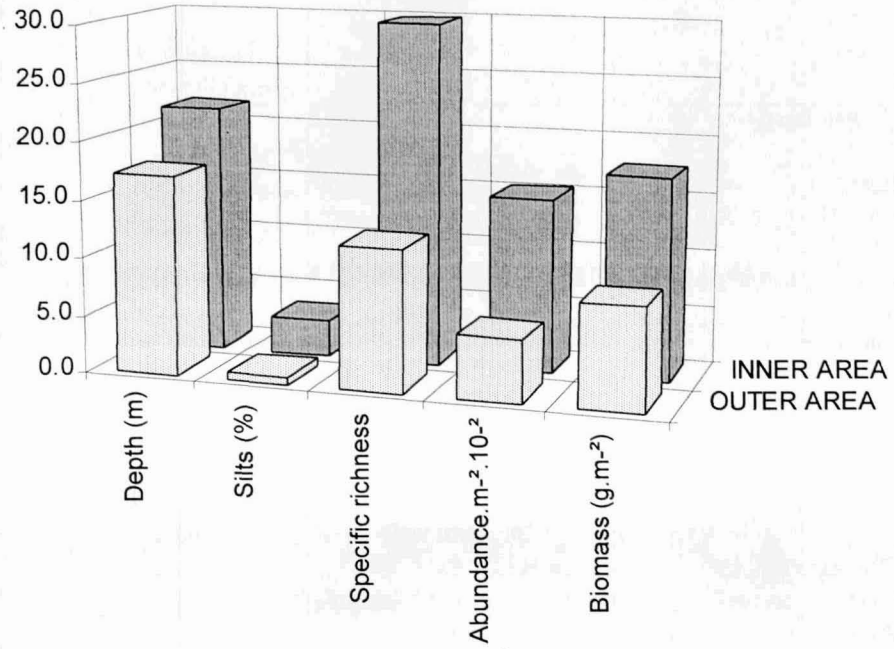

Figure 5.2 Comparison of the main physical and biological characteristics of the inner and outer areas of the CNEXO experimental dredging site.

Areas	Inner	Outer
Depth (m)	21.7	17.2
Sediment granulometry (%)		
Gravels	**9.4**	1.4
Fine sands	54.1	**68.9**
Silts	**2.9**	0.6
Benthic macrofauna		
Specific richness		
Mean number of species	**30**	12
Abundance		
Mean density (ind.m^{-2})	**1510**	538
Dominant group	Amphipods (28 %)	Polychaeta (48 %)
Dominant species	*Urothoe elegans (13 %)*	*Nephtys hombergii (31 %)*
	Cheirocratus sundevalli (5 %)	*Lumbrineris impatiens (15 %)*
Biomass		
Mean biomass (g.m^{-2} AFDW)	**17.5**	8.7
Dominant groups	Echinoderms (50 %)	Echinoderms (61 %)
	Cnidaria (21 %)	Polychaeta (27 %)
	Bivalves (14 %)	Cnidaria (2 %)
Sediment/Fauna relationships		
Mud-dwelling species		
Number	**19**	8
Relative abundance (%)	**68**	24
Sand-dwelling species		
Number	**16**	11
Relative abundance (%)	20	**65**

Table 5.1 Data summary of the physical and biological characteristics of the inner and outer areas of the CNEXO experimental dredging site.

This extraction gave interesting information on the possible quality of restoration of a marine aggregate extraction site, depending on the bottom topography after the cessation of dredging activity.

Dieppe

In 1996, 10 stations have been sampled in and around the former dredging site (Map in Annex V):

- 5 control stations, located inside the extraction area, are monitored since 1993 to point out the recolonisation rate ; 3 reference stations, away from the site, give information on natural fluctuations of benthic communities ; 2 new stations (R & S) have been sampled close to the eastern part of the site which is still slightly dredged, to quantify the impact of deposition by overflow. The bedform analysis shows a disturbed topography with large furrows (about 4.5 m deep) separated by crests of shingles ; these furrows are covered with sand coming from overflow. The sediment analysis (Figure 5.3) confirms the heterogeneity of the seabed topography :
- in the extraction area, sediments are heterogeneous and dominated both by shingles and fine sands, with a notable proportion of very fine sands ;
- sediments of the reference area are homogeneous, without very fine sands nor silts and coarse sands and gravels predominate ;
- in the deposition area, sediments are also homogeneous and largely dominated by fine sands.

	1 Deposition area	2 Dredging area	3 Reference area
Shingles & Gravels	11	32	43
Coarse sands	12	9	49
Fine sands	63	43	16
Very fine sands	13	16	1
Silts	1	1	0

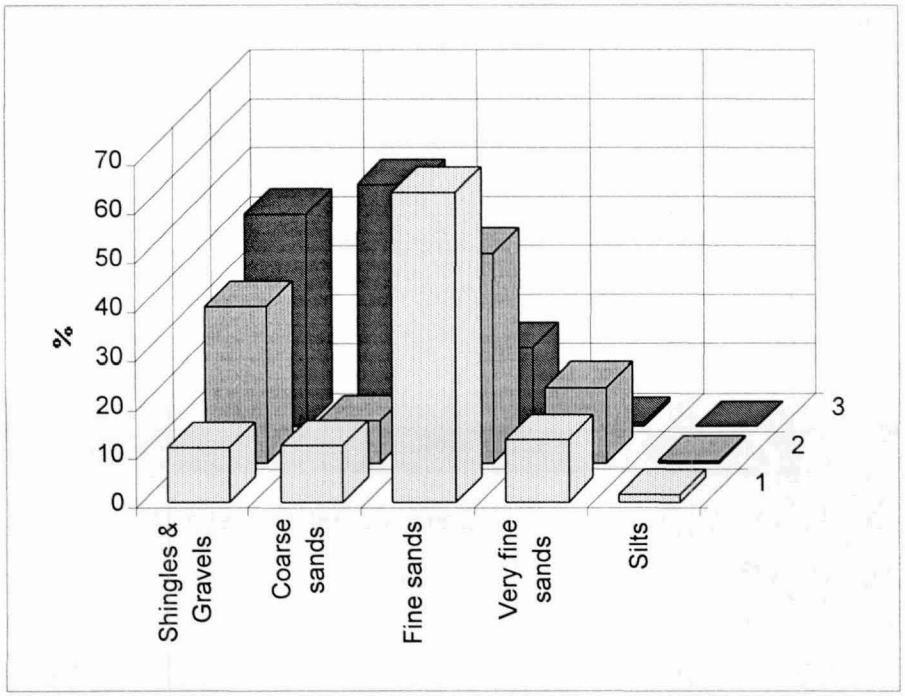

Figure 5.3 Comparison of the sediment granulometry (fractions in %) for the three sampling areas of the dredging site of Dieppe.

	1 Deposition area	2 Dredging area	3 Reference area
Biomass (g.m-²)	0.27	2.35	8.43
Abundance (ind.m-².10-²)	2.3	7.85	16.85
Specific richness	16.5	42	40

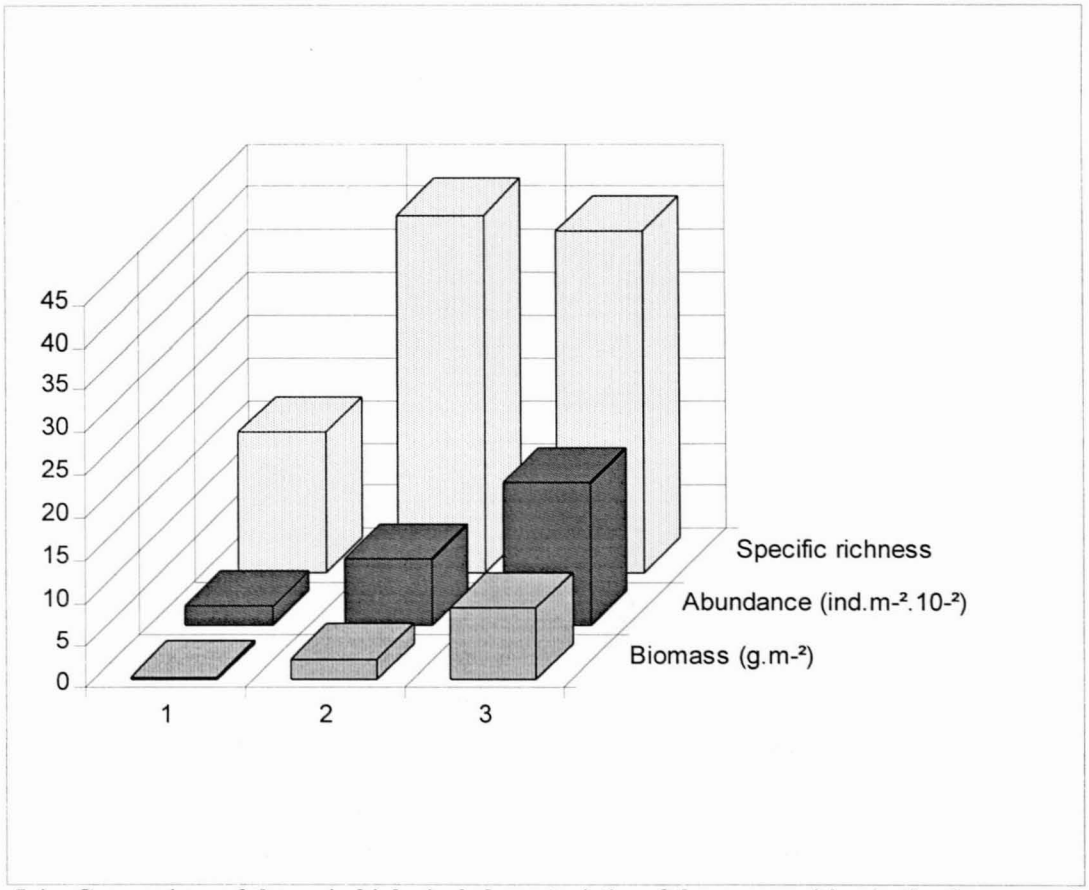

Figure 5.4 Comparison of the main biological characteristics of the communities in the three sampling areas of the dredging site of Dieppe.

From a biological point of view, the deposition area is more disturbed than the dredging one (Figure 5.4) :

- the mean number of species is 60 % lower than in the reference area, whereas the dredging one has fully restored ;
- the mean density is 86 % lower than in the reference area, whereas it is 53 % inferior in the dredging one ;
- the mean biomass is only 3 % of that of the reference area, whereas it represents 28 % in the dredging one.

The community of the deposition area is dominated by two characteristic species of fine sands, the bivalve *Tellina pygmaea* (29 %) and the annelid *Nephtys sp* (22 %) ; other sand-dwelling species, like the annelid *Scoloplos armiger* (3 %) are also observed. Characteristic species of coarse sands, *Echinocyamus pusillus* and *Amphipholis squamata*, are poorly represented (1 %) in this area whereas they are dominant in the reference area. The characteristic species of gravels and shingles are absent from the deposition area. These results show that the impact of sands depositing by overflow in the vicinity of the extraction site, can be as important as the dredging itself on the macrobenthic fauna. The next stage of the monitoring will give information about the duration of this impact.

5.6 Germany

A monitoring programme has been set up by the "Bundesanstalt fuer Gewaesserkunde" (Federal Institute of Hydrology) for the German North Sea Estuaries and the Jade Bay to describe the macrozoobenthos along the sea waterways (see Map in Annex V). This monitoring covers the brackish areas and has been designed to show the natural variability within the surroundings of maintenance dredging activities.

Therefore it will also serve to describe the natural environment of extraction sites, within maintenance dredging areas.

Stations are distributed along the Ems (5), the Jade (5), the Weser (5), the Elbe (5) and the Eider (3). At each station samples (60kg) are taken in triplicate by a van-Veen grab. The sediment is washed through a 0.5 mm sieve. In addition to the taxa list, dry and ash-free dry weight is taken for each species.

The physical impact on the seabed caused by dredging has ben investigated at the extraction site west of Westerland. Here, depressions caused by dredging persist for several years and the sediments contain H_2S. A resource assessment of the German coast is also in progress.

Regier *et al.*(1995) investigated direct and indirect impact of sand extraction on the macrozoobenthos in the area off the island Sylt (North Sea, area "Lister Tief", area "Salzsand vor Sylt"). They stated the impact as a strong disturbance of short duration in a biotope with the ability to regenerate quickly with respect to sedimentation and biocoenosis.

Several authors found regeneration times for the macrozoobenthos in dredging and dumping sites between 1 and 3 years for tidal and estuarine areas in the North Sea (see Leuchs *et al.* 1996). At the end of 1995, the Bundesamt für Naturschutz, INA Insel Vilm, Abt. Kuesten- und Meeresnaturschutz (Federal Agency of Nature Conservation, INA Isle of Vilm, Dept. of Coastal and Marine Nature Conservation) and The Landesamt fuer Umwelt und Natur (Agency for Environment and Nature of Mecklenburg-Western Pommerania) ordered an investigation program to assess the ecological impact of sand and gravel extraction on the Baltic ecosystem (Gosselck *et al.* 1996). This study is a review of the current state of knowledge of geology, hydrology and biology in nine areas where sediment extraction is intended.

Biological data come from the 1994 Macro Zoobenthos Coastal Monitoring Programme (Gosselck et al. 1994).

The authors of the first study assume three sources of threat:

- The layer of extractable sediment is quite thin, on the average less than 1m thick. This will result in extraction over extended areas. Furthermore the removal of the complete layer will change the habitat often to marly soil which hinder resettlement of macrobenthic invertebrates.
- The submerged elevations have a value special value in terms of hydrography as they can prevent upwellings of oxygen deprived waters from deeper areas into the inner bays.
- There are also important feeding areas for wintering Nordic benthophagic birds (e.g. Eider and Scoters, *Somateria sp. Melanita sp.* and Long-tailed ducks *Clangula sp.*).

Preliminary results from Krause et al. (1996) and Arlt & Krause (1997) show that up to a third of the common species occurring in low numbers are potentially endangered by dredging since they are unable to resettle quickly in the exploited areas.

5.7 The Netherlands

<u>Environmental Research 1996</u>

Borrow Pits

In fall and winter 1996/97 a beach nourishment was executed at the central Dutch coast near Heemskerk/Wijk aan Zee. For the nourishment the pin-point dredge technique was used. The borrow pit was located at a waterdepth of 7m and reached a depth of 19m below the seafloor.Because of technical problems with the pin-point dredge, the nourishment was completed by the traditional method. This will not influence the ecological monitoring of the borrow pit and its environment. A pre-nourishment and a pre-fill survey were carried out, followed by a survey just after the completion of the refill. Several further surveys are planned. The first results are expected in December 1997.

Riacon Project

The final report on the ecological effects of subaqueous sand extraction North of the Island of Terschelling has been completed. The report describes the effects on the benthic fauna of a sand extraction (2.5 $x10^6$ m^3) carried out in 1993. One pre-extraction survey and two post-extraction surveys were carried out. After one year, a change in benthic community structure was observed due to a reduction in long-living species and recolonisation by opportunistic species. After two years the original structure had largely been restored. Nevertheless, adult specimens of longer-living species are rare. The total biomass after two years is still less than that before extraction. Complete recovery is predicted to take a further few years (Van Dalfsen & Essink).

Large Scale Projects

At present several plans for huge land reclamation projects are being launched in the Netherlands. In June 1997 a decision is expected about an extension of the Rotterdam harbour area. The amount of sand needed for this new harbour area will vary between 400 and 800 $x10^6$ m^3, depending on the chosen design. This amount is 17 to 35 times the amount of the present yearly extraction of marine sands.

Two other plans, which are much less certain, are the construction of an airport in sea and a land reclamation along the coast between Hoek van Holland en Scheveningen. For these plans a sand supply is needed of 800 $x10^6$ m^3 and 400 $x10^6$ m^3 respectively.

Future Developments

New techniques, such as pin-point dredging, and the possibility of very large scale sand extraction due to huge reclamation projects, force a reconsideration of the extraction policy.

An important issue is the maximum extraction depth. At present it is defined at 2 metres to keep the same sediment at the seabed and to facilitate recolonisation. In the navigation channels the extraction depth is 5 metres. With large scale extractions, this policy will lead to very large impacted areas. Studies are planned to compare the ecological and morphological effects of large scale shallow extraction and smaller scale deep extraction.

Although for each huge reclamation project an individual Environmental Impact Assessment Study has to be carried out, the general policy concerning the extraction of marine sediments will be revised. The text of the revised Regional Extraction Plan for the Dutch part of the North Sea will be ready in autumn 1998.

Environmental Impact Assessment

In 1997 a start has been made for a update of the Regional Extraction Plan For The Dutch Part Of The North Sea and Environmental Impact Assessment (RON/EIA). The updated RON/EIA has to be finished in 2000.

In 1996 the North Sea Directorate decided that no further research on the ecological effects of gravel extraction on the Klaverbank would be undertaken. The most recent report of this work (Annex VI) therefore must be considered the final report of these studies.

References

Busschbach, H., C.Dijkshoorn & A.Stolk (1997) Shell extraction in the Netherlands (in Dutch). Ministry of Transport, Public Works and Water-management Directorate North Sea, Rijswijk.

Van Dalfsen, J.A. & K.Essink (1996). Risk analysis of coastal nourishment techniques in the Netherlands (RIACON), draft version. National Institute for Coastal and Marine management/RIKZ.

5.8 Poland

Information about the lithology of sediments – grain size distribution, mineralogical composition and chemical composition – was obtained as a result of large projects of geological and geochemical mapping of the Polish EEZ carried out by Branch of Marine Geology of the Polish Geological Institute. Many pieces of detailed information on seabed features were collected during the documentation works of aggregate deposits. During these surveys the sea floor was observed by scuba divers at 36 stations on the Slupsk Bank, at 60 stations on the Southern Middle Bank and at 305 stations in the shallow-water area between Darlowo and Jaroslawiec (the area of the "Koszalin Bay" deposit). The most important data on seabed features – sedimentary structures and their temporal variations - and about benthic communities were collected during investigations on the test field located on the Slupsk Bank.

General information on sediment features

Sandy and gravelly–sandy sediments which occur outside the coastal zone, to depths of about 25 m, are moderately and poorly sorted (σ_i between 0.5 and 1.0 and >1), the content of heavy minerals in the 0.25 – 0.125 mm fraction exceeds 1.0%, and values of the G/A mineral indicator (garnet to amphibole content) are larger than 1.0. In accordance with the C–M (Passega diagram, which classifies sediments in terms of their mode of transport), these sediments most often belong to type I, in some places to type II or IV. Locally there are boulders which are the residue left from washed out Pleistocene deposits. Often in the regions where boulders occur, gravel and gravelly–sandy deposits are present, as well as sand deposits characterised by moderate and poor sorting (σ_i>0.5) and heavy mineral content in the 0.25–0.125 mm fraction very often exceeds 2%. The garnet/amphibole ratio is larger than 2 (G/A>2). In accordance with the C–M diagram, these deposits belong to type I.

In the 10 to 25 m water depth zone, ripplemarks commonly occur on the surface of the deposits. On fine and medium sands the spacing of ripplemark crests is 0.1 to 0.4 m and crest height is 0.02 to 0.05 m. These are predominantly wave/current ripplemarks with asymmetric, rounded crests; in some places they are symmetrical wave ripplemarks. In the horizontal plane, the pattern of the crests is strongly differentiated, with straight–lined and rounded ripplemarks, mainly not in phase, broken and bifurcating. In coarse and gravelly sands (with grains smaller than 32 mm) ripplemarks occur with crest to crest distance of 0.5 to 1.5 m, height 0.08 to 0.3 m, and crest length not exceeding 5–6 m. As a rule the crests are asymmetrical and rounded. Their orientation is very variable, and — as repeated observations made at the same points have shown — it changes with time. It was also found that at a small distance from each other (several to about a dozen metres) there occur different populations of ripplemarks, characterised by different dimensions and sometimes also by different orientation. Also superposed ripplemark populations are observed, with crests running in the same direction or crossing at various angles. Areas of seafloor on which sandy gravel and gravel sediments occur, containing coarse gravel (32–64 mm), are even with no ripplemarks.

In the 10–25 m depth zone, large-scale bed forms also occur. Side scan sonar profiling carried out on Slupsk Bank and Southern Middle Bank, and in several other regions of the southern has shown that there are sand patches and forms similar to sand ribbons, known from the North Sea and the Danish Straits, however they are less regular. The sand patches and ribbons occur on the surface of gravel and gravely-sandy deposits. Dimensions of the sand patches vary from several to over a dozen metres. They also vary in shape — often irregular, sometimes oval or elongated. Sand ribbon-like forms have lengths reaching 500 m, widths of about 40–50 m and variable spacing. In most cases, both the sand patches and the sand ribbons are built of fine sand, and generally their thickness does not exceed 0.5 m. The surface of the patches and ribbons is often covered by ripplemarks. Sometimes within the larger sand patches mega-ripplemarks occur, with crest-to-crest spacing of up to 100 m and crest length reaching several hundred metres. Such forms are present on Odra Bank, Slupsk Bank and in the Gulf of Gdansk.

These lithological characteristics and sedimentary structures occurring at depths between about 10 and 25 m, are evidence of the high dynamics of processes on the seafloor. As in the coastal zone, processes of redeposition predominate here. Sediments in this zone are within the reach of influence of average storm waves. During strong storms, the gravel and gravelly-sandy deposits may be periodically eroded and the

sandy fraction is washed out of them. Coarse and medium sands (2.0–0.25 mm) are rolled or dragged over relatively small distances. Fine sands migrate over the surface of the gravelly-sandy deposits in the form of sand patches or ribbons, and after multiple redeposition are transported outside the zone of storm wave action. Direct observations of the bottom and measurements at reference marks installed on the seafloor of Slupsk Bank and the Southern Middle Bank have shown that during storms gravel of up to 3 cm diameter is being transported. Indications were found that the mobilised layer of sandy-gravelly deposits is up to 30 cm thick, and that whole patches of fine sand are moved over the surface of the gravelly deposits.

Chemical analysis of sands (fraction < 0.2 mm) from areas of aggregate deposits shows very low contents of metals. Typical contents are as follows: As < 5, .Cd < 0.5, Cr <2, Cu < 1, Ni <1, Pb < 5, Zn <10 ppm. Also contents of total organic carbon and phosphorus are very low. Content of TOC varies from <0.01 to 0.07%, P – from < 0.01 to 0.04%.

Bathymetry, geological features and dynamics of the seafloor within the test field on the Slupsk Bank

The water depth within the experimental area, delimited by the following coordinates: 54°56.55'N, 16°50.67'E; 54° 56.39' N, 16°51.56' E, 54°55.88' N, 16 51.28' E; 54°56.04' N, 16°50.38' E, is 15.8 m in the western and 20.2 m in the north-eastern part; on average the water depth is 16 to 18 m. The bottom is slightly sloped to the north-east and does not show local deviations. The maximum slope of the bottom (increase of depth by 3 m over a length of 140 m) occurs in the north-eastern part of the test field.

The substratum of the natural aggregate deposit layer within the test field is composed of fine sand containing *Cardium* shells and broken shells. The thickness of the layer of natural aggregate, represented by gravel, sandy gravel and gravelly sand, ranges from 0.15 to 2.18 m. In the southern part of the test field, a cover of fine sand (thickness 0.1 to1.16 m) occurs on top of the aggregate. Over the rest of the field this cover appears only locally in the form of small areas of several square meters surface and less than 0.1 m thickness, but the aggregate lies usually directly at the seabed. Ripplemarks are common on the seafloor.

In order to obtain more knowledge about the dynamics of the seafloor, especially to define manifestations of erosion and accretion of sediments, and to determine the thickness of the active layer which is displaced during storms, the following, tasks were performed:

- repeated observations at the same location on the bottom, around the datum points, and of sedimentation structures,
- repeated measurements at the datum points,
- placement of dyed gravel, repeated observations of bottom and sampling,

Ripplemark interpretations indicate that where coarse sand with an addition of gravel and fine gravel occurred on the bottom, the upper layer, at least 0.2 m thick, layer is mobile, the thickness being equal to the maximum height of ripplemark crests.

In these areas and in areas with coarser gravel and no ripplemarks, no erosion or accretion was observed during the whole period of measurements. In areas where there is a cover of fine sand on top of the gravel, the process of forming ripplemarks is accompanied by local erosion and accretion. Maximum recorded accretion was +0.15 m, erosion –0.15 m. These processes are connected with movement of fine sand fields over the gravel sediments.

Much information on bottom dynamics and nearbottom current intensity was obtained from the experiment with dyed gravel. It was found that strong enough currents occurred between August and October 1988 to remove artificial cones of 1 m diameter and 0.2 m and 0.11 m height. Single grains of dyed gravel of up to 30mm diameter were observed in October 1988 and May 1989 at 5 m distance from the point in which they were placed in August 1988.

Benthic biocoenosis

Benthic biocoenoses of the Slupsk Bank were examined in 1987–1990. Additionally, many Plexiglas plates and microscopic slides fouling (periphyton) were examined in the experimental area

Such artificial hard substrate overgrown with various organisms resemble some stony bottom covered with many epibionts. Besides attached organisms, many species of the vagile–benthon can be found on hard substrata. Therefore, there is not any distinct border line between lithophilous and glareophilous and psammophilous biocoenoses. It should be pointed out that red algae almost always occur as haptophytes attached to stones or mussel shells.

A study on an all–in aggregate excavating effects on benthos of the Slupsk Bank has been carried out since 1987. In the gravelly sandy bottom areas of the Slupsk bank, *Bathyporeia pilosa* and *Pygospio elegans* form a glareophilous–psammophilous community. The average abundance of the crustacean *B.pilosa* amounted to 360 ind./m^2 and its maximum abundance reached up to 1320 ind./m^2. The polychaete *P. elegans* maximum abundance reached up to 4500 ind./m^2, with the average abundance amounting to 970 ind./m^2. It is worth mentioning the almost complete absence of snails of the family Hydrobiidae in the Slupsk Bank.

The Slupsk Bank water body usually is well oxygenated, at least up to full saturation, due to the intensive wind mixing. During storms, the near–bottom current velocity can reach 50 cm/s in the area. The high water dynamics, affecting even the bottom, induces mobility of the sand and gravel down to 30 cm depth all year round. This is the reason of the abundance and biomass of zoobenthos in unfixed deposits being rather low. Besides, these deposits contain very little detrital organic matter, which limits the occurrence of the bivalve *Macoma balthica* in particular, the average abundance of which in the Slupsk Bank (26 ind./m^2) is 25 times lower than that in the corresponding depth zone (10–20 m) of the Gulf of Gdañsk (650 ind./m^2). *M.balthica* feeds on detritus and is a perfect biological indicator of eutrophication of the Gulf of Gdañsk.

In boulder areas and in the vicinity of gravel deposits, the bivalve *Mytilus edulis* and red algae form the most characteristic biocoenosis of the Slupsk Bank.

The following red algae species, particularly *Rhodomela confervoides, Furcellaria lumbricalis, Phyllophora brodiaei, Ceramium diaphanum, Hildenbrandtia prototypus* and *Delesseria sanguinea*, were found attached to boulders and stones which are relatively abundant and scattered on the Slupsk Bank bottom.

Apart from an appropriate hard substrate and sufficient amounts of nutrients, the red algae in the area enjoy favourable light conditions due to the low depth (up to 20 m) and significant water transparency throughout the year. Even during periods of the intensive phytoplankton growth, the water body is transparent down to the bottom, which corresponds with a high Secchi depth reaching even up to 10 m. The high water transparency of the Slupsk Bank results, among other things, from the luxuriant growth of many various suspension feeders, especially *Mytilus edulis* that feeds on seston. The mussel plays the dominant role in terms of abundance and biomass in the lithophilous biocoenosis of the Slupsk Bank.

In the case of 5 boulders raised from the bottom in May 1989, the mussel creates the most characteristic community by forming its dense or compact layer. The bivalve covers about 50% of the upper boulder surface, the lateral surfaces being covered in almost 100%. The surfaces not covered by the mussel usually are more densely overgrown with red algae. The red algae also found attached in large quantities to the mussel shells, larger and older shells being preferred. The maximum abundance of the mussel in a stony bottom can reach 22,000 ind./m^2. In the mussel and the red algae biocoenosis, *Gammaras salinus* with its abundance reaching 360 ind./m^2 is a subdominant from the quantitative point of view.

With respect to the periphyton scraped from the plexiglass plates, it can be said that *Mytilus edulis* can reach densities of over 400 ind./20 cm^2,which corresponds to 20 ind./cm^2. That was the case in October 1988, the whole mussel assemblage being dominated by individuals 1–, 2–, and 3– mm long. The colonial

hydroid *Laomedea geniculata* (about 150–200 colonies per cm^2) and the crustacean *Gammarus salinus* (20 ind./20 cm^2) accompanied the mussel in mass quantities.

The periphyton on the plexiglass plates exposed from May until August 1988 was found to contain 28 taxa; among these taxa there was the diatom *Nitzschia acicularis* which grew particularly abundantly on the slides exposed 7 m below the sea surface. The diatom was accompanied by numerous sessile peritrichous ciliates. The colonial ciliate protozoan Zoothamnium commune developed mass quantities and formed almost a monoculture of a kind on the slides exposed 30 cm above the sea bottom at the test site. The species played also the dominant role in the periphyton on the plexiglass plates fixed to the marker shelves. A total of 31 taxa were identified in the periphyton on the plexiglass plates exposed from May until October 1988. *Mytilus edulis* and the colonial hydroid *Laomedea geniculata*, the latter growing in an underwater meadow or a mat of a kind on the plates, were co–dominants in terms of abundance and biomass.

Table 5.2 Benthos of the Slupsk Bank and some data on periphyton taxa found in 1987-1990

Taxa (the most significant)	gravel fields	boulder areas and a vicinity of gravel deposits	artificial substrata
Delesseria sanguinea (L.) Lamour		+	
Rhodomela confervoides (Hudson) Silva		+	
Furcellaria lumbricalis (Hudson) Lamour		+	
Phyllophora brodiaei (Turner) J.G.Ag.		+	
Ceramium tenuissimum (Lyng.) J.G.Ag.		+	
Ceramium diaphanum (Lightf.) Roth		+	
Hildenbrandtia prototypus Nardo		+	
Spongomorpha uncinalis (O.F.Muell.)J.G.Ag.		+	+
Zoothamnium commune Kahl			+
Cordylophora caspia (Pallas)		+	+
Laomedea geniculata (L.)		+	+
Electra crustulenta v. balthica Borg		+	
Oligochaeta	+	+	
Pygospio elegans Claparede	+	+	
Nereis diversicolor O.F.Muell.	+	+	
Antinoella (Harmothoe) sarsi (Kinberg)	+	+	
Gammarus salinus Spooner	+	+	+
Gammarus oceanicus Segerstrale	+	+	+
Bathyporeia pilosa Lindstrom	+	+	
Corophium volutator Pallas	+	+	
Corophium crassicorne Bruzelius	+		
Jaera albifrons s.l.	+	+	+
Idotea granulosa Rathke	+	+	
Idotea chelipes (Pallas)	+		
Euridice pulchra Leach	+		
Diastylis rathkei Kroyer	+		
Balanus improvisus Darwin		+	+
Mysis mixta Lill.	+	+	
Praunus inermis Rathke	+	+	
Crangon crangon (L.)	+		
Mytilus edulis (L.)		+	+
Mya arenaria (L.)	+		
Cardium glaucum Bruguiere	+		
Macoma balthica (L.).	+		
Theodoxus fluviatilis L.	+	+	
Hydrobiidae	+		

ENVIRONMENTAL EFFECTS OF DREDGING

Investigations aimed at obtaining knowledge about the environmental effects of aggregate dredging from the sea bottom were carried out on the Slupsk Bank. The test field was located in the eastern part of the Slupsk Bank, within a documented resource field. The area of the test field was 1x1 km. Special attention was given to the magnitude and reach of hydrologic conditions and to dynamics of the sea bottom

resulting from both natural causes and from mining of the aggregate. A very important part of the investigation was a detailed study of benthic biocoenosis and its possible changes caused by exploitation of aggregate dredging.

Temporal changes and spatial variability of light extinction coefficient and water temperature

One evident effect of dredging is the disturbance of bottom sediments, both during the sucking in of the material and in the effect of the dredger screws operations. An additional source of suspended matter is the water which flows off the hopper of the dredger. In order to evaluate the changes of the light extinction coefficient caused by aggregate dredging, it was necessary, at first, to evaluate whether recorded changes of this parameter are not due to its general variability. Therefore, at one station within the test field during three days (before, during and after dredging) vertical distributions of extinction coefficient, temperature, and conductivity were measured every 3 hours. The results of measurements show that light conditions varied relatively little with depth. As a rule, a slight increase of the extinction coefficient was observed at the water surface. The cleanest water nearly always was found at the bottom.

An analysis of the light extinction coefficient shows that its value is significantly influenced by plankton occurrence. The 24-hourly cycle of plankton migration from the sea surface to bottom clearly was observed. In general, it may be stated that during the period preceding test mining, changes of the light extinction coefficient did not exceed a value of 0.26.

For comparison, changes of water temperature during the same period were measured. As stable wave conditions persist thermal stratification was rebuilt, and accompanied by advection of cool water at the bottom. The temperature distribution shows a clear 24-hour cycle, resulting from solar energy supply. Because of the relatively high vertical gradient of temperature during the experiment, water temperature proved a good indicator of upward movement of nearbottom waters. Temporal changes of temperature on each of the measurement horizons did not exceed 1° C and vertical gradients reached 1.7° C.

In order to determine the deformation of the temperature and light extinction fields resulting from dredging of aggregate, knowledge of the spatial background of these parameters is necessary. On the day before and two hours immediately proceeding test dredging, nearly simultaneously temperature, conductivity and light extinction distributions were measured on the profile across the test field. Variability of the temperature field was relatively small, maximum differences of temperature not exceeding 0.5° C. Horizontal variability of the light extinction coefficient did not exceed a value of 0.25.

During the test dredging measurements were done directly after passage of the dredger (to be exact, directly behind her stern) on profile perpendicular to the dredger route. The distinct trace of the dredger's passage was visible, both the light extinction coefficient and the temperature curves show distinct peaks with values significantly larger than the earlier measured temporal and spatial background variations. The width of the zone of disturbance did not exceed 50.

Results from towing the probe along the axis of the dredge trail, directly after dredging terminated, show that both the temperature and the light extinction coefficient fields quickly return to equilibrium state, or in other words, that the advection disturbance flow away from the line of passage. On vertical profiles measured 2 hours after the mining, traces of mining operations are even smaller. In temperature distributions, changes only connected with solar radiation heightening of temperature in the surface layer are observed. The light extinction coefficient measured 2 hours after mining does not show clear traces of dredger passage too.

Changes of suspended matter concentrations in sea water

Observations of suspended matter concentrations in sea water were carried out on the Slupsk Bank test field in May, August and October 1988. In August 1988, water samples for suspended matter analysis were taken 1 day before, during, 1 hour after, and 1 day after the test dredging of aggregates. The samples were taken at the surface, and at 8.0 and 16.0 m depth. Before and after the test mining, samples were

taken at 4 stations. During and 1 hour after dredging sampling was carried out at 8 stations placed on 2 perpendicular dredger route profiles, and 50 m, 150 m away from the dredger's route (on both sides of it).

Concentration of suspended matter in sea water within the test field in May 1998 varried fom 0.7 to 2.1 mg/l. In August 1988, 1 day before test dredging concentration of suspended matter varied from 0.9 to 3.9 mg/l, and 1 day after dredging from 1.0 to 1.9 mg/l. The highest natural concentrations (1.6-3.9 mg/l) were observed in October 1988. During the test dredging of aggregates concentrations of suspended matter varied from 1.0 to 32.0 mg/l at a distance of 50 m from dredger route, and from 0.7 to 2.2 mg/l at the distance 150m. One hour after mining concentrations of suspended matter were from 0.9 to 8.6 mg/l at the distance of 50 m, and from 0.4 to 2.9 mg/l at the distance of 150m from the dredger's route. Presented results suggest that values higher than 3-4 mg/l can be assumed to be caused by artificial activities such as dredging.

Sedimentological impacts on seabed

Concentrations and granulometric compositions of suspended matter flowing with water off the dredger were determined in three samples (2 samples of 24 litres, and 1 of 48 litres volume). The concentrations were 10,860 mg/l, 11,250 mg/l and 1,510 mg/l, respectively. The particle size distribution was fine sand (0.25–0.125 mm), 71.9%, 71.1% and 25.3%, respectively and very fine sand (0.125–0.063 mm), 15.5%, 10.9% and 3.9% respectively. Smaller grain sizes, were observed in amounts smaller than 1%. Maximum grain sizes of particles settling on the seafloor were in the three samples 8.0 mm, 3.1 mm and 0.8 mm, respectively.

Settling of suspended matter onto the seafloor was estimated through the use of sixteen sediment traps, placed on the datum points (ca. 1 m above sea bottom), along two profiles applying eight traps on each profile. The traps were placed at distances of 50, 150, 300, and 500 m on both sides of the dredger's course. The amount of suspensions settling along the dredger's route was evaluated from observations and direct measurement of the thickness of the layer of sand that fell into the troughs left after the mining. Thickness of the sand layer in the troughs was 0.5 to 1.0 cm which, after conversion, gives settling rates of ca. 7500 to 15000 g/m^2. In traps located 50 m away from the dredger's route the settling rates were between 1.29 and 1221.52 g/m^2. At distances larger than 50 m the amount of suspenions settling on the bottom decreased very quickly.

The granulometric composition of suspensions settling on the seafloor is quite similar to the composition of suspensions flowing off the dredger, i.e. fine and very fine sand fractions. In the traps placed 50 m from the dredger route, fine sand size fractions 0.25–0.125 mm formed 81.1% and 70.1%, and very fine sand fractions 0.125–0.063 mm gave 27.9 % and 17.7% of the samples. Fractions smaller than 0.063 mm did not exceed 0.4%. The diameter of largest grains caught in the traps was less than 1.6 mm.

The behavior of the cloud of suspended matter resulting from dredging operations is related to its granulometric composition. In sediments of the dredged layer, grains with diameter below 0.063 mm occur in very small amounts. Therefore, material washed of the dredger lacks fractions which could stay in suspension for a longer time. Sand-size grains of the plume settled very quickly on the bottom. Because there were weak currents and no waves during the experiment, nearly all material settled within 50 m of the dredger's route.

The behavior of post-dredging troughs was observed in August 1988, i.e. directly (10 –20 min) after the dredging commenced, in October 1988 (2.5 month later), and in May 1989 (9 months after the dredging). Trough depth measured directly after the mining was 0.2 to 0.7 m.

By October 1988 the troughs became partly filled. Trough depths were 0.1–0.15 m, and were independent of their initial value. In May 1989 traces of the troughs were still visible, and their depth was 0.04 to 0.12 m.

Observations at datum rods, driven into the troughs and granulometric composition of sediment filling the troughs showed that the trough filling is caused partly by material sliding down from trough edges and partly by bottom–migrating fine sands, to which the troughs act as sedimentation traps. In October 1989 further filling of the troughs, but also their partial uncovering due to erosion of the fine sands, were observed.

The maintained traces of the troughs and their independence of initial values, constant depth, existing in spite of visible accretion of sediments in the troughs and their surroundings, probably result from a loosening of the gravel caused by mining with the suction dredger, and from its later recompaction. Probably, the period of observations was too short to observe a complete evening out of the post–mining troughs.

Nature of biological impacts on seabed

The very low content of detrital organic matter in the Slupsk Bank deposits results in a very low content of different chemical pollutants in the deposits, especially organic matter. This is the reason why the undersize particles–containing effluent released by trailing suction hopper dredgers that operated in the Slupsk Bank is considered to be almost neutral to biota, from the chemical point of view.

Recolonization of the post-mining troughs took place very quickly. One year after exploitation it was observed many juvenile *Mytilus edulis* L. in partly filled by sand and gravel post-mining troughs. Also Polychaeta, because of its planctonic larvae recolonized the bottom in a short period. It is important to leave some parts of hard bottom in the base of the exploited layer to make easier the recolonization processes. The research carried out so far has showed that aggregate excavation in the Slupsk Bank has not disturbed its ecosystem balance.

5.9 United Kingdom

Research

(a) Seabed Sediment Mobility Study - South West Isle of Wight

This 18 month project started in November 1996. The contract was awarded to Hydraulics Research Wallingford and the British Geological Survey, and is managed by CIRIA. Funding was from a wide range of organisations. The aim is to investigate sediment transportation pathways and sediment movement in this important dredging area.

Work to date has included the production and distribution of a questionnaire which was sent to interested parties to identify areas of concern, and available information for the area. Information on sediment bedforms, geomorphology and geology has been collated.

The next step is to determine the most appropriate model to use for the West of the Isle of Wight area, and to further develop the criteria for determining the critical factors which need to be addressed when choosing a model so as to make the findings of this research more applicable to UK waters as a whole.

(b) Recovery of the Seabed

The jointly-funded project by the Crown Estate and MAFF looking at recovery of an experimental dredging plot off North Norfolk has been extended for a further three years. The site will continue to be monitored until dredging related changes have stabilised. Fish populations in the vicinity of aggregate areas will also be sampled and their feeding preferences determined through analysis of stomach contents. The information can then be used to assess how commercial dredging affects the seabed food resource in different areas and whether these effects change with the season. Plume dispersion will also be examined. The geographical scope of a study aimed at characterising the marine life inhabiting gravel deposits near areas of commercial interest will be extended and quantitative techniques employed.

It is now more than four years since the dredging of the experimental site off North Norfolk. The latest samples analysed (3 years post-dredging) show that the area has fully recovered both in terms of the stability of the sediment and range of species.

(c) Seabed Habitat Mapping

The BioMar team at the University of Newcastle has developed a technique using acoustic signals for mapping habitats on the seabed. The acoustic signals reflected from the seabed are analysed using specially developed software packages. The results can be displayed in real time on board the survey vessel or with more sophisticated analysis in the laboratory to produce maps or overlays on existing charts. It is then relatively straightforward to relate the habitats to seabed features such as wrecks, reefs, banks, pipelines, cables etc. and areas which are subject to disruption e.g. dredging, beam trawling, drilling, discharges etc.

The BioMar project epitomises the holistic approach now taken to marine environmental studies. The Conservation Agencies want to map the whole of the UK seabed and Continental Shelf very much as the land is mapped. They need this information for defining SSSI's, MNR's, SAC's etc. as well as providing baseline information against which to judge future proposals. This will clearly require large resources and take a long time. By taking a joint approach, extra resources can be made available to complete the whole picture whilst focusing on areas of special interest or sensitivity to particular groups. It will also have the major benefits of ensuring consistency of approach and comparability of results.

Unlike many of the other techniques for surveying seabed habitats e.g. grab samples and divers, acoustic mapping is quick and cost effective, allowing large areas of seabed to be mapped economically.

In 1993, English Nature and Scottish Natural Heritage commissioned the BioMar team to map specific marine habitats and their associated communities, a key requirement for the designation of Marine Nature Reserves and Special Areas of Conservation under the EU Habitats Directive. The results of the programme have shown good correlation between existing data collected by physical sampling and the acoustic mapping surveys.

(d) Anglian Coastal Authority Group (ACAG) N.E. Regional Study

This study continues to look at the sediment regime out to the 50m depth contour from the Holderness Coast to the Thames Estuary. The first stage is design of a database likely to include at least 4500 published references to relevant research plus unpublished but verified survey results. The results will be used to develop a conceptual model of sediment movement in the survey area. Stage two is intended to look to develop the model and verify the predictions with field studies. The results will help assess the impact of existing and future marine aggregate extraction.

(e) CIRIA Beach Recharge/Resource Study

The aim of this study was to identify resources of material around the coast of England and Wales suitable for use in coast protection schemes and to provide advice on the procedures for obtaining the material. The final report has been approved by the Steering Committee and was launched in February 1996 at a series of three or four regional seminars in London, Wales and on the East and South Coasts.

(f) Bristol Channel marine aggregates: resources and constraints project

Dredging in the Bristol Channel supplies over 80% of the sand used in South Wales and is also an important source of supply to sand to the South West of England.

The Bristol Channel has the second highest tidal range in the world and consequently has a very dynamic physical environment. It supports a diversity of marine flora and fauna, some of which are rare, and contains a number of sites of national and international importance. There are also adjacent coastal areas of high amenity value, and important submerged archaeological remains.

The overall hydrodynamics and movement of sediments in the Bristol Channel is not fully understood, and information on the extent of sand and gravel resources and constraints on working are sparse. Consequently it is difficult to predict the effects of individual and cumulative dredging activity on hydrodynamics and sediment movement or to assess the effects of dredging activity in relation to natural processes, harbour capital and maintenance dredging, or other engineering works.

This is a major Welsh Office research initiative funded by the Department of the Environment and the Crown Estates. The principal aims of the project are:

- to further develop understanding of the sediment transport regime in the Bristol Channel, and the extent to which the sediment deposits are interlinked;
- define the marine aggregate resources and to evaluate constraints on their extraction in the Bristol Channel;
- prepare a report on the above to assist those organisations involved in the Government View Procedure (and any subsequent arrangements) in the evaluation of proposals for future dredging.

Work commenced on 1st September 1996. The project is scheduled to finish in February 1999.

The first few months of the project have comprised an extensive consultation and data collection exercise, including contacting 224 groups and organisations. The objectives of the initial consultation exercise were to:

- ensure that those groups and organisations with an interest in marine aggregates dredging in the Bristol Channel were made aware of the project, its terms if reference and the approach adopted;
- ensure that interested parties were provided with an opportunity to raise issues, to make the study team aware of their concerns, and to raise questions which they felt that the study should be trying to address;
- identify potentially useful sources of data, reports and other information.

The next steps are to analyse the data, design a framework for undertaking primary research, set out ideas for modelling overall sediment transport and sediment budgets, and then run the model. Eventually the project will set out the potential constraints on the utilisation of the marine aggregate resource and develop a methodology which can be used to determine linkages between dredging, sediment transport and deposition, and coastal erosion.

(g) Seabed Characterisation

This project aims to bring into a common format as wide a range of geoscientific data as possible from within the inshore zone (up to 20 km offshore) of England and Wales, and to present such data in a way that will assist understanding of the modern hydraulic processes controlling sedimentation, the geometry and lithology of seabed sediments, and the bedrock geology of the zone. A range of wider environmental data are also included. A considerable amount of new information on sediment transport has been obtained from detailed sidescan interpretation.

The project is being carried out by the Coastal Geology Group of BGS and it started in late 1995 with completion by early 1999. The research is looking at six sectors off the coast of England and Wales, concentrating on those areas most affected by mineral extraction.

Work on the first two sectors Shoreham-Dungeness, and Flamborough Head to Gibralter Point are complete, while work on the third sector (North Norfolk) is advanced. It has been agreed that the fourth sector would cover the area between Winterton and Harwich on the East coast.

Using the second sector as an example, the research has collated data on the following topics:

Onshore geology
Offshore pre-quaternary geology
Bathymetry
Offshore quaternary sediments
Seabed sediments
Seabed morphology and bedforms
Sediment transport regime
Littoral Cells
Coastal morphology and littoral sediments
Tidal information
Sea level change
MAFF sediment and chemical data
Sites of special scientific interest
Offshore hazards
Aggregate industry interest
Hydrocarbon interests
CIRIA report on beach recharge materials
Quaternary sediment volumes.

The results are digitised using the Microstation Intergraph digital cartographic system. Data were stored in 31 files, which were then transferred onto Microstation Review. The files may be viewed on screen individually or in combination.

5.10 United States

Ecological studies, other than those mentioned in Section 3.12, are primarily undertaken by the US Fish and Wildlife Service and these studies can be reviewed on the WWW site WWW.FWS.GOV/.

6 REVIEW OF DEVELOPMENTS IN NATIONAL AUTHORIZATION AND ADMINISTRATIVE FRAMEWORKS AND PROCEDURES

6.1 Belgium

The new royal decree concerning the conditions concerning the exploration and exploitation of sand and gravel in the territorial sea and the continental shelf will be published in the course of 1997. The final draft is reproduced in Annex VI. This royal decree supersedes all the individual royal decrees for the permit holders (art. 18).

Belgian dredgers are not only working on the Belgian continental shelf but also on the Dutch continental shelf and Dutch dredgers are also working on the Belgian continental shelf. Discussions have already taken place with the Dutch authorities and a common black-box has been developed. It is the intention of the Belgian authorities to establish in the future a convention between the Netherlands and Belgium in order to come to an agreement how the information which comes out of the black-box can be exchanged. Contacts with the UK authorities still need to be made. The Belgian authorities are favouring a harmonized approach.

6.2 Canada

No new information to report.

6.3 Denmark

The Forest and Nature Agency is, according to the Raw Materials Act, responsible for the administration of marine aggregate extraction in territorial waters and on the continental shelf.

A new Raw Materials Act has entered into force on 1 January 1997 Ministerial Order No. 1007 of November 1996). From this date all dredging activities will take place in permitted areas. A 10 year transitional period is allowed for dredging in existing areas.

New dredging areas are subjected to a Government View procedure including public and private involvement. The applicant is requested to provide sufficient documentation about volume and quality of the resources in the area and to carry out an environmental impact assessment Ministerial Order No. 1167 of 16. December 1996). Permits will be granted for a period of up to 10 years.

Extraction activities which can be assumed to have a significant impact on the environment may be granted only on the basis of an assessment of the environmental consequences in accordance with the EC-directive 85/337. The procedure is laid down in Consolidation Act No. 1166 of 16. December 1996. Dredging of more than 1×10^6 m^3 for a specific project or in a single area will always be subjected to this procedure.

Besides permits for dredging in specific areas dredgers must have an authorisation to dredge in Danish Waters. In order to maintain a sustainable and environmentally justifiable dredging activity the total tonnage of the dredging fleet will be held on the present level.

The National Forest and Nature Agency is responsible for the mapping of sand and gravel in Danish Waters. Since 1990 the Geological Survey of Denmark and Greenland (GEUS) has carried out the mapping projects.

6.4 France

A working group managed by the General Secretary of the Sea and make up by Ministry of Industry, Ministry of Environment, IFREMER, Public Works Administration, Fisheries Administration has proposed a new regulation for all marine aggregates extraction (calcareous and siliceous).

The new text includes mainly an environmental impact assessment with side scan sonar and bathymetric, and sedimentological biological samples each five years.

6.5 Germany

Sediment extraction is covered by the "Bundesberggesetz" (Federal Mining Law) and the following regulations as the "Bergverordnung fuer den Festlandsockel" (Mining Regulation for the Continental Shelf) and the "Verordnung ueber die Umweltvertraeglichkeitspruefung bergbaulicher Vorhaben" (Regulation for the EIA of Mining Projects). The last one names the type of projects for which an EIA has to be made. Sediment extraction areas are not belonging to those projects. The law and the amendments demand descriptions of the impact on the coastal (and island) stability and on fisheries. The Mining Law states in §55 that extraction can not been permitted when impact on plants and animals exceeds the acceptable limit (... nicht unangemessen beeinträchtigt). The mining regulation determines additionally activities which have certain impact on seabed and fisheries. These are described in more detail in the "Requirements for the Aspects of fisheries and Ecology" of the guidelines of the Regional Mines Inspectorate (cited below).

For the German part of the North Sea, belonging to the competence of the "Oberbergamt" (Regional Mines Inspectorate) in Claustal-Zellerfeld, the inspectorate introduced a guideline for permission of sediment extraction :

Principles for the Granting of a Permit

1.1 A permit for sand and gravel extraction may only be granted on condition that a geological, and possibly bioecological, preliminary exploration of the reservoir sites carried out.

1.2 To protect the ecosystem and fisheries, certain periods may be determined during which dredging is not allowed.

1.3 Type and production capacity of the extraction sites shall be clearly specified.

1.4 Procedures and sites for the disposal of waste sand shall be specified.

1.5 Permits for sand and/or gravel extraction shall be limited to small areas of about 5 square kilometers.

1.6 Areas where extraction continues throughout the year shall be limited.

1.7 Permits granted shall include the stipulation that the companies have to prepare production statistics which also contain information on grain sizes and gravel content (in percent) of the total material.

1.8 Permits granted shall include that stipulation that the companies have to submit to the authorities a precise work and time schedule, including a station network if possible.

Obligations to protect the interests of fisheries and ecology

2.1 The Deutsches Hydrographisches Institut (now: Bundesamt fuer Seeschiffahrt und Hydrographie) shall be notified of the extraction areas, with a precise site plan.

2.2 The sand and gravel extraction shall be carried out in such a way that no till or clay is exposed. The remaining sand or gravel cover must be 0.3 to 1.0 m thick.

2.3 One year after the end of exploitation, at the latest, there shall remain no areas with uneven surfaces hindering fisheries. The gradient between extraction site and natural seabed must not exceed the ratio 1:20.

2.4 Rocks with a diameter exceeding 30 cm, which are exposed during extraction shall not be left on surface of the sea floor.

2.5 Upon request by the Institut fuer Kuesten- and Binnenfischerei (Institute for Coastal and Freshwater Fisheries) of the Federal research Centre for Fisheries, one of its employees shall be allowed to observe the operations on board one of the vessels used during the exploration and extraction activities.

6.6 The Netherlands

On 1 January 1997 a new Extraction Law has been entered into force for the mainland and whole Dutch part of the North Sea.

For dredgers which are extracting from licensed sites on the Dutch and Belgian sectors of the North Sea, an administrative framework is planned to harmonise the data exchange between both countries. The goal is that only one black box has to be installed on board of the dredgers, working on both continental shelves.

At the end of 1996 a pilot project has been started for realising an ARC/INFO Geographic Information System (GIS). The system is based on a PC station using the package ARCVIEW 3. If the decision for using GIS has been taken ARCVIEW will be installed on a network.

6.7 Poland

Principal Law

Polish Geological and Mining Law (1994, supplement 1996).

Relevant authorities:

For licences procedures - Licence Bureau in Ministry of Environmental Protection, Natural Resources and Forestry
For geological and mining surveillance - District Mining Office

Administration procedures:

Licence for reconnaissance and exploration (documents required):
– Application of investor to Ministry
– Project of geological (exploratory) works
– Environmental Impact Assessment of exploration
– Criteria of resources balance (proposed by investor and approved by Ministry)

Licence for exploitation (documents required):
– Licence for exploration
– Geological documentation of resources (approved by Ministry)
– Environmental Impact Assessment of exploitation
– Delimitation of mining territory and premises (approved by District Mining Office)
– Plan of resources field development and detailed plan of exploitation (approved by Ministry)

Exploitation (documents and reports required)
– Licence for exploitation
– Annual balance of resources
– Quarterly report on exploitation (for exploitation fee)

Law and practice for monitoring and surveillance

– Monitoring regulations
– Electronic devices for surveillance and monitoring

6.8 United Kingdom

Regulation/Government View Procedure

Applications to extract marine material remain subject to the non-statutory Government View procedure. Which includes studies by Hydraulics Research to determine the effect dredging activity woudl have on

the adjacent coastline. The statement also identifies any appropriate mitigative measure. Any particular requirements are stipulated as conditions to the licence. Applications are accompanied by a full environmental statement. The Crown Estate will only issue a licence following a favourable Government View from the DoE or Welsh Office as appropriate.

The Department of the Environment issued a news release on the 16 November 1995 confirming their intention to introduce a statutory procedure for marine aggregate licensing. This will be based on the Town and Country Planning system.

Management by the Crown Estate

Since 1990 the Crown Estate has operated an Arc/Info Geographic Information System (GIS) as the primary source of data relating to the management of offshore marine aggregate extraction licences. The GIS essentially links graphical information to database tables and contains information on dredging licences, admiralty features, seabed geology, prospecting surveys and a wide range of other seabed uses and activities offshore.

The system is based on a stand-alone UNIX SunSparc station which has been enhanced recently through the addition of a package known as ArcView which allows access to backdrop data and manipulation to create a second tier of reports, maps, statistics and charts for management purposes.

In January 1993 the Crown Estate introduced an electronic monitoring system (EMS) which records the date, time and position of all dredging-like manoeuvres. All vessels dredging on Crown Estate licences must be fitted with the EMS which records time and status of the vessel at 30 minute intervals on standby or 30 second intervals if indicators show the vessel to be dredging. To ensure security information from the various sensors is encrypted on the diskettes which are changed every month. The diskettes are analysed by the Crown Estate within 20 working days of the month end.

In 1996 some 40,000 hours of dredging records were analysed with less than 0.01% of the total hours dredged being out of area, in all cases licensees provided adequate explanations.

The Crown Estate has provided information on both the GIS and EMS to various groups and has, where appropriate, made detailed information available.

7 REVIEW OF THE EFFECTS OF EXTRACTION OF MARINE SAND AND GRAVEL ON THE BALTIC ECOSYSTEM

The following section of the Annual Report of the ICES Working Group on the effects of extraction of marine sediments on the marine ecosystem reviews the information and discussions on the effects of extraction of marine sand and gravel on the Baltic Ecosystem. This task, set out in the Terms of Reference for its meeting (C Res 1996/2:28 (a)), was requested by the Helsinki Commission (HELCOM 1996/11) and required the provision of information on the extent and volumes of sand and gravel extraction in the Baltic Sea, and on known impacts on eg. benthos, diving seabirds and bottom spawning fish and invertebrates.

In undertaking this task the Working Group was conscious that:-

i) certain historical activities in the Baltic Sea had not conformed with the ICES Code of Practice and that observed deleterious impacts associated with these were a feature of this departure from good practice rather than illustrative of particular risks in the Baltic from extraction operations,

ii) that the sources of environmental disturbance associated with sand and gravel extraction in the Baltic Sea, providing good practice is followed, would be similar to those from extraction operations found in other locations, but

iii) that the specific composition and structure of Baltic ecosystems are substantially different from those in the North Sea and NE Atlantic where extraction activities are undertaken by other states.

The consequence of this is that the Working Group in addressing potential effects have assumed that good extraction practice would be followed and that the sources of environmental disturbance arising would be similar to those noted elsewhere (see for example ICES *Cooperative Research Report* No 182). The consideration of potential environmental impacts has been limited by the need for more detailed information on the Baltic ecosystem, notably in areas of very low salinity, and the requirement for further evaluation involving specialists in these areas of Baltic Sea ecology.

The Working Group did not specifically address the potential physical effects of extraction operations on coastal processes. Certain extraction operations in the Baltic have led to coastal erosion and altered sediment transport patterns. These risks would usually be evaluated as part of the environmental impact assessment for any project (see ICES Guidelines for the preparation of an Environmental Impact Assessment evaluating the effects of seabed aggregate extraction on the Marine Environment) and have been discussed in detail elsewhere (ICES *Cooperative Research Report* No 182).

7.1 EXTRACTION OF MARINE SEDIMENTS IN THE BALTIC SEA BY COUNTRY

The following sections provide information on the reported aggregate extraction activities in Baltic states. It is known that aggregate extraction operations occur in other areas but data was not available to the Working Group on these.

7.1.1 Denmark

The extraction of marine sand and gravel in the Danish Exclusive Economic Zone of the Baltic represents 30-50 % of the total marine production of materials for construction and reclamation. Most of the material dredged comes from areas along the east coast of Sjælland, Møn and Falster and from Adler Ground-Rønne Bank and Kriegers Flak.

The amount of materials dredged for construction has increased slightly since 1992.

During the construction of the fixed link between Denmark and Sweden 3 $x10^6$ m^3 of sandfill will be dredged from the Kriegers Flak in the Baltic. The dredging started in January 1996 and is expected to last 4 years. To date, some 350,000 m^3 has been dredged in this area.

Table 7.1: Extraction of marine sediments from the Danish Exclusive Economic Zone of the Baltic Sea

Year	Sand 0-2 mm	Gravel 0-20 mm	Gravel/Stones 6-300 mm	Sand fill
1990	0.2 x10^6 m^3	0.1 x10^6 m^3	0.2 x10^6 m^3	0.1 x10^6 m^3
1991	0.3 x10^6 m^3	0.2 x10^6 m^3	0.4 x10^6 m^3	0.2 x10^6 m^3
1992	0.3 x10^6 m^3	0.1 x10^6 m^3	0.7 x10^6 m^3	0.2 x$10^6 m^3$
1993	0.3 x10^6 m^3	0.1 x10^6 m^3	0.6 x10^6 m^3	
1994	0.5 x10^6 m^3	0.1 x10^6 m^3	0.7 x10^6 m^3	0.1 x10^6 m^3
1995	0.6 x10^6 m^3	0.1 x10^6 m^3	0.5 x10^6 m^3	
* 1996	0.6 x10^6 m^3	0.1 x10^6 m^3	0.5 x10^6 m^3	0.6 x10^6 m^3

* The figures for 1996 are preliminary.

7.1.2 Estonia

No data available to the Working Group

7.1.3 Finland

The volume of sand and gravel extraction varies from year to year and there are no official statistics available. The annual average extraction of sand and gravel is, however, estimated to be less than 0.5 x10^6 tonnes. The principal areas where extraction operations have occurred in recent years are in coastal areas off the cities of Helsinki, Kotka, and Pori (in the Gulf of Bothnia).

7.1.4 Germany

In 1995, approx. 1 x 10^6 tonnes of sand and gravel were dredged in the Baltic and in the coastal seas. It is expected that especially dredging for coastal protection will have increased in 1996. The sand was dredged from areas near the coast.

7.1.5 Latvia

No data available to the Working Group

7.1.6 Lithuania

No data available to the Working Group

7.1.7 Poland

From 1985 to 1989, about 1.4x10^6 tonnes of aggregates were dredged from the Slupsk Bank. In 1990, exploitation was stopped for economic reasons. Test dredging was carried out from the Southern Middle Bank and in Koszalin Bay during 1987-1989. Approximately 4,000-6,000 tonnes were removed from each deposit. During the 1990s, a few thousand tonnes of aggregates were extracted from the eastern part of Pomeranian Bay without any formal controls.

A 1 km^2 sand extraction field located 4 km north-east of Jastarnia on the Hel Peninsula was used in 1993 and 1995 for beach nourishment needs (total amount of extracted sand was ca. 200,000 m^3). Sand is currently extracted in a 5 km^2 area north-east of Cape Rozewie for the needs of artificial beach nourishment. It has been dredged since 1995 at a rate of 100,000 m^3/year.

Since 1989 sand has been extracted at four sites in the Puck Lagoon for sand nourishment on the Hel Peninsula. Since 1993 two sites have been closed. From the remaining two areas sand is presently extracted at a rate of 150,000 - 300,000 m^3/year, but this is planned to be (except in instances of coastal catastrophy caused by storm activity) stopped by 1998. The total amount of sand extracted from the Puck Lagoon is about 6,000,000 m^3.

Sand is also extracted from approach channels to ports and from sand traps at ports within operation of artificial sand by-pass systems; such extraction has taken place since about 1990 at the ports of Kolobrzeg ca.60,000 m^3/year), Darlowo (ca. 80,000 m^3/year), Ustka (80,000 m^3/year), Leba (30,000 m^3/year), Wladyslawowo (ca. 200,000 m^3/year).

7.1.8 Russia

No data available to the Working Group

7.1.9 Sweden

No commercial dredging has taken place in the Swedish Exclusive Economic Zone of the Baltic in recent years.

7.2 OVERVIEW OF DATA ON THE BALTIC SEA ENVIRONMENT

7.2.1 Benthic communitites in the Polish marine area

Distribution of the bottom macrofauna depends strictly on the type of the bottom in a given area. In the Baltic Sea sand is the dominating type of bottom sediment down to 50 m. In the deeper part of the sea the bottom is composed mainly of muddy sediment. Composition and spatial variability of benthic species also reflect a whole range of diversity of environmental factors such as temperature, salinity, oxygen content in both water and bottom sediments.

In terms of species composition and macrofauna abundance, six bottom macrofauna communities have been identified in the Polish Marine Area (Figure 7.1). The communities described below are named according to the occurrence of the most characteristic species (the most frequently found, dominating in terms of total biomass or abundance during the whole year). While the Working Group was only in a position to consider such data for Poland it was of the view that this provided an important illustration of types of benthic community likely to occur in many areas of the Baltic. In the Northern and Eastern parts of the Baltic, however, benthic communities more characteristic of freshwater environments will occur; no data was available to the Working group on these.

A - *Macoma balthica* - *Mya arenaria* community occurring on sandy bottoms down to 20 to 25 m (the limit of warm water during the summer). This is a very diverse community composed of 20 macrofauna species, mainly of Atlantic or Atlantic-Boreal origin. Some fresh water species can be also found in this zone.

In terms of abundance the most dominant species in this community is the sedentary polychaete *Pygospio elegans*. The bivalves *Mya arenaria*, *Cerastoderma lamarcki*, *Macoma balthica* and the amphipod *Corophium volutator* are common as well. Bivalves make up about 90% of total biomass. The supralittoral zone (splash zone) is a hostile habitat for benthic species due to wave action. Only a few species (*Bathyporeia pilosa*, *Eurydice pulchra*) are able to tolerate these conditions.

B - *Mytilus edulis* - *Gammarus salinus* community occurs in the sandy-stony bottom of the Slupsk Bank at depths ranging from 14 to 20 m.

Algae covered stones create a diversified habitat, enhancing the faunal diversity: some 18 species are recorded including 11 crustacean species. In terms of both abundance and biomass *Mytilus edulis* is the dominant species constituting 72 and 96 % of the total macrofauna, respectively. Among the other species, only *Gammarus salinus* accounts for more than 1% of the total biomass.

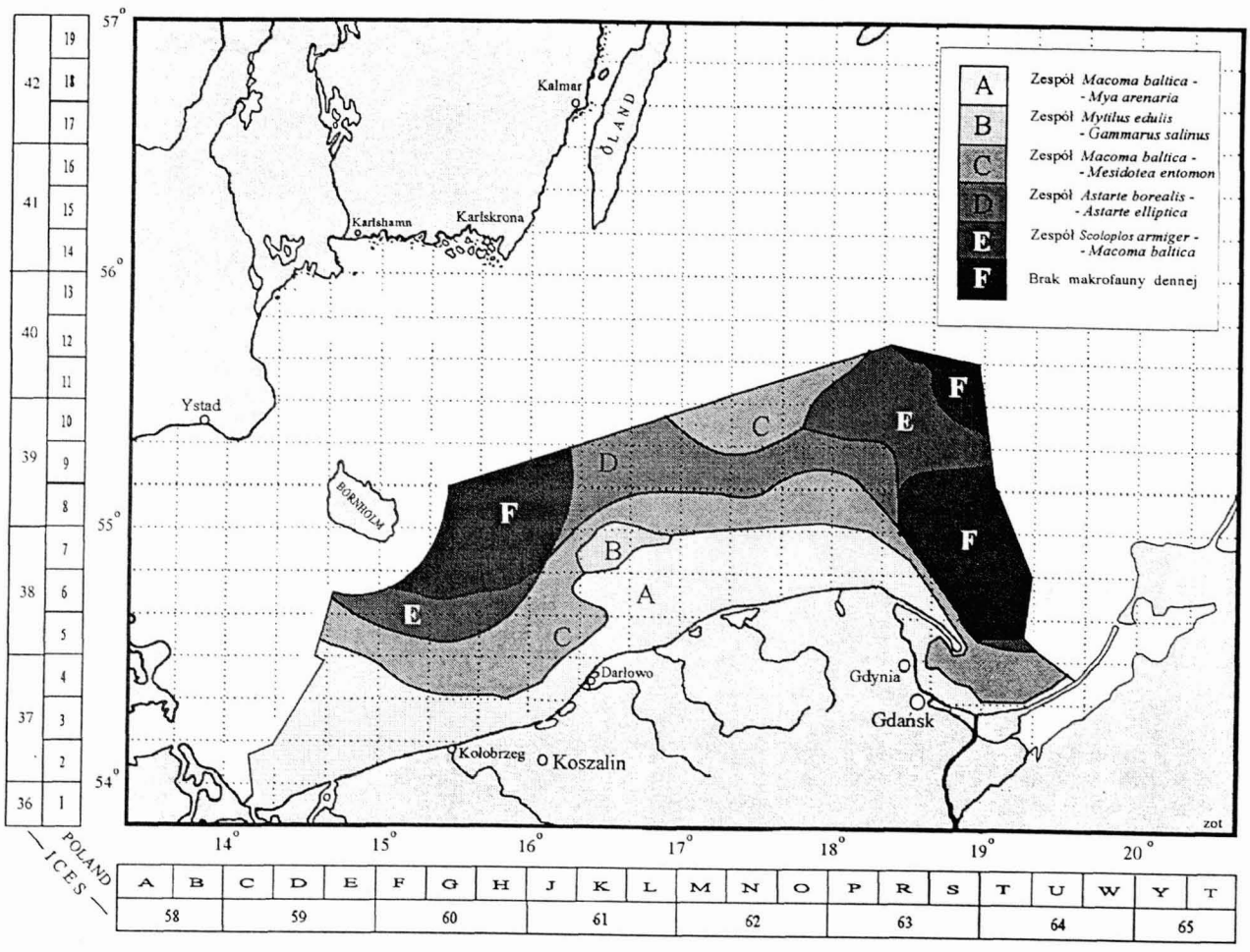

Figure 7.1: Benthic macrofauna communities inhabiting Southern Baltic area

A - ***Macoma balthica -Mya arenaria*** community
B - ***Mytilus edulis - Gammarus salinus*** community
C - ***Macoma balthica - Mesidotea entomon*** community
D - ***Astarte borealis - Astarte elliptica*** community
E - ***Scoloplos armiger - Macoma balthica*** community
F - Lack of bottom macrofauna

C - ***Macoma balthica - Saduria entomon*** **community** occurs in sandy as well as sandy-muddy bottoms at a depth range of 25 to 60 m.

Approximately 20 benthic macrofauna species can be found in this community. As far as biomass is concerned *Macoma balthica* is the dominant species; however, the most abundant are the crustaceans *Pontoporeia affinis* and *Pontoporeia femorata*. *Macoma balthica* and the crustaceans *Saduria entomon*, *Pontoporeia affinis* and *Pontoporeia femorata* are the most frequently occurring species in this community.

D - ***Astarte borealis - Astarte elliptica*** **community** occurs in the clay, sand and gravel bottom of the slopes and sills of the Slupsk Furrow at depths between 60 and 90 m.

The community consists of 20 specimens, with *Astarte sp., Saduria entomon, Scoloplos armiger* and *Terebellides stroemi* predominating. The clams *Astarte sp.* found in this community only, predominated both in terms of abundance and biomass, contributing about 66% and 87% respectively.

E - *Scoloplos armiger* - *Macoma balthica* community occurs in the least populated, mainly muddy bottom area below 60 m.

This community comprises species which are able to tolerate extensive changes in oxygen concentration such as the polychaetes species *Scoloplos armiger, Bylgides sarsi, Arcidea suecica* and also the most ubiquitous benthic species occurring in the Baltic Sea, *Macoma balthica.* In this community the most frequent and abundant species, which also comprises a large part of the biomass, is *Scoloplos armiger.* In this zone it is possible to observe temporary disappearance of some species due to oxygen deficit as well as recolonisation of the bottom after refreshed oxygen conditions (inflow of oxygen-saturated water from the North Sea).

F - Lack of bottom macrofauna - the muddy bottom region, below 70 m is practically not inhabited by benthic organisms due to the long term oxygen deficit. Only a few small organisms such as nematodes exist at this depth. Recolonisation in this area has been observed; however, it has usually been short term.

Significant dominance of bivalves is a characteristic feature of almost all communities except *Scoloplos armiger - Macoma balthica,* where polychaetes contribute 50% of total biomass.

7.2.2 Macrophytes in the Baltic Sea

The Baltic macrophyte community is composed of marine and limnic plants and algae. Most of the marine algae can also be found in the North Sea. Due to the specific hydrodynamics and geomorphology both the limnic and marine species have to cope with physiological stress caused by the very large range in salinity, annual temperature fluctuations and seasonal changes in the intensity of the light in northern areas. The substrate type is also of great importance, as the Southern Baltic and the Baltic Proper consist mainly of sand and finer sediment, macroalgae have few areas to attach themselves. These areas are dominated by perennial higher plants such as eel grass, pond weed and reed.

Since the 1960's growing evidence of a massive macrophyte decline has been reported. Climatic and hydrological changes, and euthrophication have been identified as the most important reasons for this decline. The increasing nutrient concentrations (P and N) stimulate particularly the primary production of planktonic algae and fast growing epiphytic green algae. As a result the community composition, production and depth contour of the Baltic flora has changed. The most objective changes are the declining perennial macrophytes, (eg *Fucus* and *Zostera*) and an increase of the algal blooms (Schramm 1996).

From the 1950's to the end of the 1980's (Vogt & Schramm 1991; Schwenke 1965) a tremendous loss in abundance and biomass has been observed for *Fucus* in Kiel Bay due to a shift in the lower depth contour from 10 m to 2 m. During the same period the lower depth distribution of the red algae community in Kiel Bay shifted from 20 m to 18 m, while the contour of maximum biomass moved from 14-16 m to 8 m. The community changed from a *Furcellaria sp.* dominated to a *Coccotylus sp.* and *Phycodrys sp.* one (Schramm 1996).

7.2.3 Fish in the Baltic

There are around 200 species of fish found in the North Sea, but this number reduces in the brackish waters of the Baltic with many of the marine species being replaced by purely freshwater species in the North and West of the Baltic Sea (Table 5.2). No detailed information on freshwater fish populations was available to the Working Group.

Table 7.2: Change in fish species and relative abundance of marine and freshwater types

	Marine species	Migratory species	Freshwater species	Total species
Baltic Total (without Kattegat)	97	7	40	144
Beltsee and Arkonasee (Western Baltic)	97	7	22	126
Bornholmsee, Gotlandsee and Rigaer Meersbusen (Baltic proper)	41	7	23	71
Alandsee, Scharenmeer, Finnischer Meerbusen and Bottensee (Northern and Eastern Baltic)	27	5	33	65
Bottenwiek	10	5	25	40

source: Thiel *et al* (1996)

In addition to commercially important species, there are several species that are protected by the Bern Convention, or which appear on the 3 protected fauna lists of the EU Habitats Directive. The marine species in this category are shown in Table 7.3, but it should be noted that there will be several other freshwater species on these lists. Several of these species also spawn on seabed substrates or have close associations with the seabed environment.

While less productive than the North Sea the Baltic Sea supports a productive fishery, with the marine species of herring, sprat and cod the most economically important. Catches of these species peaked in the late 1970's and early 1980's but in recent years catches have declined. Recruitment in the cod fishery may have been reduced by the prolonged period of lowered salinity. While less important in commercial terms there are also several fisheries for freshwater species.

Table 7.3 Marine fish species protected by the Bern Convention or appearing in the species protected lists of the EU Habitats Directive

Species	Endemic/non-endemic	Geographical distribution
Alosa alosa	non-endemic	southern Baltic
Acipenser sturio	non-endemic	all
Alosa fallax	non-endemic	all
Coregonus albula	endemic	Gulf of Finland, northern Gulf of Bothnia
Coregonus lavaretus[1]	non-endemic	all
Cottus gobio	non-endemic	all
Cottus poecilopus	non-endemic	southern and north-western Baltic
Lampetra fluviatilis	non-endemic	all
Triglopsis quadricornis (*Myoxocephalus*)	non-endemic	all
Petromyzon marinus	non-endemic	southern Baltic
Pomatoschistus microps	non-endemic	middle and southern Baltic
Pomatoschistus minutus	non-endemic	middle and southern Baltic
Salmo salar	non-endemic	all

[1] Subspecies

C. lavaretus lavaretus: gillrakers 22-29 (mean 25), usually smooth; Gulf of Finland and Gulf of Bothnia.

C. lavaretus mediospinatus Pravdin: gillrakers 27-40 (mean about 35), mostly with denticulations; Gulf of Finland.

C. lavaretus pallasi Valenciennes: gillrakers 39-48 (mostly 42-44), usually with minute denticulations; Gulf of Finland.

C. lavaretus oxyrinchus Linnaeus: gillrakers 35-44 (usually 40), snout pointed; western Baltic and south-eastern North Sea.

C. lavaretus pidschianoides Pravdin: gillrakers 21-33 (usually 25-26), lower jaw about equal to caudal peduncle depth; south-eastern Barents and White Seas.

7.2.4 Importance of the Baltic to seabirds

The seabird fauna of the Baltic is primarily characterised by the almost 10 million birds estimated to overwinter in the region (Durinck et al. 1994). The winter bird fauna of the Baltic is numerically dominated by benthivorous species, especially seaducks which comprise about 80% of the total number of birds. Eight species occur in the Baltic in numbers representing more than half the number in Western Europe (Rose & Scott 1995) and hence these species are most likely to become detrimentally affected at the population level: Red-/Black-throated Diver (*Gavia stellata/arctica*), Mute Swan (*Cygnus olor*), Long-tailed Duck (*Clangula hyemalis*), Black Scoter (*Melanitta nigra*), Velvet Scoter (*Melanitta fusca*), Smew (*Mergus albellus*), Razorbill (*Alca torda*) *and* Black Guillemot, Baltic form (*Cepphus g. grylle*).

7.2.5 Sensitive and Designated Areas and Habitats

It was noted that the 62 Baltic Sea Protected Areas (BSPAs) provided a network of protected sites of conservation importance, that red book data were being worked on and that there is ongoing work on habitats and threatened habitats. Further information on these is likely to be available in the coming months.

7.3 ENVIRONMENTAL IMPACTS AND IMPACT ASSESSMENT

The Working Group noted that several of the dredging operations in the Baltic on which it had information had not conformed to good dredging practice. Departures from agreed good practice (such as dredging fine material or dredging deep pits) may result in deleterious environmental effects, such as the release of nutrients into the water column or the development of anoxic conditions. The Working Group stressed the importance of dredging operations following the ICES Code of Practice and generally seeking to follow good dredging practice.
The Working Group commended to HELCOM the ICES Code of Practice and Guidelines on environmental assessment for the extraction of sand and gravel. It noted the requirements under the Espo Convention (not yet in force) for impact assessments where projects may give rise to transboundary effects, and additionally the requirements of the European Union with regard to EIA. It is assumed that such projects would be subject to environmental impact assessments in the Baltic Sea area, which is the case in most North Sea and NE Atlantic areas.

The notes below have also highlighted the importance of a full assessment of risk to seabirds, fish, the benthos and to other special habitats, in particular the Baltic Sea Protected Areas (BSPAs).

7.3.1 Chemical Impacts on seabed and water column

Seabed disturbance of sediments may result in mixing of the sediment with the overlying water. Additional inputs arise as a result of discharge of fine sediments from the dredger overflow which may give rise to localised turbidity.

The disturbance of sediment with a significant content of fine material will result in the mixing of interstitial water with overlying seawater and potentially the release of chemical components from the sediments. The composition of the interstitial water is likely to be most strongly affected by organic matter within the sediments. For example, the decomposition of this material can lead to *inter alia* nutrient and metal release from particulate to dissolved phases.

Decomposition of organic matter, desorption of components from organic matter and clay minerals, and dissolution of soluble material may also occur when sediment particles and water are mixed by disturbance, during uplift or discharge. The effects of mixing on the water column may include increased consumption of oxygen by decomposing organic matter and release of nutrients and metals. Equally, suspended clay minerals, with a high surface activity may act as adsorbents of some dissolved species (eg. trace metals).

It should be emphasised that the chemical effects arising from aggregate dredging are likely to be minor on account of the very low organic and clay mineral content of the sediments suitable for commercial extraction. In addition, dredging operations are very localised and transient which further limits such effects.

7.3.2 Impacts on Benthos

The Baltic environment is potentially much less stable than the North Sea and English Channel. For example, in addition to the effects of natural sediment disturbance, caused primarily by wave action, there are large scale spatial and temporal variations in salinity and temperature which can range over the entire Baltic Sea between 2 - 30 and 5 - 12 °C, respectively. Such conditions favour the development of a benthic fauna more typical of an estuarine environment, and deposits of sand and gravel in the Baltic tend to be dominated by species such as *Macoma balthica, Mya arenaria, Mytilus edulis, Cerastoderma glaucum* and *Hydrobia ulva*. Research into the effects of sand and gravel extraction in the Baltic indicates that, where these animals occur, they quickly return to their pre-dredged status. Three examples provide information on the impact and the recolonisation of the macrofauna after dredging.

- In 1988 an area called Slupsk Bank, off Poland, at a depth of 17 metres and a salinity of 7 psu (Okolotowicz, 1991), was extensively dredged. An examination of the macrobenthos following dredging indicated that the total number of taxa returned to the pre-dredged value within one year.

- In 1985 off the town of Kotka in Finland (Winterhalter; 1990), 100,000 cubic metres of sand was dredged; this led to a significant deepening of the site down to 17 m, resulting in the total elimination of the macrofauna. After one year, the number of species had returned to the baseline level, but the abundance and biomass remained at a low level, suggesting that the community would need several years to fully recover.

- Between July 1987 and March 1988, three million cubic meters of sand were dredged off Denmark in Køge Bay, creating 10 m deep pits with anoxic conditions having significant effects on the benthos below 7m depth (Norden Andersen *et al.* 1992). In addition, trailing suction dredging removed up to 2 m on the sea floor, leaving a pattern of 1.5 m wide and 0.5 m deep furrows on the sea bed. In this area the benthic macrofauna had recovered in numbers of taxa, abundance and biomass within 17 months after dredging. The settlement of mussels, however, on boulders (exposed by the dredging operation) changed the composition of the former community.

However, there are a number of benthic species and communities which are of particular sensitivity. For example:

- Habitats which support large slow growing invertebrates, namely; *Artica islandica, Astarte spp.*
- Areas with macrophytes which provide important habitats for many other invertebrates, such as species of gastropoda (*Rissoidae*), isopoda (*Cyathura*) and amphipoda (*Gammarus sp.*).
- Spawning areas for fish.
- Areas of sea-bed which are important as feeding grounds for wintering sea ducks, such as eider, scooter and long-tailed ducks.

7.3.3 Effects on macrophytes in the Baltic Sea

Parts of the macrophyte distribution in the Baltic Sea overlap with candidate areas for sand and gravel extraction. As there are only a few studies which address growth and recolonization of macrophytes, the dredging of sand and gravel in areas stressed by euthrophication is of particular concern. As a consequence, shallow coastal sandy areas to 8m depth and boulder areas to 20m depth should be treated as particularly sensitive.

7.3.4 Effects on fish and fisheries

In its *Co-operative Research Report* No 182, the Working Group stressed the importance of careful evaluation of seabed spawning habitats where the licensing of gravel extraction operations is being considered. The Report stressed, in particular, the requirement for herring spawning grounds and whitefish (*Coregonus*) spawning grounds to be assessed where extraction operations were planned in the Baltic Sea area.

There are a number of ways in which aggregate extraction operations may affect populations of fish:-

- Localized avoidance of any disturbance caused by extraction activities (notably of suspended material in the plume eg. Westerberg *et al*, 1996).
- Localized alteration of the benthos and possible reduction in food resources for certain fish species.
- Localized alteration of seabed habitat caused by removal of sediment and settling of suspended material (identified as of particular importance for bottom spawning fish with discrete spawning grounds occurring in candidate extraction areas).
- Localized effects of suspended sediments on egg and larval stages (important also for pelagic spawning fish eg. Westerberg *et al*, 1996).

As with marine mammals turbidity in the water column may result in avoidance behaviour by fish species. The environmental assessment should evaluate potential impacts particularly for any species with critical migrations through any areas likely to be affected in this way. Given the size of extraction areas any effects of altered benthic communities on fish stocks is likely to be small and not detectable against natural variation in the fish stock. It is, however, important that all licensed extraction operations retain the nature and type of the original surface sediment layer and that no areas are dredged to a depth which results in an altered sediment type. Particular attention should be given to seabed spawning species and this aspect of the biology of freshwater species requires further attention.

Recent work in the Baltic has also highlighted the possible effects that suspended sediments may also have on the buoyancy of fish eggs and on the survival rate of ichythyoplanktonic stages (Westerberg *et al*, 1996). The adhering of particles to cod eggs causes loss of buoyancy and the eggs sink to the bottom. Given the avoidance reaction of fish to suspended sediments, it is difficult to extrapolate from this work the likely effects on a stock but again critical spawning areas for pelagic spawning fish should also be reviewed in any environmental assessment.

Conclusions on Fish

The Working Group was of the view that the sources of environmental disturbance arising from extraction operations that might potentially have effects on fish and fisheries would be similar in the Baltic Sea to those recorded for other areas. The fish species, their ecology and populations are, however, much more specific to this sea area and this feature would benefit from further investigation involving those with specialist knowledge of this aspect of Baltic Sea ecology. The principal means of ensuring extraction operations do not have deleterious effects on fish and fisheries is good management. In this regard any impingement on either critical spawning seasons or critical migrations can be avoided by selectively halting extraction operations at certain times of the year if necessary. Similarly, as elsewhere, licensed extraction operations may not be permitted on known critical seabed spawning habitats (eg. herring spawning grounds). The general view of the Working Group was that while the Baltic Sea ecosystem was unique and different from the truly marine areas where extraction operations occur, extraction activities could be properly managed so as to ensure no detrimental effects to fish or fisheries.

7.3.5 Impacts on seabirds in the Baltic

General

Only in a very few recent assessments has the extent and nature of the impact of extraction activities on seabirds been investigated. The populations and distributions of seabirds in the Baltic may be affected in the following ways:

- Reduction of feeding conditions for plunge and pursuit diving birds through reduction of water clarity;
- Reduction of food resources for herbivorous species through negative impacts from sediment dispersal on vegetation;
- Reduction of food resources for piscivorous species through negative impacts from sediment dispersal on vegetation and fish larvae;
- Reduction of food resources for benthivorous species through removal of benthic communities and negative impacts from sediment dispersal on the settling of mussels;
- Avoidance of any disturbance caused by extraction activities.

The Working Group regarded all such potential effects as being localised and confined to the vicinity of any extraction operation.

Potential impact on benthivorous seabirds

Assessments of the impact of dredging activities associated with the construction of the fixed links across the Great Belt and the Sound support the general concept that impacts on seabirds are local and site specific (Tasker *et al* in press). No impact has so far been experienced in relation to the earth works in the Sound (Miljø- og Energiministeriet 1996), whereas a strong local (<5 km radius from the source) effect on the number of wintering Eiders *Somateria mollissima* has been reported in the Great Belt (Jensen & Skov 1997). The overall distribution of birds wintering in the Baltic is characterized by a large number of spatially discrete areas with distinct populations with strong gradients in densities of birds occurring over short distances. This characteristic, the variation in the response of prey species on sediment loads and type of extraction makes extrapolation of results from site to site very difficult.

Sensitive areas and habitats

Due to the heterogeneity of the distribution of seaducks in the Baltic, future research should be directed to the core feeding areas in the coastal lagoons and on the offshore banks, where densities above 1000 birds/km^2 may be found. All available information on seabird distribution and numbers in the Baltic has been put together in a geographical information system and published in Durinck *et al* (1994). Based on this information, 39 areas of international importance for seabirds were determined, of which only 10 areas held about 90% of the total estimated number of seabirds wintering in the Baltic Sea. Clearly, in these key areas, it is important that birds need to be given due consideration during the preparation of environmental impact assessments in relation to future extraction activities.

Conclusions on birds

There are likely to be only limited and very local effects on bird populations from aggregate extraction activities. Major concentrations of seabirds can readily be avoided by selectively choosing certain locations and seasons.

Information necessary for an assessment:

- proportion of the total population represented by any specific area (here 1% threshold noted as representing a frequently used threshold of significance)
- is the population of regional or national importance?
- is it a rare or protected species and/or is it endemic to the Baltic?
- depth range for feeding (overwintering migrants and those staking)

- breeding sites etc for resident species.

7.3.6 Mammals

It was noted that effects on marine mammals had not been considered for the fixed link project. Populations of marine mammals seemed to be increasing. Haul-out sites were coastal and not likely to be affected. There was a view that any indirect effects (loss of food chain production) would be insignificant. Perhaps localised avoidance behaviour might be observed as the only direct effect.

Conclusion on mammals

Marine mammals should be considered in any environmental assessment but the view was that such effects were not likely to be of significant concern.

7.3.7 Conservation and Protected Areas

As a general rule, dredging operations would not be permitted in conservation areas. The Working Group felt that any effects of dredging extraction were likely to be localised. However, specific local conditions should be appraised and potential effects on any nearby protected or sensitive areas addressed in the environmental impact assessment. The Group noted that during dredging in Oresund a plume of suspended materials of up to 40 km has been observed. Such factors clearly require proper evaluation prior to the licensing of an extraction operation, but in many areas of the Baltic such turbidity would be far more localised perhaps only extending to 1000 m or so.

Conclusion on Protected Areas

Clearly, any licensed extraction activities should ensure the integrity of protected and sensitive sites and, for species, their favourable conservation status.

7.4 RECOMMENDATIONS

The ICES Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT) should collect further information on the effects of extraction of marine sand and gravel on the Baltic Ecosystem with the understanding that in 1999 a combined meeting of members of this Working Group shall take place with members from HELCOM EC NATURE in one of the Baltic states.

7.5 REFERENCES FOR SECTION 7

Durinck, J., H. Skov, F.P. Jensen & S. Pihl, 1994. Important Marine Areas for Wintering Birds in the Baltic Sea. EU DG XI research contract no. 2242/90-09-01. Ornis Consult report, 110 pp.

Jensen, F.P.J. & Skov, H. 1997. The number and distribution of Eiders *Somateria mollissima* wintering in the Great Belt 1987-1996. With an assessment of the impact of sediment dispersal caused by the construction of the Great Belt Link. A/S Storebælt. 50 pp.

Miljø- og Energiministeriet 1996. 2. halvårsrapport om miljøet og øresundsforbindelsens kyst-til-kyst anlæg. Miljø- og Energiministeriet, Trafikministeriet, Kontroll- och Styrgruppen för Öresundsförbindelsen. 42 pp.

Norden Andersen, O. G., P. E. Nielsen & J. Leth 1992. Effects on sea bed, benthic fauna and hydrography of sand dredging in Køge Bay, Denmark. Proc. of the 12th Baltic Mar. Biol. Symp. 1 pp.

Okolotowicz, G. (1991): Benthos of the Slupsk Bank and the Gulf of Gdansk (Preliminary information). Data Ichthyologica et Piscatoria 21(supplement): 171-179.

Rose, P.M. & D.A. Scott, 1994. Waterfowl population estimates. IWRB Rapport No. 29, 102 pp.

Schramm, W. (1996): Veraenderungen von Makroalgen- und Seegrasbestaenden. In: Lozán et al. (eds.) Warnsignale aus der Ostsee. Parey Berlin.

Schwenke, H. (1965): Beitraege zur angewandten marinen Vegetationskunde der westlichen Ostsee (Kieler Bucht). Kieler Meeresforsch. 21, 144-152.

Tasker, M., L. Canova. & G. Tucker (in press). A marine habitat conservation strategy for birds in Europe. BirdLife International.

Thiel R., Winkler H. and Urho L., 1996. Fische und Fischerei. pp 181 - 201 in Warnsignale aus der Ostsee. Blackwell Wissenschafts-Verlag, Berlin.

Vogt, H. & Schramm, W. (1991): Conspicuous decline of Fucus in Kiel Bay (western Baltic): what are the causes? Mar. Ecol. Prog. Ser. 69, 189-194.

Warzocha, J. (1997). Personal communication to the ICES WGEXT, April 1997. (Sea Fisheries Institute, Gdinya).

Westerberg, H., P. Rönnback and H. Frimansson, (1996). Effects of suspended sediments on cod egg and larvae and other behaviour of adult herring and cod. ICES C. M. 1996 (E:26 (Marine Environmental Quality Committee)), 13 pp.

Winterhalter, B. G. L. (1990). The Baltic marine environment as a source of aggregates and as a recipient of dredged material. In; D. A. Ardus and M. A. Champ (eds), Ocean Resources, Vol 1: 153+158. Kluiver, Netherlands.

8 COOPERATIVE RESEARCH REPORT

It was agreed that there was not sufficient time at the meeting to complete an acceptable final draft of the Cooperative Research Report. Recognizing the urgency and importance of this task, however, it was agreed that Sections 1 to 5 of the report would be compiled by the appointed section editors noted below:

Section 1	Introduction	Dr Tony Murray Crown Estate, UK
Section 2	Aggregate dredging, coastal engineering and related activities	Dr Tony Murray Crown Estate, UK
Section 3	Effects of extraction activities on living resources and related activities	Dr Andrew Kenny CEFAS, UK
Section 4	Management	Dr Tom Simpson DoE, UK
Section 5	Seabed mapping programmes	Dr Ruud Schuttenhelm Inst. Applied Geoscience, TNO Netherlands

The final text of Sections 1 to 5 is to be sent (on disk) to Dr Jonathan Side by the end of May 1997, thus individual contributions for each section should be sent to the appropriate section editor prior to this and preferably within the next week or so.

It was agreed that Dr Jonathan Side would produce a draft of Section 6 (Discussion) and Section 7 (Conclusions and Summary) for discussion at the next meeting of the Working Group, and edit Section 1, 2, 3, 4 and 5 for submission to ICES in the first week of June 1997.

9 ROLE OF THE WORKING GROUP

Resources of marine sand and gravel in ICES countries are finite, but quite extensive in the United Kindom, Denmark, Canada and at least some Baltic countries. In many areas, marine sands are essentially limitless in relation to the amounts presently extracted. Marine sediments are an important source of raw materials for a number of ICES countries for building, land reclamation and coast/flood protection. For some uses, e.g. construction and fill, marine aggregates directly replace extraction from land-based sources. For beach and foreshore replenishment, marine materials are preferred as they are better suited technically, environmentally and from an amenity point of view and could be difficult to supply from land-based sources. Sand and gravel is mainly recovered from dedicated extraction areas, although an amount of material can be supplied from navigational dredging activities.

The Working Group has gathered information on the marine extraction industry in ICES countries as well as on the physical, biological and chemical impacts on the ecosystem, including the influence on fishing. The assessment of this information led to the preparation and publication of Co-operative Research Report Number 182 in 1992. This report recommended a number of lines of enquiry which have been followed up in specific studies in the member countries. The Group has been able to discuss these studies and review this and other related research on a regular basis. Annual reports of the Group are considered a useful source of information in member states and outside the ICES community.

On the basis of the wide scientific, professional, technical, planning and administrative experience available to ICES through the diverse membership of the Working Group, the Group has also prepared a Code of Practice for the marine aggregate industry as well as guidelines for assessing the environment impacts of extraction proposals.

These diverse skills are a major strength of the Group. Notably, the combination of geological and biological experience in the assessment of the impacts of extraction on the marine environment is essential. The physical environment is a major influence on the biological communities. This Working Group represents the principal source of marine geological expertise available to ICES within its current structure.

10 DRAFT TERMS OF REFERENCE

The Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT), Chairman Dr. S. J. de Groot will meet from 21 - 24 April 1998 in The Netherlands Institute of Applied Geoscience (NITG-TNO), Haarlem, The Netherlands*, to carry out the following tasks at the next meeting:

a) to finalise the Conclusions/Recommendations of the ICES Cooperative Research Report (see ICES C. M. 1997: E4) final revision of all other sections to be available beginning of June 1997;

b) to collect further information on the effects of extraction of marine sand and gravel on the Baltic ecosystem, including the extent and volume of such extractions, and known impacts on e.g. benthos, diving seabirds and bottom-spawning fish and invertebrates (see ICES C. M. 1996: E7, Terms of Reference) with the understanding that in 1999 a combined meeting of members of this Working group shall take place with members from HELCOM EC NATURE in one of the Baltic states;

c) to report and review developments in new technology for high resolution seabed characterisation such as micro and macro topography, complex sediment distribution and process interpretation. These developments provide the essential data for sustainable development of resources and the definition of habitats in the coastal zone;

d) to report and review the results of environmental research, and on the effects of turbidity caused by dredging or large scale natural erosion;

e) to report and review the status of marine sediment extraction activities (in relation to use categories), the development of sea bed resource mapping and developments in legal and administrative framework and procedures;

* It is anticipated that members of WGEXT would take the opportunity to discuss and appraise the three proposed major extraction projects (each about 800 $x10^6$ m^3 of sand) in the Dutch Coastal Zone and meet with representatives of the regulatory authorities and dredging companies before WGEXT meeting on the 20 April.

11 CLOSE OF MEETING

The Report of the Working Group was agreed by the participants. The Chairman thanked the participants for their contributions and requested that for the next meeting as much material as possible should be supplied in advance and where possible on disk. The Chairman thanked the Rapporteur and the staff of the National Forest and Nature Agency who had provided assistance for the meetings of the Working Group. The meeting was formally closed by the Chairman.

ANNEX I

AGENDA

ICES WG On the Effects of the Extraction of Marine Sediments on the Marine Ecosystem

15-18 April 1997, Copenhagen, Denmark

Annex 1 - Agenda

1. Welcome by representatives of the National Forest and Nature Agency
2. Welcome by Chairman
3. Appointment of Rapporteur
4. Terms of Reference (see ICES C.Res. 1996/2:28)
5. Adoption of Agenda
6. Short introduction and explanation by national representatives of the routine information as collected during earlier meetings on the status of marine sediment extraction, new legal and administrative frameworks and procedures. (Information to be supplied on disk)
7. Information on the effects of extraction of marine sand and gravel on the Baltic ecosystem, including the extent and volume of such extraction, and known impacts on eg. benthos, diving seabirds and bottom spawning fish and invertebrates (HELCOM 1996/11)
8. Complete work on the revision of ICES Coop. Res. Rep. 182 with the aim of finalising a new publication (see Annex V of last years meeting report ICES CM 1996/E7)
9. Recommendations
10. Date and place of next meeting
11. Close of meeting

ANNEX II

TERMS OF REFERENCE

The Terms of Reference of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (Chairman: Dr S J de Groot, Netherlands) were set out by ICES Council Resolution (C.Res 1996/2:28) as:-

a) provide information on the effects of extraction of marine sand and gravel on the Baltic ecosystem, including the extent and volume of such extractions, and known impacts on, e.g. benthos, diving seabirds, and bottom-spawning fish and invertebrates [HELCOM 1996/11];

b) complete work on the update of the ICES Cooperative Research Report No 182 with the aim of finalising a revised edition at this meeting, including:

   i) approaches to Environmental Impact Assessments, relative to marine extraction operations;
   ii) the evaluation of the effects of marine sediment extraction activities on benthos and fisheries, in particular, the development of concerted approaches to critical habitat mapping and classification.

ANNEX III

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ANNEX IV

REFERENCES CITED IN THE NATIONAL REPORTS

Arlt, G. & Krause (1997): Ökologische Bedeutung der Grobsand- und Kiesgebiete der deutschen Ostseeküste für das Makrozoobenthos mit besonderer Berücksichtigung von „Rote-Liste-Arten". Unpublished Report to the Federal Agency of Nature Conservation.

Busschbach, H., C.Dijkshoorn & A.Stolk (1997) Shell extraction in the Netherlands (in Dutch). Ministry of Transport, Public Works and Watermanagement Directorate North Sea, Rijswijk.

Ebbing, J.H.J., 1996. Voorstudie naar geschikte zandvoorkomens in het onderzoeksgebied Maasvlakte II, (preliminary study of suitable sand resources in the Maasvlakte II area), Rept BP 3110000 (in Dutch).

Gosselck, F., Bönsch, R. & Kreuzberg, M. (1994): Das Makrozoobenthos der Flachwassergebiete (0 - 10m) der Ostseeküste Mecklenburg-Vorpommerns. Küstenmonitoring. Unveröffentlichtes Gutachten im Auftrage des Landesamtes für Umwelt und Natur, Stralsund.

Gosselck, F., Lange, D. & Michelchen, N. (1996): Auswirkungen auf das Ökosystem Ostsee durch den Abbau von Kies und Kiessanden vor der Küste Mecklenburg-Vorpommerns. Unveröffentlichtes Gutachten im Auftrage des Landesamtes für Umwelt und Natur Mecklenburg-Vorpommern.

Janus, R.G., 1996. Vergelijking geo-electrische methoden versus geofysisch onderzoek op zee, (comparison of geo-electric and seismic methods in potential sand extraction areas), Rept MK 3130001 (in Dutch)

Krause, J. Chr., von Nordheim, H. & Gosselck, F. (1996): Auswirkungen submariner Kiesgewinnung auf die benthische Makrofauna in der südlichen Ostsee. Dt. hydrol. Z. (Suppl. 6)

Klugt, P.C.M., van der, 1996. De lithologie van drie boringen t.b.v. de aanleg van een winput nabij Wijk aan Zee, (lithology of 3 boreholes dug for the construction of a temporary storage pit near Wijk aan Zee), Rept. MK 300244 (in Dutch).

Klugt, P.C.M., van der, 1996. De lithologie van twee boringen t.b.v. de aanleg van een winput nabij Ameland, (lithology of 2 boreholes dug for the construction of a temporary storage pit near Ameland), Rept MK 300245 (in Dutch).

Klugt, P.C.M., van der, 1997. Onderzoek zeezandwingebied nabij Ameland Blok M8/M9, (sand extraction area survey near Ameland), Rept. NITG 97-20-B (in Dutch).

Leuchs, H & Nehring, S. 1996: Auswirkungen von Baggern und Verklappen auf das Makrozoobenthos im Küstenbereich - Dargestellt an einem Beispiel aus dem Elbeästuar. Dt. hydrol. Z. (Suppl. 6).

Schramm, W. (1996): Veraenderungen von Makroalgen- und Seegrasbestaenden. In: Lozán et al. (eds.) Warnsignale aus der Ostsee. Parey Berlin.

Schwenke, H. (1965): Beitraege zur angewandten marinen Vegetationskunde der westlichen Ostsee (Kieler Bucht). Kieler Meeresforsch. 21, 144-152.

Van Dalfsen, J.A. & K.Essink (1996). Risk analysis of coastal nourishment techniques in the Netherlands (RIACON), draft version. National Institute for Coastal and Marine management/RIKZ.

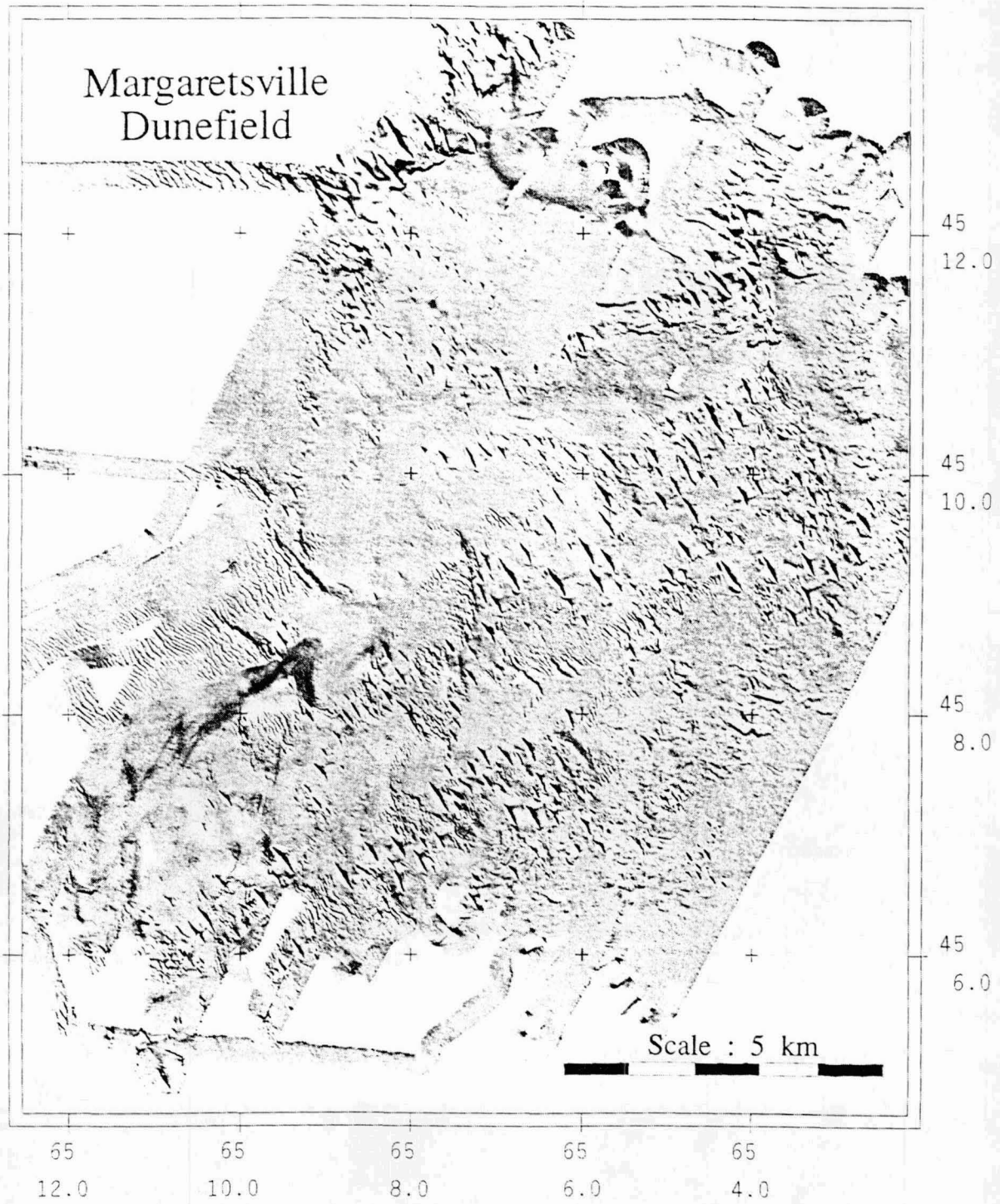
Vogt, H. & Schramm, W. (1991): Conspicuous decline of Fucus in Kiel Bay (western Baltic): what are the causes? ar. Ecol. Prog. Ser. 69, 189-194.

Zwanenburg-Nederlof, H.P., 1996. Geologisch onderzoek 27 tijdelijke putten Noordzee, (geological survey of 27 temporary sand storage pit sites in the North Sea, Rept MK 300553 (in Dutch).

ANNEX V

SUPPLEMENTARY MAPS FOR INCLUSION IN THE REPORT OF THE MEETING

Map 1 Topographic representation of seafloor - illustration of Canadian survey using multi-beam bathymetry.



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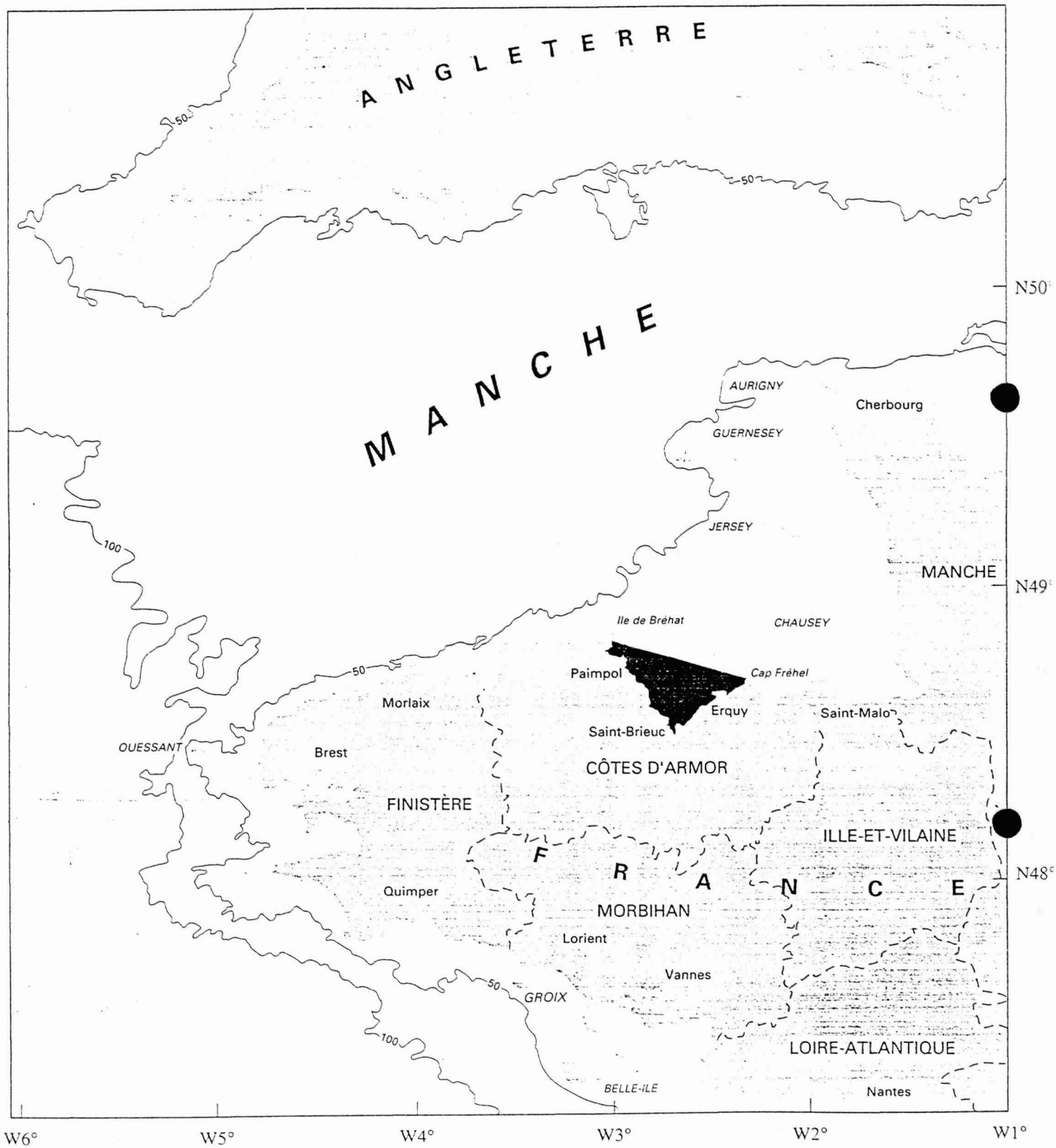
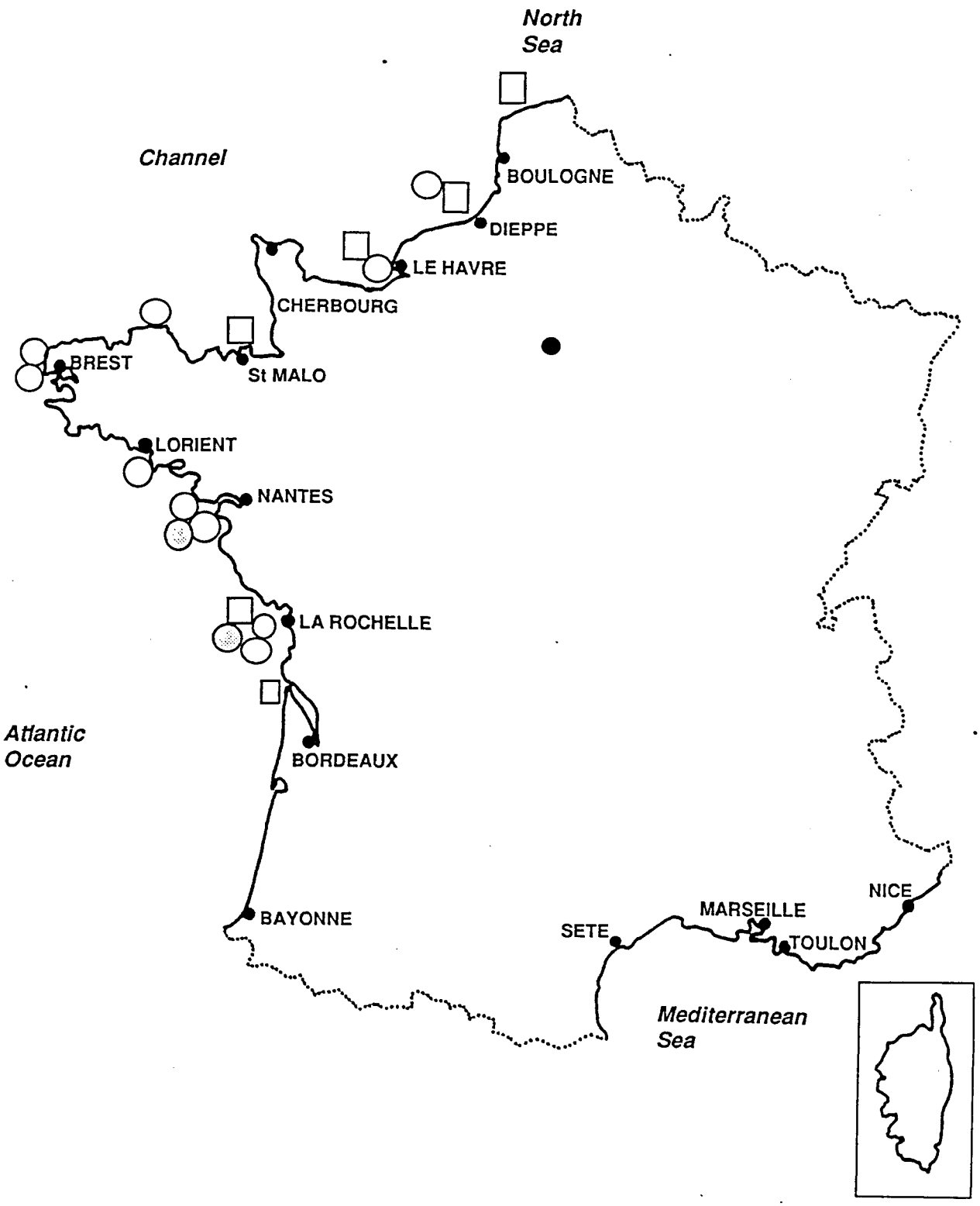
Topography

Map 2 Sediment mapped area in Bay de Saint-Brieuc, France

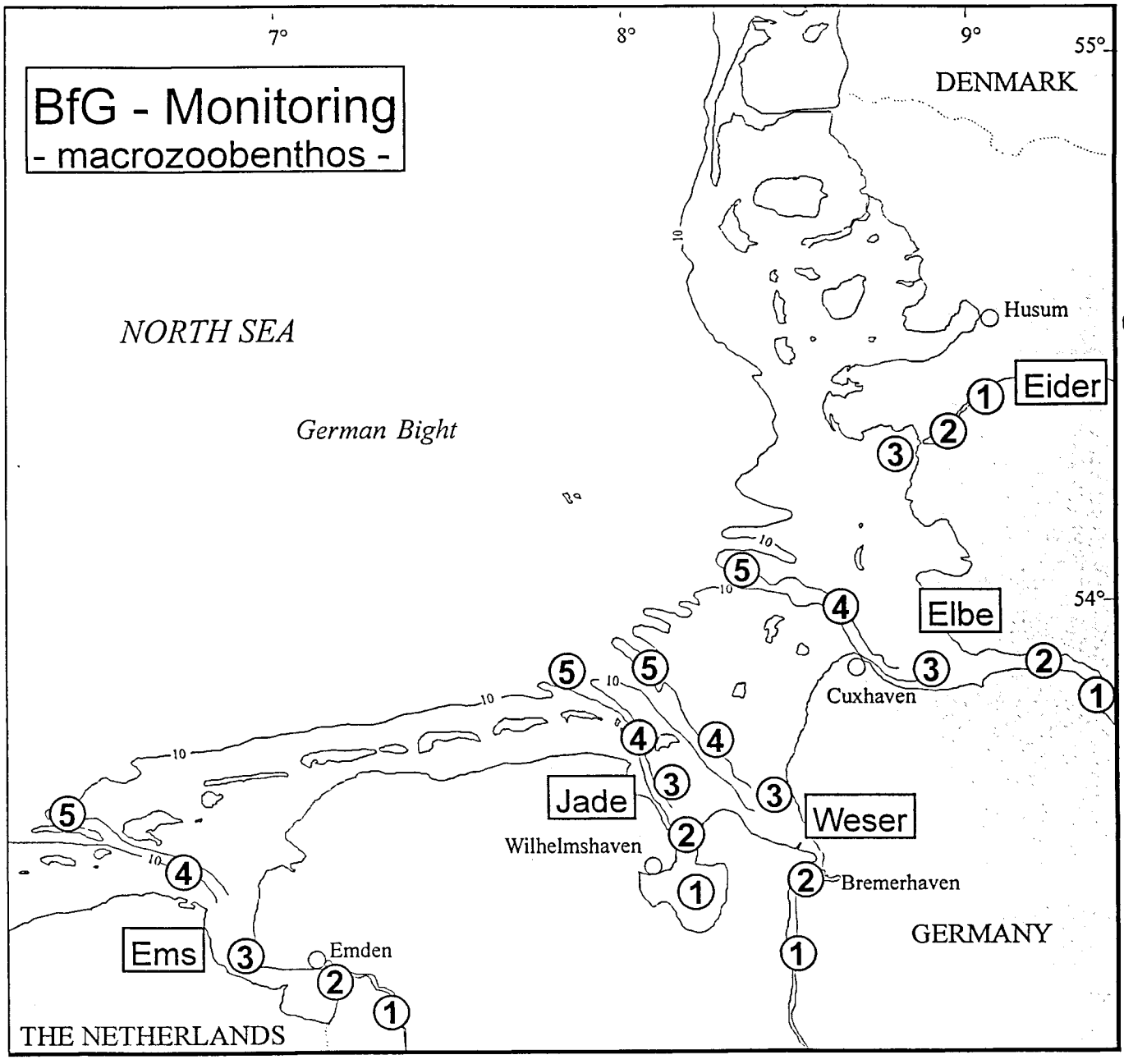


Map 3 French siliceous marine aggregate licenses in 1994

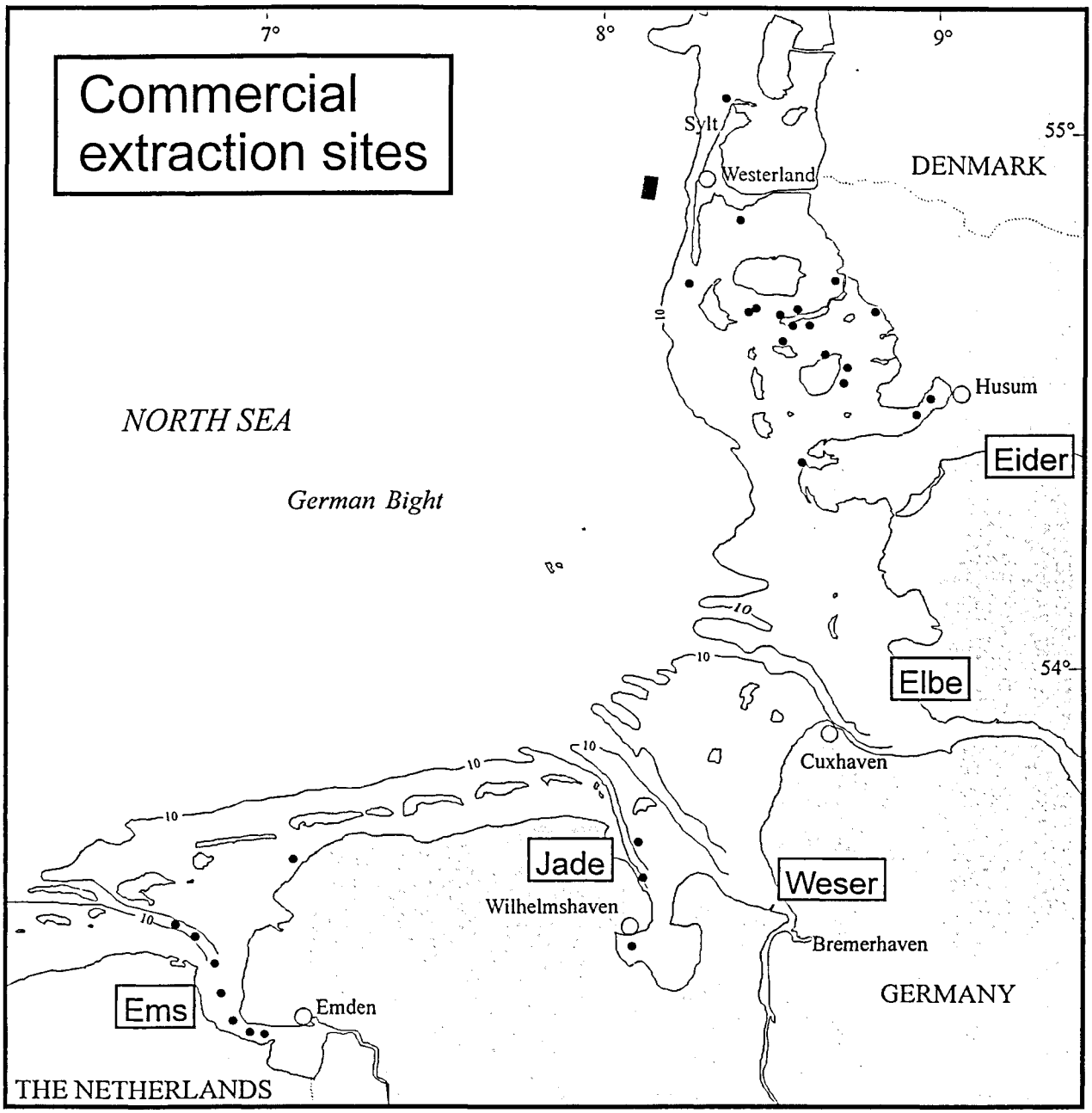
□ licence in instruction ○ license allowed ◎ renewing of license



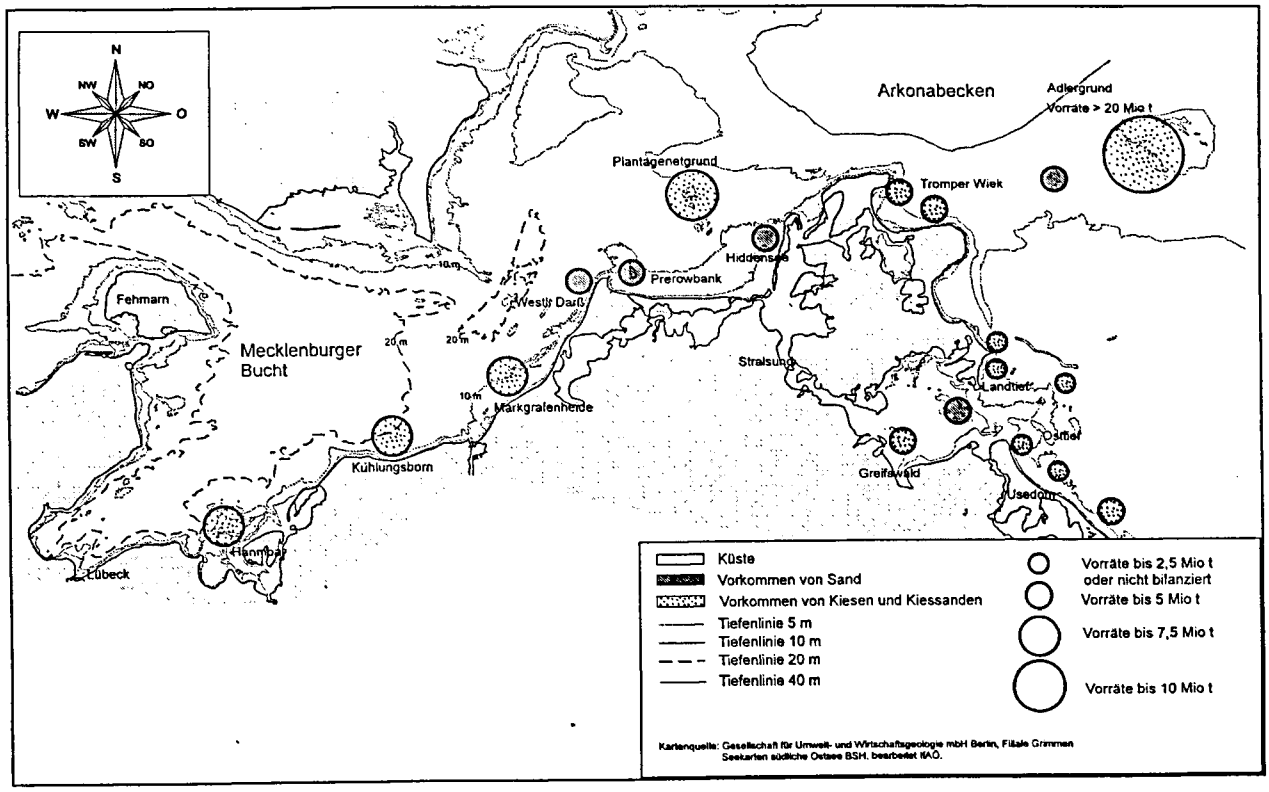
Map 4 Locations of the monitoring of the Federal Institute of Hydrology (BfG) in the German Bight in regard to dredging and dumping within the estuaries.



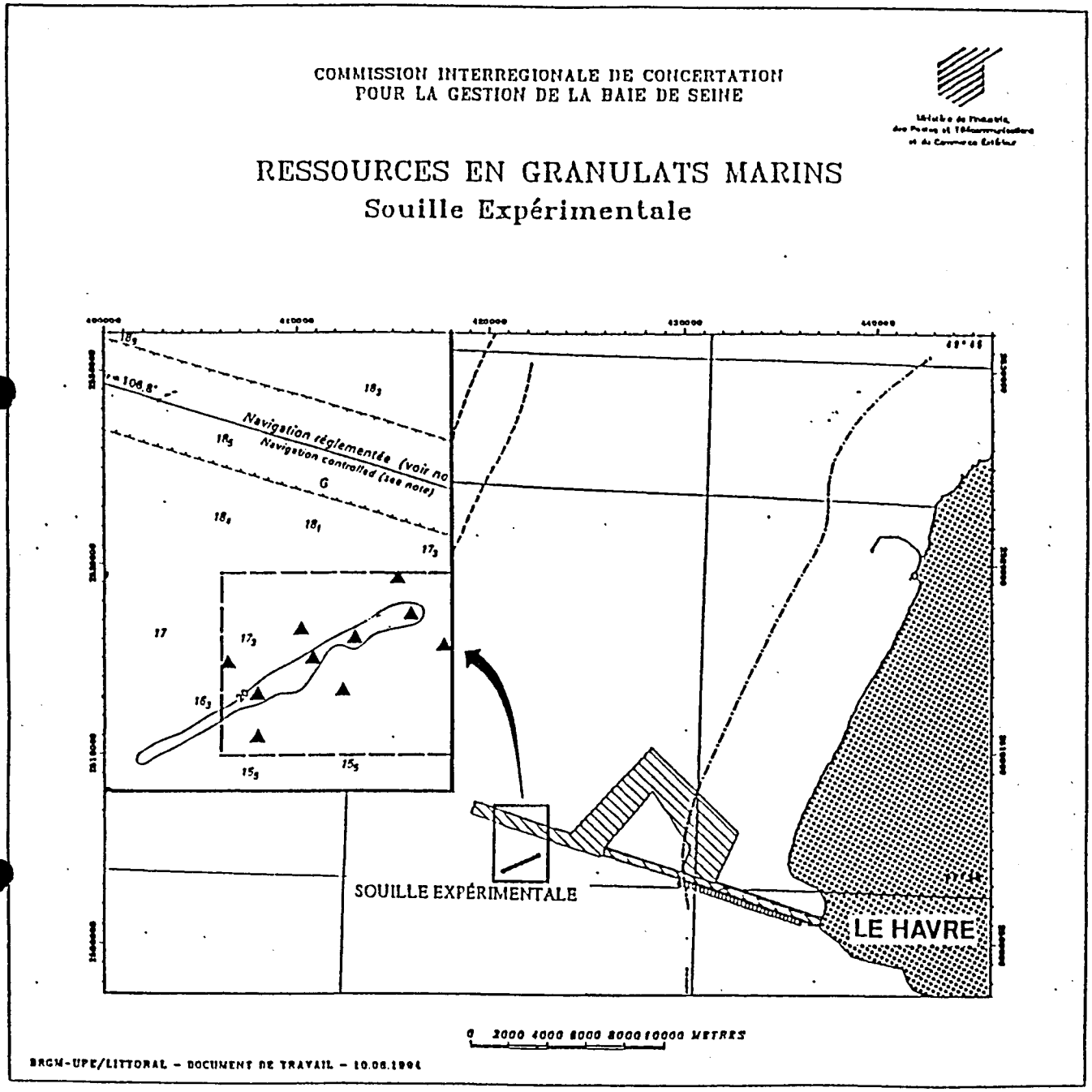
Map 5 Locations of extraction sites in the national area of Germany in the south eastern North Sea



Map 6 Sand and gravel extraction in the territorial waters of the German Baltic Sea

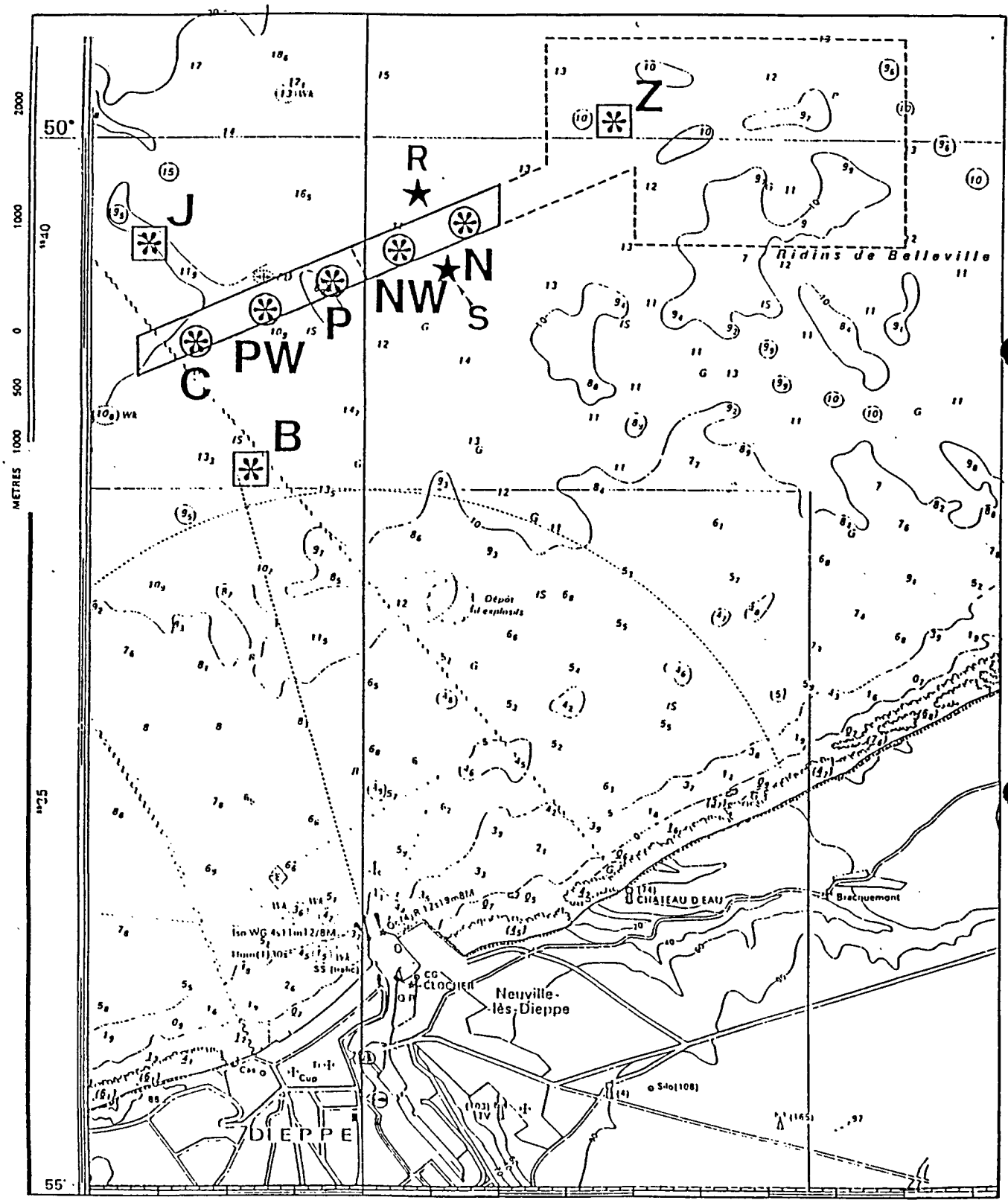


Map 7 Location of the CNEXO experimental dredging site (1974-1980) and of the monitoring stations (▲).



Map 8 Location of the dredging site and of the monitoring stations of Dieppe:

★ ○ Control Stations
□ Reference stations
▭ Former dredging site
▭ Present dredging site



Map 9 Longitudinal bathymetric transect of the dredging site of Dieppe with location and depth (meters above chart datum) of the control stations (soundings from <<Arco Thames>>, July 1995)