Marine Habitat Committee

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REPORT OF THE

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

Gdansk, Poland
11–14 April 2000

International Council for the Exploration of the Sea

Conseil International pour l’Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

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1 INTRODUCTION

The Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT) was welcomed to Gdansk by the Director of the Marine Geological Branch of the Polish Geological Institute, Dr J. Zachowicz. She outlined the range of activities her department is involved with and briefly described Poland's interests in marine sand and gravel extractions.

Dr J. Side (Chair) duly opened the 2000 meeting and the terms of reference (see below) were adopted. Dr S. Boyd was appointed as Rapporteur for the meeting. Dr Side provided feedback to the Group on the 1999 ICES Annual Science Conference and informed members that an ICES Council resolution recommending the publication of the ICES Co-operative report produced by WGEXT had been passed. He also thanked WGEXT members for providing their national reports in advance of the meeting.

A number of regular contributors to the annual meeting sent apologies for not attending. These included the previous Chair, Dr B. de Groot (Netherlands), Dr D. Harrison (UK), and Professor H. Bokuniewicz (USA).

2 TERMS OF REFERENCE

Under ICES C. Res. 1999/2E:07 the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem [WGEXT] (Chair: Dr J. Side, UK) met in Gdansk, Poland from 11-14 April 2000 to:

a) review data on marine extraction activities, developments in marine resource mapping, information on changes to the legal regime (and associated environmental impact assessment requirements) governing marine aggregate extraction, and review scientific programmes and research projects relevant to the assessment of environmental effects of the extraction of marine sediments.

b) commence work (taking into account relevant work under and requirements of OSPAR and HELCOM) on the updating of:

    i) the ICES Code of Practice for the Commercial Extraction of Marine Sediments (including minerals and aggregates), produced in 1992,

    ii) guidelines for the preparation of an Environmental Impact Assessment evaluating the effects of seabed aggregate extraction on the marine environment, including as appropriate guidelines on monitoring and standardised procedures, reviewed most recently in 1998 for inclusion in the forthcoming ICES Co-operative Research Report;

c) undertake an assessment of the comparative resolution of both side-scan sonar and multi-beam bathymetric mapping systems under a variety of operational conditions including water depth, acquisition speed and system design; examine the requirements for calibration of such systems, and review the requirements for habitat classification of non-cohesive sediments in this respect; this review should be passed to SGMHM for comment;

d) examine means of adequately identifying spawning grounds of critical fish species in relation to aggregate extraction activities, particularly herring;

e) review conclusions drawn from the completion of biological monitoring of the Øresund fixed link with a view to applying this knowledge to other large-scale extraction projects;

f) review the biological and sedimentological effects of bed level alterations caused by dredging and update knowledge of plume effects, specifically with respect to recent scientific studies in the Netherlands and Germany and the recent literature review of the European Construction Industry Research and Information Association (CIRIA).

g) WGEXT will report to the ACME before its June 2000 meeting and to the Marine Habitat and Resource Management Committees at the 2000 Annual Science Conference.

2.1 2.1 Justification

a) Each year WGEXT reviews relevant developments under these headings and includes a summary of them in its report. In order to maximise time spent discussing other topics, this is to be conducted in advance and circulated as a draft prior to the meeting.

b) This is a response from WGEXT to the six objectives of the marine Habitat Committee. Members of WGEXT have indicated that they would be willing to undertake this task if ICES wishes, however, WGEXT feels that it is not the most appropriate group to examine fishing gears.

c) This is a response from WGEXT to a number of recent requests and the recognition that these documents should take into account Annex V of the 1992 (OSPAR) Convention on the Protection of the Marine Environment of the Northeast Atlantic, and other developments, for example, in strategic environmental assessment.

d) WGEXT has been reviewing new technologies and techniques necessary for the study of seabed sediments and benthic habitats in relation to its core focus on marine sediment extraction. While it has an interest in marine habitat classification and mapping more generally, this work is concentrating on scientific applications to assessment of environmental effects associated with marine sediment extraction.

e) While in recent years much effort has been directed to the observation of effects on the marine benthos, WGEXT has on several occasions examined effects at higher trophic levels and on fisheries, and this topic was raised during such discussions at last year's meeting.

f) The completion of biological monitoring on this project enables a critical review of such data in relation to other proposed large extraction projects.

g) A series of studies will be concluded and reported in 1999 and early 2000 on these topics which WGEXT wishes to review in order to improve knowledge on the evaluation of plume effects and arising from stationary extraction (in pits or resulting in bed level alteration).

3 3 REVIEW OF NATIONAL MARINE AGGREGATE EXTRACTION ACTIVITIES

A detailed breakdown of each country’s dredging activities is provided below:

3.1 Belgium

Marine aggregate (sand and gravel) extraction figures for Belgium in 1999:

DREDGING AREA	AMOUNT (m^3)
Flemish Banks (Buitenratel, Oost Dyck, Kwintebank)	1,690,000

In 1999 a total of 1,690,000 m^3 of sand was extracted from extraction zone 2 on the Belgian continental shelf, which is an increase of approximately 20% from 1998. Twelve license holders are currently involved. As in previous years, most of the sand was extracted from the northern part of the Kwintebank.

Amount of material extracted for beach replenishment projects for 1991-2000:

a) beach replenishment

DREDGING AREA	MATERIAL	AMOUNT (m³)	YEAR
De Haan – central	sand	794,000	1992
De Haan – west	sand	1,440,000	1994-1995
De Haan – east	sand	1,002,000	1996
Blankenberge	sand	486,000	1998-1999
Knokke	sand	486,500	1999

Please note that all the material in the above table is derived from maintenance dredging activity.

b) beach nourishment banks

DREDGING AREA	MATERIAL	AMOUNT (m³)	YEAR
De Haan – central	sand	662,000	1991-1992
De Haan – west	sand	649,000	1993-1995
De Haan – east	sand	471,500	1996-1998
De Haan	sand	95,000	1998-1999

3.1 3.2 Canada

Marine mineral extraction presently does not take place in Canada. The Canadian federal government continues to investigate the development of legislation to permit and control marine mining. The Provinces of British Columbia, Nova Scotia and Newfoundland continue to express a strong interest in furthering this activity. Government advisory groups have been established and meetings have been conducted on both coasts of Canada to initiate a process of consultation. Documents are in the final stage of preparation on the socio-economic implications, technological assessment, a public consultation and communication strategy, and a strategic environmental assessment. An aboriginal communication strategy document is in the early stages of preparation. Consultations with stakeholders are planned to be extensive and will be undertaken co-operatively by federal and provincial governments.

Plans formulated in 1999 were for the offshore mineral initiative team to meet independently with stakeholders and interest groups during 2000. These plans have recently been altered to reflect activities associated with the new Oceans

Act of Canada. The marine mineral initiative will now be folded into meetings and deliberations of an Oceans Act committee to begin in late 2000.

The marine mineral extraction industry continues to express interest in mining for offshore placers and aggregates, but the lack of a legislative framework remains as a deterrent to further investment and investigation. Marine mining assessment projects remain in the final stages of publication for areas of the Scotian Shelf and have been completed and published for Newfoundland, off the east coast of Canada. These have been cosponsored by the federal government and the provincial governments of Nova Scotia and Newfoundland

3.3 Denmark

Marine sand and gravel represents 10-20 % of the total production of materials for construction and reclamation.

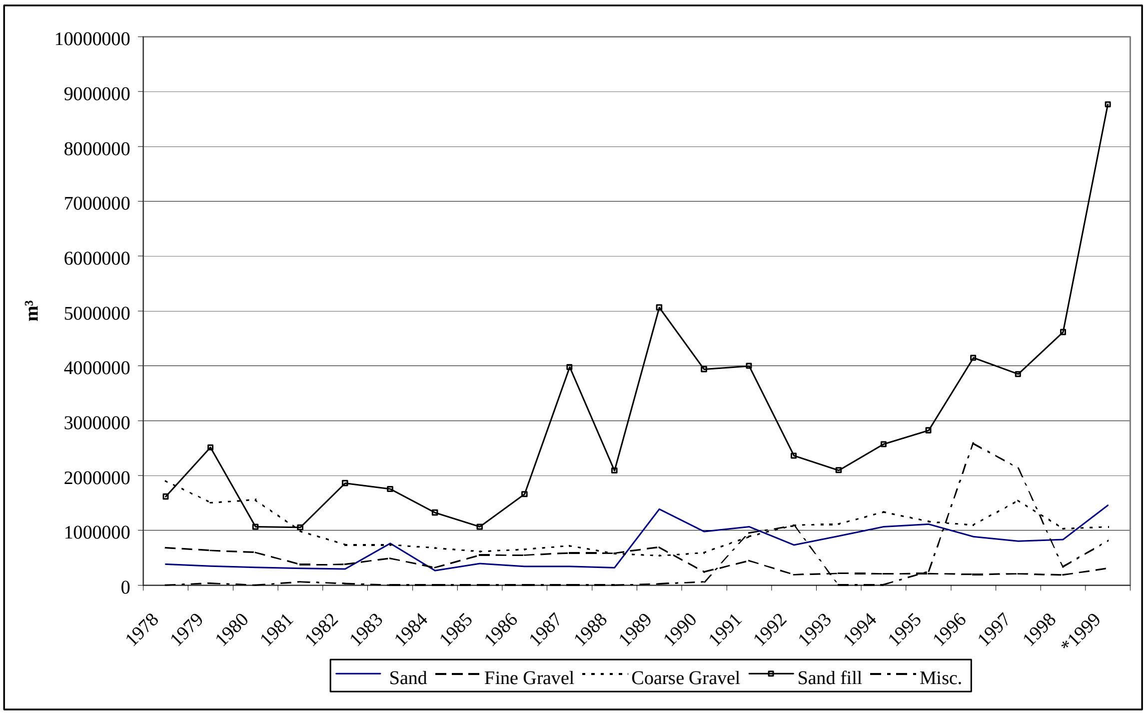


Figure 1 Production of sand and gravel from 1978 – 1999.

* The figures for 1999 are preliminary

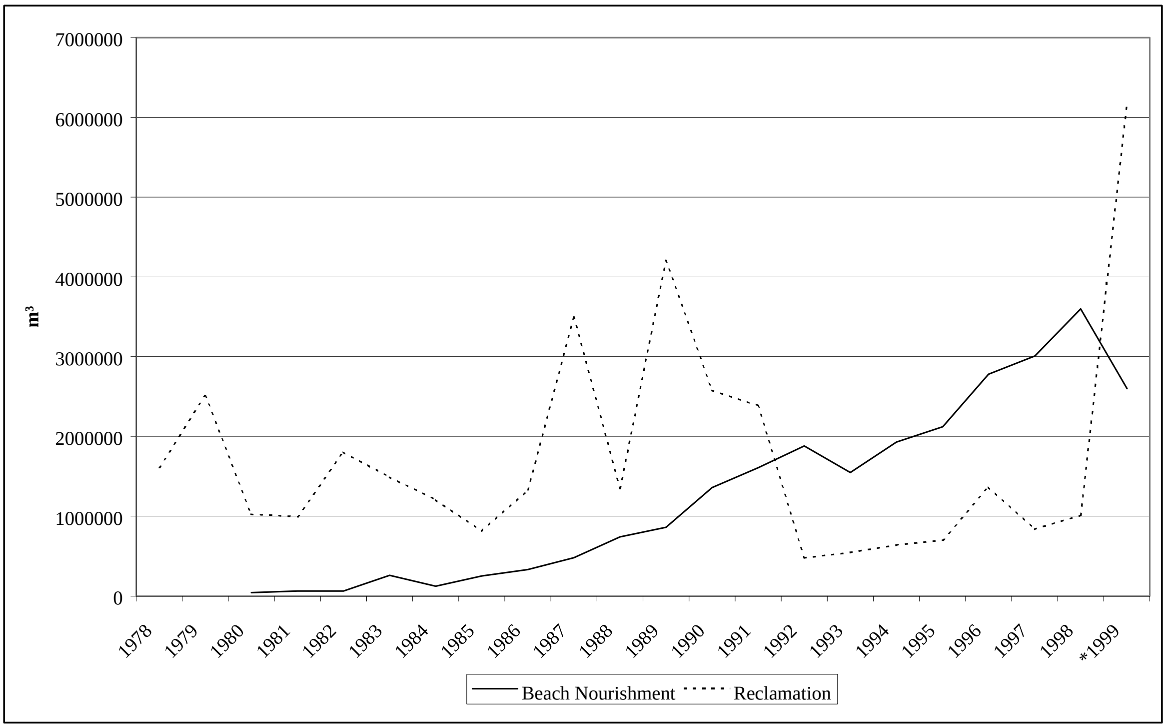
The dredging of sand fill for land reclamation has increased markedly over the last 10 years as a result of several large construction projects in coastal areas.

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

During the construction of the fixed link between Denmark and Sweden 1.3 x 10^6 m^3 was dredged with a spill of only 2.8 %. In the same period 7 x $10^6$$m^3$ of dredged glacial till and limestone was reused for reclamation and as hydraulic fill in ramps for the bridge and tunnel.

A major enlargement of Århus harbour will require more than 8 x $10^6$$m^3$ of sand fill. The construction started in the autumn of 1998. However, only 7 x 10^6 m^3 has been dredged so far from 2 areas in Århus Bight. The overspill from the dredging operations was 3.7 %.

The extraction of sand for beach replenishment on the West Coast of Jytland has increased from 40,000 m^3 in 1980 to more than 3.5 x 10^6 m^3 in 1998.



*the figures for 1999 are preliminary.

Figure 2 Production of sand for beach nourishment and reclamation.

No detailed forecast for future extraction has been prepared, although the level of extraction has been predicted to be approximately 3 x 10^6 m³/year. In general, extraction varies in line with the development of the national economy.

Several major construction projects have considerably increased the demand for sand fill since 1995. These projects will finish in 2000 and the demand is then expected to decrease. However, a further enlargement of the Århus Harbour and plans for the construction of a new container terminal in 2003 will require up to 7 x 10^6 m³ of sand fill.

It is expected that the total marine extraction of construction aggregates will remain at the current level for the next 5 years, perhaps with a slight decrease in the extraction of coarse aggregates due to an expected slight decline in the construction industry.

In 1996, The National Forest and Nature Agency commissioned the Geological Survey to evaluate the total reserves of sand and gravel in Danish Waters based on existing data collected since 1979. The results are now available (in Danish). A total of 4.5 x 10^6 m³ have been identified so far, of which 3.5 x 10^6 m³ is potentially available for extraction. Most of the materials are sands suitable for fill and construction, with only limited resources of coarse aggregate available. An overview was published by GEUS in 1999.

Calculation of reserve volumes were based on known technical limitations (i.e. overburden) and present environmental restrictions. All identified resources in the Inner Danish Waters have been evaluated. The present knowledge of resources and the environmental conditions in the North Sea and the Baltic is still limited. However, there are thought to be large resources available in unmapped areas.

3.2 3.4 France

There were no new developments in 1999. Production has remained stable at approximately 3 million tonnes per annum in recent years.

3.3 3.5 Germany

Marine aggregate extraction (sand and gravel) figures for Germany in 1999:

DREDGING AREA	AMOUNT
North Sea	1,367,630 m³
Baltic Sea	1,033,835 m³

North Sea Ems estuary: 312,000 m³

Weser estuary: 350,000 m³

Offshore (“Westerland II”): 705,630 m³

AMOUNT OF MATERIAL EXTRACTED IN GERMANY FOR BEACH REPLENISHMENT PROJECTS IN 1999:

DREDGING AREA	MATERIAL	AMOUNT
Westerland II	Sand	705,630 m³
Baltic Sea	Sand	699,859 m³

Historic patterns of marine aggregate extraction in Germany (Mm³):

Extraction Area	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total 1989-99
Westerland II	1,966	1,250	2,020	2,080	1,370	0	1,003	1,384		0,700	0,706	12,479
Salzsand	0	0	0	0	0,840	0	0,536	0				14,369

Theeknobssand	0	1,020	0	0	0	0	0	0				1,020
Landtief				0	0	0,002	0,111	0,112	0			
Tromper Wiek 1				0	0	0,003	0,007	0,007	0,086			
Tromper Wiek 2				0	0	0,019	0,086	0,021	0			
Tromper Wiek 3						0	0	0	0			
Kühlungsborn				0,076	0,047	0,098	0,146	0,275	0,090			
Greifswalder Bodden				0	0,045	0,021	0,068	0,157	0,090			
Markgrafenheide				0,039	0,047	0,022	0,054	0,046	0,003			
Plantagenetgrund				0,090	0,011	0,033	0,004	0	0,006			
Plantagenetgrund NW				0	0	0	0,003	0,001	0			
Adlergrund NE				0	0,001	0,004	0,058	0,090	0,026			
Darßer Schwelle				0	0,177	0,006	0,002	0	0			
Adlergrund N				0	0	0,009	0,093	0,007	0,038			
Adlergrund SW				0,205	0,328	0,536	0,632	0,779	0,355			
Hiddensee					0,138	0,191						
Wismarbucht						0,258						
Graal-Müritz						0,057	0,116	0,442	0,259			
Koserow					0,258			0,936				
Prorer Wiek							0,036		0,397			

Trollegrund									0,244			
Wustrow									0,600			
Plantagenetgrund SE									0,028			

3.5.1 Current licence position in Germany - Summary

- 2 applications for offshore gravel extraction in the North Sea
- 3 licences for sand extraction in the North Sea by the state of Schleswig-Holstein
- 14 licences for gravel extraction along the Baltic Sea off Mecklenburg-Vorpommern
- licences for sand extraction along the Baltic Sea by the state of Mecklenburg-Vorpommern

3.4 3.6 Ireland

There is now an increased interest in the extraction of aggregates off the Irish Coast resulting in a number of applications for extraction licenses within the Irish Sea and Celtic Sea. There is also a renewed interest in the extraction of maerl deposits. Commercial dredging activities in Ireland for sand and gravel are not well developed and as a result national policy regarding the issue of extraction licenses is not well established. A number of objections regarding one of the applications had resulted in a debate between fishermen, fishery scientists, environmental consultants and the licensing authorities because the proposed extraction is situated within a well-known herring spawning ground. Though no herring eggs have been located within the proposed extraction site, three separate spawning beds have been identified close to this area (i.e. between 1 to 4 nautical miles away). As this is the first commercial application to be dealt with a decision regarding the issue of this license is proving very problematic. The two delegates representing Ireland have been sent to the working group to discuss this issue with the view to discovering the position of other countries regarding the issues of extraction licenses and in particular the perceived safe distance (i.e. buffer zones) between herring spawning beds and extraction sites.

- 1,000,000 m^3 of sand and gravel has been removed from a sand bar in the Shannon Estuary for channel clearance purposes. This material has been deposited further offshore.
- One exploratory licence has been awarded for the extraction of maerl off the South West Coast. The E.I.S. has been performed and the licence is currently being considered.
- An application for the extraction of aggregates off the South East Coast is still under review.
- Two applications to extract aggregates off the East Coast have been submitted.
- One dredging licence was issued during 1999 for the extraction of 250,000m^3 of material from the Codling Bank in the Irish Sea. This material was intended for use in a coastal protection scheme in Bray, Co. Dublin.

3.5 3.7 The Netherlands

3.5.1 3.7.1 Sand extraction in 1999

The amount of sand extracted from the Dutch sector of the North Sea in 1999 was as follows:

Euro-/Maas access-channel to Rotterdam	$1.4 \times 10^6 m^3$
IJ-access-channel to Amsterdam	$5.0 \times 10^6 m^3$
Dutch Continental Shelf	$16.0 \times 10^6 m^3$
Total sand extraction in 1999	$22.4 \times 10^6 m^3$

The main uses of the extracted sand are for beach nourishment programmes and for land use. In 1999, approximately 6.2 x $10^6 m^3$ was used for beach nourishment and approximately 16.2 x $10^6 m^3$ was used mainly for landfill, of which a very small part was used for the concrete and masonry industry in Belgium and the south-western part of the Netherlands.

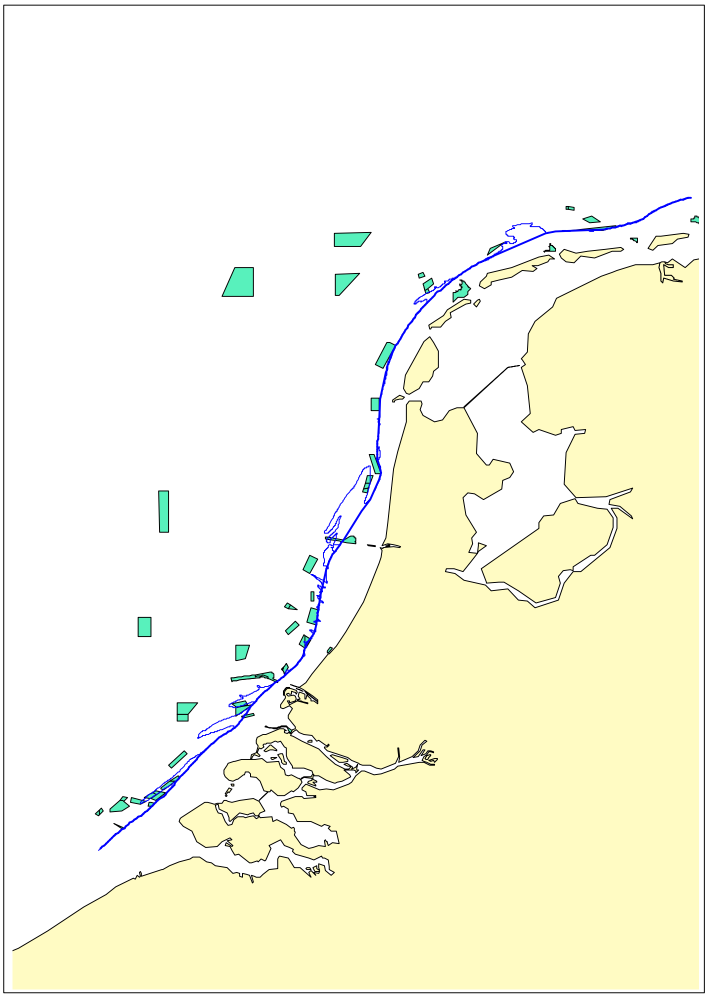


Figure 3 The location of sand extraction licences in relation to the 20m contour line.

3.5.2 3.7.2 Gravel extraction in 1999

No extraction of gravel took place in the Dutch part of the North Sea in 1999. Due to the Dutch policy on the extraction of surface minerals contained in the Structure Plan for Surface Minerals, extraction on the Claever Bank will not be permitted before the termination of ongoing gravel extraction activity to lower 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 Delta Plan for the major Rivers. This plan will lead to the production of relatively high quantities of gravel in a short period of time (up to 2005). The total available quantities will increase from 35 to 60 million tonnes as a result.

3.5.3 3.7.3 Shell extraction in 1999

On the basis of the National Policy Note and the EIA for shell extraction dated 15 December 1998 maximum permissible amounts have been defined for 1999 onwards.

The total amount of shell extracted from the Wadden Sea, North Sea and Internal Waters (in m³) from 1992 to 1999 was as follows:

The sea-inlets of the North Sea (marked grey).

	1992	1993	1994	1995	1996	1997	1998	1999*
Wadden Sea	89.285	90.394	125.755	102.503	93.670	64.938	107.933	104.255
Sea-inlets	82.460	80.396	79.715	68.666	55.025	70.998	52.007	102.787
Total	171.745	170.790	205.470	171.169	148.695	135.936	160.000	207.042

* from 1999 the allowable amount for the Wadden Sea is 90,000 m³

* 120,000 m³ for the Sea-inlets or in total 210,000 m³.

The total amount (in m³) of shell extracted from the south-western part (Zeeland) and the North Sea (marked grey).

	1992	1993	1994	1995	1996	1997	1998	1999**
Eastern Scheldt	490	1.475	5.575	300	750	0	0	0
Western Scheldt	21.225	14.390	4.158	26.850	21.025	28.340	16.600	3.250
Voordelta	10.975	23.750	6.750	20.505	22.500	48.415	55.285	31.075
rest of the N.S.	0	0	0	0	0	0	0	47.550
Total	32.690	39.615	16.483	47.655	44.275	76.755	71.885	81.875

** from 1999 the allowable amount is 0 m³ for the Eastern Scheldt, 40,000 m³ for the Western Scheldt, 40,000 m³ for the Voordelta and unlimited for the rest of the Dutch sector of the North Sea.

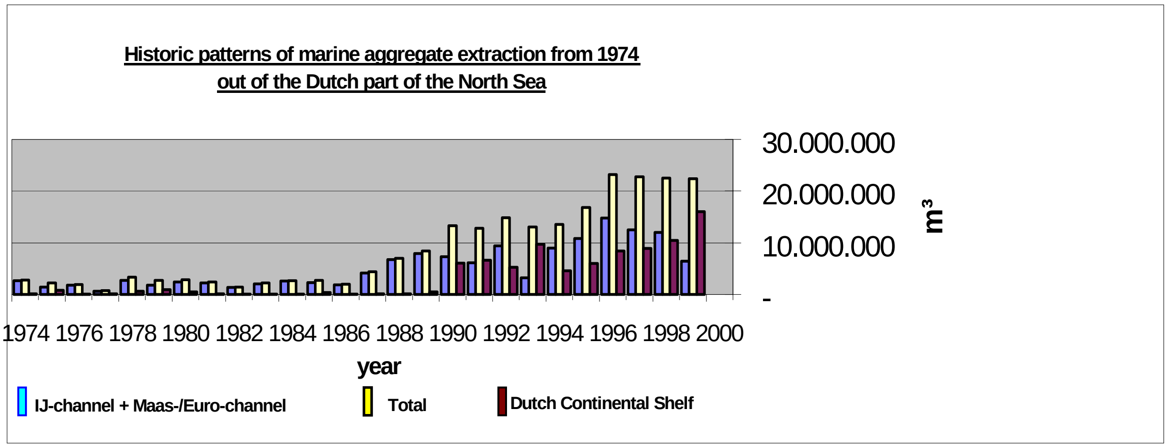


Figure 4 Historic patterns of marine aggregate extraction from the Dutch part of the North Sea.

3.8 Norway

No sand and gravel extraction took place on the Norwegian shelf in 1999. Carbonate sand extraction has decreased from 84,000 tonnes in 1998 to 80,000 tonnes in 1999.

3.9 Poland

Marine aggregate (sand and gravel) extraction figures for Poland in 1999.

DREDGING AREA	*AMOUNT*
Slupsk Bank	73,000 m^3
Jastarnia field	375,860 m^3
Wladyslawowo fairway	146,030 m^3
Jastarnia fairway (Puck Bay)	35,900 m^3
Vistula Lagoon, Piaski pit	26630 m^3
Vistula Lagoon, Tolkmicko pit	82000 m^3

Slupsk Bank — extraction of gravel for export to Germany

Jastarnia field (open sea north of Hel Peninsula) — extraction of medium grained sand for beach nourishment

Wladyslawowo fairway — fine grained sand from fairway used for beach nourishment

Jastarnia fairway (Puck Bay) — information not available

Vistula Lagoon (Piaski and Tolkmicko pits) — fine sand, slightly clayey for dams

There is no aggregate extraction currently in the Polish EEZ of the Baltic Sea.

Exports of marine aggregate from Poland in 1999:

PORT (landing)	*AMOUNT*
Rostock, Greifswald	73,000 m^3

Gravel extracted from Slupsk Bank is exported to Germany

Amount of material extracted in Poland for beach replenishment projects in 1999:

DREDGING AREA	*MATERIAL*	*AMOUNT*
Jastarnia field	medium sand	375,860 m^3
Wladyslawowo fairway	fine sand	146,030 m^3

Historic patterns of marine aggregate extraction in Poland (m^3):

Extraction Area	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*Total 1989-1999*
Slupsk Bank	206400	0	0	54400	0	6400	0	0	3200	0	73000	343,400
Kuznica field (open sea)	0	0	0	0	0	0	0	134000	60000	0	0	194,000
Jastarnia field (open sea)	0	0	0	42600	246810	0	0	0	187310	88870	375860	941,450
Jastarnia II field (open sea)	0	0	0	0	0	0	90200	0	0	0	0	90,200
Wladyslawowo fairway	0	180000	78700	573480	311700	401020	278980	418350	340000	419310	146030	3,147,570
Chalupy pit (Puck Lagoon)	205000	290785	105215	383308	68908	0	0	0	0	0	0	1,053,216
Kuznica II pit (Puck Lagoon)	407000	755573	615535	134852	379200	166290	60580	0	0	0	0	2,519,030
Jastarnia pit (Puck Bay)	0	0	45700	256296	279880	85120	129940	0	0	0	0	796,936
Jastarnia fairway (Puck Bay)	0	0	0	0	0	0	0	0	0	0	35900	35,900
Tolkmicko pit (Vistula Lagoon)	78761	69088	80304	0	0	0	0	0	0	0	82000	310,153
Vistula Lagoon field 24.3-25.3	0	0	0	0	0	0	0	0	0	82900	0	82,900
Vistula Lagoon field 59.5-60.5	0	0	0	0	0	79620	0	0	0	0	0	79620
Vistula Lagoon field 61.8-62.7	0	0	0	0	0	0	0	366800	0	0	0	366,800

Vistula Lagoon field 62.7-63.8	0	0	0	0	0	0	0	300000	0	0	0	300,000
Vistula Lagoon field 63.8-64.5	0	0	0	0	0	0	248870	0	0	0	0	248,870
Vistula Lagoon field 64.5-65.5	0	0	0	0	0	0	0	0	0	96000	0	96,000
Grochowo pit (Vistula Lagoon)	65250	51600	68420	137697	61718	0	0	0	0	0	0	384,685
Piaski pit (Vistula Lagoon)	0	0	0	0	0	0	0	0	0	0	26630	26,630
TOTAL	962411	1347046	993874	1582633	1348216	738450	808570	852350	957310	687080	739420	11,017,360

Total extraction of gravel between 1989-1999 was 343,400m^3

The total amount of material extracted for beach nourishment projects was 8,778,302 m^3.

- open sea: 1,225,650 m^3
- Wladyslawowo fairway: 3,147,570 m^3
- Puck Lagoon: 4,405,082 m^3

Extraction for rebuilding of dams and land reclamation (Vistula Lagoon): 1,895,658 m^3

3.5.4 3.9.1 Current licence position in Poland - Summary

- 2 licences for aggregate extraction have been issued by the Ministry of Environmental Protection, Mineral Resources and Forestry
- 1 application for aggregate extraction is being considered by the Ministry of Environment (the name of the Ministry changed in 1999).

3.10 Sweden

During 1995 one new permit for marine exploitation was granted in Sweden. This was a permit for the Oresund Link Consortium to dredge new stretches for part of the Flint shipping channel between the Saltholm island and the coast of Scania in connection with the construction of the new Oresund Link between Sweden and Denmark. All the materials dredged were used for construction of two islands south of the Saltholm island at the Danish side of the Sound. The amount extracted was 2,500,000 m^3.

One application for marine exploitation is still being processed by SGU. The city of Ystad is applying for permission to dredge 500,000 m^3 for ten years on the bank of Sandhammaren for beach nourishment.

Extraction of marine aggregate (m^3) in Sweden from 1989 – 1999:

Extraction Area	*1989*	*1990*	*1991*	*1992*	*1993-1997*	*1998*	*1999*	*1989-1999*
Disken								
Sandflyttan	1 692	1 692	423					
Vastra Haken	35 509	31 302	33 840	52 739				153
L. Middelgrund								
S. Middelgrund	30 768	138 776	82 534					252
Faro	2 400							
Oresund Link						2 500 000		2 500 0[illegible]
TOTAL	70 369	171 770	116 797	52 739	0	2 500 000	0	911 675

3.11 United Kingdom

Marine aggregate extraction figures for the UK in 1999:

Dredging Area	*Amount (Tonnes)*
Humber	2,840,261
East coast	9,131,512
Thames	971,960
South Coast	5,885,332
South West Coast	1,719,803
North West Coast	355,044
Rivers & Misc.	6,273
TOTAL	20,910,185

Licences especially for contract fill and beach replenishment (in Tonnes) were as follows:

Contract fill	489,482
Beach replenishment	2,279,090
Total	**2,768,572**

Total production of marine aggregate grew from 22.9×10^6 tonnes in 1998 to 23.7×10^6 tonnes in 1999.

There was no calcareous seaweed extracted from Crown Estate licences in 1999.

UK exports of marine sand and gravel in 1999:

Port	*Amount exported (Tonnes)*
Amsterdam	1,828,003
Antwerp	1,142,947
Brugge	475,992
Calais	138,433
Dunkirk	685,368
Fecamp	43,192
Flushing	1,038,050
Harlingen	365,275
Honfleur	60,043
Nieupoort	228,141
Ostend	380,385
Roscoff	56,539
Rotterdam	278,989
Treguier	28,401
Vatteville	3,654
Zeebrugge	473,137
Total	7,226,549

Amount of material extracted in the UK for beach replenishment projects in 1999:

Dredging Area	*Material*	*Amount (Tonnes)*
Clacton	Sandy aggregate/ aggregate	718,905
Eastbourne	Aggregate	424,078
Felpham	Aggregate	72,367
Minehead	Sand	274,024
Pevensey Bay	Aggregate	17,094
Shoreham Beach	Aggregate	63,309
Tankerton	Aggregate	250,587
Skegness	Sand	458,726
TOTAL		2,279,090

3.11.1 Current licence position in the UK - Summary

- 72 extraction licences (31/01/2000) containing 287 million tonnes of sand and gravel.
- 30 applications in the Government View Procedure containing 360 million tonnes of sand and gravel.
- 7 prospecting licences

Historic patterns of marine aggregate extraction in the UK (Tonnes, excluding beach replenishment and fill contracts)

Extraction Area	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
Humber	0.00	0.00	0.00	0.00	0.00	1,910,064.00	1,788,452.00	1,903,678.00	2,351,233.00	2,694,977.00	2,840,261.00	13,488,665.00
East coast	10,895,791.00	10,897,217.36	9,220,517.03	10,255,813.00	9,812,236.00	9,384,860.00	10,497,352.00	9,306,920.00	9,397,705.00	8,923,562.00	9,131,512.00	107,723,485.39
Thames	3,603,132.00	2,101,910.35	1,505,111.48	1,504,471.00	1,223,190.00	2,001,208.00	1,661,324.00	1,115,597.00	1,125,921.00	862,834.00	971,960.00	17,676,658.83
South Coast	5,703,875.00	6,186,726.43	5,280,684.98	4,794,290.00	4,361,796.46	4,932,372.44	4,428,356.56	4,738,401.77	4,733,824.55	5,821,701.00	5,885,332.00	56,867,361.19
South West Coast	2,910,258.50	3,252,892.00	2,065,840.50	2,388,148.00	2,172,576.00	2,259,045.50	2,285,898.50	2,019,304.50	2,048,014.29	1,886,289.46	1,719,803.00	25,008,070.25
North West Coast	467,714.00	490,812.00	305,653.50	310,782.00	380,336.00	290,846.00	278,126.00	287,251.00	284,497.00	275,590.00	355,044.00	3,726,651.50
Rivers & Misc.	118,669.00	97,171.00	40,236.00	17,998.00	12,650.64	14,490.73	14,113.53	21,783.50	18,587.30	6,238.00	6,273.00	368,210.70
Yearly total	23,699,439.50	23,026,729.14	18,418,043.49	19,271,502.00	17,962,785.10	20,792,886.67	20,953,622.59	19,392,935.77	19,959,782.14	20,471,191.46	20,910,185.00	224,859,102.86

3.6 3.12 United States of America

Marine aggregate (sand and gravel) extraction figures for the USA in 1999/2000:

DREDGING AREA	AMOUNT
New York Harbour	1,300,000 m^3

The only commercial, marine sand mining operation is currently extracting material from the main shipping channel into New York Harbour (the Ambrose Channel). This sand is fairly fine-grained. It is mixed with crushed rock to provide a suitable aggregate used primarily for highway construction.

Amount of material extracted in the USA for beach replenishment projects in 1999/2000:

DREDGING AREA	MATERIAL	AMOUNT
New Jersey Coast	sand	2,600,000 m^3
New York	sand	14,000 m^3

In the northeast Atlantic coast of the United States (above 37° N), some 2.6 X 10^6 m^3 of marine sands were dredged for beach replenishment in 1999. A single project in New Jersey required 2,100,000 m^3. Other projects included Cape May, New Jersey (306,000 m^3) and Barnegat Inlet, New Jersey (191,000 m^3).

Historic pattern of marine aggregate extraction in the USA (10^6 m^3)

Extraction Area	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*Total*
New York	-	c.0.2	0.8	0.8	1.5	1.7	1.4	c.1.4	c.1.4	c.1.3	1.3	11.8

The only active aggregate mining activity has been done by one company in the state of New Jersey operating in the main shipping channel of New York Harbour. The aggregate is used for construction. Other sand extractions along the U.S. Atlantic coast have been for beach replenishment.

3.12.1 Current licence position and future exploitation of marine aggregates in the USA

The U.S. Minerals Management Service is considering opening for lease approximately 540 square kilometres on the Atlantic Shelf in Federal Water (beyond 5.6 km from the shoreline) off the New Jersey Coast (approximately centred at 73°47'W; 40°15'N). If they decide to proceed, an Environmental Impact Statement must be prepared.

4 4 REVIEW OF NATIONAL SEABED RESOURCE MAPPING PROGRAMMES

4.1 Belgium

A shallow water multibeam system has been installed on the Belgian Oceanic Research Vessel RV Belgica in 1999. Currently the system is being tested and personnel are being trained in its use.

4.1 4.2 Canada

Marine geoscience mapping is the responsibility of the Geological Survey of Canada (GSC), with projects on the Atlantic, Pacific and Arctic coasts. Surveys are conducted in the nearshore, on the continental shelf, and slope. As a result of changes to the scientific project definition and selection process of the Geological Survey of Canada in 1999, projects of seabed resource assessment and regional mapping continue to be curtailed. Mapping programmes are presently focusing on the southern areas of Canada where societal pressures are the greatest. These include programmes for habitat mapping on offshore banks and scallop grounds; in deep water areas where potential exists for hydrocarbon development; studies associated with seabed hazard characterisation; and in newly declared marine protected areas.

Federal and provincial co-operative efforts in preliminary aggregate and placer gold assessment in offshore Atlantic Canada have largely been completed. These studies have delineated vast quantities of aggregate at a regional level on the shallow offshore banks and in other areas of the inner, central and outer Scotian Shelf. The suitability of the materials for varied industrial uses is known. On the west coast of Canada, surficial sediment mapping programs have been less systematic, and little is known concerning the placer and aggregate resource potential. The sea level history is regionally understood and specific placers have been identified in a few areas.

The collection of multibeam bathymetric data is considered the most important first step in seabed resource mapping. Co-operative survey efforts are in place with the Canadian Hydrographic Service to collect this information. Recently mapped areas of the continental shelf in 1999 include Bay of Fundy, German Bank, off Cape Breton Island, north of Prince Edward Island, the south coast of Newfoundland and Georges Bank. Additional surveys are planned for 2000 - 2001.

The Geological Survey of Canada continues with development of a two-phased project for high-resolution seafloor characterisation and mapping. 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 sidescan sonars and high-resolution seismic reflection profilers to portray seafloor characteristics of grain size, sediment patchiness, particle shape, porosity, roughness, relief and subbottom stratigraphy. The second phase of the project will be to extract and compare quantitative sediment characterisation data from the acoustic signals of multibeam bathymetry, sidescan sonar and seismic reflection systems. Acoustic backscatter calibration will provide a remote lithologic mapping tool. This project has recently received additional support.

Other projects regarding seabed habitat characterisation will continue for Browns Bank, Georges Bank and German Bank in the Gulf of Maine. Georges Bank is the most prolific scallop producing bank in Canada. The fishing community has embraced the new seafloor mapping technologies as essential tools for a sustainable fishery and to maximise their operations for efficient and safe fishing practices. A new proposal for a regional multibeam mapping project called “SeaMap” is in the early stage of assessment. If implemented, Canada will establish a new long-term ocean mapping program to serve a multitude of users.

4.2 4.3 Denmark

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

The mapping programmme continues and is concentrated in the North Sea, Kattegat and the Baltic. Since 1991 mapping programmmes have been carried out on Jytland Bank and Horns Reef in The North Sea and in Femer Baelt, Adler Ground, Rønne Banke and Kriegers Flak in the Baltic. Maps have been produced at a scale 1:100,000 and include surface sediments, Quaternary geology and sand and gravel resources. At present, between 80% and 90% of the potential resource areas in the Inner Danish Waters have been mapped.

In 1999 reconnaissance mapping was carried out at greater water depths in the central part of Kattegat and in the North Sea. The preliminary results indicate the presence of interesting resources in the deeper parts of the Kattegat area.

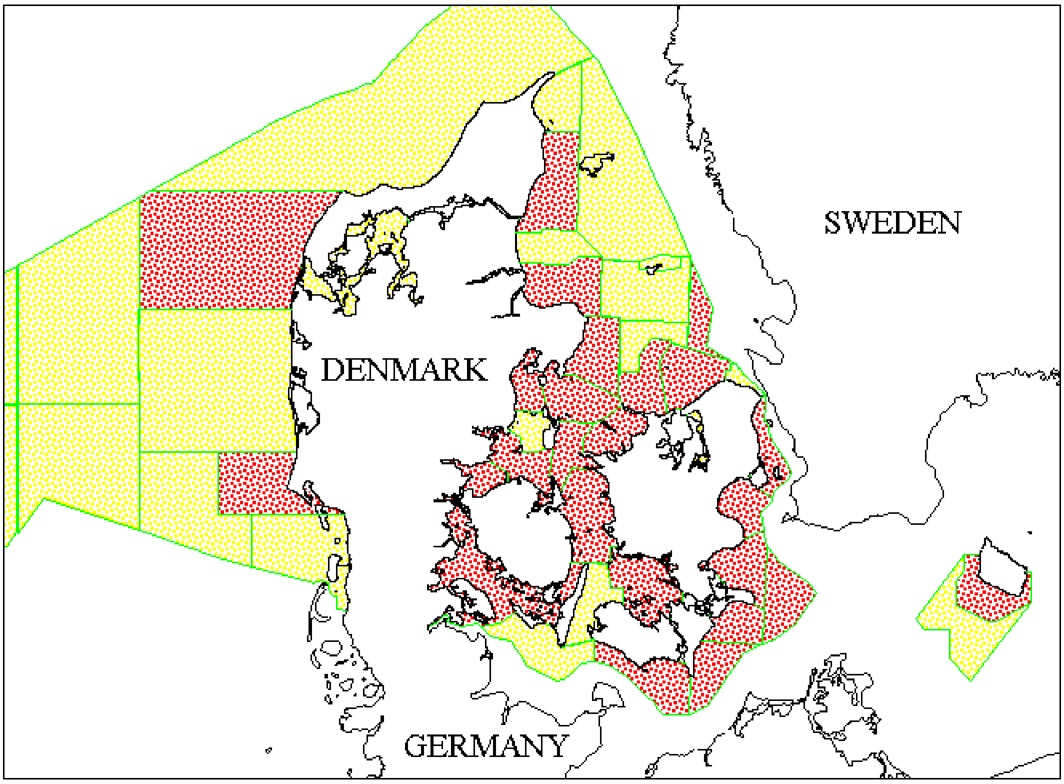


Figure 5 Mapping programme in Danish Waters. Dark shaded areas indicate where surface sediment maps have been prepared during the reconnaissance mapping programme (unpublished and published data).

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.

In 1997, detailed seabed mapping was carried out for a possible fixed link between Germany and Denmark in the Femer Belt between Putgarten and Roedby.

Detailed seabed mapping programmes have been carried out in relation to applications for dredging permits, e.g. in the Bay of Århus, Kattegat, Great Belt and North Sea.

A surface sediment map of the Jytland Bank, North Sea will be published in 2000.

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

The existing map "Bottom Sediments around Denmark and the Western Sweden has been updated with results from the recent mapping projects and will be published on a CD-ROM. The CD-ROM will be available from GEUS during 2000.

4.3 4.4 France

BRGM published 5 new littoral maps (1:50,000) of Brittany containing information on sediments. The organisation has also developed a national marine geology database for marine users including dredging companies, fishermen and other groups requiring geological information such as sediment types, deposit thickness and bathymetry.

BRGM is involved in two European projects (EUMARSIN and EUROCORE) with the following objectives:

- correlation of sedimentological data from the continental shelf of European seas (EUMARSIN) and from deeper seas coring programmes (EUROCORE);

- development of a European web-site (http://www.eu-seased.net) for data distribution.

4.4 4.5 Germany

The Federal Maritime and Hydrographic Agency, Hamburg (BSH) and the Institute for Baltic Sea Research, Warnemünde (IOW) have been carrying out mapping programmes. The survey methods employed include coring, diver observations and seismics. Both existing and new data have been used in the production of maps.

Areas: sheet “Arkona”, scale = 1: 100,000

4.5.1 Published seabed resource maps in 1999

Zeiler M., Schulz-Ohlberg J. & Figge K. (2000): Sediment Inventory Along the German North Sea Coast (in German). Die Küste, 62 (in press).

Tauber F., Lemke W., Endler R. (1999): Sea bottom sediments of the Western Baltic Sea, Map sheet “Falster-Møn”, scale = 1: 100,000. German Hydrographic Journal, 51 (maps can be ordered from dhz@bsh.d400.de)

4.5.2 Future marine resource mapping programmes

German sector of the Baltic Sea by IOW:

sheets “Arkona”, Mecklenburg Bight, Kiel Bight, Rügen-Usedom, Adlergrund, Pommersche Bucht

scale = 1:100,000

4.6 Ireland

4.4.1.1 Underway

- Funding has been granted to undertake a five year swath bathymetric survey and benthic characterisation of Irish territorial waters. The inshore work (50m to 300m) will be carried out using Ireland’s research vessel the *R.V. Celtic Voyager*. It is envisaged that a new Irish research vessel will carry out the second leg of the offshore work. The offshore mapping (300m to 4000m) phase of this project has been tendered.

- Lophelia / carbonate mounds project (FP5). These projects are designed to provide detailed ecological and environmental data on selected sites off the east Atlantic where Lophelia colonies occur. Work includes reproductive ecology, epifauna, longevity, local oceanography, and rates of accretion.

Completed

- A survey to map the location and extent of herring spawning grounds off the Irish Coast.

- A desk study to determine the distribution of maerl beds off the Irish Coast (see Annex XII).

4.5 4.7 The Netherlands

Resource mapping in the Netherlands is the responsibility of the national geological survey. The survey is a component body of the national applied science and technology conglomerate TNO named ‘Netherlands Institute of Applied Geoscience TNO, - national geological survey’.

A review of the progress in the field of seabed resource mapping in 1999/2000 is presented below. Corresponding maps showing the advancement of the mapping programmes are in the previous progress report.

4.5.1 4.7.1 1:250,000 geological reconnaissance map series

This map series includes amongst others a surface geology (sea bed sediments) sheet, which includes a main map in UTM (ED 50) at scale 1:250,000 showing the uppermost 10 cm of the seabed following the Folk classification system and various subsidiary maps. These maps are on a scale of 1:1,000,000 and 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 the sand fraction, geochemistry of surface sediments (Oyster Grounds map), a key to colours and symbols and a short description. Each mapped area covers 1° latitude and 2° longitude.

All the sheets of the 6 mapped areas are now available in digital format. The seabed sediment map of Terschelling Bank (53°-54ºN, 4°-6ºE) is currently being prepared.

See the ICES WG EXT report for 1998/9 for figures showing the progress of this and the next mapping programme.

4.5.2 4.7.2 1:100,000 geology & resource map series

This map series consists of digital map sheets with both geological and resource information.

The geological component includes a fence diagram with the geological structure of the younger layers (1:100,000), a bathymetric map at 1:150,000, 1:250,000 maps on geomorphology, the occurrence of Holocene formations, 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 of the stratigraphic units.

The resource component includes a map of the mean grain size and mud content of the uppermost metre at 1:100,000, a similar map of the metre below at 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 second metre and a short note on methodology, sediment classification and the availability of further information. Digital grain size information is also available at 2-3 and 3-4 m below the seabed.

The map sheets Rabsbank (51°20'-51°40'N, 3°–3°40'E) and Buitenbanken (51º 40'-52ºN, 3°-3º 40'E) have also been printed (in 1992 and 1996 respectively). Schouwenbank (51º 40'-52ºN, 3º 40'-4º 30'E) was the first sheet to become available in digital form only. The Indusbank (52°-52º 20'N, 3º 50'-4º 30'E) and IJmuiden Ground (52º 20'-52º 40'N, 4°-4º 40'E) sheets are in various states of progress. Work on the Indus Bank sheet is almost completed, the digital resource maps have been finalised. Data acquisition on the next sheets to the north i.e. Egmond Gronden (52° 40'-53° 00'N, 3° 50'-4° 30'E) as well as the offshore part of the adjoining Fransche Bank sheet (52° 40'-53° 00'N, 4° 30'-5° 10'E) is completed, the inshore part of the latter sheet remains to be done. The Keysersplaat sheet (53° 00-53° 20'N, 4° 20'-5° 00'E) survey programme is currently under way. This sheet covers the marine areas around Texel Island.

The survey methods employed in the data acquisition phase of the mapping programmes include sampling and the use of coring devices such as the Hamon grab (for sand and gravel down to 0.2 m), electric and hydraulic vibrocorers (for short cores 1 m and 4-5 m in length respectively), and Geodoff and Roflush counterflush sampling systems (for disturbed sub-seabed samples down to 12 m and 25 m respectively). Seabed and sub-seabed information is obtained by conventional echosounders and multibeam (bathymetry), side scan sonar and multibeam (morphology), various sub-bottom profilers (the uppermost few tens of meters max.) and sleeve guns (the Quaternary succession reaches a thickness of many hundreds of meters).

4.5.3 4.7.3 Published seabed resource maps in 1999/2000

As stated above, 6 sheets of the 1:250 000 series have been published since 1984, a seventh sheet is currently in preparation. Only the first two sheets of the 1:100 000 series have been printed in 1992 and 1996 respectively. These and all further sheets are available in digital format. The institute's digital database allows the production of specific maps of any part of the sub-seabed.

4.5.4 4.7.4 Future marine resource mapping programmes

In 1999, a 4-year research project was started to investigate the spatial and temporal grain size variability and crest stability of a particular North Sea sandwave. The outcome of this study will be useful for detailed extraction policies in areas with sandwaves and/or other bedforms.

4.5.5 4.7.5 Applied and other geological investigations in 1999

Several studies have been carried out in recent years to evaluate extraction sites for Rotterdam harbour extension schemes (the Maasvlakte 2 project) and other major infrastructural plans. One study has been completed during the last year, i.e. Kok, P.T.J., Mesdag, C.S. & Laban, C. (1999) Seismisch onderzoek ten behoeve van Maasvlakte 2 – interpretatie enkel- en meerkanaalsopnamen. (Seismic investigation for the Maasvlakte 2 project – interpretation of single and multichannel registrations). Rept. NITG 99-213-C (in Dutch), 62 pp.

Further studies on a harbour dredge spoil dumpsite off Rotterdam resulted in the following report: Zwanenburg-Nederlof, H.P. (1999) Onderzoek korrelgrootteverdeling van het gestorte materiaal Loswal NW – steekboringen juli 1999. (Grain size investigations of the dumped material at the Loswal NW site – July 1999 cores). Rept. NITG 99-174-C (in Dutch), 3 pp.

In 1999, the department was engaged in an image analysis study on sand grains. The aim of the work was to set up and validate parameters for grain shape and grain roundness analysis. A report is being finalised. Potential applications include provenance and sediment transport studies and normalisation of sand grain properties.

Geochemical distribution graphs of surface sediments, as outlined in an earlier ICES progress report, are being prepared for the 1:250,000 Terschelling Bank sheet and now also for the southern half of the Dutch sector. The aim is to provide reliable information on natural background values and their variation and on human-induced changes. Occasionally longer cores are being investigated as well. In doing so, the thickness of the mobile layer (mobile since the start of the industrial revolution) might also be estimated.

A study has started to formulate a set-up and a legend for (digital) maps that provide information on seabed morphology **and** seabed dynamics.

NITG-TNO has continued the development of the 'Roflush' sampling system during the past year. This was conducted in order to explore aggregate resources at greater depth below the seabed. The system consists of a counter-flush sampling device equipped with a flexible hose with a weight at the end connected to a complicated nozzle system, which enables sediment penetration. It is operated through a moon pool. Successful tests at sea were held in the early months of 2000, involving sampling at 13 stations down to a depth of 23 m.

The development of the 'Roflush' system is related to the expected demand for large quantities of sand in connection with major infra-structural plans currently under consideration in the Netherlands, i.e. an offshore extension of the port of Rotterdam, a possible national airport on an artificial island and a major land reclamation scheme in front of the existing coastline near The Hague.

4.6 4.8 Norway

The Geological Survey of Norway is trying to initiate a large marine mapping programme on the mid-Norwegian shelf with several other Norwegian institutions, including the Norwegian Petroleum directorate, Norwegian Hydrographic Service and Institute of Marine Research. The programme will involve the compilation of existing data and the collection of new data. Many themes will be covered, such as bathymetry (regional/detailed), geology (seabed sediments etc.), and biology (habitat mapping and pollution).

4.9 Poland

4.6.1 4.9.1 Pre-quaternary geology in the southern Baltic on the basis of high-resolution reflection seismics data

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The Polish Geological Institute recently carried out high-resolution seismic profiling of the Southern Baltic to provide new data on the geological structure of pre-Quaternary and on the relief of the sub-Quaternary surface. The investigations resulted in a geological map of the sub-Quaternary surface, and a series of geological cross-sections, showing the geological structure to a depth of several hundred metres (0.8 sec TWT) (Kramarska, Krzywiec & Dadlez, 1999).

The sub-Quaternary surface lies at depths of between 0 and 190 metres below the water surface, resulting from glacial erosion. Additionally, it is cut by subglacial troughs with relative depths locally exceeding 100 m. These troughs are best developed where the pre-quaternary deposits are composed of easily erodable Tertiary, Cretaceous or Silurian deposits.

The geological structure of the sub-Quaternary surface reflects the division of the Southern Baltic into two parts. The eastern part belongs to the Precambrian Platform, the western part to the Palaeozoic Platform. The boundary between them is the Koszalin Fault Zone.

In the eastern part, on the lifted tectonic blocks of Slupsk and Leba, Silurian deposits directly underlie the Quaternary. In the Rozewie and Kurland blocks, Devonian deposits directly underlie the Quaternary. These blocks are marked by a sub-longitudinal system of faults with distinct reversed fault characteristics. In the layers directly below the Quaternary, these faults are accompanied by flexures and fault-related folds.

In the southern area of the eastern part, a younger Zechstein-Mesozoic complex covers the Silurian and Devonian deposits. In the southern part of the Leba block, Zechstein and Lower Triassic deposits occur locally below the Quaternary. Upper Cretaceous deposits are the most extensive, extending far northwards in to the Gdansk Basin. They form pre-Quaternary deposits in the Bornholm-Darlowo zone and in the area north of the Christiansø block, where they connect with the Hanö Bay Cretaceous field. The Cretaceous and locally Jurassic deposits are also uncovered locally along the Polish coast at the bottom of deep subglacial troughs. The arrangement of the Zechstein-Mesozoic complex is dependent on the changeable dynamics of marine transgressions entering into the Southern Baltic area from the direction of the Mid-Polish Trough. The numerous tectonic deformations in this complex were caused by tectonic activity in the area during the late Cretaceous. These are reversed faults, flower or pop-up type structures. The strongest tectonics and traces of shifting may be observed in the Bornholm–Darlowo zone.

In the western part of the Palaeozoic Platform area, Mesozoic sediments appear on the pre-quaternary surface. In the structural system conditioned by inversion of the area at the break of the Cretaceous and Tertiary, three main blocks are present: the Wolin, Arkona, Gryfice and Kolobrzeg blocks, separated by fault zones. These faults are mainly of reversed fault character. In the near-ceiling part of the complex they are accompanied by flexures and fault-related folds. Along the lifted western edges of the Kolobrzeg and Gryfice blocks, anticlines were formed, in which Jurassic and Triassic deposits are present. The remaining part of the area is composed of Cretaceous deposits.

The high-resolution seismic profiles show numerous details on the geological structure of the youngest complex built of Tertiary deposits. Palaeocene sediments occur in the western part of the Precambrian platform, along the Koszalin fault zone, and mark the boundary of the inversion area of the Mid-Polish Trough. Deposits of upper Tertiary sediments, from Eocene to Miocene, cover the central part of the Polish zone of the Baltic Sea. These deposits are arranged horizontally on top of older deposits of various ages. The Tertiary cover is not continuous, and its present appearance and distribution is basically the result of erosion including Quaternary glacial erosion.

References

Kramarska R., Krzywiec P. & Dadlez R., 1999 — Geological map of the Baltic Sea bottom without Quaternary deposits 1:500 000. Polish Geological Institute, Gdansk–Warszawa.

4.10 Sweden

Marine geological mapping of the Swedish EEZ is the responsibility of the Geological Survey of Sweden (SGU). During the last 4 years the Survey has been mapping (scale 1:100 000) the Stockholm Archipelago located in the western Baltic. The size of the area is about 14,000 km^2 and it contains about 20,000 islands. The first of six map sheets is ready to be published this year.

The survey carried out in the Archipelago includes investigations with shallow seismic (air gun), subbottom profiler (7 kHz), complete coverage with chirp side scan sonar (90-110 kHz), followed by vibrohammer coring, piston coring, gravity coring and grab samples from more than 2,000 sites. Each site was examined with underwater video before coring and sampling. In selected deposition areas, 1-m gravity cores were taken and x-rayed with the recently developed digital sediment-scanner which was installed onboard the SGU survey vessel. Afterwards the cores were subsampled and analysed for ^{137}Cs-activity, 57 elements of the periodic table and about 40 organic contaminants such as PCBs, DDTs, PAHs, etc. The geochemical data is stored in a database, which now contains more than 50,000 analyses. These data have been used to develop Swedish Quality Criteria of sediments in 1999. All the results of the mapping surveys will be published in different thematic maps.

The marine geological mapping programme of Sweden has recently changed from detailed mapping at the 1:100,000 scale to a regional mapping programme designed to produce overview maps at the 1:500,000 scale. This programme will continue until 2008, when the Swedish EEZ will have been mapped and stored digitally in databases. The regional mapping programme will start later this year with the investigation of the Swedish part of Skagerrak.

4.7 4.11 United Kingdom

4.7.1 4.11.1 Inshore seabed characterisation of the inshore zone – Thames estuary

The British Geological Survey (BGS) reported in 1998 on research they had undertaken for the Department of the Environment, Transport and the Regions (DETR) and the Ministry of Agriculture, Fisheries and Food (MAFF) to bring into a common computer format information on the offshore geology of the seabed within the inshore zone (in general terms, to the 12 mile limit), including information on sediment transport regimes and potential sand and gravel resources. The initial study covered the seabed from Flamborough Head to the Deben estuary on the east coast of England, and from Portland Bill to Dungeness on the south coast (Evans *et. al.* (1993) ‘Inshore seabed characterisation of selected sectors of the English Coast’ BGS Technical Report WB/98/45).

DETR have let a further contract to enable BGS to undertake a similar exercise for the seabed between the Deben estuary and Dungeness (i.e. the Thames Estuary) out to the median line. However, the study goes further than before, to assess the potential contribution the geological and other data can make to other initiatives, and in particular, to habitat mapping.

The programme of work includes a number of tasks:

(i) Prepare maps and themes for digitisation following the scheme adopted previously, to produce a sea bed facies map of the outer Thames Estuary;

(ii) Examine habitat mapping exercises being undertaken east of the Isle of Wight and off the Wash and compare with sampling methods adopted by BGS;

(iii) Visit the main researchers and users of habitat mapping techniques and discuss the principles behind the methods and classification systems used, in order to attempt a correlation between the BGS methodology and habitat mapping systems adopted within the UK;

(iv) Produce recommendations for a seabed classification system that would assist facies and habitat mappers;

(v) Produce a draft combined map of the seabed facies and habitat for the Outer Thames Estuary.

The project will be completed by July 2000.

4.8 4.12 United States of America

Organisations undertaking seabed mapping programmes: U.S. Geological Survey, U.S. Minerals Management Service

The U.S. Geological Survey has a continuing programme to evaluate sand resources on the Northeast U.S. Continental shelf. This effort is primarily to identify sources of sand for beach replenishment. Side-scan sonar and multibeam surveys are conducted. Vibrocores have been taken at selected inshore sites. Details can be found at:

http://woodshole.er.usgs.gov/projects99/schwab34080.html

http://woodshole.er.usgs.gov/projects99/butman35140.html

An associated effort is the Atlantic Offshore Minerals (Aggregates) Assessment co-sponsored by the U.S. Minerals Management Service, The U.S. Army Corps of Engineers and The U.S. Geological Survey. No new samples are to be collected but existing analyses of sediment samples from various sources are to be compiled.

See page 8 of

http://coastal.er.usgs.gov/soundwaves/Jul99/

and, http://coast-enviro.er.usgs.gov/aggregat/

The Minerals Management Service also contracts with the geological surveys of several states to conduct inventories of offshore sand using seismic reflection, side-scan sonar and vibrocores. Details may be found at:

http://www.mms.gov/intermar/marineac-htm

5 5 REVIEW OF DEVELOPMENTS IN NATIONAL AUTHORISATION AND ADMINISTRATIVE FRAMEWORK AND PROCEDURES

5.1 Belgium

The legislation relating to the marine environment was subjected to a major overhaul in the last two years.

1. A new law on the protection of the environment in the marine areas under Belgian jurisdiction, came into force on 22-01-1999 (published on 12-03-1999 in the “*Belgisch Staatsblad / Moniteur belge*”).

   The law covers all activities listed in the law of 13-06-1963 on the Belgian Continental Shelf, (i.e. sand and gravel extraction, cables, pipelines, harbour dredging operations and navigational dredging) except commercial fisheries, scientific research at sea and navigation. These exceptions, covered by the second new law (see below), must be covered by an environmental impact report (EIR). The EIR is carried out and paid for by the applicant. After obtaining the permit, all activities are subject to continuous monitoring programmes, which are also paid for by the permit holder.

The implementation of this law by Royal decree is underway.

2. The second law which concerns the exclusive economic zone of Belgium in the North Sea, came into force on 22-04-1999 (published in the "*Belgisch Staatsblad / Moniteur belge*" on 06-07-1999). This law covers the exceptions mentioned in 1 above. In particular the law of 13-06-1969 (on the exploration and exploitation of non-living resources in the territorial sea and the continental shelf), which was the basic legislation for sand and gravel extraction, has undergone major changes. A copy of the co-ordinated version of the law of 13-06-1969 as updated by the laws of 20-01-1999 and 22-04-1999 is given in Annex XIII.

Regarding sand and gravel extraction, the main points can be summarised as follows:

(i) Each application for a permit must be accompanied by an EIR, which the applicant is responsible for conducting and paying for. The application is subject to an environmental impact assessment (EIA). The Royal decree concerning the rules, procedures, content and the form of both EIR and EIA are under development through close co-operation between the Minister of Economic Affairs and the Minister of the Environment.

(ii) Exploration and exploitation is subject to continuous monitoring.

(iii) The Minister of the Environment advises on the EIR and the results of the EIA.

(iv) If the advice of the Minister of the Environment is negative, no permit will be granted by the Minister of Economic Affairs.

(v) An Advisory Commission has been established to ensure co-ordination between the administrations concerned with the management of the exploration and exploitation of the continental shelf and the territorial sea.

(vi) Every three years a summary report describing the results of the continuous research (monitoring) is presented to the Advisory Commission.

(vii) The Advisory Commission can, based on these results, advise on modification to the regulations, and formulate policy statements concerning sand and gravel extraction.

5.1 5.2 Canada

In January 1997, Canada proclaimed the Oceans Act, which recognises in domestic law Canada's jurisdiction over its Maritime zones. It establishes authorities and responsibilities required to support Canada's new oceans management regime. Using the concept of integrated management, the Oceans Act is based on five principles:

- sustainable development

- management of oceans as ecosystems

- integrated management of activities occurring in, or affecting, estuaries, coastal and marine waters

- use of a precautionary approach in decision making

- full stakeholder involvement

The Oceans Act represents a new way of doing business in the oceans for Canada. All activities will need to be integrated and the maintenance of ecosystem health is paramount in decision making. Special areas termed "marine protected areas" (MPA's) will be given protection in the act. Overall the objective is to strike a balance between maintaining sustainable marine ecosystems and development of marine resources. The Oceans Act provides the context within which existing and future activities in, or affecting, marine ecosystems will occur. Therefore, initiatives regarding marine mining will be assessed according to the guidelines and principles of the Oceans Act. The Oceans Act team plans countrywide meetings in 2000 to discuss stakeholder visions on further developments and refinements under the act.

5.2 5.3 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 came into force on 1 January 1997 (Consolidated Act No. 569 of June 30, 1997). As of this date, all dredging activity will have to take place in permitted areas (Figure 5.1). A 10-year transitional period has been allowed for dredging in existing areas.

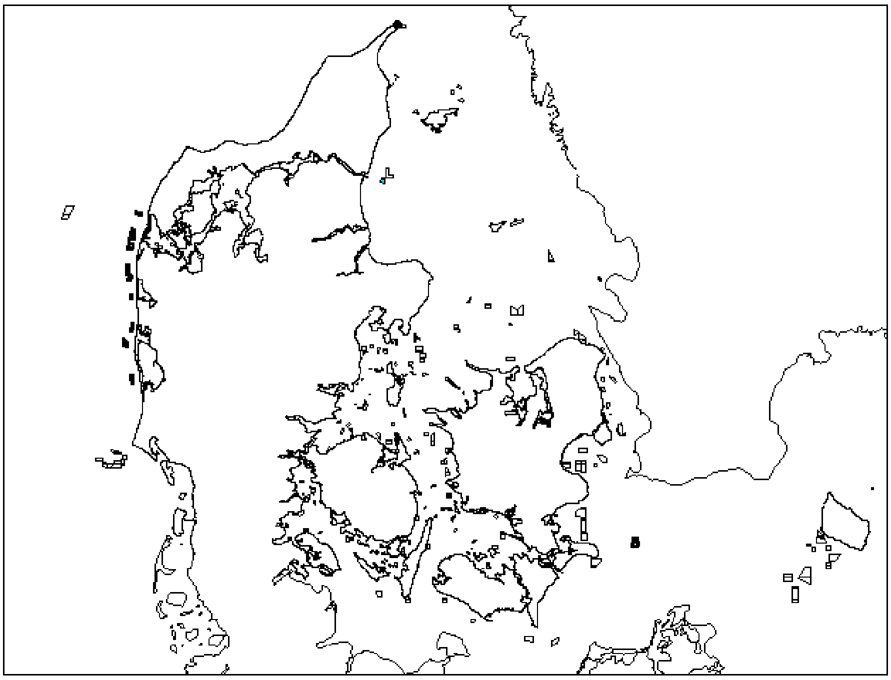

Figure 6 Dredging areas in Danish Waters, January 2000.

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

Extraction activities, 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 Ministerial Order No 126 of 4 March 1999. Dredging of more than 1 x 10^6 m^3 a year or 5 x 10^6 m^3 in total for a specific project or in a single area will always be subjected to this procedure.

In addition to 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 maintained at the current level.

5.4 France

No changes in 1999, although legislation is always under revision by the Ministry of Industry.

This Ministry requested the compilation of a report entitled ‘Guidance instrument for the investigation of applications for marine aggregates’, in order to gain a global overview of the environmental framework for sediment extraction. The main issues of this report deal with:

- the physical and biological impact of dredging activity on the seabed and water column;
- the recovery of dredging sites;
- methods for monitoring extraction activity;
- comparison of the relative impact of dredging and trawling activities.

This report includes a summary of sedimentological and biological characteristics for all existing and potential extraction areas along the French coasts (Atlantic and English Channel).

The creation of a Biological Sensitivity Index has been proposed, integrating the trophic value (expressed in benthic biomass) of each area and its importance for fishing activity. This Index would be a useful guidance instrument for the application process and administration of marine aggregate licences.

5.5 Ireland

Policy and monitoring protocols are currently being considered.

5.3 5.6 The Netherlands

5.3.1 5.6.1 Regional Extraction Plan for the North Sea

An update of the Regional Extraction Plan for the North Sea (1991) will be published later this year. The Ministry of Transport, Public Works and Water Management, Directorate North Sea will be responsible for administering the new legislation. The affected area is the Netherlands Continental Shelf. A major issue in this new plan will be the difference in approach to small and large-scale extraction of marine sands. For the small-scale regular extraction of marine sand (<10 million cubic metres), the management policy in the Netherlands is already in place. The maximum extraction depth for such extraction activities will be 2 metres.

For the large-scale extraction ($>10 \times 10^6 m^3$) for land reclamation and concrete sand the general policy will be revised. For this type of extraction a greater maximum extraction depth can be allowed under certain conditions.

Studies taking into account the pit design in relation to local conditions concerning hydrodynamic, sedimentological and ecological circumstances must result in an acceptable maximum extraction depth for a restricted area.

As result of the policy plan for shell extraction in the Dutch waters out to the limit of 50 km from the shore, there is an increasing interest for shell extraction in the new licensed areas, especially in the southern part of the North Sea (Zeeland). This is one of the reasons that fewer shells have been extracted in the Western Scheldt and the Voordelta. Investigations to identify more shell extraction areas in the northern part of the North Sea (Waddensea) are still negative.

Due to the investigations for marine aggregates in the North Sea there is a joint venture between the Ministry of Transport, Public Works and Watermanagement/Rijkswaterstaat, the provinces of North and South-Holland, Utrecht and Flevoland. To improve the knowledge of aggregates (coarse sand for the concrete industry) there is a programme for deeper than usual boreholes using the ro-flush. Information on material up to 20 m or more below the seafloor will be available for future extractions

5.4 5.7 United Kingdom

5.4.1 5.7.1 Regulation under the Government Procedure

Contrary to the statement in the 1999 ICES report, the Environmental Impact Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations did not come into force on 14 June 1999 as planned. It is now hoped that the Regulations, which will apply to England, Wales and Northern Ireland will come into force later this year. Scotland will introduce their own Regulations in due course.

In the meantime, applications for new aggregate dredging areas are continuing to be considered under the Interim Government View (GV) procedures introduced in 1998. The 'interim' procedures reflect many of the provisions which it is hoped will be introduced with the Regulations, although they do not have statutory force.

In particular, applications for a GV are made to the Department of the Environment, Transport and the Regions (DETR) or the National Assembly for Wales (NAW) as appropriate. In reaching its decision DETR/NAW will consider all the information submitted with the application, including reports on the environmental effects of the proposed dredging, all comments received in response to consultation with interested parties and comments received following advertisement of the application. There is also provision to hold a public inquiry or informal hearing, to resolve outstanding issues.

There is therefore already a requirement for applicants for dredging licences to undertake an Environmental Impact Assessment which must include a coastal impact study, and an assessment of the effects of the proposal on the marine environment, fisheries and other legitimate users of the sea.

5.4.2 5.7.2 Management by the Crown Estate

GIS (Geographic Information System)

The Crown Estate developed a Geographic Information System in 1990 as a tool to retrieve and display data relating to the management of offshore marine aggregate extraction licences. The GIS includes data on admiralty features, seabed geology, cables and pipelines. Environmental coverages are also included for England and Wales.

EMS (Electronic Monitoring System)

All vessels operating on Crown Estate licences are fitted with an EMS system that automatically records and encodes the date, time and position of all dredging activity. The information is stored on computer discs and analysed each month. Any breach of licence conditions e.g. out-of area dredging, is investigated and confirmed incidents are reported to the DETR.

During 1999, 39 vessels dredged on 74 licences (3 surrendered and 1 issued during 1999). There was a total of 31,898 hours of dredging. A total of 9 hours and 4 minutes was confirmed as out of area dredging (0.0284% of total hours dredged).

5.5 5.8 United States of America

In the United States, the Outer Continental Shelf Lands Act 1983, (amended 1994) allows leasing of areas of the shelf for sand and gravel extraction. In 1999, the Minerals Management Service and the U.S. Army Corps of Engineers, who has responsibility for many beach replenishment projects, developed a "Memorandum of Understanding" for the co-ordination and co-operation of the two agencies related to sand resources on the outer continental shelf. One recent issue that would affect the extraction of marine sand and gravel is in the Sustainable Fisheries Act (1996), which has required the National Marine Fisheries Service to define essential habitat for various commercial species. All Federal agencies must consult with the National Marine Fisheries Service on any actions that may adversely affect essential fish habitats.

6

7 6 REVIEW OF APPROACHES TO ENVIRONMENTAL IMPACT ASSESSMENT AND RELATED ENVIRONMENTAL RESEARCH

7.1 6.1 Canada

Although no marine mining presently takes place in Canadian waters, harbour dredging and port maintenance are major activities. Co-operative projects to assess the effects of seabed trawling and clam dredging on seabed habitats are in the final stages of field survey and the results can apply to potential seabed mining activities. These projects are being conducted together with the Department of Fisheries and Oceans. The Geological Survey of Canada is providing geoscience survey and interpretative support. Results of these surveys will be a quantitative assessment of the effects of the bottom fishing gear on seabed alteration, biodiversity, community complexity and ecosystem reoccupation. Research planned for the future will assess the effects of scallop fishing on the seabed.

7.2 6.2 Denmark

7.2.1 6.2.1 Øresund Link

All primary dredging works related to the project have now finished. The removal of temporary structures is still going on, but all marine works will be finished before the opening of the Link on 1 July 2000. A total of 14.2 x 10^6 m³ of material has been dredged during the project with an average spill of 4.1 %.

Only minor effects resulted from the construction works. These effects were predicted and are within the tolerance limits for environmental effects required by the authorities.

The sand fill for the construction of the Link was dredged on Kriegers Flak in the Baltic.

Before the commencement of the project, a detailed resource assessment and an environmental impact assessment of sandfill extraction was carried out on Kriegers Flak in the Baltic by the Øresund Consortium. The assessment was prepared in accordance with the EC Directive 85/337.

During the project 1.3 x 10^6 m³ of sand fill was dredged from Kriegers Flak with a spill of 2.8% (WaterConsult 1997, Øresundskonsortiet 2000).

Sediment spill and the environmental impact of the dredging activities has been monitored in detail during the dredging operation, and a final report on the findings will be completed in April 2000. The preliminary results indicate, in accordance with the EIA, that there is no environmental impact outside 1000 m from the dredging area.

7.2.2 6.2.2 The Harbour of Århus

A major enlargement of the harbour of Århus will require dredging of more than 8 x 10^6 m³ of sand fill. Based on prospecting carried out by the Harbour, two areas in Århus Bight were selected for dredging. Due to the size of the project the Harbour was requested to carry out an environmental impact assessment in accordance with the EC Directive 85/337 as part of the application. Based on the assessments, acceptable spill limits were set at 6 % and 7 % respectively. The spill must be measured from every 10th cargo. In addition, the Harbour has set up a monitoring programme to ensure that the environmental impact is within the limits stated in the permission.

Preliminary results from monitoring of the bottom fauna after dredging of approx. 6 x 10^6 m³ of sand indicate that the changes outside the dredging areas are very small and of the same magnitude as in the reference area. The results in both the impact area and the reference area indicate a significant and parallel increase in the number of species and the abundance (Århus Havn, 2000).

7.2.3 6.2.3 Eastern Kattegat

Investigations of the potential impact on bottom fauna and birds are being carried out off Limfjorden prior to commencement of dredging of sand for cement production.

7.2.4 6.2.4 Stigsnæs

An Environmental Impact Assessment in accordance with the EC Directive 85/337 has recently been carried for a proposal to construct a Container Terminal Hub near Stigsnæs, Western Sealand. The public procedure will run from April to July 2000. The project includes dredging of 5.6 x 10^6 m^3 of sand fill in a very environmentally sensitive area. To fulfil the environmental requirements, direct pumping from the dredging site and use of sedimentation basins is expected to be necessary (The Baltic Gate Terminal A/S, 2000).

7.2.5 6.2.5 North Sea

The Danish Coastal Authority (DCA) is launching an Environmental Impact Assessment in accordance with the EC Directive 85/337 for areas in the North Sea to be used for dredging of sand for beach nourishment in the next 10 years. The project will include geological and biological mapping. In addition DCA is planning to carry out a separate Environmental Impact Assessment for both onshore and near shore nourishment.

7.2.6 6.2.6 Emissions from Dredgers

A study of the energy consumption and emissions from dredging and transport of marine and land based resources was finished in 1999.

7.2.7 6.2.7 Statistics

The National Forest and Nature Agency has recently completed a study on the use of statistical analyses in environmental monitoring of dredging spill. The study describes the theoretical background and gives a number of examples of the use of statistics for setting up administrative requirements and for evaluating the necessary number of measurements for obtaining a specified uncertainty/variation of the considered parameter (Skov- og Naturstyrelsen 1999).

Later this year the Agency will launch a scoping study on the environmental, social and economical aspects of dredging on land and sea. Based on this project key aspects will be selected for further studies.

7.2.8 6.2.8 Impact of dredge spill on the benthos

The Forest and Nature Agency has initiated a research project on the impact of dredge spill on benthos in co-operation with the National Environmental Research Institute.

A detailed study of the ecological consequences of dredging in coarse sediments was started in May 1996. Especially the effects on the benthic flora and fauna on surrounding stone reefs will be evaluated (National Forest and Nature Agency 2000).

7.2.9 6.2.9 Environmental effects of dredging in the North Sea

The Forest and Nature Agency and the Coastal Protection Agency have initiated a monitoring programme off the West Coast of Jytland to study the effects of dredging of sand for beach protection.

The study is based on a comparison with simultaneous changes in a reference area. The post-nourish temporal development is analysed using the BACI concept (B(efore) A(fter) C(omparison) I(impact)). A complete quantitative recovery including the number of species, the abundance and the biomass of the bottom has occurred in less than one year after the sand extraction. However, the predominance of a supposed opportunistic species of polychaete (*Spio filicornis*) in the borrow area may indicate a pioneer recolonisation. The impact of sand extraction on the predator populations is limited due to a patchy exploitation pattern leaving plenty of food in 70% of the (undisturbed) bottom and a recovery of the benthic biomass in less than one year.

7.2.10 6.2.10 Autonomous Underwater Vehicle, AUV

In association with Maridan, the National Forest and Nature Agency will test the ability of Maridans AUV to monitor the environmental conditions in existing and future dredging areas. The AUV is equipped with side scan sonar, sub bottom profiler and video camera and is able to find the survey area, perform the survey and return to base without any connection to the base during the survey. The purpose of the test is to verify the performance of the AUV and the quality of the collected data. The system is expected to reduce survey costs by 50 % and may be a realistic alternative to some of the traditional surveys and diving operations.

7.2.11 6.2.11 Effects of Excavations for Natural Resources on Benthic Epifauna

7.2.11.1.1.1 Preliminary research results

Prepared for National Forest and Nature Agency by: Jens Kjerulf Petersen, National Environmental Research Institute

The purpose of this project is to determine different kinds of effects on benthic epifauna as a result of excavations for sand, gravel or stones. The aim is to describe both short term and long term effects related to spill from the dredging operations. The results of the investigations will be combined with data on spill percentage, particle size distribution and sedimentation in order to obtain an overall estimate of secondary effects of these operations.

Effects of sediment spill were evaluated on three levels: Short term effects, long term effects and worse case scenario. Short-term effects of elevated levels of suspended material were examined by measuring filtration rate and activity pattern in 4-5 different phyla of epibenthic suspension feeders, i.e. ascidians, bryozoans, bivalves, polychaetes and marine sponges. Performing growth experiments at elevated concentrations of inorganic suspended material on 2-3 different model organisms will elucidate long-term effects. In the worst case scenario, experimental plots in the field were covered with inorganic sediment and divers will follow the recolonisation of the plots for one year, using direct observations.

Preliminary results show a reduced filtration rate in some of the investigated species. This was expected since most of the species are not capable of sorting particles. The reduced food intake is due to dilution of food with inorganic particles derived from sediment overspill. The results were, however, not unequivocal since some species, like bryozoans, did not show changes in feeding activity. In the worst case scenario, the first visit after the sedimentation event showed a marked change in species composition and abundance in the experimental plots. Final results are expected to be ready by the end of 2000.

7.2.12 6.2.12 Recent literature and reports

The Baltic Gate Terminal A/S, 2000: Environmental Impact Assessment for Dredging of Sand for The Baltic Gate Terminal. Report prepared for The Baltic Gate Terminal A/S by GEUS in cooperation with Carl Bro A/S and Bioconsult A/S. (in Danish).

GEUS, 1999: Treasures hiding in the Sea. Marine raw material and Nature Interests. An evaluation by GEUS and The National Forest and Nature Agency. Geological Survey of Denmark and Greenland, 1999, 20 p.

GEUS, 2000: Bottom Sediments around Denmark and the Western Sweden. (CD-ROM in press).

National Forest and Nature Agency, 2000. Effects of excavations for natural resources on Benthic Epifauna. National Environmental Research Institute, 2000 (in prep.).

Skov- og Naturstyrelsen, 1999: Måleomfang og usikkerhed – tilfældige fejl. Rapport udarbejdet for Skov- og Naturstyrelsen af Rambøl. English abstract: Statistic – a Tool to Control Requirements. Prepared for National Forest and Nature Agency by Christensen, C. F., Rambøll, 2000.

WaterConsult, 1997: The Fixed Link across Øresund. Spill Monitoring at Reclamation of Sand at Kriegers Flak for use at the Fixed Link across Øresund. Report prepared for National Forest and Nature Agency and Øresundskonsortiet by Water Consult.

Øresundskonsortiet, 2000: Dredging on Kriegers Flak. Sediment spill. Final report, March 2000. Report prepared for Øresundskonsortiet by WaterConsult. (In Danish).

Århus Havn, 2000: Marinbiologiske undersøgelser. Råstofindvinding, Århus Havn 1999. (Abstract in English: Marine Biological Investigations, Dredging of Sand).

6.3 France

A study on sedimentological and biological effects of sand deposition was carried out around the extraction site of Dieppe in 1999 (see Annex VII). A negative impact, including an increase of fine sand content and a decrease in specific richness, abundance and biomass, was observed in the eastern areas of the study site, in line with the direction of the prevailing tidal currents. In addition, a positive effect was detected northwards and westwards, mainly as an increase in biomass, although no effect in species richness or abundance could be detected. Comparison with Poiner and Kennedy's results (1984) in Australia shows that macrobenthic communities are mainly affected by a change in the sediment type.

7.3 6.4 Germany

7.3.1 6.4.1 Regeneration of Sediment Extraction Sites in North and Baltic Sea

In March 1999, the Federal Maritime and Hydrographic Agency (BSH) initiated a 3 year research project to investigate the sedimentological processes which control the refilling of sediment extraction sites along the North and Baltic Sea coast. The extraction sites studied include: Westerland II (North Sea), Pohnshalligkoog near the island of Pellworm (North Frisian Wadden Sea), Graal-Müritz 1 and Tromper Wiek (both in the Baltic Sea off Mecklenburg-Vorpommern).

Westerland II is a sand extraction site, which is used for coastal protection of the island of Sylt. The Tertiary sands and gravels are extracted by anchor dredging from 10-12 m deep pits in a water depth of 15 m. Since extraction commenced in 1984, the site has been frequently echosounded and these data are used to evaluate the behaviour of the adjacent sea floor. The pits act as sediment traps for fine-grained material, which accumulates in the deeper parts. Analyses of organic pollutants and the heavy metal composition of the muddy refill will be used to indicate the source of the material (i.e. whether it originates from the Wadden Sea or from riverine input).

A single sediment extraction exercise was conducted in 1994 at Pohnshalligkoog near Pellworm for a dike protection in 1 m water depth. The pit was stable for several years and in 1999 was almost completely refilled. Sediment cores will be retrieved in summer 2000 to obtain information on the sedimentological processes, which are responsible for the refilling of pits in the Wadden Sea.

There is a huge activity along the Baltic Sea coast of Mecklenburg-Vorpommern to extract sand and gravels from shallow waters for coastal protection and industrial use, respectively. At Graal-Müritz 1 sand extraction will take place in 2000 for the protection of a nearby coast. Trailer dredgers will extract about 500,000 m³ of mobile sands from an area that is characterised by a sand thickness of 2-4 m. Since the beginning of the project, the sediment distribution has been mapped three times in order to compare the natural variability in this area with anthropogenic induced processes responsible for refilling the furrows.

In the Tromper Wiek both gravelly sands for industrial use and sands for coastal protection are extracted from water depths of 10-20 m. Gravelly sands are sieved on board the anchor dredgers and the sandy fraction is returned to the sea with the overflow. The behaviour of this mobile sediment and the stability of the pits are of major interest at this site.

The main aims of the project are:

- to evaluate the influence of sediment transport (along and at right angles to the coastline) on the physical refilling of extraction sites

- to estimate the duration of refilling in shallow waters (10-20 m water depth) and

- to estimate the size of sea bed areas involved in the sediment delivery

Methods used in this projects are single beam and multi beam echosounding, sidescan sonar, subbottom profiling (chirp sonar, boomer), grab samplers, vibrocoring, diving observations, underwater camera, current and wave measurements.

The project is funded by the Federal Ministry of Education and Research (BMBF).

7.4 6.5 Ireland

7.4.1 6.5.1 The location and extent of the main herring (*Clupea harengus*) spawning grounds around the Irish Coast

This project was funded under the Marine Research Measure of the Operational Programme for Fisheries (1994-1999) administered by the Marine Institute and part funded by the European Regional development Fund. The aim of this research was to delineate the location and extent of the major herring, *Clupea harengus*, spawning grounds around the Irish coast, and where possible to map the extent of the actual spawning beds within these areas. This project was undertaken in response to a growing interest in coastal and offshore resources, resulting, for example in applications for sand and gravel extraction and the dumping of dredge-spoil from maintenance dredging. The information obtained was used to provide an atlas of the areas to which careful consideration should be given before the issue of licences for the extraction of marine aggregates & for dumping at sea.

Information from the Irish herring fishery, Irish herring larval surveys and current herring fishermen was used to delineate the spawning grounds and identify the peak spawning times for the various stocks. The consistency of these data both between years and between methods has shown that this information can be used successfully to delineate the approximate locations of herring spawning grounds. Though not providing exact information on the location of the spawning grounds, this information facilitated the detection of the spawning beds by providing a starting point from which herring egg surveys were based. Close contact was maintained with herring fishermen while the egg surveys were underway in order to obtain information on the positions of capture of spawning herring (Stage VI), and in particular the locations where these fish were being consistently caught. It was found that preliminary surveys of the spawning grounds using the RoxAnn™ seabed discrimination system were useful in identifying areas containing suitable spawning substrates prior to actually surveying for herring eggs. This identified areas where herring are likely to spawn and also reduced the size of survey areas by providing information on the location of substrates, which would be considered unsuitable for spawning (i.e. mud & fine sand). These data were also used a method of identifying potential herring spawning grounds.

Grabs and dredges were used to actually locate the herring eggs *in situ*, while also providing the sediment samples necessary to ground-truth the RoxAnn™ data. Using these techniques it was possible to delimit the boundaries of the spawning beds and provide an estimate of the area of egg coverage. This phase was used to identify the actual individual herring spawning beds within the spawning grounds. Four separate herring spawning beds were mapped during the course of this study. The contribution of members of the fishing industry towards the success of this work was highlighted. The spawning substrates in three of the spawning beds were typical of those identified by other authors, however, the fact that the substrate at the fourth spawning bed was composed of flat rock would appear to be a unique observation. An additional area of work involved the evaluation of the RoxAnn™ hydroacoustic processor as a method of monitoring a designated dredge-spoil dumpsite off Power Head, Co. Cork. This study was undertaken in order to investigate the potential threat posed by this operation to one of the more important South Coast herring spawning grounds, which is situated adjacent to the dumpsite. Another RoxAnn™ survey was carried out to map the seabed sediments within a proposed aggregate extraction site which was located within a well known spawning ground off the South East Coast of Ireland. The report concluded that the full extent of the spawning grounds should be protected in line with the precautionary approach to fisheries management.

7.5 6.6 The Netherlands

7.5.1 6.6.1 EIA of an area off the coast of Zuid - Holland

An Environmental Impact Assessment has been carried out within an area off the coast of the province of Zuid-Holland. This study is general in nature and has focussed on the environmental impact of the extraction of sand for concrete from a depth of 5 to 30 metres below the seabed. Special attention is given to the way the cover layer of lower quality sand will be handled. The results of the environmental impact assessment point towards a refill of the pit with the sand from the cover layer, or to a combination with land-reclamation projects.

7.5.2 6.6.2 Rotterdam Harbour

Planning for the enlargement of the Rotterdam Harbour has entered a new phase, which is to include the reclamation of 1000 ha of land in a combined public/private project. This will involve the extraction of between 500 and 700 million m^3 of sand depending on the resulting project design. Before the Government makes its final decision, an Environmental Impact Assessment including a study of the morphological and ecological effects of large-scale extraction must be carried out.

7.5.3 6.6.3 Island Airport

Plans have been made in the last few years for the construction of an offshore island airport. The amount of sand required for this project would be in the order of 1500 x 10^6 m^3. In December 1999, the Dutch Government decided to facilitate an increase in air traffic at Amsterdam Airport in lieu of an island airport. However, a minor research programme will be carried out to assess the island airport option.

7.5.4 6.6.4 PUTMOR Project - Physical monitoring of a deep sand pit

This 2-year project commenced on 10 May 1999 and is being conducted by the Ministry of Transport, Public Works and Water Management, Directorate North Sea and the National Institute for Coastal and Marine Management.

In the past few years the effects of marine sand extraction to a depth of 10 metre or more has been studied by modelling. A field experiment was lacking. The extraction of sand from borrow pits which will be refilled with dredged material give the opportunity to carry out field monitoring of the morphological behaviour of the pit and of the hydrodynamic changes in the pit due to extraction. The dimensions of the pit are 500 by 1300 metres at a depth of 10m below the seabed. To execute the monitoring, the refilling of the pit was postponed for six months. The pit was open from 1 October 1999 to 1 April 2000. In this period several bathymetric surveys were carried out. The currents were measured by moored ADCPs and by a ship mounted ADCP. Vertical tidal movement was measured by pressure sensors. Salinity, temperature, turbidity and oxygen content of the water were measured regularly. Bottom samples were taken to determine changes in grainsize. The aim of the study is to determine any changes in physical parameters resulting from extraction. The physical parameters are important to quantify and qualitatively describe the morphological and ecological effects of sand extraction pits. The field study will also be used to validate models on hydrodynamics and morphology.

7.6 6.7 United Kingdom

7.6.1 6.7.1 Assessment of rehabilitation of the sea-bed following marine aggregate dredging

The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) in collaboration with Hydraulics Research Wallingford and the British Geological Survey have been commissioned to undertake a 4-year study to assess the rehabilitation of the seabed following marine aggregate dredging. The project is jointly funded by the department of the Environment Transport and the regions (DETR), the Ministry of Agriculture, Fisheries and Food (MAFF) and the Crown Estate.

This field-based study is designed to enhance understanding of the processes leading to physical and biological recovery of the sea bed following dredging, thereby aiding the identification of practices to minimise environmental harm at such sites, and to promote rehabilitation on cessation. In combination with ongoing CEFAS R and D, which ranges from an evaluation of the cumulative effects of dredging activity and the modelling of plume dispersion, to studies of environmental recovery following experimental dredging and the development of new methodology for characterising gravel habitats, the outcome will provide a significant advance in understanding, and hence in the scope for effective management, of commercial extraction and its aftermath.

The work will involve a number of stages including:

(i) A literature review on the environmental effects of aggregate dredging;

(ii) Selection of study sites for field sampling. These will be representative of different effective dates of cessation of dredging; and will, as far as possible, be selected to represent a range of geographical conditions around the coastline, and allow for the occurrence of ongoing dredging activity to a different degree. To augment the range of possible scenarios, the identification of 'fallow' areas within a currently zoned licence will be sought.

(iii) Development of suitable sampling designs which combine 'once-off' and annual sampling events.

(iv) To complement the field surveys, descriptive summaries and quantitative indices of prevailing hydrographic conditions in the vicinity of centres of dredging activity, will be developed. This will provide a means to interpret survey data from this and other studies, and improve predictive capability with regard to environmental effects of dredging activity, whether recently ceased, ongoing or planned.

(v) A review of information on sediment characteristics and transport pathways as part of the assessment of the potential for any area to undergo morphological changes.

(vi) To conduct a review of the 'state of the art' means to identify best practice in the future management and monitoring of the physical consequences of dredging activity.

The project started on 3 April 2000 and will be completed in June 2004.

7.6.2 6.7.2 Procedural guidelines for the conduct of benthic studies at aggregate dredging sites

DETR have commissioned CEFAS to prepare guidance on procedures for undertaking benthic studies in relation to aggregate dredging activities. Its purpose will be to provide a more consistent approach to such assessments, and to enhance the quality and compatibility of data generated. The output will be relevant either to studies undertaken as part of a pre-application Environment Impact Assessment, or as part of a programme to monitor the effects of dredging.

The study is desk-based, and will cover:

(i) Rational for, and aims and objectives of, environmental appraisals;

(ii) Survey frequency;

(iii) Sampling design;

(iv) Field sampling methods, including operating procedures for the range of equipment employed, accompanied, where appropriate, by design specifications;

(v) Laboratory methods for analysing samples;

(vi) Methods of data analysis;

(vii) Format for reporting findings;

(viii) Quality control procedures covering field and laboratory work;

(ix) Assessment of new developments likely to affect the future scope of environmental impact assessments and the methodology employed for the conduct of surveys.

The project started in April 2000 and will be completed in April 2001.

7.6.3 6.7.3 Scoping study to assess the environmental effects of sediment plumes arising from dredging

The Construction Industry Research and Information Association (CIRIA) commissioned Posford Duvivier Environment, in collaboration with HR Wallingford and CEFAS to review the current state of knowledge on sediment plumes arising from marine dredging. The study was not confined to aggregate dredging and looked also at capital and maintenance dredging. It therefore considered the effects of dredging different bed materials (i.e. muds, sands and gravels), in different environments (estuarine, coastal and marine) and using different techniques (e.g. trailing suction hopper dredgers, cutter suction dredgers, grab dredgers).

The report of the study will be published shortly. It will address the following objectives:

(i) to review research and relevant case studies (in the UK and elsewhere) on sediment plumes arising from dredging activities;

(ii) to examine current knowledge on the environmental impacts arising from sediment plumes;

(iii) to review the relevance of legislation relating to sediment plumes;

(iv) to identify gaps in current knowledge and research initiatives to address them;

(v) to produce a comprehensive report on current understanding;

(vi) to recommend further work required to produce guidance, review modelling techniques, and develop a comprehensive framework for the assessment of the environmental effects associated with dredging plumes.

7.6.4 6.7.4 Southern North Sea Sediment Transport Study

Date of commencement*:* Estimated as June 2000.

Duration of project*:* 3 years

Organisations undertaking research project*:*

Ministry of Agriculture Fisheries and Food (MAFF)

Anglian Coastal Authority Group (ACAG)

Humber Estuary Coastal Authority (HECAG)

The Crown Estate

The purpose of this research programme is to improve understanding of the Southern North Sea sediment transport system and its impact on the eastern English coastline between Flamborough Head and the River Thames. Information to be obtained includes sediment sources, transport pathways, volume of sediment, areas of deposition and offshore features.

Phase I of the project was completed in 1996. It included a literature review, the creation of a database and the creation of a concept for a sediment transport model.

Phase II will address the gaps in information identified in Phase 1. It will update the database and amend the transport model to take account of further information provided since Phase I.

7.6.5 6.7.5 Marine Life Information Network

Duration of project*:* 3 years

Organisations undertaking research project*:* Marine Biological Association of the UK (MBA)

Sponsors: ABP Research & Consultancy

Countryside Council for Wales (CCW)

Joint Nature Conservancy Council (JNCC)

Department of Environment Transport and Regions (DETR)

English Nature

The Environment Agency

Scottish Natural Heritage

The Crown Estate

Objectives:

- To identify sources of marine biological data and to access, grade and use that data to identify distributions of biotopes and species
- To develop a network of data access for collaborators in the programme

7.6.6 6.7.6 Broadscale Mapping – Development of Techniques

Duration of project: 1 year

Organisations undertaking research project:

The SeaMap Research Group of the University of Newcastle

Centre for Environment, Fisheries and Aquaculture Science (CEFAS)

This project aims to review existing methodology and technology used in Broad Scale Mapping with a view to establish their effectiveness in assessing potential dredging areas. The review will consist of analysis of both CEFAS and SeaMap data sets and a comparison with existing biological, particle size and side scan sonar data collected from the survey area.

7.6.7 6.7.7 Cumulative Environmental Impacts of Aggregate Extraction

Date of commencement*:* April 1st 1998

Duration of project*:* 4 years

Organisations undertaking research project*:*

Funded by the Ministry of Agriculture, Fisheries and Food (MAFF) and the Crown Estate

Project undertaken by the Centre of Environment Fisheries and Aquaculture (CEFAS)

The objective of the study is to distinguish natural changes from dredging-induced changes to allow scientific evaluation to be made regarding multiple extraction activities.

The programme has involved biological and environmental sampling of dredging sites to allow predictions of the cumulative impacts of future dredging projects.

The desk-based portion of the study has so far involved the collection of data on the relevant licensed areas, Electronic Monitoring System (EMS) data, the analysis of aerial surveillance data and consultation with relevant organisations. Field investigations have also been carried out on active licence areas.

Further steps will include the establishment of referenced stations for further monitoring and further investigation of fisheries data.

7.7 6.8 United States of America

7.7.1 6.8.1 Borrow Area Monitoring New York and New Jersey

Organisations undertaking the research project: U.S. Army Corps of Engineers and various subcontractors

Funding bodies: U.S. Army Corps of Engineers

Active borrow areas off the coast of New Jersey for benthic resources (primarily shellfish), benthic prey for demersal fish and finfish populations. Unpublished reports include:

The 1999 Bio Monitoring Program report Phase II-III, and

Raritan Bay and Sandy Hook Bay Offshore Borrow Site Area Analysis. 1999 finfish and Invertebrate Summary Report.

Monitoring at excavated borrow sites showed decreased both total abundance and biomass of benthic communities of the dredged borrow area, but both appeared to recover within 8-9 months. Biomass composition was also impacted, but had not completely recovered a year after dredging. Likewise, the average weight of sand dollars, the biomass dominant, was still lower at dredged than reference sites a year after dredging.

Similar studies have been done or are underway in borrow areas along the New York Ocean coastline.

8 7 GUIDELINES FOR ENVIRONMENTAL IMPACT ASSESSMENTS OF MARINE AGGREGATE EXTRACTION

The UK and Danish Governments tabled papers at the meeting relating to their own draft guidelines for environmental impact assessments of marine aggregate extraction (see Annex VI and Annex XV). These guidelines will be considered, together with those being developed by Belgium (to be circulated) with a view to producing a draft set of ICES guidelines at the next meeting of WGEXT.

9 8 CODE OF PRACTICE FOR THE COMMERCIAL EXTRACTION OF MARINE SEDIMENTS (INCLUDING MINERALS AND AGGREGATES)

The Working Group discussed the updating of its earlier Code of Practice. Dr Side agreed to present a summary of good practice for the next meeting and other WGEXT members offered to assist with this task.

10 9 A REVIEW OF HABITAT MAPPING TECHNIQUES AND THE REQUIREMENTS FOR HABITAT CLASSIFICATION OF NON-COHESIVE SEDIMENTS

Following several sessions considering the draft paper tabled by Dr Andrew Kenny a revised version was produced. This was sent to the SGMHM for comment and the group's suggestions were incorporated. Dr Andrew Kenny agreed to take this forward on behalf of WGEXT as a paper submitted too the ICES Annual Science Conference. Other potential contributions to the Theme Session on Habitat Mapping were also discussed. The WGEXT paper, in draft version agreed by WGEXT at its annual meeting, appears as ANNEX XVI.

10 AN EXAMINATION OF THE MEANS TO ADEQUATELY IDENTIFY SPAWNING GROUNDS OF CRITICAL FISH SPECIES IN RELATION TO AGGREGATE EXTRACTION, PARTICULARLY HERRING.

The results of a project concerned with mapping the location and extent of the main herring spawning grounds around the Irish Coast were presented (Breslin, 1998) and was considered together with a working paper produced by CEFAS (see Annex III). The former project was undertaken in response to a growing interest in coastal and offshore resources, resulting, for example in applications for sand and gravel extraction and the dumping of dredge-spoil from maintenance dredging. A number of methods were used prior to conducting herring egg surveys at sea in order to delineate the extent of the spawning grounds. Information from the Irish herring fishery, Irish herring larval surveys and current herring fishermen was used to delineate the spawning grounds and identify the peak spawning times for the various stocks. The consistency of these data both between years and between methods has shown that this information can be used successfully to delineate the approximate locations of herring spawning grounds. Though not providing exact information on the location of the spawning grounds, this information facilitated the detection of the spawning beds by providing a starting point from which herring egg surveys were based. Close contact was maintained with herring fishermen while the egg surveys were underway in order to obtain information on the positions of capture of spawning herring (Stage VI), and in particular the locations where these fish were being consistently caught. It was found that preliminary surveys of the spawning grounds using the RoxAnn™ seabed discrimination system were useful in identifying areas containing suitable spawning substrates prior to actually surveying for herring eggs. This identified areas where herring are likely to spawn and also reduced the size of survey areas by providing information on the location of substrates, which would be considered unsuitable for spawning (i.e. mud & fine sand). These data were also used as a method of identifying potential herring spawning grounds. Grabs and dredges were used to actually locate the herring eggs *in situ,* while also providing the sediment samples necessary to ground-truth the RoxAnn™ data.

Similar methodologies have been used by other authors to delineate the location and extent of herring spawning grounds. Some of the herring spawning grounds around the coasts of Scotland have been described, based on the following sources of information:

i) position of catches of haddock which had been recently feeding on herring eggs (Bowman, 1922)

ii) the position of drift net catches of spawning herring (Wood, 1971)

iii) the distribution of <10mm herring larvae (Wood, 1971 & Rankine, 1986)

iv) the locations of known gravel deposits (Rankine, 1986).

Bowman referred to these haddock as “spawney” and used the occurrence of these fish as an indicator of the location and extent of herring spawning grounds. Postuma *et al*. (1975) reviewed all of the available data for defining the spawning grounds of autumn spawning herring in the North Sea. The spawning areas as defined by the positions of capture of spawning herring and of recently hatched larvae, were described. They concluded that the consistency of these data, both between years and between methods, gave considerable confidence that data of this nature may be used to provide reliable indications of where herring deposit their eggs. This type of information can only provide a broad description as to the location of spawning areas because haddock with herring eggs in their stomachs, catches of spawning herring and, catches of <10 mm larvae may have been captured some distance away from the spawning beds. The results of such investigations delineate extensive spawning areas rather than exact spawning locations (Bowers, 1980). The only definite way to locate a herring spawning site is by the actual identification of herring eggs which have been taken from a known area on the seabed. This however, can be an extremely difficult task and actual documented occurrences of spawning beds are extremely rare. The information described above can aid in the detection of herring spawning beds by providing a starting point from which egg surveys can be based. Rankine (1986) also noted that the consistency of such data, both between years and between methods, suggested that this type of information provided useful first approximations as to the location of certain herring spawning beds around the Scottish coasts.

DISCUSSION

The group discussed the various methods that could be used to identify and map the location and extent of spawning grounds and spawning beds.

METHODS TO DELINEATE HERRING SPAWNING GROUNDS

- review the available historic information on herring fisheries to identify spawning times for different spawning components.
- positions of capture of recently hatched herring larvae (i.e. < 10mm).
- positions of capture of Stage VI spawning herring.
- positions of capture of other fish species, which had been feeding on herring eggs e.g. cod and haddock.
- location of fishing gear on which herring eggs have been deposited e.g. lobster and shrimp pots
- sediment mapping surveys using acoustic tools can be used to identify the location of suitable and unsuitable substrates for herring spawning.

METHODS TO MAP THE LOCATION AND EXTENT OF HERRING SPAWNING BEDS

- Grabs and dredges e.g. Forster Anchor Dredge, Day Grab, Van-Veen Grab
- Photography, Video and camera mounted in Remote Operated Vehicles (ROV), Autonomous Underwater Vehicles (AUV) and SPI Camera.
- Diver observations
- Suction samplers
- Hydrological studies to identify larval drift could be used to infer the locations of the spawning beds.

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11 11 A REVIEW OF THE BIOLOGICAL MONITORING OF THE ØRESUND FIXED LINK

The final Environmental Impact Report from the Øresund Link project documenting the results of monitoring and assessment will be published in June 2000 before the opening of the Link 1 July 2000.

The report will address the environmental impact from the extraction of more than 7 x10^6 m³ of glacial till and limestone in the Øresund and 1.3 x106 m³ of sand fill at Kriegers Flak during the project.

It was therefore agreed by members of the WGEXT to postpone the discussion of the results until the next meeting. The report will be sent to the members of the WGEXT in advance of the next meeting and will include an extended abstract of the latest impact assessment of the sand extraction at Kriegers Flak.

At the meeting a special session will be dedicated to a detailed discussion of modelling of sediment plumes, statistical analysis and the results of the impact studies on benthos, eelgrass, algae and birds.

12 12 A REVIEW OF THE BIOLOGICAL AND SEDIMENTOLOGICAL EFFECTS OF DREDGING INCLUDING PLUME EFFECTS

12.1 12.1 Introduction

CIRIA commissioned Posford Duvivier Environment together with HR Wallingford and the Centre for Environment Fisheries and Aquaculture Science (CEFAS) to undertake a desk-based review of the current state of knowledge on the nature of sediment plumes arising during dredging operations and their effects on the environment. The work was funded by a number of organisations (including the UK and Netherlands Governments, and sectors of the dredging industry) reflecting the wide range of interests involved. The project focussed mainly on the situation in the UK but several case studies and research from other countries was included.

The study considered both the generation and subsequent mobility of plumes and the associated environmental effects, and undertook provisional work to develop a structured framework for assessing the environmental effects arising from dredging activities. This could be used as part of the EIA process to determine whether plumes are likely to have unacceptable effects on the environment. Consideration was also given to mitigating measures to reduce potential impacts. The study looked at both aggregate dredging and capital and maintenance dredging. It did not look at the effect of plumes from disposal operations or the secondary re-suspension although it is recognised that this might be significant. The following summary focuses on those aspects in the report that are relevant to sand and gravel extraction, together with additional points made by the Working Group.

12.2 12.2 Sources of sediment plumes

Dredging releases sediment into the water column. Two ‘phases’ have been described - the dynamic phase (where the plume moves under its own volition) and the passive phase (where the plume moves due to other influences acting upon it, although it is possible to have both phases present at the same time. In the dynamic phase, plume behaviour is determined mainly by the nature and concentration of the material and the means by which it is placed in the water. In the passive phase, plume movement is controlled to a greater extent by the hydrodynamic environment (mainly the strength and direction of the current). The primary factors that determine the nature of the plume are the dredging technique, the sediment type, the hydrodynamic conditions and their interaction.

12.3 12.3 Effects of sediment plumes on the marine environment

The report identified a number of effects that plumes could potentially have on the marine environment. A number were considered to constitute major effects, while others were potentially of minor significance (being more relevant to capital and maintenance dredging). The following section briefly summarises the level of knowledge in relation to some of the main effects.

12.3.1 12.3.1 Effects on seabed communities

- Increased sediment deposition and the modification of sediment type are potentially the most significant effects on marine ecology after the direct removal of the substratum and associated communities by the drag pipe.
- There is little field evidence regarding the level and nature of the impact.
- In sheltered areas sedimentation is mainly confined to a zone of a few hundred metres from the point of discharge (i.e. Newell *et al.*, 1998).

- In high energy environments impacts of deposition can extend far from the dredging area (>1km). Should significant deposition of sand occur in areas that have a similar sediment type, the impacts on the benthic communities are likely to be small or can actually result in an enhanced biomass or diversity (for example - see Annex VII).

- The effects of elevated turbidity and sedimentation are more significant in environments that have naturally low concentrations of fine sediments, particularly in areas dominated by gravel substrata.

- Reduced light penetration can effect macrophytes (see for example ICES 1998 report on the Baltic, and the 1998 report on the Oresund fixed link).

12.3.2 12.3.2 Effects on fish

- Fish are potentially sensitive to sediment in the water column and material settled on the seabed.

- Dredging plumes may affect fish larvae and eggs that concentrate in the surface layers. However, there has been little work on the subject.

- Fish spawning is affected where the settlement of sediment directly smothers fish eggs or changes the composition of the substratum of a nursery area.

- An increase in the fines content may prevent the eggs of species such as herring and sand eel from adhering to the sediment, and can cause smothering of the eggs.

- Demersal spawning species which require a particular sediment type on which to spawn are possibly most susceptible to changes in sediment composition.

- Possible direct effects include abrasion resulting in the removal of mucus and the clogging of gills. However, it is uncertain whether these effects are likely to occur to a significant extent in practice, as fish are likely to avoid areas with sufficiently high turbidity.

- Plumes may change the behaviour of fish that target their prey visually. Fish that normally inhabit relatively clear water may have their feeding pattern impaired.

- The potential for impacts on fish migration depends on the duration and timing of dredging.

- Migration is seasonal so the impact would be more significant if the dredging occurred during the critical period.

12.3.3 12.3.3 Effects on shellfish habitat

- Settlement of the sediment can affect epifaunal crustaceans

- A localised redistribution of crustaceans can occur as a reaction to habitat loss

- Silting up of pots can lead to declining catches from traditional fishing grounds

- The limited near-field dispersion and short-term duration of significant sediment plumes would only result in localised direct impacts on shellfish. However, such effects can impact on commercial shellfisheries.

12.3.4 12.3.4 Effects on primary production

- Increased turbidity may also depress phytoplankton productivity due to a reduction in light penetration into the water column. This effect is localised and is unlikely to be significant in terms of total production.

12.3.5 12.3.5 Cumulative effects

- In the context of sediment plumes, a cumulative impact is considered to constitute more than one dredging event creating multiple plumes.

- In isolation, one dredging regime may not have a significantly impact. However, the cumulative effect of several dredging regimes might be to exceed a critical threshold.

12.4 12.4 Prediction of environmental effects

To predict and assess the effects of sediment plumes on the environment it is necessary to accurately describe the characteristics of the environment that could be affected. This should include the species and habitats present, their sensitivity, tolerance and acceptable thresholds for change.

Once the baseline environment has been described, and the generation and movement of the plume predicted, an assessment of the potential environmental effects can be made. This should consider not just the direct and immediate effects, but potential cumulative impacts, which might arise in combination with the effects of other projects.

It is essential to consider the extent to which effects will be significant i.e. will the change constitute an impact. This will require quantification of the change and its comparison to background tolerances and thresholds.

12.5 12.5 Mitigation of environmental effects

12.5.1 12.5.1 Choice and operation of the dredging plant

- Limiting sediment re-suspension at sea during extraction operations.

- Control dredging to maximise concentrations and minimise outflows.

- Direct overflow stream to the suction mouth at the point of extraction for dredgers equipped with water jets

- The use of the de-gassing equipment.

- Reduce the water volume in the empty hopper before commencing dredging operations

- Utilise anti-turbidity overflows

- Optimise the dredge mouth type to suit the nature of the material being dredged.

- Careful selection of sites to minimise plume generation or extent of dispersion.

12.6 12.5.2 Environmental windows

- Environmental windows are essentially time zones that provide mitigation by restricting dredging to avoid adverse environmental effects

- The aim should be to protect sensitive biological resources or their habitats.

- There are two fundamental site-specific factors to take into account: (i) the environmental interests at risk e.g. location of shellfish beds, fish migration routes etc; and (ii) the environmental factors affecting the distribution and impact of the plume e.g. tidal excursion, sediment type, and quantity.

12.6.1 12.6 Recommendations made in the CIRIA report

- Development of a comprehensive assessment framework

To adopt an assessment framework that indicates the method steps required to make an assessment and the information required to inform decisions.

Fill the knowledge and technology gaps in the assessment process through research, development and monitoring

Produce good practice guidelines on the assessment of sediment plumes.

There is a need to be able to comprehensively describe the turbidity plume. This requires better quality baseline data and improved modelling techniques. To be cost effective, it is necessary to develop predictive techniques that can be used to assist in determining the acceptability of a particular operation. Other recommendations include:

- Development of an internationally accepted monitoring protocol
- Field testing suspended sediment monitors
- Determine a standard procedure for measuring the disaggregation index
- Monitoring benthic boundary processes
- Monitoring environmental effects
- Filling gaps in modelling capability
- Developing best practice guidance for assessing environmental effects
- Understanding environmental effects (prediction and field monitoring)
- Guidance on the assessment of sediment plumes: impact prediction
- Development of an indicative environmental effects framework

12.7 12.7 Recommendation of the working group on sediment plumes

The group should try to take these recommendations into account when taking forward its own guidelines for EIA and monitoring.

13 REVIEW OF REPORT PRODUCED BY SGMHM

The ICES SGMHM were unable to provide their draft report on recent developments in marine habitat classification during the course of the meeting for WGEXT. However WGEXT reviewed extracts from the EUNIS classification system and following a discussion, agreed a draft resolution to be put forward for consideration by the Marine Habitat Committee (see Section 14).

13 14 RECOMMENDATIONS AND DRAFT COUNCIL RESOLUTIONS

13.1 Draft Resolution 1: Future meeting of WGEXT

The Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem [WGEXT] (Chair Dr J. Side, UK) will meet in Copenhagen from 3-6th April 2001 as guests of the ICES Headquarters in order to:

a) review data on marine extraction activities, developments in marine resource mapping, information on changes to the legal regime (and associated environmental impact assessment requirements) governing marine aggregate extraction, and review scientific programmes and research projects relevant to the assessment of environmental effects of the extraction of marine sediments. National reports to be provided electronically no later than 16 March 2001.

b) continue work (taking into account relevant work under and requirements of OSPAR and HELCOM) on the updating of:

– the ICES Code of Practice for the Commercial Extraction of Marine Sediments (including minerals and aggregates), produced in 1992.

– guidelines for the preparation of an Environmental Impact Assessment evaluating the effects of seabed aggregate extraction on the marine environment, including as appropriate guidelines on monitoring and standardised procedures, reviewed most recently in 1998 for inclusion in the forthcoming ICES Co-operative Research Report. In taking forward the production of draft ICES guidelines, WGEXT will review draft guidelines tabled at the last meeting by the UK, Denmark and once available Belgium (to be circulated), HELCOM work and other guidelines being developed by other ICES members. WGEXT will endeavour to produce a draft set of revised ICES guidelines at this meeting.

c) commence work on developing criteria for the selection, design and operation of a series of test ranges in the offshore in order to:

– Assess the capability of Acoustic Ground Discrimination Systems (AGDS) for detecting and delineating biological communities

– Compare and contrast the relative resolution and capability of AGDS with conventional side scan sonar, multibeam and high resolution seismic reflection methods

– Determine the relative resolution, operational parameters of AGDS and conventional mapping systems in a variety of water depths and substrate types, primarily focussing on habitats relevant to aggregate extraction activity.

– Determine the need for testing/intercalibration ranges in ICES member countries taking into account the role of the manufacturers in testing their equipment.

d) examine the methods that might be used to assess localised impacts from aggregate extraction on fisheries, and the means to adequately protect known herring spawning beds in the vicinity of extraction operations.

e) undertake a review of reference site data sets used in the monitoring of, and in research on, the effects of aggregate extraction in order to establish their usefulness in determining the degree of natural variability in biotopes.

f) review conclusions drawn from the completion of biological monitoring of the Øresund fixed link with a view to applying this knowledge to other large-scale extraction projects;

Priority	The current activities of the Group are concerned with developing understandings necessary to ensure that marine sand and gravel extraction is managed in a sustainable manner, that any ecosystem effects of this activity are better understood so that mitigative measures can be adopted where appropriate. These activities are considered to have a very high priority.
Scientific Justification	Term of reference a) An increasing number of ICES member countries undertake sand and gravel extraction activities, while others are looking at the potential for future exploitation e.g. Ireland and Canada. Each year WGEXT reviews relevant developments under these headings and includes a summary of them in its report. This provides a forum for information exchange. In order to maximise time spent discussing other topics; this is conducted in advance and circulated as a draft prior to the meeting. Term of reference b) This is a response from WGEXT to a number of recent requests and the recognition that these documents should take into account Annex V of the 1992 (OSPAR) Convention on the Protection of the Marine Environment of the Northeast Atlantic, and other developments, for example, in strategic environmental assessment. Term of reference c) WGEXT has been reviewing new technologies and techniques for the study of seabed sediments and benthic habitats in relation to its core focus on marine sediment extraction. While it has an interest in marine habitat classification and mapping more generally, this work is concentrating on scientific applications to assessment of environmental effects (and determination of vulnerable habitats) associated with marine sediment extraction. Discussions at WGEXT 2000 identified that several countries are conducting studies to establish the scope and limitations of AGDS in comparison to more conventional acoustic techniques. This would be a timely review of a rapidly developing subject. Term of reference d) While in recent years much effort has been directed to the observation of effects on the marine benthos, WGEXT has on several occasions examined effects at higher trophic levels and on fisheries. Discussion at WGEXT 2000 focussed on identifying means to identify herring spawning habitat. However during the meeting the means to adequately protect such habitats from localised effects of aggregate extraction was raised as a subject worthy of further attention. Additionally there were several requests to examine the methodologies used to assess localised impacts of extraction operations on fisheries more generally. Term of reference e) Many monitoring studies and research projects being conducted by ICES

	members have been undertaken to identify the impacts of sand and gravel extraction on the seabed. The reference site data from these in some cases show little variation year on year, in other cases significant changes have been detected. This data may be useful in assessing natural variability in some marine biotopes, and hence in the design of future environmental monitoring programmes for marine sediment extraction. Term of reference f) The completion of biological monitoring on this project enables a critical review of such data in relation to other proposed large scale extraction projects. Reports were not available to WGEXT 2000 but will be published very shortly and hence the Working Group wishes to carry this term of reference over to its next meeting.
Relation to Strategic Plan	The principal focus of WGEXT work is in relation to Objective 2(c), but other terms of reference also relate to Objectives 1(a),1(c),1(e), and 4(a)
Resource Requirements	Most countries routinely collect data and information on their extraction activities which will be collated and contribute to item a). The UK and Denmark have recently developed guidelines and Belgium is currently developing guidelines (to be circulated in advance of the meeting). Resources have already been committed to develop such guidelines. The research programmes that provide the main input to item d) are currently underway and resources already committed.
Participants	The Group is normally attended by 20-25 members and guests
Secretariat Facilities	ICES Headquarters
Financial	No additional financial implications
Linkages to Advisory Committees:	ACME
Linkages to other Committees or Groups	BEWG, SGMHM
Linkages to other Organisations	Work is of direct interest to OSPAR SEBA and IMPACT, and HELCOM

13.2 Draft Resolution 4: Publication of material at ICES expense

The report on the Effects of Extraction of Marine Sediments on the Marine Ecosystem, edited by WGEXT should be published in the *ICES Cooperative Research Report Series* in accordance with the ICES Council Resolution C.Res.1999/1E02.

Priority	High priority: urgent
Scientific Justification	This report represents a synthesis of the most recent scientific work on the ecosystem effects of marine sediment extraction, in the context of the scale of this activity and the legal regime and safeguards that govern it. Both SEBA and IMPACT are awaiting its publication. WGEXT 1999 recommended that ICES consider this request as a matter of urgency. WGEXT 2000 re-iterated this view.
Relation to Strategic Plan	Objective 4(a): much of the content is also relevant to many other objectives in the strategic plan
Resource Requirements	Publication of this material will cost ??
Participants	ICES WGEXT has received from ICES Headquarters the ICES template and has transferred text across to this. A final version in the style of the new template will be available in a matter of weeks.
Secretariat Facilities	?
Financial	Publication costs
Linkages to Advisory Committees	This product has been endorsed by ACME
Linkages to other Committees or Groups	MHC
Linkages to other organisations	OSPAR SEBA and IMPACT are awaiting its publication

13.3 Draft Resolutions 5: Requesting action by the ICES Secretariat

The main ICES web site should be linked to the ICES WGEXT web site.

Priority	Responds to a request 2 years ago for the Working Group to develop web pages linked to the ICES web site
Justification	To publicise the work of the Working Group and enable some documents to be accessed inter-sessionally directly by WGEXT Participants
Relation to Strategic Plan	Relevant to most of the ICES Institutional Objectives
Resource Requirements	None. The web pages have been produced and will be regularly updated by WGEXT participants
Participants	WGEXT
Secretariat Facilities	A small amount of time to enable the link
Financial	No additional financial implications
Linkages	As for the ICES web site

The following resolution was put forward by WGEXT for discussion at the Marine Habitat Committee:

The Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem observed that the EUNIS Classification System to level 3 offered a useful way of progressing the matter of the classification of marine biotopes. It noted however that the proposed classification system to level 3 required some alteration to make it consistent with our present understanding of geological environments, processes and seabed dynamics, and current terminology in use by the geological community. EUNIS guidelines indicate that any classification system adopted should be clear and easily understood. It recommends to ICES that agreement is sought on the nomenclature to be used at level 3, and that following this ICES Working Groups (Benthos, SGMHM etc) should concentrate on the task of prioritising biotopes that are rare (e.g. bioherms) or under threat (e.g. herring spawning beds) under the level 3 classification rather than just commenting on any proposed complete and cohesive classification system at the more detailed levels.

Priority	Suggested strategic priority – of immediate relevance to work being undertaken by WGEXT, BEWG and SGMHM
Scientific Justification	The terminology used to level 3 of the EUNIS classification system is not always consistent with that generally used by the geological science community, and for example, the combination of gravel and sand needs to be further differentiated. For example, the present combination of terms “gravel” and “cobbles” leads to confusion, as gravel is *the* grain size classification that includes granules, pebbles, cobbles and boulders. A common terminology and shared understanding of the level 3 classification is sought incorporating the Wentworth grain classification scale. This should enable clarity in environmental description at subsequent levels. The immediate utility of, and perhaps urgency for, a habitat classification scheme is seen in terms of the Precautionary Principle, implicit in which is the prioritisation of protection for scarce and vulnerable marine habitats/biotopes, particularly in relation to anthropogenic sources of environmental disturbance. While not at all discouraging discourse on a general classification scheme (indeed recognising that such a “taxonomy” is an essential scientific challenge) WGEXT suggests that some emphasis should be given at the present time to the identification of priority biotopes/habitats within each of these agreed level 3 classifications
Relation to Strategic Plan	Responds to Objectives 1(c) and 1(e) with implications also for Objective 2, for example for Objective 2(c), and proposed in the spirit of Objectives 4(a) and 4(b)
Resource Requirements	No additional resources required
Participants	MHC initially
Secretariat Facilities	No additional requirements
Financial	No additional financial implications
Linkages to Advisory Committees	Of importance to ACME and ACFM

Linkages to other Committees or Groups	WGEXT, BEWG, SGMHM
Linkages to other organisations	EEA, OSPAR and HELCOM

15 CLOSE OF MEETING

The participants agreed the WGEXT 2000 report. The Chair thanked the staff at the Polish Geological Institute for their generous hospitality and support throughout the meeting. He also thanked the Rapporteur for for work conducted prior to and at the meeting. Dr J. Side also encouraged Working Group members to publish their research in peer-reviewed journals, so that the results of research are open to a wide readership. In closing the meeting Dr J. Side passed on his disappointment that Dr Bas de Groot had been unable to attend this year's meeting but fully anticipated that he would be able to participate at WGEXT 2001.

14 ANNEX I- LIST OF CONTRIBUTORS TO THE 2000 REPORT

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15 ANNEX II - REVIEW OF SAND AND GRAVEL EXTRACTION IN THE BALTIC SEA

In the Baltic Sea sand and gravel deposits are mainly of glacial origin or the result of slow postglacial erosion processes. Extracted sediments will not be replaced by natural processes in an ecologically significant time span and should therefore be considered as a finite resource.

Sand and gravel resources have traditionally been extracted in some countries. The marine sediments are mainly used as construction, fill material and coastal defence i.e. beach replenishment. Since the 1990s, Denmark (annual extracted amount between 2.3 to 5.0 x 10^6 m^3), Germany (in Mecklenburg-Vorpommern annual extracted amount between 0.37 to 2.3x 10^6 m^3), Finland (annual extracted amount 0.5 x 10^6 m^3) and the St Petersburg region of Russia (annual extracted amount 1.2 x 10^6 m^3) have extracted increasing of marine aggregates (see Figure 1). Lithuania, Latvia, Estonia and the Kaliningrad region of Russia are not currently undertaking any relevant extraction activities, however, exploitation may become significant in the future due to an increasing demand associated with their growing economies. Sweden stopped dredging activities in 1992 for environmental reasons, but has extracted sands in 1998 for the "Fixed Link" project in the Øresund.

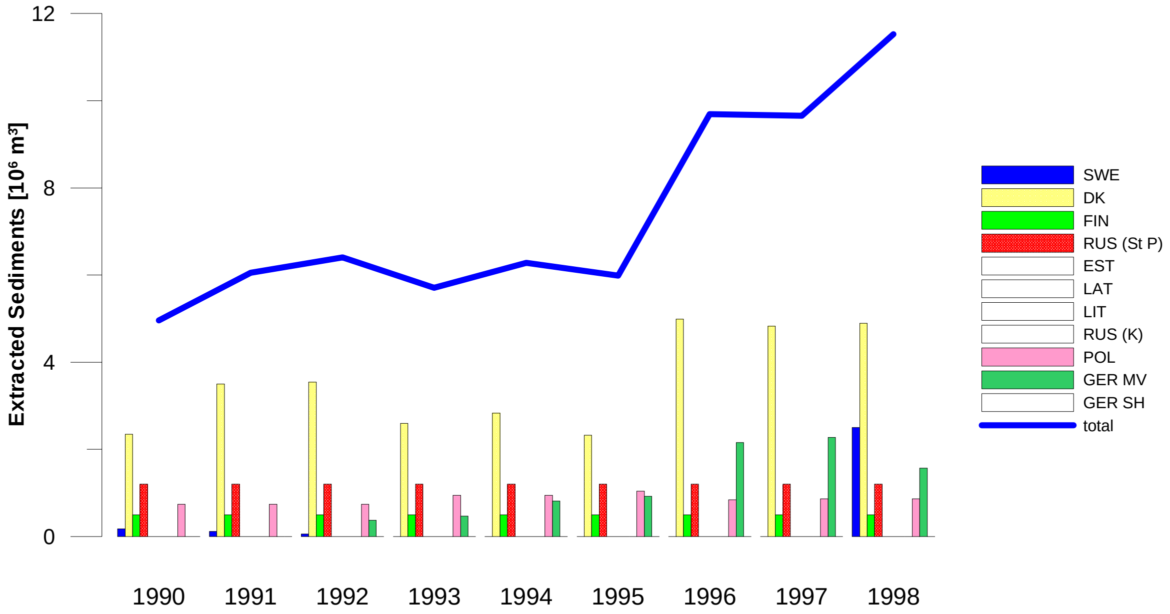

Figure 1 Amount of extracted sediments in the Baltic Sea.

Data based on information and estimates collected for the "status report" on marine extraction in the Baltic Sea (HELCOM 1999) and on personal communication by P. Kangas, G. Æertebjerg and H.-G. Jansson.

Extraction of marine sediments can potentially have considerable effects on the marine environment and fish stocks. In particular, benthic marine flora and fauna are destroyed at extraction sites and can be affected by the dispersion and sedimentation of suspended material over a larger area. Recolonisation of benthic invertebrates may take from several months to many years. Although recolonisation in some cases may be rapid, the re-establishment of the original age distribution and biomass of the communities may take a longer time span of up to several years. If the bottom substrate is irreversibly altered the original flora and fauna cannot recover (HELCOM 1999, ICES 1992, 1998). Recent results of a research project in the Southern Baltic Sea show that the uncolonised period after extraction can persist due to the topographical and morphological changes of the sea floor caused by the drag head. For more than one year after extraction, the dredged furrows were stable features of the sea bed and functioned as a sink for fine and organic material leading in summer to local oxygen depletion zones in normally well saturated areas (pers. communication by J. Chr. Krause).

If sediment extraction affects structures with high significance for hydrological conditions (e.g., submarine sills, banks, spits, and near-coastal shallow water areas), long lasting or even irreversible effects on water exchange and coastal sediment dynamics can be assumed. Such alterations may affect ecological conditions far beyond the extraction area and may also have considerable economic consequences for fisheries and coastal defence.

Since the 1970's, scientific interest has increasingly focussed on the implications of marine sediment extraction in the North East Atlantic region. In 1992 the “Working Group on the Effects of Extraction on the Marine Ecosystem” (WGEXT) of the International Council for the Exploration of the Sea (ICES) collected a growing amount of information and data on the effects of dredging and compiled a report (ICES 1992), which also includes a “Code of Practice for the Commercial Extraction of Marine Sediments”. This report was updated and finalised in 1998, but has not been published up to now. The Contracting Parties of the Helsinki Convention (HELCOM) for the Baltic Sea gave detailed advice on how to take environmental issues into account in marine sediment extraction projects in the form of HELCOM Recommendation 19/1 (Marine Sediment Extraction in the Baltic Sea, adopted 23 March 1998).

The Recommendation 19/1 advises national authorities to use adequate investigations and assessments of the natural conditions and the presumed environmental impacts as the basis for assessing applications. An Environmental Impact Assessment (EIA) is a prerequisite to any extraction permit. Permits are not granted, or are only issued after a thorough EIA has proven that there will be no major adverse impacts on sensitive areas such as regions with high protection status, endangered benthic communities, important fish spawning grounds or feeding grounds of fish and waterfowl. The choice of dredging technology must also be taken into account to minimise any environmental impact. A monitoring programme should be included as an essential component of any dredging activity.

HELCOM 1999: Marine Sediment Extraction in the Baltic Sea - Status report. Baltic Sea Environ. Proc. No. 76.

ICES 1992: Effects of extraction of marine sediments on fisheries, ICES Co-operative Research Report No. 182, Copenhagen 1992.

ICES 1998: Co-operative Research Report, Final Draft, April 24 1998.

16 ANNEX III - WORKING PAPER EXAMINING THE MEANS OF ADEQUATELY IDENTIFYING SPAWNING GROUNDS OF CRITICAL FISH SPECIES IN RELATION TO AGGREGATE EXTRACTION ACTIVITIES, PARTICULARLY HERRING.

S I Rogers.

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AIM

The purpose of this Working Paper is to address ToR d);

'examine means of adequately identifying spawning grounds of critical fish species in relation to aggregate extraction activities, particularly herring.'

SUMMARY

Some species of fish and crustacea require very specific seabed environments at particular stages of their life cycle, normally for spawning, egg brooding or egg deposition. The extraction of marine aggregates has the potential to damage these sites by removal or alteration of the sediment. One commercially important species with a very specific requirement is herring. A brief description of the seabed requirements of herring is provided, together with a protocol for identifying suitable sites currently used by the oil and gas industry. The importance of seabed sediments for other fish species, such as sea-bream, sandeel and overwintering crab, is also described.

IDENTIFYING HERRING SPAWNING GROUNDS.

In UK waters, the identification of herring spawning grounds that might be impacted by aggregate extraction could be based on well established procedures currently used by the oil and gas industry. The concern in this industry is based on the real potential of pollution and smothering of these sites by drill cuttings, lubricants and other chemicals discharged from rigs, and is particularly relevant in view of the decline in population size of North Sea herring.

To address this need for a protocol to identify herring spawning grounds, CEFAS provides the UK Department of Trade and Industry (DTI) with broad-scale information on the location of herring spawning grounds in UK waters, largely based on egg surveys. Where a spawning ground coincides with a block that has been licensed to a company for oil and gas exploration, conditions are added to the licence, which may include a range of activities, which are thought necessary to protect the marine environment. One of these conditions is the requirement to undertake a survey to locate herring spawning grounds, at a detail not available using standard CEFAS datasets.

Over a number of years CEFAS has developed a survey protocol in association with offshore operators, which should allow herring spawning grounds to be identified. Although the protocol is detailed (Appendix 1), it is not intended as a list of activities which must be completed in order to satisfy the conditions of the license. Instead, they are offered as one method of achieving the desired objective. It is based on an understanding of the environmental requirements of herring, and it is likely that a number of different techniques can achieve the required result.

Herring spawning grounds

The relationship between spawning herring and seabed substrate has been reviewed by De Groot (1980) and Nichols and Brander (1989). Herring lay eggs directly onto the seabed. Often the eggs are laid at high density, so that a well used spawning ground may support eggs in a layer several cm thick. A spawning ground of only 50m diameter can therefore support the spawning of ~1000 tonnes of adult herring. It is important that all eggs and particularly those nearest the sediment receive an adequate flow of well oxygenated water. In the central North Sea the most suitable sediments for herring are well sorted coarse sands and gravels, coarse shelly sand, or large unbroken shell fragments overlying gravel which allow good ventilation. If there is a large proportion of fine material (<63 micron) in the sample then it is unlikely to allow sufficient water circulation and it will not be suitable as a herring spawning ground. Thus sediments with plenty of ‘structure’, such as shell and stone will be more favourable than uniform coarse sand. In other areas, herring spawn directly onto rock, or small areas of hard substrate surrounded by mixed sediments. In general, a relatively strong tidal current is a feature of herring spawning grounds.

Sediments of this type often occur as raised features of the seabed because of the influence of water currents in creating these gravel and shell banks. There is, however, no specific requirement for herring spawning grounds to be raised from the seabed. Off the west coast of Scotland such raised spawning sites are common, however in the southern North Sea they do not always conform to this pattern and so can be more difficult to locate. The spawning ground survey protocol (Appendix 1) describes a method for locating patches or ribbons of coarse sediment, using a range of techniques beginning with a broad scale remote acoustic survey, and then using more precise visual methods (camera, video, sediment grabs) to ground-truth the acoustic signal. As herring spawn in restricted areas, indirect acoustic methods cover a large area quickly and so are useful as an initial survey tool. Survey recommendations are normally for a 4km by 4km side-scan sonar survey of the area, centred on the location of the well site, however alternative rectangular grids aligned with the direction of the prevailing water current (Figure 1) have also been used successfully. Areas which are identified by these remote methods should be sampled by grab so that particle size analysis can be undertaken. Photographs of the sediments before and after grab sampling are also useful, as these visual cues are often most important in deciding whether the site is a suitable spawning ground.

The distribution of herring spawning grounds is widespread in the North Sea and eastern Channel (Figure 2) (Postuma et al., 1974). Oil and gas exploration licence conditions which require these surveys are common, and several such surveys have been undertaken. The technique is not specific to this industry, however, and could be used by the marine aggregates industry to survey sites, if required.

It is important to note that there is no guarantee that a site suitable for spawning herring will support spawning fish; their protection is a precautionary measure.

IDENTIFYING SPAWNING GROUNDS OF OTHER SPECIES

Not only herring require specific sediments at a particular stage in their life-history. Male black sea-bream *Spondyliosoma cantharus* build nests in which the female lays her eggs. These nests are subsequently guarded by the male until the young hatch. Nests are build in depressions close to chalk cliffs, but very few of these sites have been identified. One such site is near Littlehampton on the south coast of England.

Sand eel (*Ammodytes* sp.) spend much of their time buried in clean sand where they hide from predators. They also deposit their sticky eggs in the same areas. Sand banks which support sandeel are common throughout the North Sea and western waters of the UK.

Female edible crab *Cancer pagurus* bury into coarse sediments during an extended period of egg brooding. Although the precise sediment preference of crab are unknown, they appear to prefer sandy gravel, gravely sand and gravel.

Sediments are also important for species which partially bury to avoid predation such as juvenile sole, plaice and other flatfish. These areas are widespread, but the importance of these nursery ground sediments is not addressed in this paper.

CONCLUSIONS

A protocol that is currently used by the UK oil and gas industry to identify potential herring spawning grounds is described. The technique is appropriate for use by others, for example the marine aggregate industry. Herring is not the only species that uses sand and gravel at a critical stage in their life-cycle, and it is necessary to examine the effect of marine aggregate extraction on a range of other fish and invertebrate species.

APPENDIX 1

SPECIFICATIONS FOR HERRING SPAWNING GROUND SURVEYS

1. AIM: To investigate and describe the superficial sediment structure in areas of proposed drilling sites and identify substrates suitable for herring spawning, such as raised gravel banks (sediment mainly >1.9mm) or substrates containing a mixture of sand and exposed gravel with low silt fraction.

1. SURVEY AREA: Grid of at least 4 x 4 km centred on proposed well site.

1. METHODS

3.1 Side Scan Sonar: Main survey to insonify seabed with minimum of 25% overlap between adjacent lines.

Range/speed/towfish depth and weather envelope shall be governed by the following requirements:

Record must extend fully to extent of paper record with no attenuation of signal due to surface noise. Fish heave or yaw should not distort the record.

Hard copy shall be slant range and towfish speed corrected with water column removed on main display. Raw signal (no corrections) will be displayed alongside main record for QC purposes, along with Range scale, frequency, time/date, Speed and course over ground, and Lat/Long annotation.

Lines shall be run parallel to axis of residual currents and three crosslines shall be run at 90 degrees to main pattern, one at top, one at bottom and one through the centre.

3.2 Positioning: Vessel positioning shall be accurate to 20 metres. Fish shall be towed with a maximum deflection angle that does not compromise coverage, and cable length shall be recorded at start and end of line. Where real time towfish positioning is not used cable length will not be changed during the survey line.

3.3 Simultaneous Bathymetry will be performed to accuracy of 2 metres. All soundings to be reduced to LAT.

3.4 Sediment identification:

3.4.1 Grab samples: A suitable sampler (e.g. Day grab) should be used to take sediment samples. One sample in which the surface sediment is undisturbed over at least 25% of the grab should be collected at each site. After allowing water to drain away, the depth of the sample in the grab should be recorded and the surface should be photographed. A representative sub-sample of approximately 250 ml should be removed from the top 5 cm from an undisturbed area of the grab sample for sediment particle analysis. The surface sediment should be described and any obvious differences in texture between the top 2-3 cm and deeper material should be noted (e.g. fine sand overlying sand and pebbles; black anoxic sediments etc).

3.4.2 Underwater 35 mm colour photographs: Single shots of the seabed should be taken at the same sites as grab samples. The minimum area of seabed covered should be around $0.1m^2$ and the height above seabed should be sufficient to allow discrimination of sediment features.

Sample frequency for both underwater photographs and grab samples will be dependent on results on the initial sonar record. For example:

i) areas of low reflectivity identified as muddy or fine sandy areas: low level of sampling required. Just sufficient to confirm nature of sediment.

ii) moderate reflectivity or variable sediment: increased level of sampling to enable comprehensive description of sediments to be made.

iii) high reflectivity of identified gravel patches: sample at sufficiently close intervals to allow the extent of any feature to be mapped.

4. **PRESENTATION OF RESULTS**

4.1 All positions should be Latitude and Longitude (Degrees, minutes and decimal minutes). Datum, grid and Geod should be same as the largest Admiralty chart of the area (usually TM/OSGB/Airy).

4.2 Examples of side scan sonar records which illustrate differences in sediment reflectivity or particular features should be included. All other sonar records should be kept for possible verification but need not be included in the report. Vessels DGPS position should be automatically input and anotated on all sonar records, i.e. RS232 link from DGPS RX. Two minute intervals is reasonable.

4.3 A table should be provided, listing the nature of the sediment at each grab site based on (a) sonar (b) underwater photograph and (c) description of surface sediment in grab.

4.4 Examples of underwater photographs and photographs of the undisturbed grab samples should be included, clearly referenced to position taken, to illustrate differences in sediment types. All other photographs should be kept but need not be included in the report.

4.5 Results of sediment particle size analysis should be presented as tables or plots of % weight for each fraction together with summary statistics including, as a minimum, man particle size, percentage <.063 mm, percentage >1.9mm.

4.6 Charts should be prepared showing the following:

- general location of survey area in relation to UK coast.

  large scale chart (approx. 1:7500 or 1:10,000) showing sonar track plot and with any areas where 25% overlap was not complete being clearly identified

- large scale chart (approx. 1:7500 or 1:10,000) showing as a minimum(a) seabed contours (b) general areas of sonar reflectivity (c) interpreted seabed substrates (d) positions of underwater photograph and grab sample sites.

4.7 The nature of the sediments in the survey area should be described and any areas with material over 1.9mm or with high content of material <0.63mm should be clearly identified.

REFERENCES

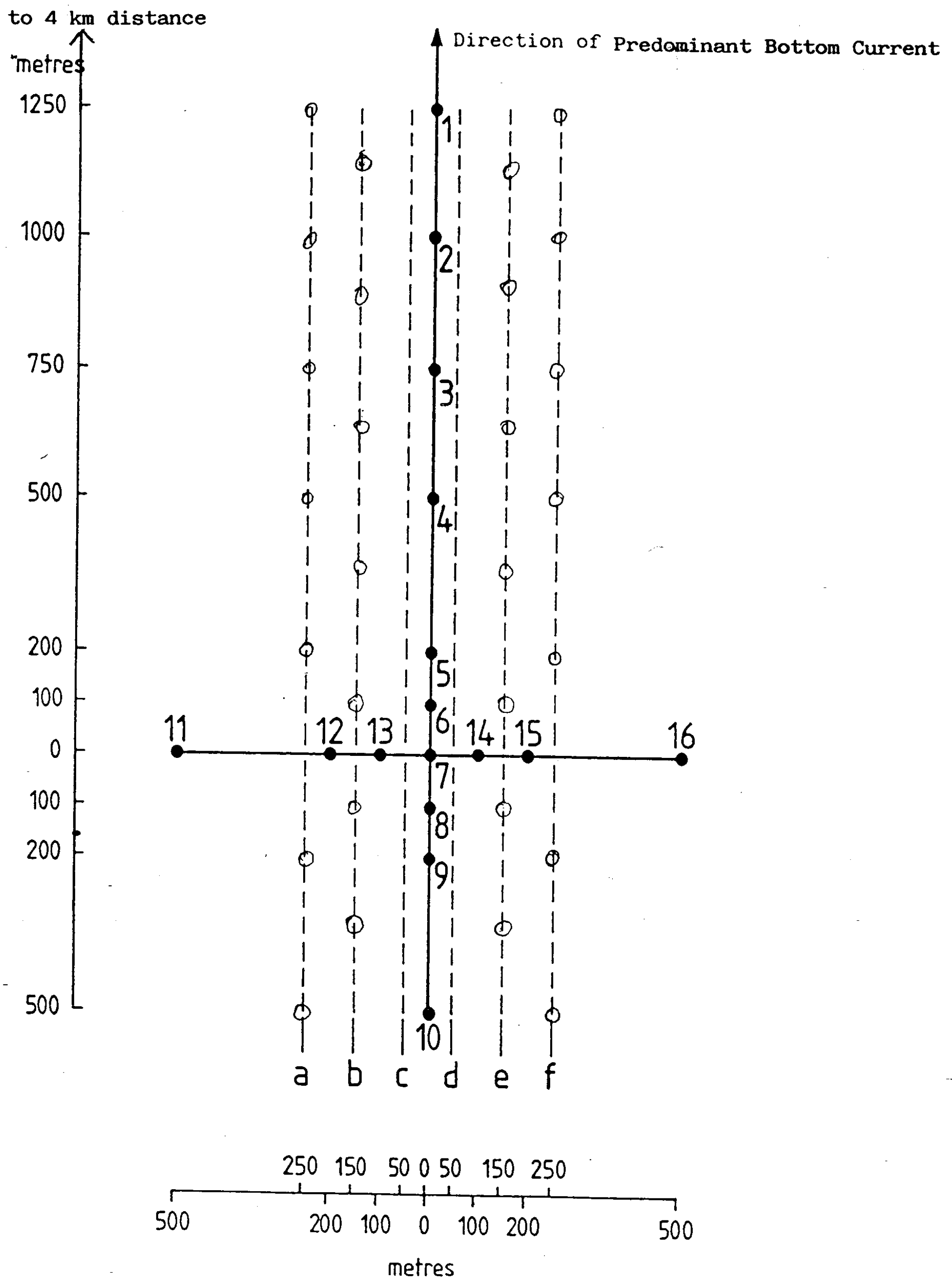
De Groot, SJ de 1980 The consequences of marine gravel extraction on the spawning of herring *Clupea harengus*. J. Fish Biol. 16: 605-611.

Nichols, JH & Brander, KM 1989 Herring larval studies in the west-central North Sea. Rapp. P-v. Cons. Int. Explor. Mer. 191: 160-168.

Postuma, KH, Saville, A & Wood, RJ 1974 Herring spawning grounds in the North Sea. Unpublished ICES Working Paper, Working Group on North Sea herring larval surveys, 14 pp.

Figure 1

Pre-drilling survey area showing locations of fixed grab sampling stations for chemical analysis of sediments and underwater closed-circuit television transects.



1-16 inclusive. Fixed Grab Sampling Stations. (Station 7 - Proposed Drilling Location) **for sediment chemical analysis.**

a-f inclusive. Underwater Closed-Circuit Television Transects.

o and ● suggested sites for core samples (Craib corer or cores from grabs) to show sediment type and confirm TV and photographic results.

FIGURE 2

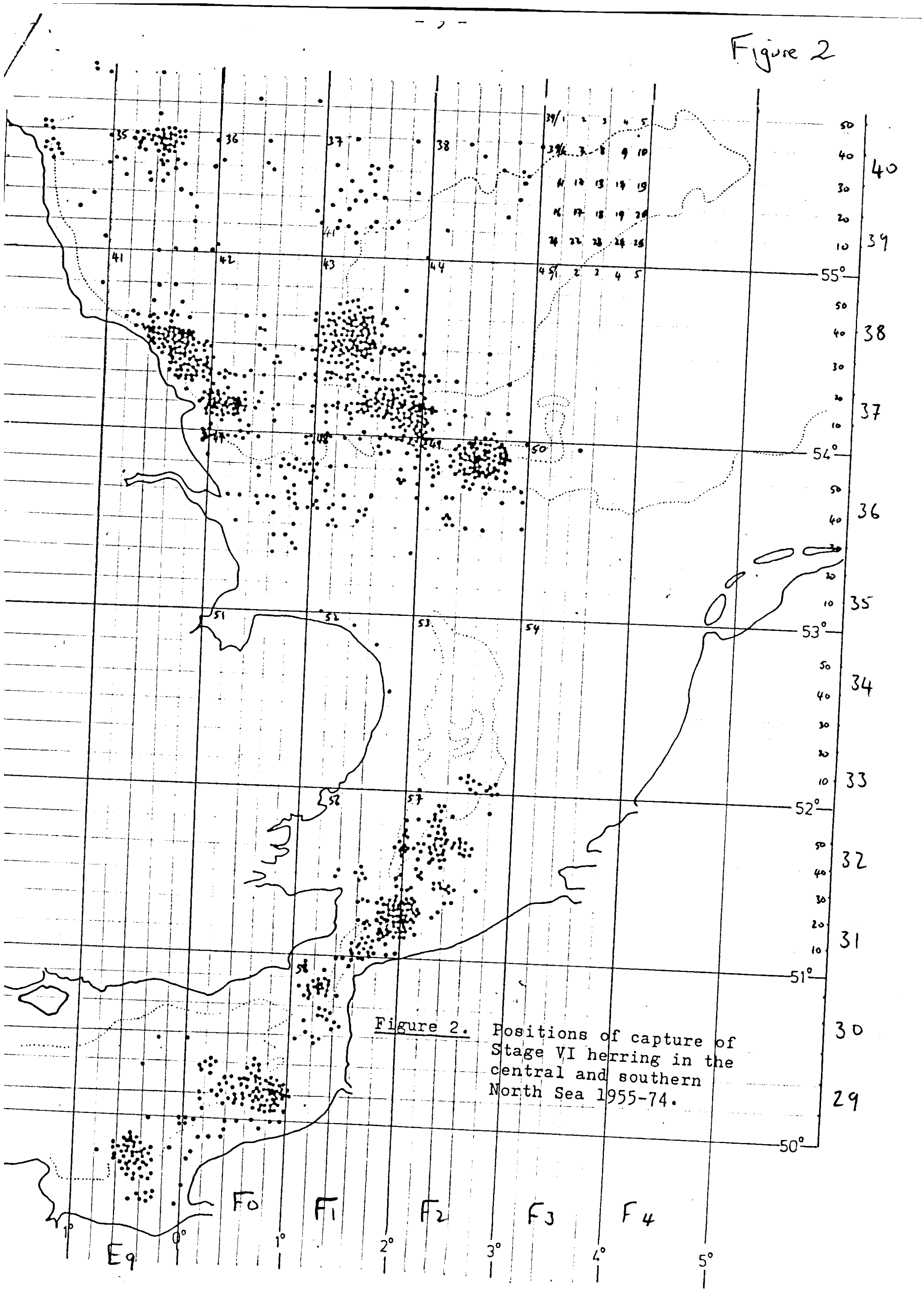


Figure 2. Positions of capture of Stage VI herring in the central and southern North Sea 1955-74.

ANNEX IV - STATISTICS - A TOOL TO CONTROL REQUIREMENTS

Prepared for The National Forest and Nature Agency, Denmark, by:

C. F. Christensen, M.Sc., Ph.D. Rambøl

Abstract:

When a physical parameter is evaluated by direct measurements or indirect by calculations based on other parameters, it is also often necessary to get an indication of the quality of the result. The indication is important for those who will ultimately use the result or make decisions based on it. Without an indication of uncertainty, the results based on different assumptions and methods cannot be compared. This abstract attempt to illustrate some of the advantages of statistical methods in relation to requirements stated by the different authorities.

The recognition that the world is not deterministic is making progress and the statistical method is therefore beginning to propagate into requirements made by different authorities. It is acknowledged that even though a result is corrected for all known errors there will always be some uncertainty and the natural question is therefore how well does the result reflect the true but unknown parameter.

The fairness in statistical requirements is obvious. The outcome of a situation where a measurement is less than the required limit does not necessarily mean that the requirement is fulfilled. However, a repeatable number of measurements that fall within given limits will provide a higher level of confidence that the requirements are being met. There will be an obvious indication that the former result will be less certain.

The statistical viewpoint is illustrated in Figure 1 which shows environmental capacity. The distribution is obtained on the basis of expectations and/or evaluations of models describing the environmental capacity. This evaluation will be uncertain and the width of the distribution indicates the uncertainty. The wider the distribution the greater the uncertainty. The expected environmental capacity is also shown and in this case it corresponds to the most likely value. If this value is exceeded the probability of damaging the environment will be around 50 % depending of the type of distribution.

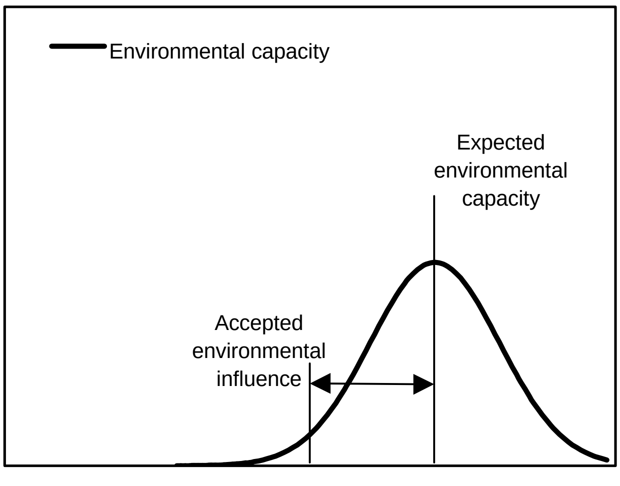


Figure 1: Decision process – Excepted environmental influence.

In order to ensure that the environment will not be damaged, it would be reasonable to choose a requirement that lies in the lower part of the distribution where the probability of damaging the environment is minimal. The effect of the work is included in Figure 2. In the phase before the work has started the distribution may be obtained on the basis of model calculation, experience from previous work or a best guess. In the phase where the work is ongoing, an estimate of the true distribution can be obtained from values or calculations based on the measurements.

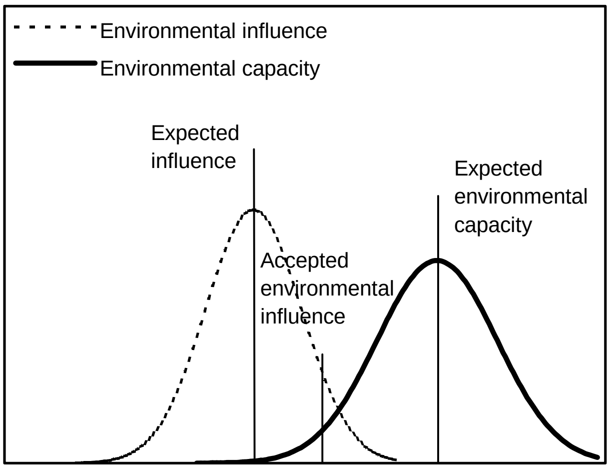


Figure 2: Decision process – Capacity and influence.

It can be seen from Figure 2 that the two distributions are overlapping each other. There is therefore a small probability that the effects f the work will exceed the environmental capacity. It can also be seen that there is a small probability that the effects of the work will influence the environmental beyond the acceptable environmental influence.

It is important to realise the fact that no matter how many restrictions and requirements are stated, there will almost always be a probability of damaging the environmental. It is therefore important to have a tool to control this probability.

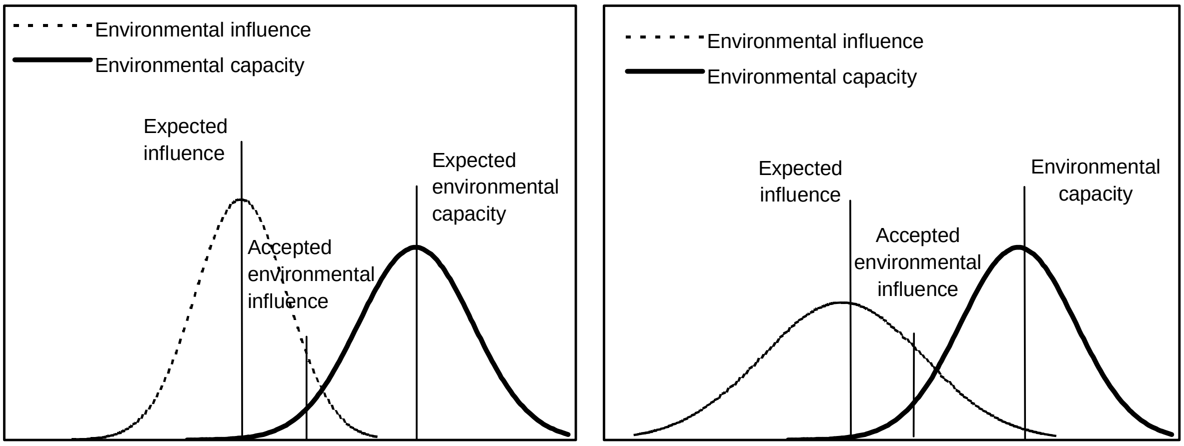


Figure 3: Decision process – Capacity and influence.

The effect of different evaluations of the uncertainty from the activity is shown in Figure 3. In both figures the expected influence is the same, but the estimated influence in Figure 3 left, is well determined and the width of the distribution is therefore reduced and the curve becomes narrow and tall. The area at the right hand side of the accepted environmental influence and below the curve describing the influence of the work is approximately 3 times as large in Figure 3 right-hand, and the probability of exceeding the limit is therefore 3 times as large in that case.

From the problem illustrated in Figure 3, it can be seen that the probability of exceeding the environmental capacity can and should be controlled through requirements of the expected influence and the maximal uncertainty on the influence of the work.

The statistical tool is particularly useful with respect to environmental monitoring, where the upper limit of the damaging effect is potentially known. The statistical requirements can be formulated in such a way, that if they are fulfilled the probability of exceeding the critical level will be very small.

Relations between uncertainty and the number of observations.

In order to get an estimate of the mean value (which often is the most likely value) it is important to get information about the uncertainty/variation of the considered parameter. The distribution of the considered parameter is often not known and the coefficient of variation for a single outcome of a measurement may therefore be estimated from the known information. This will typically be based on experience of similar cases or an engineering judgement. Based on this estimated value, the uncertainty of the mean value obtained from a given number of measurements can be found, (see Figure 4).

However, the procedure will typically occur in an opposite direction. A given requirement from the authorities could be that the parameter must be known with a given uncertainty (coefficient of variation) and in order to obtain this, the appropriate number of measurements must be found. The relationship is illustrated below.

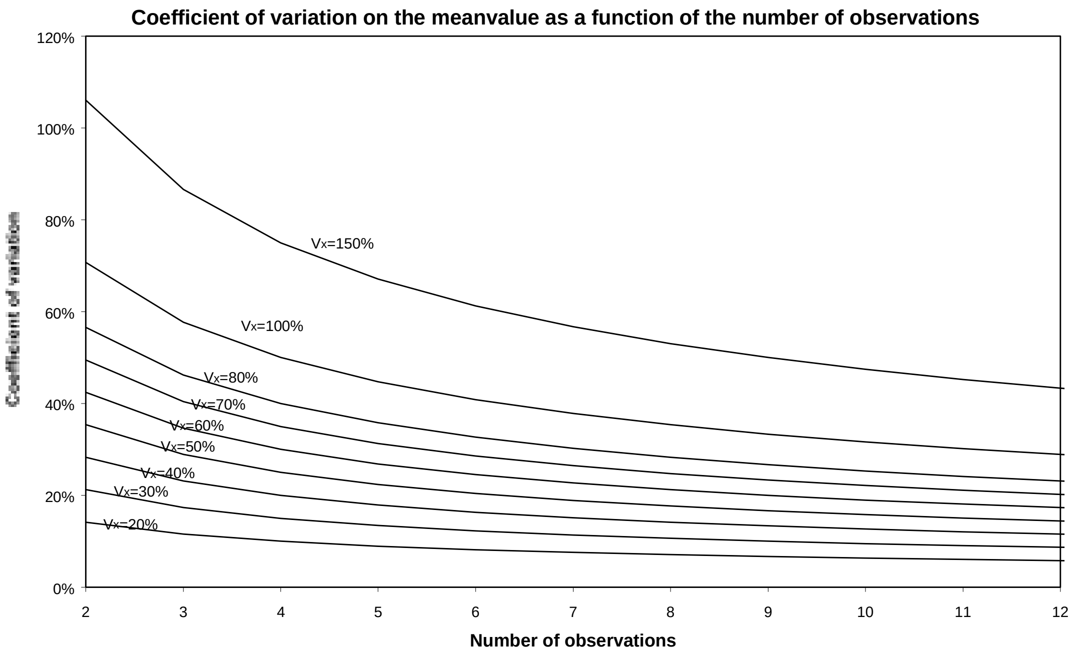


Figure 4: Relation between the uncertainty on a single measurement/observation and the uncertainty on the mean value based on a given number of observations.

It should be mentioned that this figure is based on a number of assumptions. First of all, the measurements must be uncorrelated, i.e. there is no dependency between any of the measurements. If the measurements are carried out on a slowly varying parameter the duration between each measurement must be quite large. Secondly the measurements must be representative.

This means that all important situations are covered and the main part of the measurements represents what we might call the normal case. Moreover, it is assumed that each measurement has the same weight (they have the same duration or amount etc.) and finally it is assumed that the considered parameter is stationary and there is therefore no trend in time.

ANNEX V - MAPPING OF GRAVEL BIOTOPES AND AN EXAMINATION OF THE FACTORS CONTROLLING THE DISTRIBUTION, TYPE AND DIVERSITY OF THEIR BIOLOGICAL COMMUNITIES. (PROJECT A0908)

Date project commenced: April 1998 **Duration of project:** 3 years

Organisation undertaking the research project: The Centre for Environment, Fisheries and Aquaculture Science

Funding bodies: MAFF

CEFAS is currently involved in a programme of research to evaluate the utility of acoustic techniques, used in conjunction with traditional biological sampling methods, for mapping seabed biotopes (physical habitats and their associated biological assemblages). The production of high-resolution biotope maps of the seabed would assist in future site-specific environmental assessments of potential dredging areas, and would be of value during any subsequent environmental monitoring activities. Many of the techniques under development would also be of direct relevance to a number of other environmental management/impact assessment applications (e.g. environmental monitoring of disposal sites/SACs etc.).

ABSTRACT OF RESEARCH

To establish the utility of seabed mapping techniques for surveying habitats which can then be applied in other areas to provide an essential underpinning to future site-specific environmental assessments of potential dredging areas. It will also describe the biological variation in areas dominated by the gravel biotope (i.e. habitat and associated communities) over different spatial scales and determine the major factors influencing this biotope in an area of the eastern English Channel. The biology and sedimentology of the seabed will be investigated and, with available information on the hydrodynamic regime, used to explain variability in the benthic ecosystem. Together with information on fish/shellfish stocks and the distribution of fishing effort, that will enable an assessment of the implications for resource exploitation.

The work is of direct relevance to the development of policy for extraction of the aggregate resource from the seabed ensuring sustainability of the associated ecosystems. Knowledge and techniques developed by this work will enable a more effective and structured approach to the assessment of the potential environmental impacts of applications for licences to extract aggregates from the seabed by aggregate companies and their consultants. This will both enhance the scientific basis for prediction of the effects of extraction activities and improve judgements of acceptability for licence applications.

RESEARCH AIMS

- Establish the utility of seabed mapping techniques for surveying habitats to provide an essential underpinning to future site-specific environmental assessments of potential dredging areas.

- Fill fundamental gaps in knowledge by elucidating the major factors that operate over various scales (Km^2 to m^2) and are responsible for determining the character of the gravel biotope. Such factors include substrate composition and bathymetry coupled with dynamic features of the water column. This will provide a greater understanding of the sources of ecological variation and supplement knowledge regarding the functional significance of the gravel biotope to fisheries and as an environmental resource.

A major challenge for the proposed work is to sample at relevant scales. This will be achieved by deployment of state-of-the-art seabed mapping tools, closely linked with physical and biological sampling, to derive descriptions of the nature and extent of the habitat. As an aid to interpretation of the output the data will be incorporated into a geographic information system (GIS) which will be of subsequent use in the provision of advice on specific licence applications within the areas surveyed. Appropriate measures will be identified to quantify the biological ‘sensitivity’ of seabed types in the event of future exploitation. Site specific findings will be used to derive generic hypotheses for change, thereby ensuring the wider application of the experienced gained.

RESEARCH OBJECTIVES

Summary Objective: To assess the utility of seabed mapping techniques for surveying habitats and examine the environmental influences affecting gravel biotope communities.

1. To characterise the seabed in an area of the eastern English Channel using various physical and geophysical techniques.

2. To incorporate biological, sedimentological and hydrographic information along with existing environmental and fisheries data into a geographic information system, in order to evaluate the functional role and importance of the gravel biotope relative to other substrate types, and for use in licensing procedures for the area surveyed.

3. To determine the causes of biological variation and of observed patchiness and to devise appropriate sampling strategies to allow for this variation. This work will take particular account of dynamic aspects of the environment within which the benthic communities have developed.

4. To establish the utility of seabed mapping techniques for surveying habitats.

5. To examine broad-scale fishery-independent beam trawl survey data from the eastern English Channel. Describe the range of assemblages sampled using dominance of commercially important fish and macro-epibenthic invertebrate by catch, and where possible explain the ecological rationale for observed patterns in species affinities.

6. To evaluate the susceptibility of gravel biotope benthic communities to anthropogenic disturbances in contrasting areas, particularly by dredging. This will involve the testing of established and novel methods for describing and quantifying biological status and sensitivity.

7. To report on the significance of the findings for the management of aggregate extraction activities.

SUMMARY OF THE PROJECT TO DATE

Work began in 1998 with a preliminary survey covering a small area of seabed (approx. 4 km x 11 km) to the East of the Isle of Wight. This work was reported on at last years ICES Sand and Gravel Working Group.

In year 2 of the research programme an area of seabed in the English Channel off Shoreham (12 x 28 km) was chosen for study. This area was selected following the findings of the preliminary survey, which indicated that relationships between the fauna and habitat type derived from acoustic information were more complex then initially envisaged, which were probably a reflection of the small-scale variability of the sediments in the area. In order to fully evaluate the relationship between physical seabed properties and biological assemblages, and to develop the biotope mapping methods further, it was deemed necessary to conduct the main follow up surveys across areas of seabed with strong physical and biological gradients, with distinctive boundaries between adjacent habitats of discrete, homogeneous sediment types. It is anticipated that by selecting such an area the evaluation of the use of acoustic and ground-truth methods for mapping the distribution and extent of biotopes would be facilitated. The area at Shoreham fitted these criteria. Problems encountered due to small-scale sediment heterogeneity, in areas such the Eastern Isle of Wight, would then be re-addressed towards the end of the research programme.

A further two smaller areas were also selected for study, one offshore from Hastings, and the other to the East of Dungeness. Both of these sites contain similar sediment types to those encountered off Shoreham, but have greater small-scale spatial complexity in the arrangement of their sediment types. Surveys at the three selected locations were conducted in July and August 1999.

The Shoreham and Dungeness areas were intensively surveyed in July 1999 using a combination of acoustic techniques (Data Sonics Chirps side scan sonar, RoxAnn and QTC View). Treating each site separately, the acoustic data was used to divide each area in to acoustically distinct regions. These distinct regions were then sampled during a follow up ground-truth and biological survey in August 1999, using a suite of sampling techniques (Hamon grab fitted with a video camera, Rallier du Baty dredge, underwater video). An identical procedure was carried out at the Hastings site during surveys in October and November 1999.

Biological and acoustic data are currently in the process of being worked up and findings from these surveys will be reported on in late 2000, early 2001.

17 ANNEX VI - DRAFT GUIDANCE ON ENVIRONMENTAL IMPACT ASSESSMENT IN RELATION TO DREDGING APPLICATIONS IN ENGLISH WATERS

INTRODUCTION

1. Marine sand and gravel extraction in English and Welsh waters will shortly be brought under statutory control with the introduction of the Environmental Impact Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations 2000. These Regulations will transpose the requirements of the European Community Directives on Environmental Impact Assessment for certain public and private projects[1] and on the conservation of natural habitats and of wild fauna and flora[2] into national law in so far as they relate to the marine dredging of minerals around the coasts of England and Wales.

2. In parallel with preparatory work on the Regulations, the Department of the Environment, Transport and the Regions have been preparing guidance to explain how the Regulations will work within English waters (Marine Minerals Guidance Note 1 (MMG1)), and to provide a broader policy framework for marine aggregate dredging (MMG2). These two documents will be made available when the Regulations come into force.

3. One of the key implications of the Regulations will be to make EIA a statutory requirement and bring it to the heart of decision making. MMG2 will include an Annex which contains general advice on the issues that should be considered when undertaking an EIA. A copy of the draft text is provided below. It builds on the advice provided in the MAFF Leaflet 73[3], and recent discussions between DETR, MAFF and CEFAS. DETR has also commissioned CEFAS to develop more detailed guidance on procedures for conducting benthic studies at aggregate dredging sites as part of an EIA process and for monitoring purposes. Details are provided separately.

4. This Annex is offered to ICES in its draft form as a contribution to discussions on approaches to EIA in respect of marine aggregate dredging.

DETR

April 2000

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1 85/337/EEC as modified by 97/11/EC

2 92/43/EEC

3 Campbell J.A. (1993) Guidelines for assessing marine aggregate extraction. MAFF Directorate of Fisheries Research, Lowestoft, Laboratory Leaflet (73): 12pp.

EXTRACT FROM THE WORKING DRAFT OF MARINE MINERALS GUIDANCE NOTE 2 ON ENVIRONMENTAL IMPACT ASSESSMENT IN RELATION TO AGGREGATE DREDGING APPLICATIONS.

INTRODUCTION

B1. The extraction of marine sand and gravel has the potential to impact unacceptably on the coastal environment, commercial fisheries, marine ecosystems, navigational routes, archaeological sites and other users of the sea. It is therefore important that dredging is only undertaken at a location and in a way that does not have unacceptable impacts.

B2. Regulation 4 of the Environmental Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations 2000 requires that any person wishing to carry out a dredging operation should first determine from the Secretary of State whether the proposal comprises or forms part of a relevant project. The Secretary of State is required to take account of the criteria set out in Schedule 2 to the Regulations which consider the characteristics of the project, its location and the potential impact (see MMG1). However, as indicated in paragraph 24 of this note, the Government has decided that all applications for new dredging permissions will require an EIA.

B3. The applicant is therefore required to prepare an environmental statement (ES) as part of the application process. This should include such of the information set out in Part I of Schedule 1 to the Regulations as is reasonably required to assess the environmental effects of the relevant project and which the applicant can be reasonably be required to compile, having regard in particular to current knowledge and methods of assessment. However, it must include at least the information set out in Part II of Schedule 1 (see Box 1).

B4. Guidance on the procedural steps to be taken when preparing an ES is explained in MMG1. The following text provides guidance on the issues that should be considered when assessing the environmental effects of the proposed project. It is in four sections, reflecting the requirements of the Regulations:

- Description of the proposed activity and environment
- Assessment of the potential effects of the dredging activity
- Measures to avoid, reduce or remedy significant adverse effects
- Monitoring of environmental effects

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BOX 1. SCHEDULE 1 TO THE 2000 REGULATIONS

INFORMATION REFERRED TO IN THE DEFINITION OF ENVIRONMENTAL STATEMENT

PART I

1. Description of the project, including in particular -

(a) a description of the physical characteristics of the whole project and the land-use requirements during the construction and operational phases;

(b) a description of the main characteristics of the production processes, for instance nature and quantity of the materials used;

(c) an estimate, by type and quantity, of expected residues and emissions (water, air and soil pollution, noise, vibration, light, heat, radiation, etc.) resulting from the operation of the proposed project.

2. An outline of the main alternatives studied by the applicant and an indication of the main reasons for his choice, taking into account the environmental effects.

3. A description of the aspects of the environment likely to be significantly affected by the proposed project including, in particular, population, fauna, flora, soil, water, air, climatic factors, material assets, including the architectural and archaeological heritage, landscape and the inter-relationship between the above factors.

4. A description of the likely significant effects of the proposed project on the environment, which should cover the direct effects and any indirect, secondary, cumulative, short, medium and long-term, permanent and temporary, positive and negative effects of the project, resulting from:

(a) the existence of the project;

(b) the use of natural resources;

(c) the emission of pollutants, the creation of nuisances and the elimination of waste, and a description by the applicant of the forecasting methods used to assess the effects on the environment.

5. A description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment.

6. A non-technical summary of the information provided under paragraphs 1 to 5 of this Part.

7. An indication of any difficulties (technical deficiencies or lack of know-how) encountered by the applicant in compiling the required information.

PART II

1. A description of the project.

2. A description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects.

3. The data required to identify and assess the main effects which the project is likely to have on the environment.

4. An outline of the main alternatives studied by the applicant and an indication of the main reasons for his choice, taking into account the environmental effects.

5. A non-technical summary of the information provided under paragraphs 1 to 4 of this Part.

DESCRIPTION OF THE PROPOSED ACTIVITY AND ENVIRONMENT

Description of the proposed activity

B5. This should cover the following issues:

- the location of the proposed dredging area should be specified by a list of co-ordinates together with a map showing its location in relation to the surrounding sea area and adjacent coastlines. The size of the area should be specified in square kilometres.

- the total volume of material to be extracted should be stated together with an indication of the maximum depth to which material will be removed.

- a description of the material to be extracted should be given indicating the particle size distribution of the material found within the proposed dredging area. This should be presented as the percentage of gravel, sand and finer material, at representative locations within and adjacent to the application area.

- the type of dredgers to be used should be described (e.g. trailing suction hopper dredger), together with details of the vessels' load capacity, overflow arrangements and operating methods. It should be made clear whether on-board screening (i.e. rejection of fine or coarse fractions) is to be used.

- proposals should state the proposed annual extraction rate and the predicted lifetime of the deposit.

- estimates should be provided of the likely number of shipping movements on an annual, and where appropriate, seasonal basis, and the number of vessels likely to be operating within the area at any one time. The routes likely to be taken by dredgers to and from the application area should also be specified.

- The applicant should provide details of their proposed operational control procedures to ensure that dredging only takes place in the permitted area and that interference with other users of the sea is minimised both within and outside the proposed extraction area. Applicants should consider appropriate notification and liaison arrangements with other relevant users of the sea (e.g. fishermen) to ensure harmonious working relationships between the different parties.

- Details of the wharves/ports where the extracted marine aggregate is to be landed.

- The need to exploit the resource in question through careful, comparative consideration of local, regional and national need for the material in relation to the identified impacts of the proposal and the relative environmental and social costs of provision from other marine and terrestrial sources.

DESCRIPTION OF THE PHYSICAL NATURE OF THE SEABED

B6. The physical aspects that should be considered include:

- a description of the geology and geomorphology of the application area and its surrounds, including the nearby coast, indicating where possible, its recent evolution.

- bathymetry of the seabed in the proposed area together with a surrounding strip of at least 1km outside.

- assessment of the hydrodynamics of the general area including tidal regime, wave conditions and residual water movements. Notable features on the seabed and indicators of tidal current strength and direction should be identified. Assessment of the mobility of the seabed and sediment transport pathways should be based on direct observations, numerical modelling, or inferred from bedform asymmetry and type.

- the characteristics of the seabed sediments in and around the site should be identified using side-scan sonar and grab sample data. The mineral resource characteristics including its particle size and lithology, origin and composition, thickness, and nature of underlying deposits should be identified.

- a baseline assessment should be undertaken of water quality in the area prior to dredging. This should include an assessment of suspended sediment load, and where appropriate any chemical contamination. An indication of seasonal variability is also necessary.

DESCRIPTION OF THE BIOLOGICAL STATUS OF THE PROPOSED AREA

B7. The benthic survey should be undertaken by properly qualified and experienced personnel. The sampling strategy, including the number of sampling stations, the method used to collect samples and the method of sorting and recording should be agreed beforehand with MAFF and English Nature. Further guidance on appropriate procedures for undertaking benthic surveys will be produced shortly by CEFAS on behalf of DETR.

B8. The ES should provide the following:

- a summary of the techniques used, and records of all species identified and their abundance at each sampling station

- a description of the benthic communities present within and adjacent to the application area. This should include evaluation of the typical assemblages of species, including diversity, abundance, extent, species richness, representativeness, naturalness, rarity and fragility in and around the proposed dredging area;

- an indication of the sensitivities of particular habitats and species, e.g. *Sabellaria* reefs, or *Modiolus* beds.

- an assessment of known predator-prey relationships, and measures of abundance of dominant species likely to be influenced by dredging, including temporal and spatial population dynamics of the benthic assemblages;

- the fisheries resources of the region, including the location of spawning grounds, nursery or feeding areas and migration routes, taking account of seasonal variability;

- an assessment of the importance of the general area for protected species such as sea birds and marine mammals.

Other users of the sea

B9. There are many other legitimate users of the sea. It is important that dredging does not cause unacceptable disturbance to them. The ES should identify the extent to which the following activities may be affected by dredging.

(a) Commercial fishing activity. The ES should include:

- an assessment of the nature and level of commercial fishing activities in the vicinity of the application area. This should involve consultation with the fishermen’s organisations, and analysis of published statistics on fish landings from the dredged area. However, since published statistics are normally on too coarse a scale, fishermen’s logbook data and special fishery intensity studies are preferred. Statistics should cover a period before dredging starts to provide a baseline. The natural fluctuations in fish populations from year to year mean that ideally, a number of years of pre-dredging data is required.

- information about the recent and current numbers of vessels and fishing patterns in the area, together with species, quantities and values of catches from the area, indicating the extent of seasonal activity. Consideration should be given to the number of vessels operating out of the various ports, and fishing methods used. This will have a bearing on the time that fishing gear is left at the seabed, and therefore the amount of warning required in advance of dredging operations commencing.

- for each commercial species, details of the weight of catch and catch value for each port of landing. Since official statistics are generally thought to underestimate the true landings there is a need to adjust the figures accordingly to predict the actual catch.

- using the catch information, provide an estimate of the proportion of the landing at a particular port, relating this to the amount of fishing effort over the application area. This gives some indication of the relative contribution that the application area makes to the total catch and therefore gives some indication of the commercial value for fishing of the application area.

(b) other dredging activities in the area;

(c) waste disposal operations (by dumping or pipeline) in the region;

(d) offshore oil and gas activities which might impact or limit dredging;

(d) marine archaeology e.g. wrecks and war graves;

(e) shipping and navigational hazards;

(f) location of military exercise areas;

(g) location and magnitude of recreational activities such as yachting, angling and SCUBA diving;

(h) location of pipelines, cables and other such features;

(i) location of designated conservation areas (SSSIs, SACs and SPAs) and heritage areas (Heritage Coast, AONB).

ASSESSMENT OF THE POTENTIAL EFFECTS OF THE DREDGING ACTIVITY

B10. When evaluating the potential effects of the proposed dredging programme the ES should identify and quantify the consequences of the proposal. Ideally, this should be summarised as an impact hypothesis, drawing on the results of earlier studies. The assessment of some of the potential impacts will require predictive techniques, and it may be necessary to use appropriate mathematical models. Where such models are used there should be sufficient explanation to enable an informed assessment of their suitability for the particular modelling exercise to be undertaken.

B11. The ES will also need to demonstrate that a permission is unlikely to result in unacceptable cumulative physical and/or biological impacts i.e. the combined effects of dredging and other activities in nearby areas as well as within the proposed dredging area.

PHYSICAL EFFECTS OF DREDGING

B12. To assess the physical impact of aggregate extraction on the hydrographic and seabed environments, information should be provided on:

- likely production of a sediment plume (from the draghead at the seabed, from hopper overflow, or on-board screening) and its subsequent transport within the water column or along the seabed. This should be considered together with the background suspended load.

- implications for coastal erosion (through a Coastal Impact Study), in particular;

\- whether the dredging is far enough offshore for there to be no beach draw-down into the deepened area;

- whether the dredging will interrupt the natural supply of materials to adjacent beaches through tides and currents;

- the likely effect on bars and banks which provide protection to the coast by absorbing wave energy, and the potential impact on local tidal patterns and currents;

- likely changes to the height of waves passing over dredged areas and the potential effect on the refraction of waves leading to significant changes in the wave pattern;

- the likely effects on the seabed of removing material. In particular the nature of the sediment to be left once dredging ceases, and the likely topography (e.g. ridges and furrows);

- implications for local water circulation resulting from the removal or creation of topographical features on the seabed;

- assessment of the impacts in relation to other active or proposed dredging operations in the area.

B12. Further guidance on assessing the effects of dredging on the coastline is contained in '*Regional seabed sediment studies and assessment of marine aggregate dredging'* produced by CIRIA.

BIOLOGICAL EFFECTS OF DREDGING

B13. The principle biological impacts of dredging are direct disturbance and removal of benthic species, and alteration of the nature of the seabed upon which colonisation depends. This can affect the suitability of the seabed as a fish or shellfish food resource or habitat. Dredging should aim to leave the seabed in a similar physical condition to that present before dredging started to enhance the possibility of, and rate at which, the seabed recovers physically and biologically to its pre-dredging condition.

B14. The EIA should consider:

- variability of benthic species and communities over time and spatially, together with an indication of the likely rate of recovery following the cessation of dredging;

- the potential impact on the fish and shellfish resources, both within and outside the application area. Particular attention should be given to spawning and nursery areas and overwintering grounds for ovigerous crustaceans (for example, egg bearing lobsters and crabs) and known migration routes.

- Potential impacts on seabirds, marine mammals, and sharks.

EFFECTS ON OTHER USERS OF THE SEA

(a) Potential effects on commercial fisheries

B15. Dredging has two potential effects on commercial fisheries. The first is to modify the marine environment in such a way that it affects fish stocks, for example, by interfering with fish spawning and nursery areas, or migration routes. The second is the direct effect on the activities of fishermen.

B16. Consideration should be given to the noise and the sediment plumes which dredgers may cause, which could result in the temporary movement of fish out of the area, and could therefore put some fisheries out of the reach of smaller vessels.

B17. Dredging may also affect fish stocks indirectly, by disturbing benthic communities which provide the food source for commercial fish. Depending on the size of the area affected, highly mobile fish species may be able to move to other feeding grounds. But this can affect local fishermen. The ability of fishermen to avoid dredging areas will vary depending on the fishery they pursue and the size and complexity of their boats.

B18. MAFF should be consulted on the availability of information on such matters as the location of spawning areas, important known feeding/nursery grounds, migration routes and over-wintering grounds for egg-bearing crustaceans.

(b) Other activities

- Careful consideration will need to be given to applications which may interfere with other users of the sea, shipping lanes, areas adjacent to buried pipelines and cable routes, wrecks and MOD sites.

- The effect on sports fishermen, leisure craft and divers should also be carefully considered.

POTENTIAL EFFECTS ON MARINE ARCHAEOLOGICAL SITES

B19. The Joint Nautical Archaeology Policy Committee has produced a Code of Practice for Seabed Developers[4]. This provides recommended procedures for consultation and co-operation between seabed developers and archaeologists. This is consistent with the Government's policy on archaeology as stated in PPG16[5], and should continue to be followed by the dredging industry. The Secretary of State will have regard to the Code in considering applications for dredging permissions.

MEASURES TO AVOID, REDUCE OR REMEDY SIGNIFICANT ADVERSE EFFECTS

B20. The ES should include consideration of the practical steps that might be taken to mitigate the effects of the proposed mineral extraction. These should be site specific and closely linked to particular potential environmental effects identified during the EIA process. Mitigation measures may include:

- modification of the dredging depth to limit changes to hydrodynamics and sediment transport patterns to acceptable levels;

- agreed dredger navigation routes to minimise interference with shipping, fishing and other users of the sea;

- a zoning of the permitted area to protect sensitive fisheries, optimise access to traditional fisheries, and to reduce the impact on sensitive benthic assemblages;

- exclusion zones to protect rare or stable communities identified as occurring in small areas within a much larger application area. Such exclusion zones also provide a refuge for species that may assist in the eventual recolonisation of the worked-out area. Where such an approach is considered appropriate, it is important that the exclusion zones are large enough to protect the area of critical importance.

- the choice of dredging technique and the timing and phasing of working may also assist in preventing disturbance. For example it may be appropriate to allow dredging only at particular stages of the tide to ensure that disturbed sediments are taken away from exclusion zones by the tide.

- seasonal restrictions, where appropriate, to minimise impacts on migratory fish stocks or on vulnerable life history stages of fish or the benthos;

- safety buffer zones around important wrecks, war graves, or other marine archaeological sites, pipelines and cables;

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4 Ref?

[5] Archaeology and Planning

B21. It may often be necessary to seek expert advice to devise measures to protect species such as seabirds, and marine mammals, where these are at risk. Such advice may be available from English Nature.

B22. When considering mitigating measures, a balance has to be struck between the ecological or other importance of the area and the level of protection afforded to it. If an area is identified to contain or, in some other way, to support (e.g. as feeding grounds) important species, this may be sufficient cause to prevent dredging (or other forms of seabed disturbance) altogether.

MONITORING OF ENVIRONMENTAL EFFECTS

B23. Conditions attached to permissions are aimed at minimising environmental effects by controlling the operation of dredging activity. However, in many cases it is not possible to predict all the environmental effects at the outset. A programme of monitoring can be used to assess the validity of the predictions made in the EIA as well as establishing whether the dredging conditions are adequately preventing unacceptable effects on the marine and coastal environment, fisheries and other users of the sea. The ES should include a consideration of an appropriate monitoring programme.

B24. Monitoring should take account of natural variability within the marine environment. This can best be achieved by comparing the physical or biological status of the dredging area with reference sites located away from the influence of dredging effects.

B25. The spatial extent of sampling should take account of the area permitted for extraction and areas outside which may also be affected. In most cases there should also be monitoring within an area where ‘no effect’ is expected. This will give a better indication of the extent of any effects.

B26. The frequency of monitoring will depend on the nature of the area of interest, including its sensitivity and the anticipated period of consequential environmental changes.

B27. Reports on monitoring activities should be prepared. These should provide details of the measurements made, results obtained, their interpretation and how the data relate to the monitoring objectives.

B28. Monitoring operations are expensive, as they require considerable resources both at sea and in subsequent sample and data processing. It is important, therefore, to ensure that a monitoring programme is properly designed so that it meets its objectives. The results should be reviewed at regular intervals against the stated objectives and the monitoring exercise should then be continued, reviewed or even terminated.

19 ANNEX VII - SEDIMENTOLOGICAL AND BIOLOGICAL EFFECTS OF SAND DEPOSITION AROUND A DREDGING SITE IN DIEPPE, FRANCE

Preliminary data on the impact of sand deposition were collected in 1996 and 1997 at two stations located 200m North and South of the former dredging site (Figure. 1). Nine stations were sampled in March 1999 around the new dredging site, four years after extraction commenced. Stations were located 500 m away from the dredging site, westwards, northwards and eastwards (Figure. 1). The major tidal currents are parallel to the coast with prevailing current flow orientated eastwards.

RESULTS

1. Sediment

Sediment analysis showed a difference in granulometry for the eastern stations, with sediment dominated by fine and coarse sands, whilst gravels and shingles were the major sediment fractions north and west of the dredging site (Figure. 2).

The proportion of very fine sands was shown to be highest in the eastern part whereas the mud fraction dominated the northern stations. The major impact of sand deposition can therefore be clearly indicated by the dominance of fine sands eastwards, in the direction of prevailing current flow. However, the proportions of muds and fine sands at the northern stations may also indicate a more subtle effect of sand deposition.

2. Macrofauna

Analysis of benthic macrofauna confirmed the influence of sand deposition in the eastern stations (Figure. 3):

- their species richness was 2 times lower than in the reference area;
- abundances were 3 times lower;
- biomass was approximately 40% lower.

The negative impact of sand deposition on macrofauna has therefore been located and quantified.

Biomass values of the northern and western stations were 2 times higher than reference areas, whereas species richness and abundance were similar. This enhancement may be an effect of greater food availability associated with the deposition of finer sediments compared with the original substrate of clean gravels and shingle.

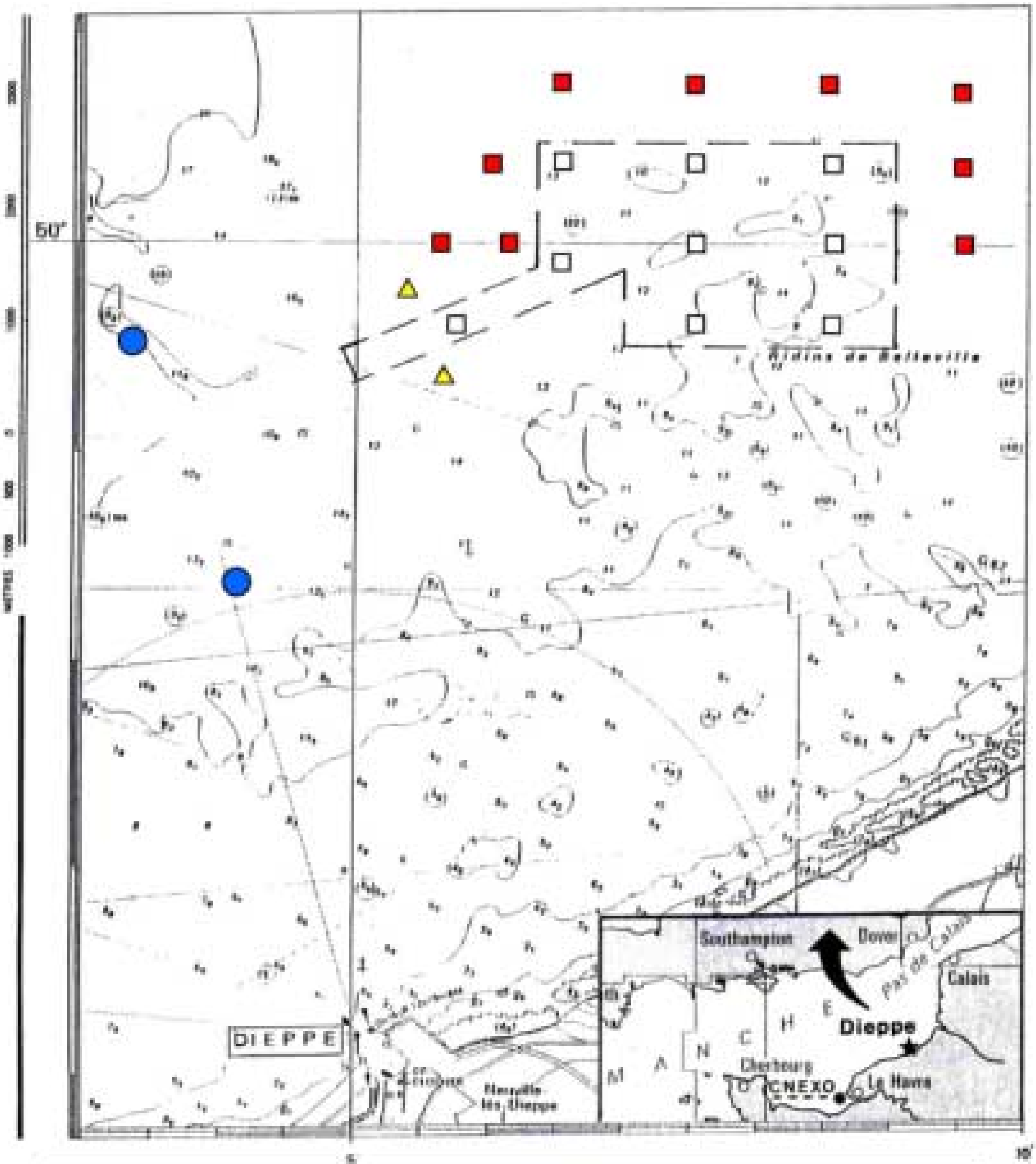


FIGURE 1:

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

- Reference stations
- Deposition control stations 1999
- Deposition control stations 1996-97
- Dredging control stations
- Dredging site

Fractions (%)	West	North	East	Reference
Shingels-gravels	54.4	51.7	16.4	31.5
Coarse sands	23.1	23.7	34.7	43
Fine Sands	21.1	20.2	40.8	24
Very fine sands	1.3	3.9	8	1
Muds	0.1	0.5	0.2	0.2

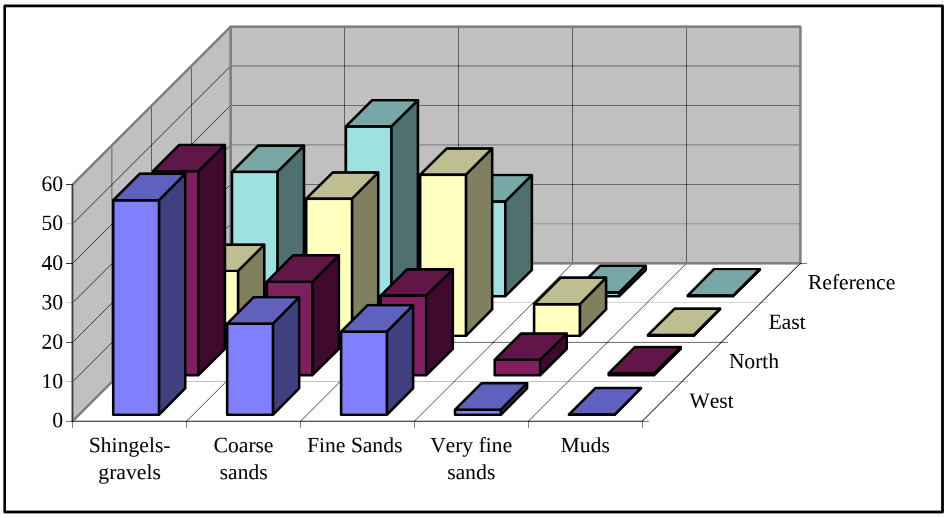


Figure 2 :
Comparison of the sediment granulometry in the reference area and around the dredging site of Dieppe in 1999.

	Biomass.m^{-2}	Abundance.m^{-2}.10^{-2}	Specific richness
Reference	8	37.8	64
West	20	35.5	57
North	14	36.5	59
East	5	12.6	28

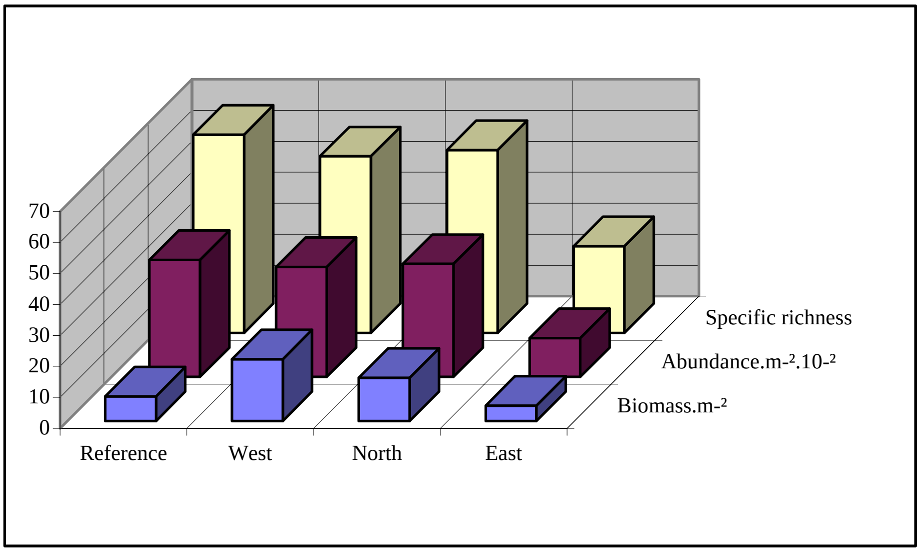


Figure 3 :
Comparison of the main biological parameters
of benthic communities in the reference area
and around the dredging site of Dieppe in 1999

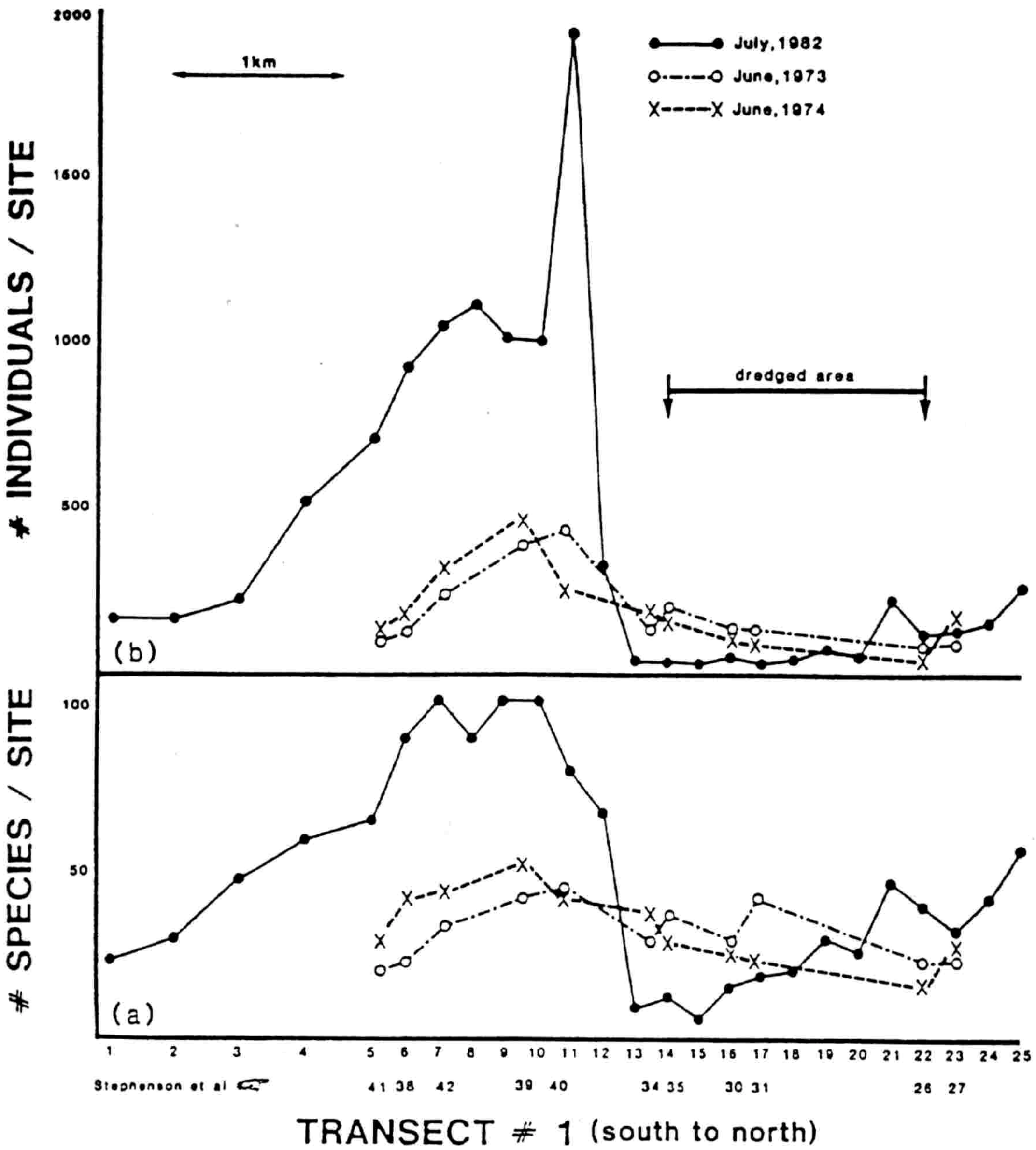
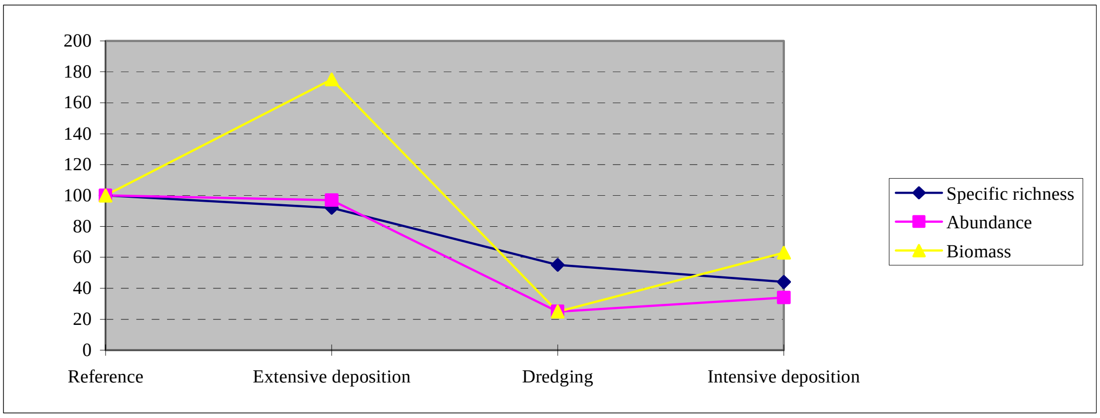


Figure 4:

Diagram showing the number of individuals and species of benthos recorded in July on a south-north transect crossing a dredged area on a sublittoral sandbank in Moreton Bay, Quenns-Australia.(Pointer & Kennedy,1984).

DIEPPE	Reference	Extensive deposition	Dredging	Intensive deposition
Specific richness	100	92	55	44
Abundance	100	97	25	34
Biomass	100	175	25	63
Sediment	Coarse sand	Muddy heterogeneous	Shingles	Fine sands



AUSTRALIE	Reference	Extensive deposition	Dredging
Specific richness	100	206	50
Abundance	100	508	32
Sediment	Medium-fine muddy sand		

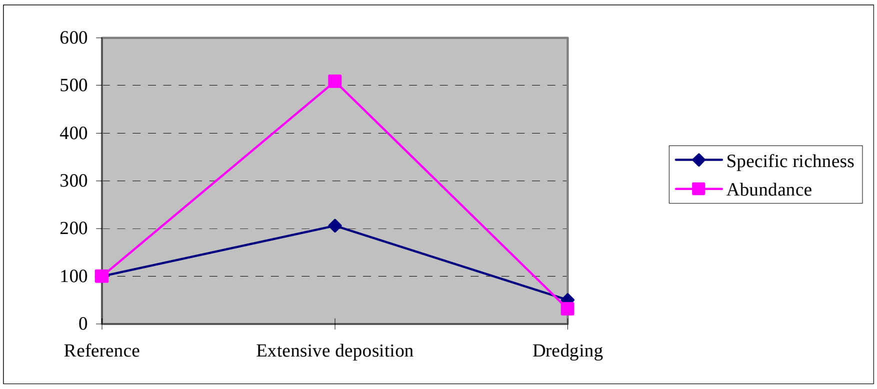


Figure 5
Comparison of the biological effects of dredging activity
in and around the extraction sites of Dieppe (F) and Moreton Bay (Aus)
(values are given in % of the reference ones)

DIEPPE	% Fine sands	Spécific Richness	Abundance.m⁻²	Biomass.m-²
1996	23	40	1688	8.4
	53	25	335	0.3
	73	8	130	0.24
1997	26	50	1938	7.8
	36	66	1090	4.7
	67	24	350	3.8
1999	24	64	3780	8
	21	57	3550	20
	20	59	3650	14
	41	28	1260	5

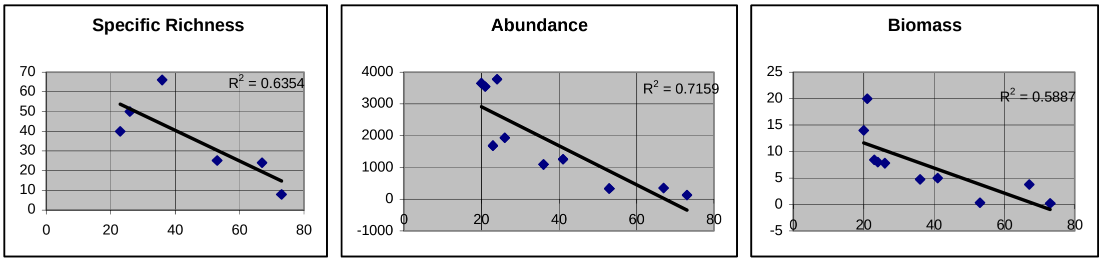


Figure 6 :
Influence of the fine sand content of the sediment
on the main benthic community parameters
in tne deposition area od the extraction site of Dieppe (F).

DISCUSSION

These data can be compared with that of Poiner & Kennedy's (1984) who sampled along a transect intersecting a dredging site located on a sand bank in an area with strong tidal currents orientated north-south along the Australian coast.

Their results (Figure. 4) showed a significant increase in both species richness and abundance around the dredging site, with a good correlation between the location and intensity of sand deposition and biological enrichment which could be detected between 0.5 and 2 km southwards.

AUSTRALIA	**Reference**	**Dredging**	**Deposition**
Species richness	32	16,6	68
Abundance.m^{-2}	148	48	752
Substrate ⇒	Medium-fine sands		

DIEPPE	**Reference**	**Dredging**	**Deposition**	
Species richness	64	35	28	59
Abundance.m^{-2}	3780	935	1260	3650

Biomass.m^{-2}	8	1.9	5	14
Substrate ⇒	Coarse sand	Shingles	Fine sands	V.f.s. & Mud

It is difficult to compare the results of these studies because of important differences in bathymetry (from -10 m to deeper than -20 m) and sediment granulometry. In Australia, dredging occurred in fine to medium sands with a notable proportion of mud (6-10 %). The nature of substrate was not altered and deposition rates were low. In contrast, dredging at Dieppe caused the progressive removal of gravels, shingles and coarse sands which were replaced by fine sands.

Both examples show that in high-energy environments, the impact on macrofauna is related to the evolution of sediment granulometry as could be demonstrated in Dieppe (Figure. 6).

20 ANNEX VIII - THE VALUE OF MARINE BENTHIC FAUNAS IN UK WATERS

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In 1997, recommendations to adopt an ecosystems approach for the management of marine communities were announced at the Intermedial Ministerial Meeting of the North Sea. Such an approach requires the integration of biological and physical data with information from seabed users who may impact these environments.

The assessment of potentially harmful effects from various anthropogenic activities such as spoil dredging, oil/gas exploration, marine aggregate extraction and bottom towed fishing gear, requires information on the geographical extent of sensitive marine habitats. Information on a broad spatial scale, which describes seabed habitats and their commercial and conservation value, is therefore, fundamental to coastal zone management. This assessment requires an understanding of two key factors a) how important/unique are the associations between the seafloor and its habitants, and b) what proportion of the total habitat available to these inhabitants is likely to be affected. These data are important because they inform a judgement on the regional importance of specific marine species and habitats.

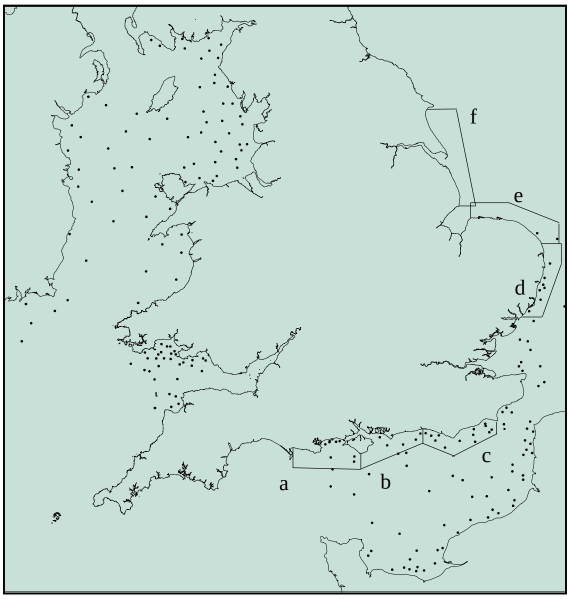
Although many previous studies have examined the spatial extent of various benthic communities in UK waters, these have been largely conducted on a small spatial scale and are generally confined to inshore regions (Eagle, 1973; Warwick, 1984; Hensley, 1996; Migne and Davoult, 1997). There is now a need to extent our understanding of these communities to more offshore regions with an emphasis on identifying their distribution patterns on a much broader spatial scale.

The purpose of this current work within CEFAS, Lowestoft Laboratory, is to identify and evaluate on a broad-scale potentially important substrate/habitat environments, with regards to fisheries, environmental assessment and conservation, and to develop a methodology for predicting the occurrence of various important demersal fish and macro-epibenthic faunas. CEFAS conducts an annual groundfish beam trawl survey in the Irish Sea, Bristol Channel, eastern English Channel and the southern North Sea (Figure 1). These surveys are well established and have already provided a considerable amount of biological and physical information relating to bottom dwelling organisms and their habitats.

The single frequency, remote acoustic ground discrimination system QTC (Quester Tangent Corporation) has been used during our surveys to examine associations between the benthos and the seafloor. The intention is to encompass various physical and biological characteristics of the seafloor such as substrate, bedforms, bathymetry and structural faunas (e.g. sponges and bryozoans), within a unique acoustic signature. This will provide a potential means to remotely identify and determine the geographical distribution of various benthic faunas, thus saving both time and money when large areas of the seafloor need to be surveyed. Extensive work will be necessary to describe the link between the benthic organisms collected at each of our survey sites and the nature of the seafloor they are found on.

Broad-scale investigations, however, require samples to be taken at well-spaced intervals, which is both expensive and time consuming. Even when samples have been collected, the data is site-specific and extrapolation to unsampled areas is usually difficult and inaccurate. The production of digitised seabed sediment charts by BGS in 1999 has provided a potential method of estimating the total geographical area of various seabed substrates (e.g. Figure 2) and extrapolating these site-specific data to much larger regions. The use of QTC, therefore, means that the nature of the seafloor and its associated faunas outside of the BGS charts can also be evaluated. Ultimately, it is hoped that the broad-scale mapping of demersal fish and macro-epibenthic assemblages, taxonomic groups and species, based on their association with the seafloor, will be feasible.

Figure 1. The geographical location of areas digitised by BGS and the location of groundfish survey stations within the Irish Sea, Bristol Channel, eastern English Channel and the southern North Sea; • denotes survey stations.



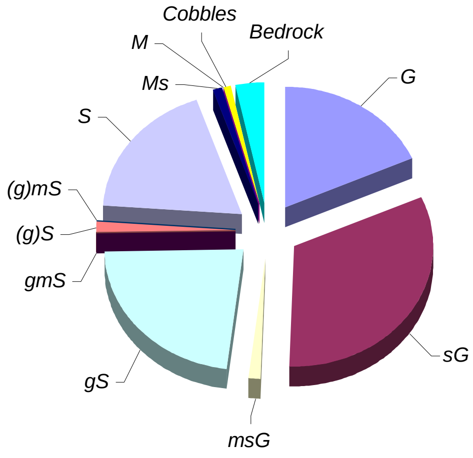
Portland Bill to St Catherine's Point d) Deben Estuary to Winterton-on-Sea

a) St Catherine's Point to Shoreham e) Winterton-on-Sea to Hunstanton

c) Shoreham to Dungeness f) Gibraltar Point to Flamborough Head

Figure 2. Percentage of the total geographic area of the major seabed sediments within the BGS digitised charts. Abbreviations of seabed sediment classification; *G* Gravel, *sG* Sandy

gravel, *msG* Muddy sandy gravel, *gS* Gravelly sand, *gmS* Gravelly muddy sand, *gM* Gravelly mud, *(g)S* Slightly gravelly sand, *(g)mS* Slightly gravelly muddy sand, *S* Sand, *Ms* Muddy sand, and *M* Mud.



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21 ANNEX IX THE EFFECTS OF DREDGING INTENSITY ON THE MACROBENTHOS IN COMMERCIAL AGGREGATE EXTRACTION SITES IN THE ENGLISH CHANNEL

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ABSTRACT

A survey was designed to examine the nature of impacts on the benthos arising from commercial aggregate extraction at sites east of the Isle of Wight in the English Channel. Samples of sediments and the associated macrofauna were collected from areas subjected to different levels of dredging intensity. Several of the sampled sediments collected from within areas of intensive dredging contained reduced quantities of gravel. However, changes in particle size were not sufficient to account for differences in assemblage structure between areas that had only limited exposure to the direct effects of dredging compared with undredged areas. Samples from intensively dredged sediments differed from undredged sites due to significant reductions ($p<0.05$) in numbers of species, biomass, species richness and diversity. Intermediate values of all calculated univariate measures were also observed in areas of reduced dredging intensity. Populations of the reef forming polychaete *Sabellaria spinulosa* were found to be particularly susceptible to dredging disturbance. This is in contrast to *Balanus* juveniles, which were observed to be more numerous in intensively dredged sediments, compared with elsewhere, suggesting that some settlement of this taxon occurs even during times of extraction.

The implications of these findings for assessing the potential for cumulative environmental impacts as a consequence of aggregate extraction are discussed.

INTRODUCTION

Historically in the UK, environmental impact assessments of the effects of aggregate extraction have concentrated on individual aggregate extraction licences to the exclusion of nearby dredging activity. However, impacts that may be viewed as insignificant as a result of dredging at an individual extraction licence could potentially accumulate in a region over time or combine with impacts from nearby dredging activity. Such impacts are termed ***cumulative***, and these are of concern as they may lead to the gradual degradation of a particular habitat or the loss of a key component of the ecosystem (Erikson, 1994). Cumulative impacts may occur as a result of dredging at a single locality but, more commonly, concerns are directed at the cumulative consequences of aggregations of licensed dredging activity (Jewell and Roberts, 1999). Consideration of this issue will also become increasingly important in the U.K., in view of the move towards statutory control of aggregate dredging activity through the introduction of Environmental Impact Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations 2000.

From a practical perspective, the assessment of any cumulative environmental impacts as a consequence of aggregate dredging requires an understanding of the effects of dredging and the definition of appropriate spatial and temporal boundaries (Preston and Bedford, 1988). In addition, the potential for cumulative environmental impacts of dredging will depend upon many factors including the intensity and duration of dredging within an area, the spatial extent of effects, and the rate of recovery of the community. Most studies on the effects of aggregate extraction have concentrated on establishing the rates and processes of macrobenthic recolonisation upon cessation of dredging (Van der Veer et 1985; Van Moorsel, 1994; Kenny & Rees, 1994; 1996). These studies indicate, typically, that dredging causes an initial reduction in the abundance, species diversity and biomass of the benthic community. However, Lees *et al*. (1990) working in an area east of the Isle of Wight in the English Channel, was unable to establish a causal link between the distribution of faunal assemblages and dredging intensity inferred from sonographs of the seabed and diver observations. In this area there are a number of extraction licences, within which the seabed has been subjected to the effects of dredging for the last 25 years or more. In recent years, approximately 2-3Mt of sand and gravel has been extracted each year from this region.

The work described here is part of an ongoing field assessment programme designed to investigate the potential for the cumulative environmental consequences of aggregate extraction within licences east of the Isle of Wight, and elsewhere. More specifically, the purpose of this survey was to further examine the nature of impacts arising from commercial aggregate extraction and to test the null hypothesis (H_o) that there is no significant difference between the effect of different levels of dredging intensity on macrofauna assemblages.

METHODS AND MATERIALS

Since 1993, every vessel dredging on a Crown Estate licence in the UK has been fitted with an Electronic Monitoring System (EMS). It consists of a PC electronically linked to a navigation system and one or more dredging status indicators. This automatically records the date, time and position of all dredging activity every 30 seconds to disk. Many of the dredgers operating in UK waters are fitted with Differential GPS navigation systems, which allows the EMS to operate with an accuracy of ±10m.

EMS information was interrogated in order to locate areas of the seabed within extraction licences to the east of the Isle of Wight, which had been subjected to different levels of dredging intensity. Six replicate stations were randomly selected from areas representing 3 different levels as follows: 1) >15 hours (15h) of dredging within a 100m by 100m block over 1998, 2) <1 hour (1h) of dredging within a 100m by 100m block over 1998 and 3) no dredging (0h) activity recorded within a 100m by 100m block over a period of 5 years (Figure 1). The dredging history of each sampling location is presented in Table 1.

With this design, the 15h treatment represents conditions following the repeated removal of commercial aggregate from most of the total surface area of a 100m by 100m block, many times over the course of 1 year. This assumes that a dredger, typically a trailer suction hopper dredger, moves slowly over the seabed at a speed of 2kt and creates a dredge track of approximately 2.5m wide. It also assumes that the dredger works systematically across an area. In practice, particular deposits will be more frequently targeted by the dredging industry and therefore, under the 15h treatment, some areas of the seabed may be dredged on a regular basis whereas other areas of the seabed may only be dredged once or twice in a year. In contrast, the 1h treatment represents conditions after the removal of up to about 90% of the total surface area in a similar 100m by 100m block. However, some locations within this treatment may have only experienced limited exposure to the direct effects of extraction, allowing survival of some species and recolonisation by others. In addition, the 1h sampling points were all located close to centres of intense dredging activity. Therefore these sites were potentially subjected both to the direct effects of minimal dredging and any indirect effects (e.g. settlement of plume material) associated with the nearby more intensive dredging activity. This scenario is further complicated, as anchor hopper dredgers carry out dredging in some of the extraction sites in this area. In this case the dredger anchors over the deposit and mines it by forward suction through a pipe (ICES, 1992). This results in localised pits on the seafloor.

The 0h samples were located in areas that had not been subjected to dredging for the past 5 years (known from EMS records) and away from indirect effects of dredging activity. In these areas, dredging may never have taken place, as such areas usually contain sub-commercial deposits. However, this is difficult to verify, as, prior to the inception of EMS, historical records on the location of dredging activity are more sporadic. All these samples were located in commercial extraction sites where dredging was still active, and in that sense this was not a controlled field experiment, rather this study is a more pragmatic attempt at assessing the effects of commercial dredging activity. In addition 4 replicate samples were collected from a nearby reference site located away from both indirect and direct effects of dredging. Samples were collected using a $0.1m^2$ Hamon grab on 25 and 26 May 1999 from within a 50m range ring, using the SEXTANT hydrographic software package and DGPS position fixing (Figure 1). Following estimation of the total sample volume, a 500ml sub-sample was removed for laboratory particle size analysis. The whole sample was then washed over 5mm and 1mm square mesh sieves to remove the fine sediment. The two resultant fractions (1-5mm and >5mm) were back-washed into separate containers and fixed in 4-6% buffered Formaldehyde solution (diluted in seawater) with the addition of a vital stain " Rose Bengal".

Laboratory analysis

The 5mm sample fraction was first washed with fresh water over a 1mm mesh sieve in a fume cupboard, to remove excess Formaldehyde solution, then back-washed onto a plastic sorting tray. Specimens were removed and placed into labelled glass jars containing a preservative mixture of 70% methanol, 10% glycerol and 20 % distilled water. Specimens were identified, where possible, to species level. The 1-5mm fraction was first washed over a 1mm sieve then back-washed into a 10 litre bucket. The bucket was filled with fresh water and the sample was then gently stirred in order to separate the animals from the sediment. Once the animals were in suspension, the sample was decanted over a 1mm mesh sieve. This process was repeated until no more material was recovered. Specimens from this fraction were placed into labelled petri-dishes for identification and enumeration. The sediment was then placed on plastic trays and examined under an illuminated magnifier for any remaining animals such as bivalves not recovered in the decanting process, which were then added to the petri-dishes. The blotted wet weight (in grams) for each species recorded from replicate samples was also recorded.

Sediment sub-samples for particle size analysis were initially wet sieved over a 63μm mesh sieve to provide an estimate of the fine fraction. The remaining sample was then oven-dried and sieved through a stack of geological test sieves ranging from -6 phi (64mm) to +4 phi (0.063mm). The percentage distribution, by weight, of particles for each size fraction was then calculated.

Data analysis

The following univariate measures were calculated: total abundance (A), numbers of species both including (S) and excluding (T) colonial taxa, Shannon-Wiener diversity index $H'\log_2$ (Shannon-weaver, 1949), and Margalef's species richness (d). Ash-free dry weights were calculated using standard conversion factors (Rumohr *et al*., 1987; Ricciardi & Bourget, 1998).

Differences between each level of dredging intensity were determined through calculation of Least Significant Intervals (LSI's). This method assumes that where the means do not overlap there is a statistically significant difference at the 95% probability level (Andrews *et al*., 1980). The inter-relationships between the dredging history at each sample location over different years, sedimentary parameters and a range of univariate indices of biological structure were examined using Pearson product moment correlation coefficients.

Non-metric multi-dimensional ordinations of the inter-sample relationships (Kruskal & Wish, 1978) were produced to view the similarity of samples in terms of their species composition. The ordination was based on a lower triangular similarity matrix of log-transformed abundance data using the Bray-Curtis similarity co-efficient (Bray & Curtis, 1957). To test the null hypothesis H_o that there were no significant differences in community composition between samples collected from areas subjected to differing levels of dredging intensity, an analysis of similarities was undertaken employing the ANOSIM procedure (Clarke, 1993). As a basic aim of this study was to provide an empirical basis for describing the effects of aggregate extraction, it was important to establish the species contributing to any observed differences in the community composition of fauna. This was established by means of similarity percentage analyses (SIMPER) on the species sample matrices, which revealed any characteristic species contributing to the Bray-Curtis dissimilarity between sample groups (Clarke, 1993).

To examine which factors are important in accounting for the distribution of faunal assemblages, information on the dredging history and sediment variables were compared singly or in combination with the ranked dissimilarity matrix of faunal abundance data (see Clarke and Ainsworth, 1993). Sub-sets of environmental parameters that were found to best explain the biological variability were then identified by the highest correlation coefficients (p_w).

RESULTS

Dredging history of sites

The maximum number of hours of recorded dredging at each sample location for 1993-May 1999 inclusive are given in Table 1. In general, the level of dredging at each sampling position was relatively stable over time. Actual values of recorded dredging over 1998 for 15h replicates range from 9 to 59 hours of dredging. The lower than expected value of recorded dredging in 1998 at 15hF is due to errors associated with accurately collecting samples at sea from target areas.

Physical observations

In general, 0h sediments contained similar proportions of sand and gravel (Figure 2A), having a characteristic bimodal distribution. A distinctive mode was observed at about 16mm (gravel) and a smaller secondary mode at about 250µm (medium sand). A similar pattern was observed with 1h sediments, although there was a tendency for particles to be less well-sorted (Figure 2B). However, the particle size distributions of sediments from the 15h sample replicates were much more variable than both the 1h and 0h sediments, with several samples (15hC, E & F) containing a reduced quantity of gravel (Figure 2C). A silt-clay fraction was also more prominent in one of the 15h sample replicates (15hE) than other sampled sediments.

Biological observations.

Overall, relatively few species were abundant and 69 of the 231 recorded taxa (including colonial taxa) were single occurrences. Variations in total numbers of individuals (non-colonial taxa only) are considerable (Figure 3). This has been noted previously in individual EIA's for aggregate extraction (Oakwood Environmental, 1999) and reflects both a highly diverse fauna and a patchy distribution of the populations in the region (see also Lees *et al*., 1990). Nevertheless, both the numbers of non-colonial species (S) and values of species richness (d) are significantly reduced ($p<0.05$) in the dredged sediments (1h & 15h) compared with the 0h sample group. For example, the average number of non-colonial species recorded from 6 Hamon grab samples from the 0h treatment group was 45 compared with an average number of 27 and 8 species from the 1h and 15h sample replicates respectively. Indeed, excepting the numbers of individuals, all other univariate measures calculated reveal significantly lower values ($p<0.05$) in the 15h treatment compared with the 0h treatment (Table 2, Figure 3). Intermediate values of all measures were observed in the 1h treatments and these differences were significantly lower ($p<0.05$) than 0h sample replicates for species richness and numbers of non-colonial taxa. There were no significant differences ($p>0.05$) for any of the calculated univariate measures when comparing 0h and reference site samples. Trends in biomass for each treatment are in general agreement with those for numbers of species with intermediate values obtained for 1h sediments. The mean biomass for 0h sediments was 59.8g (ash free dry weight) m^{-2}; this was reduced in 1h sediments and 15h sediments with mean values of 9.82g and 0.73g m^{-2} respectively. This reflects the removal of a range of macrofaunal species including the slipper limpet *Crepidula fornicata,* the reef forming polychaete *Sabellaria spinulosa*, the bivalve *Nucula nucleus* and a number of tunicates such as *Polycarpa pomaria*, *Dendrodoa grossularia*, and *Pyura microcosmos,* which were locally abundant in the 0h sample replicates.

The outcome of non-metric multi-dimensional scaling (MDS) indicates that the 15h samples are clearly separated from both the 1h and 0h sample replicates (Figure 4). Furthermore the 15h replicate samples are widely separated on the MDS plot indicating that they are biologically dis-similar. Results of pairwise analyses of similarities (ANOSIM) on log-transformed data confirm that differences between the 15h treatment and all other assemblages are significantly different (Table 3). Repeating this analysis with 4th root transformed data, a less severe transformation when used on low abundance data sets such as this, also confirms that the differences between all assemblages within extraction sites are significantly different ($p<0.05$) (Table 4). The disturbance from dredging within the 1h treatment also provoked less severe changes in the community composition compared with dredging disturbance in the 15h treatment (Table 4). These results imply that the null hypothesis (H_o) of no significant difference in community composition as a consequence of dredging intensity can be rejected. However, differences between the reference site and both the 1h and 0h treatments were not significant ($p<0.05$), but this appears to be largely a function of the lower numbers of replicate samples collected at the reference site which reduced the discriminatory power of the analysis. This also reflects the generally low and variable abundances of individual species, which masked any differences between assemblages observed at the 1h and 0h sites and the reference site.

The distribution of organisms that were influential in accounting for the distinctions between sample groups is presented in Table 5. The 15h samples differed from the both the 1h and 0h groups largely due to the elimination or reduced abundance of a range of macrofaunal taxa including the polychaete *Sabellaria spinulosa,* the tunicate *Dendrodoa grossularia* and the barnacle *Balanus crenatus*. Conversely, higher densities of newly recruited Balanidae juveniles within the 15h sample group also contribute to the observed dissimilarities, albeit at a lower level of similarity. This probably reflects a recent larval settlement of this species on the denuded sediments. Adults of the barnacle *Balanus crenatus* were also more abundant in the 1h samples than elsewhere. Higher densities of the r-selected species *Dendrodoa grossularia* in 1h and 0h samples also helped to distinguish these groups from the reference site samples.

There was also a discernible trend towards increasing abundance of *Sabellaria spinulosa* with decreasing levels of dredging disturbance, with the greatest cover of *Sabellaria* reef found at the reference site. A range of infaunal and epifaunal polychaete species such as *Typosysllis* spp., *Ehlersia ferrugina*, *Autolytus* sp., *Pomatoceros lamarcki*, *Polydora caeca* (agg.), *Perkinsiana rubra* and *Pseudopotamilla reniformis* were also more numerous at the reference site compared with extraction site samples, implying that these species live in association with *Sabellaria*.

21.1.1.1.1.1.1 Biotic and environmental relationships

A correlation matrix for a range of biological and sedimentary variables, and recorded dredging effort for each year is given in Table 6. In general, there is a relatively strong negative correlation between the numbers of taxa (both colonial and non-colonial) found in May 1999 and the maximum level of recorded dredging effort in each year. There are also strong negative correlations between species richness (d) and dredging effort for most years. The correlation analyses therefore confirm that there is an adverse effect on the numbers of species (both colonial and non-colonial) in sites exposed to dredging disturbance. There were no significant relationships between any of the biological measures and sediment characteristics. Overall, this suggests that the level of dredging disturbance is more influential in determining the structure of biological assemblages than sedimentary parameters.

Relationships between dredging effort and biological variation were also explored using the method of Clarke and Ainsworth (1993). The highest correlation ($pw = 0.715$) arose from a combination of 5 variables: dredging effort in 1993, 1996 and 1998, % medium sand and % silt/clay (Table 7). However, the level of recorded dredging effort in 1999 explains most of the variability in the biological data with a correlation coefficient of 0.661. Similarly, a relatively high correlation coefficient ($pw = 0.637$) was obtained with recorded dredging activity in 1998, suggesting that it is recent dredging events that are most critical for defining the biological community structure. Lower correlations were found with sedimentary parameters.

DISCUSSION

During 1999, when these sites were sampled, approximately 20% of the area, licensed for sand and gravel extraction in this region was dredged (Crown Estates *pers. comm*.). Of this area, most of the dredging effort consisted of <1h of dredging recorded in 100m by 100m blocks over the course of the year. This level of dredging effort has been relatively stable over the last five years (see Figure 5). Furthermore the location of active dredging (known from EMS records) has been similar between years for the same period. Therefore the findings from this study can be considered as representative of conditions at these extraction sites in recent years.

The reduced gravel component observed in several of the 15h sediments may, in part, be explained by screening activities carried out by the aggregate industry in order to meet specific sand/gravel requirements. Such requirements are met through the separation of different fractions of sediment whilst at sea, by passing the aggregate through a series of screens on board the dredger, one fraction being preferentially loaded and the unwanted material being discharged to sea via a reject chute. Dearnaley *et al.* (1996) estimated the material lost through spillways on board a dredger in comparison with material rejected and returned to the water column due to the screening process. These estimates were based on the analysis of measurements of a number of screened cargoes, and indicated that approximately 35kg total dry solids per m^3 of material was discharged as overspill, 40% of which consisted of silt/clay material. However, material returned overboard through screening activities was estimated to be an order of magnitude higher at around 500kg total dry solids per m^3. Of this, approximately 1% of the material consisted of silt/clay. When such estimates are scaled up, it has been calculated that, during the loading of a screened cargo, a total mass equivalent to about twice that of the total cargo is released back into the water column (Hitchcock & Dearnaley, 1995). Clearly estimates such as these are site specific, and will vary in relation to the grain size of seabed sediments, the grading required for the cargo and the efficiency of the dredger. However, estimates by Hitchcock and Drucker (1996) for a dredger working in our study area, suggest that for a trailer suction hopper dredger of 4500 t capacity, 7223 t of material are rejected by screening. Furthermore in this area, the majority of the rejected material is likely to consist of sands and fine gravels (EEL, 1999). Video footage of dredging during routine loading of a cargo has also indicated that the greatest proportion of the discharged material is deposited beneath the dredger (Davies and Hitchcock, 1992). Over time, the progressive removal of the original sandy gravel and its replacement by sandier sediments may lead to a gradual fining of the sediment within the extraction licences. This accumulation of sandy material may not be considered to be significant when caused by dredging at a single extraction licence. However, when impacts of this type occur across a region, then they are potentially of greater concern and can be interpreted in the broadest sense as constituting a cumulative impact i.e. when the sediments and impacts "accumulate" in a region over time (Cada and Hunsaker, 1990). Whether this quantity of rejected material significantly alters the composition of the sediment in the longer-term will depend upon how quickly the material is eroded away by tidal current and wave action. A change in the composition of sediment following aggregate extraction has also been observed in intensively dredged sediments off Dieppe (ICES 1992, 1993). However, at this site the fine material, which infilled the dredged furrows, resulted from a combination of plume settlement and from the transport and trapping of bedload sediments. In contrast, an experimental study off North Norfolk reported the coarsening of seabed sediments, as result of the exposure of deeper gravelly deposits following dredging (Kenny and Rees, 1996).

Although differences in the particle size distributions may account for contrasts in the fauna between areas of intense dredging (15h) and other sites, they are not considered sufficient to fully explain the differences in the fauna between sites exposed to limited dredging intensity (1h) and non-dredged sites within the extraction sites (0h). This suggests that the physical disturbance associated with extraction activity is also influential in determining the community composition. Gravel extraction can have a number of physical effects including the removal of the resident seabed fauna, the exposure of uncolonised sediments, increased turbidity and redistribution of fine sediments. Newell *et al*. (1999) have also recently claimed that fragmented benthos discharged with the outwash from working dredgers can contribute to an organic enrichment effect. However their measurements of the discharged organics were from unexploited deposits, whereas the extraction sites examined in this study have been worked over a number of years. Given that the biomass of benthic invertebrates was significantly reduced within the intensively dredged areas, it is unlikely that such an enrichment effect would be detectable in this area.

Lees *et al*. (1990) sampled part of the same area as the current study and, despite differences in sampling methodology, the faunal assemblages recorded are broadly similar. Nevertheless, they were unable to detect consistent differences in assemblage structure between stations unaffected by dredging disturbance and those that were inferred to be subjected to dredging activity, although they did observe a difference in the numbers of ascidians. The sampling conducted by Lees *et al*. during 1989 was conducted using a modified Forster anchor dredge (see Eleftheriou and Holme, 1984). This sampler is a non-quantitative device and hence it would limit the scope for accurately characterising the fauna. Advancements in the positioning capability of ships and the recording of EMS information have also undoubtedly improved the potential for accurately locating areas of seabed subjected to dredging activity.

Sabellaria spinulosa was found to be present at the reference site, reduced in abundance within areas exposed to limited dredging disturbance (0h & 1h), and absent from heavily exploited areas (15h). Connor *et al*. (1997) describe similar communities living in association with *S. spinulosa* reef, to those recorded at the reference site, with an infauna consisting of polychaetes, as well as the bivalves *Abra alba* and *Nucula nitidosa* and an epifauna including attached *Polydora* tubes. Indeed populations of this reef-forming polychaete have been shown to promote short-term stability and permit diversification (see e.g. George and Warwick, 1985; Holt *et al*., 1995; Rees *et al*., 1999). The elimination of this species in areas of intense dredging, and its reduced abundance elsewhere in the extraction sites, presumably as a result of its susceptibility to dredging disturbance, may also limit the scope for recolonisation by other species upon the cessation of dredging. Furthermore, the larvae of this species are considered to be stimulated to settle by the presence of adults, with settlement occurring more slowly in the absence of either dead or living cementation (Wilson, 1970; Holt *et al*., 1998). Thus it would appear that aggregate extraction has the potential to gradually reduce the spatial coverage of this important biotope. However, further research is needed to quantify the geographically extent of *Sabellaria* in the area, and to establish its rate of recovery following damage from extraction activities (Holt *et al*., 1998) before the significance of this "nibbling" effect (Preston and Bedford, 1988) can be fully assessed.

In contrast, the barnacle *Balanus crenatus* was found to be more numerous (as juveniles) in intensively dredged sites, and as adults in areas of more limited dredging compared with undredged sites. This suggests that recolonisation by this species proceeds relatively rapidly, with some settlement occurring even during times of extraction. This accords with observations by Kenny and Rees (1994, 1996) and Kenny *et al*. (1998), at an experimentally dredged site off North Norfolk where there was substantial recolonisation by *B. crenatus* within 12 months of the cessation of dredging. Furthermore the r-selected species *Dendrodoa grossularia*, which was also found to have a fast colonising ability at the North Norfolk Experimental site, occurred in high densities within the east of the Isle of Wight extraction sites (0h & 1h), but was absent from the nearby reference site. This would suggest that this species is able to quickly colonise areas disturbed by dredging but may be competitively excluded in more stable areas.

Most of the seabed dredged in this region in recent years is likely to be similar in nature to the 1h treatment, although locally there are "hotspots" of more intensive dredging activity. Therefore we can assume that large proportions of the dredged areas have a reduced abundance of *Sabellaria* and as a consequence a more limited number and diversity of associated taxa. However there is also likely to be an increase in the numbers of more opportunistic taxa such as *Balanus crenatus* and *Dendrodoa grossularia* which have taken advantage of the exposure of hitherto uncolonised sediments. At present, the significance of this change in the benthic fauna for other components of the ecosystem cannot be quantified. Therefore, further studies in this area, aimed at better identifying the nature of biological effects with a view to assessing the potential for cumulative impacts arising from aggregate extraction, are continuing.

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TABLE 1 – Maximum number of hours of recorded dredging at each sample location over time (values for 1999 are for January to May 1999 inclusive).

Sample	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*
0hA	0	0	0	0	0	0	0
0hB	0	0	0	0	0	0	0
0hC	0	0	0	0	0	0	0
0hD	0	0	0	0	0	0	0
0hE	0	0	0	0	0	0	0
0hF	0	0	0	0	0	0	0
1hA	0	0	0	0	<1	<1	<1
1hB	0	0	<1	0	<1	<1	<1
1hC	0	<1	<1	<1	<1	<1	<1
1hD	0	0	0	0	0	<1	<1
1hE	<1	<1	<1	0	<1	<1	<1
1hF	0	<1	<1	<1	<1	<1	<1
15hA	0	<1	0	0	0	33.49	10.74
15hB	<1	18.24	12.49	9.99	14.99	16.49	3.24
15hC	<1	3.24	8.49	15.99	9.49	16.74	6.74

15hD	0	4.49	22.24	14.25	9.24	58.99	44.99
15hE	3.25	11.24	10.49	15.49	10.24	16.99	6.75
15hF	0	<1	<1	<1	1.49	8.74	2.99

TABLE 2 – F ratios and significance levels (from $F_{3,18)}$ from 1 way ANOVA tests for differences in various univariate measures of community structure between treatments.

Univariate measure	F	p
S (non-colonial taxa)	8.30	<0.01
A	1.21	0.34
H'	4.39	0.01
d	12.20	<0.01
T (all taxa)	9.47	<0.01
AFDW	2.33	0.10

TABLE 3 – R-values from pairwise analyses of similarities to test significant differences between treatments based on log-transformed data

	Ref	0h	1h
Ref			
0h	0.187		
1h	0.246	0.161	
15h	0.310*	0.419*	0.374*

Asterisk (*) denotes significant difference at $p<0.05$

TABLE 4 – R-values from pairwise analyses of similarities to test significant differences between treatments based on 4th root transformed data

	Ref	0h	1h
Ref			
0h	0.214		
1h	0.218	0.191*	
15h	0.325*	0.415*	0.361*

Asterisk (*) denotes significant difference at $p<0.05$

TABLE 5 – The average abundance of the top 15 ranked species 0.1m^{-1} contributing to the dissimilarity between sample groups derived from SIMPER analyses of log-transformed data; species are ordered in decreasing contribution.

SPECIES	15h	0h
Sabellaria spinulosa	-	18.67
Clymenura sp.	-	3.67
Lumbrineris gracilis	0.67	7.00
Dendrodoa grossularia	-	86.83
Amphipholis squamata	0.33	6.83
Caulleriella zetlandica	0.17	1.83
Balanus crenatus	1.17	3.00
Praxillella affinis	-	2.83
Pomatoceros lamarcki	0.17	8.67
NEMERTEA	0.17	3.33
Crepidula fornicata juv.	-	18.00
Notomastus	1.00	4.50
Balanidae juv.	26.17	-

SPECIES	1h	0h
Dendrodoa grossularia	13.33	86.83
Balanus crenatus	68.83	3.00
Sabellaria spinulosa	7.33	18.67
Lumbrineris gracilis	2.33	7.00
Leptocheirus hirsutimanus	4.00	0.33
Pomatoceros lamarcki	3.17	8.67
Crepidula fornicata juv.	0.33	18.00
Amphipholis squamata	0.50	6.83
Praxillella affinis	-	2.83
Notomastus sp.	1.33	4.50
Polydora caeca (agg.)	2.00	4.83
Nucula nucleus	0.33	10.00
Harmothoe impar	-	2.83

SPECIES	1h	15h
Balanus crenatus	68.83	1.17
Sabellaria spinulosa	7.33	-
Dendrodoa grossularia	13.33	-
Leptocheirus hirsutimanus	4.00	0.17
Clymenura sp.	2.50	-
Pomatoceros lamarcki	3.17	0.17
Lumbrineris gracilis	2.33	0.67
Polycirrus sp.	2.67	0.33
Balanidae juv.	-	26.17
Notomastus sp.	1.33	1.00
Pygospio elegans	2.67	-
Sphenia binghami	1.33	-
Thelepus setosus	1.17	-

Harmothoe impar	-	2.83
Exogone verugera	-	0.83

SPECIES	15h	Ref
Sabellaria spinulosa	-	69.75
Pomatoceros lamarcki	0.17	19.00
Crepidula fornicata juv.	-	10.25
Balanus crenatus	1.17	16.75
Typosyllis armillaris	-	12.75
Balanidae juv.	26.17	2.50
Autolytus sp.	-	4.25
Sphenia binghami	-	4.00
Polycirrus sp.	0.33	4.25
Typosysllis sp.	-	4.75
Crepidula fornicata	-	2.75
Lumbrineris gracilis	0.67	3.75

Polycirrus sp.	2.67	1.00
NEMERTEA	1.33	3.33

SPECIES	Ref	1h
Balanus crenatus	16.75	68.83
Sabellaria spinulosa	69.75	7.33
Typosysllis armillaris	12.75	0.17
Dendrodoa grossularia	-	13.33
Crepidula fornicata juv.	10.25	0.33
Pomatoceros lamarcki	19.00	3.17
Leptocheirus hirsutimanus	0.50	4.00
Crepidula fornicata	2.75	-
Lumbrineris gracilis	3.75	2.33
Typosyllis variegata	4.75	1.00
Autolytus sp.	4.25	0.83
Ehlersia ferrugina	2.50	-

NEMERTEA	1.33	0.17
Bathyporeia elegans	0.83	0.50

SPECIES	Ref	0h
Sabellaria spinulosa	69.75	18.67
Balanus crenatus	16.75	3.00
Typosyllis armillaris	12.75	1.83
Pomatoceros lamarcki	19.00	8.67
Crepidula fornicata juv.	10.25	18.00
Dendrodoa grossularia	-	86.83
Amphipholis squamata	0.75	6.83
Polycirrus sp.	4.25	1.00
Crepidula fornicata	2.75	2.33
Autolytus sp.	4.25	1.00
Polydora caeca (agg.)	2.25	4.83
Typosysllis variegata	4.75	2.83

Ehlersia ferrugina	-	2.50	*Polydora caeca* (agg.)	2.25	2.00	*Notomastus* sp.	1.50	4.50
NEMERTEA	0.17	2.50	*Perkinsiana rubra*	2.50	-	*Praxillella affinis*	-	2.83
Perkinsiana rubra	-	2.50	*Pseudopotamilla reniformis*	5.00	-	*Ehlersia ferrugina*	2.50	-

TABLE 6 - Pearson product moment correlation coefficients between biological and environmental variables at each sampling point (n=22). Significance levels:*0.05-0.01;**0.01-0.001;***<0.001.

	1993	1994	1995	1996	1997	1998	1999	total	% gravel	% coarse sand	% medium sand	% fine sand	% silt/clay
1993													
1994	0.67***												
1995	0.43*	0.69***											
1996	0.68***	0.70***	0.88***										
1997	0.65**	0.91***	0.87***	0.91***									
1998	n.s.	n.s.	0.82***	0.67***	0.59**								

1999	n.s.	n.s.	0.83***	0.60**	0.48*	0.93***							
total	n.s.	0.64**	0.96***	0.86***	0.82***	0.93***	0.88***						
% gravel	-0.71***	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.					
% coarse sand	0.68***	0.42*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-0.48*				
% medium sand	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-0.44*	n.s.			
% fine sand	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-0.59**	n.s.	n.s.		
% silt/clay	0.69***	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-0.76***	n.s.	n.s.	0.60**	
Nos. of species	n.s.	-0.43*	n.s.	-0.49*	-0.51*	-0.49*	n.s.	-0.50*	n.s.	n.s.	n.s.	n.s.	n.s.
Abundance	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
D	n.s.	-0.44*	n.s.	-0.48*	-0.51*	-0.48*	n.s.	-0.49*	n.s.	n.s.	n.s.	n.s.	n.s.
$H'log_2$	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Nos. of taxa (incl. colonial)	n.s.	-0.47*	-0.46*	-0.52*	-0.54**	-0.53*	n.s.	-0.55**	n.s.	n.s.	n.s.	n.s.	n.s.
Biomass	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

1999:hours of recorded dredging in 1999 (Jan to May incl.);

1998:hours of recorded dredging in 1998 etc; total: total number of hours of recorded dredging from 1993-May 1999incl.;

TABLE 7 - Spearman rank correlations between macrofauna and environmental similarity matrices.

Numbers of variables	Best variable combination	Spearman rank correlation *(pw)*
1	1999	0.661
1	1998	0.637
1	total	0.606
2	1993,1998	0.687
2	1993,1999	0.664
2	1998,1999	0.657
3	1993,1998,%medS	0.682
3	1993,1998,1999	0.679
3	1993,1996,1998	0.675
4	1993,1998,%medS,%s/c	0.705
4	1996,1998,%medS,%s/c	0.704
4	1993,1996,1998,%medS	0.695
5	1993,1996,1998,%medS, %s/c	0.715
5	1993,1998,total,%medS, %s/c	0.711
5	1993,1997,1998,%medS,%s/c	0.709

1999:hours of recorded dredging in 1999 (Jan to May incl.);

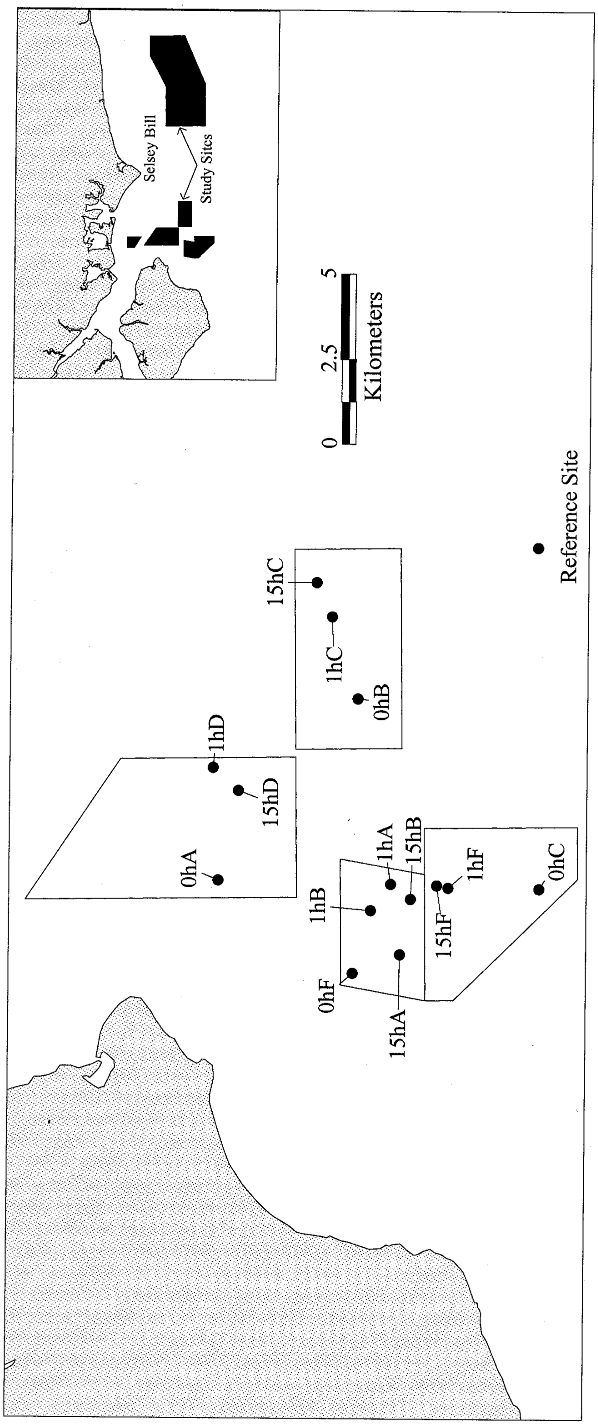
1998:hours of recorded dredging in 1998;

1997: hours of recorded dredging in 1997 etc.

total: total number of hours of recorded dredging from 1993-May 1999incl.;

%medS: % medium sand;

%s/c: % silt and clay.



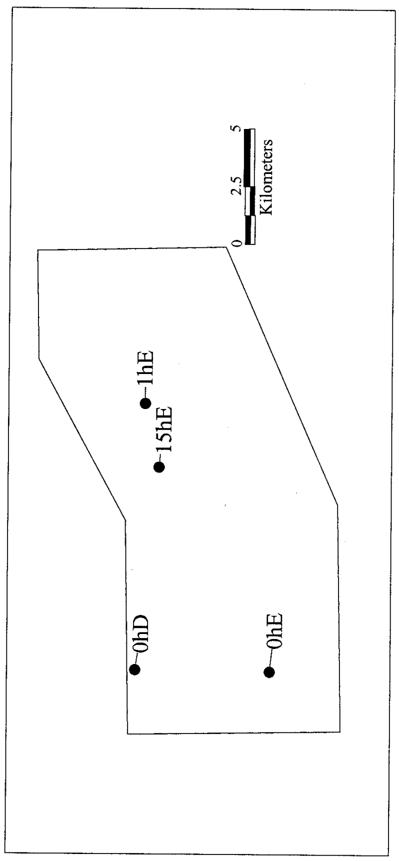
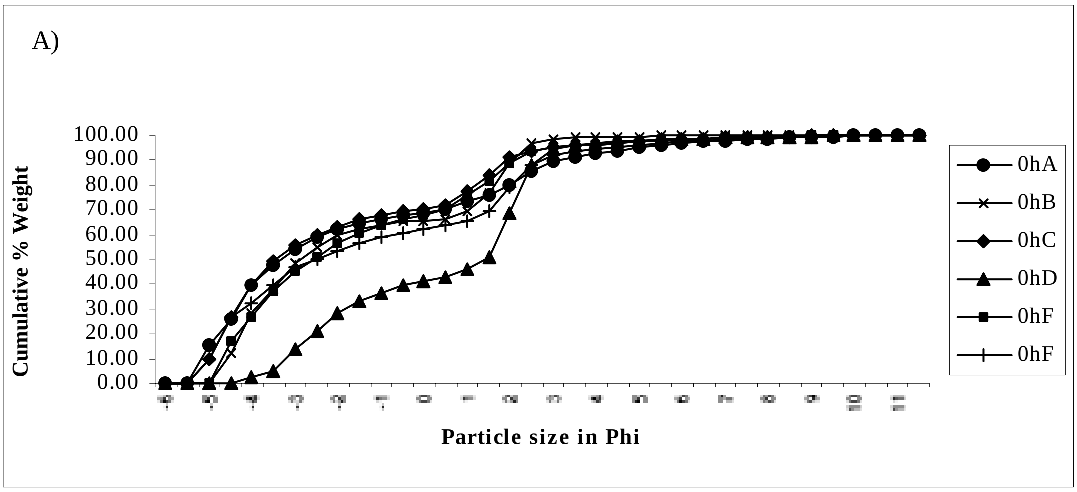
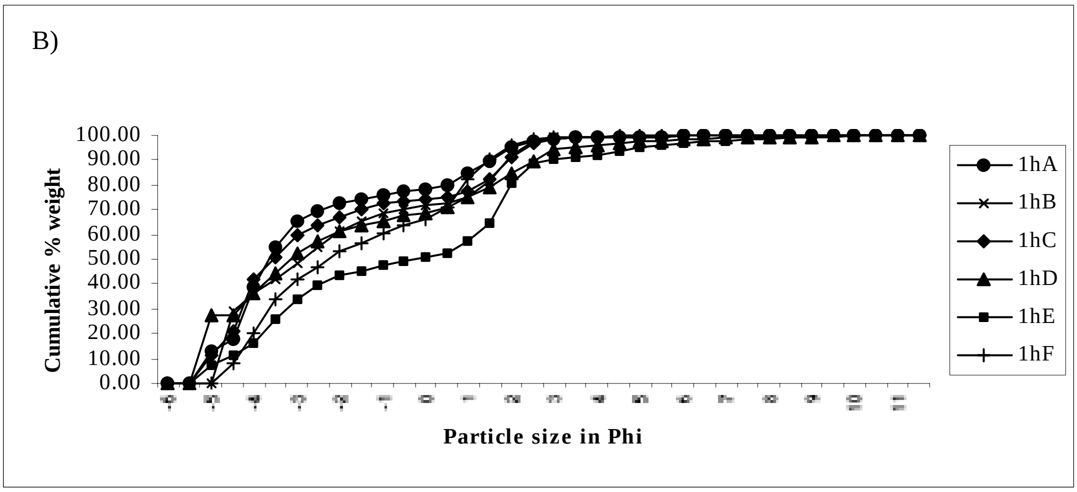


Figure 1 Map showing the location of commercial aggregate extraction licences and sample positions in the Eastern English Channel.

Figure 2 - Particle size distributions determined from samples taken from each level of dredging intensity.





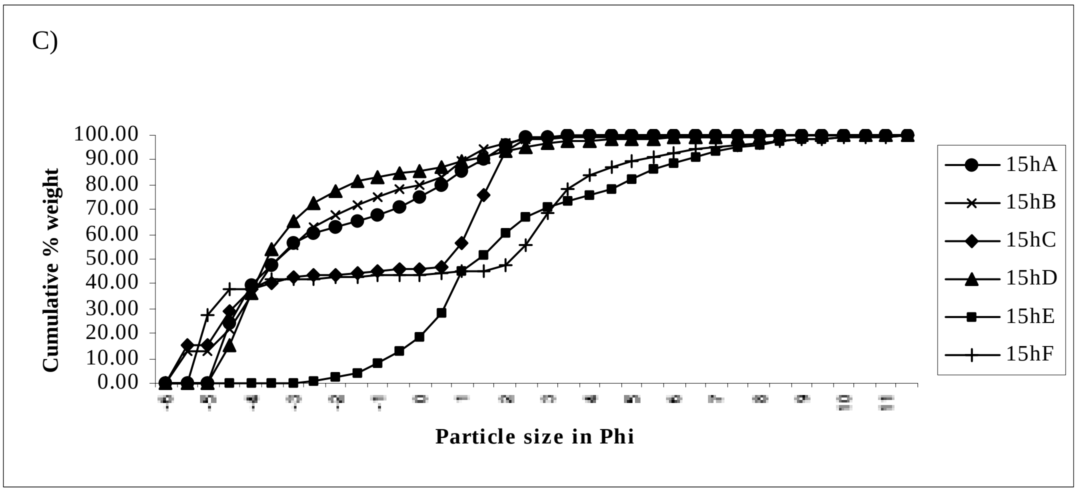
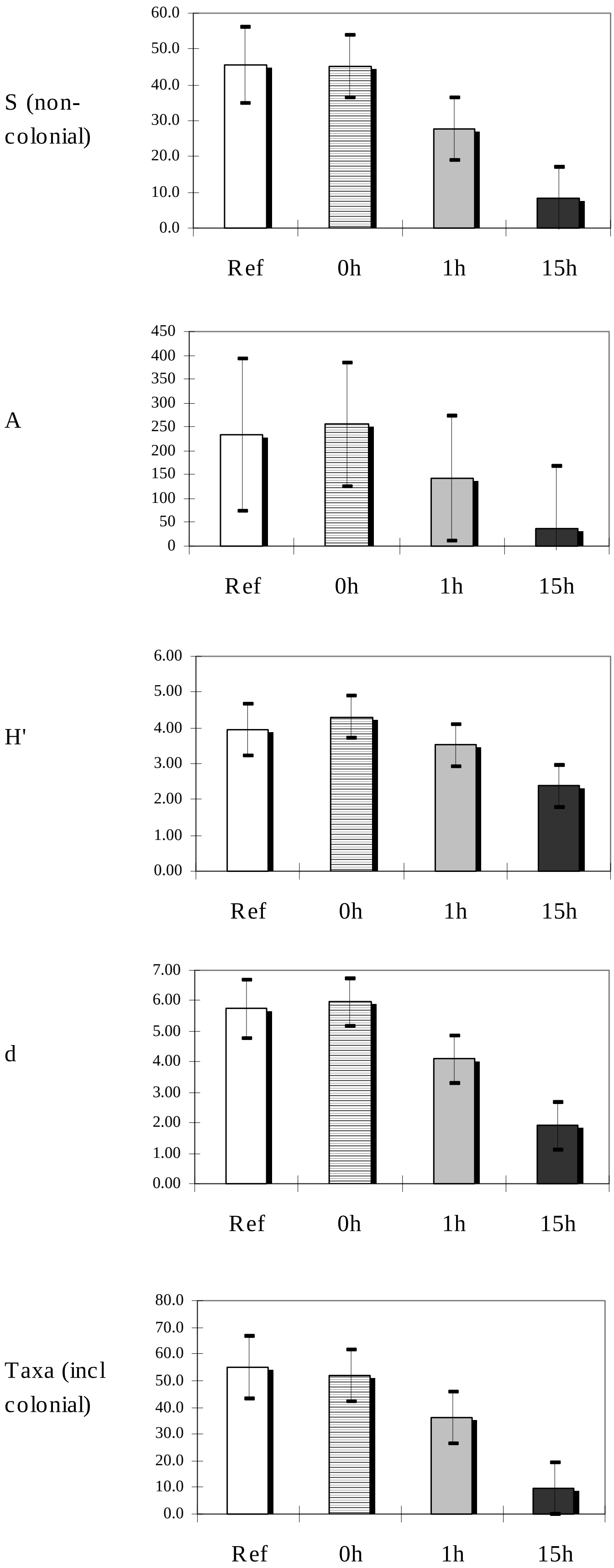


Figure 3 - Means and 95 % LSI's for univariate measures of community structure for



each level of dredging intensity.

Figure 4 - Non-metric multidimensional scaling (MDS) on Bray-Curtis species similarities following log-transformation.

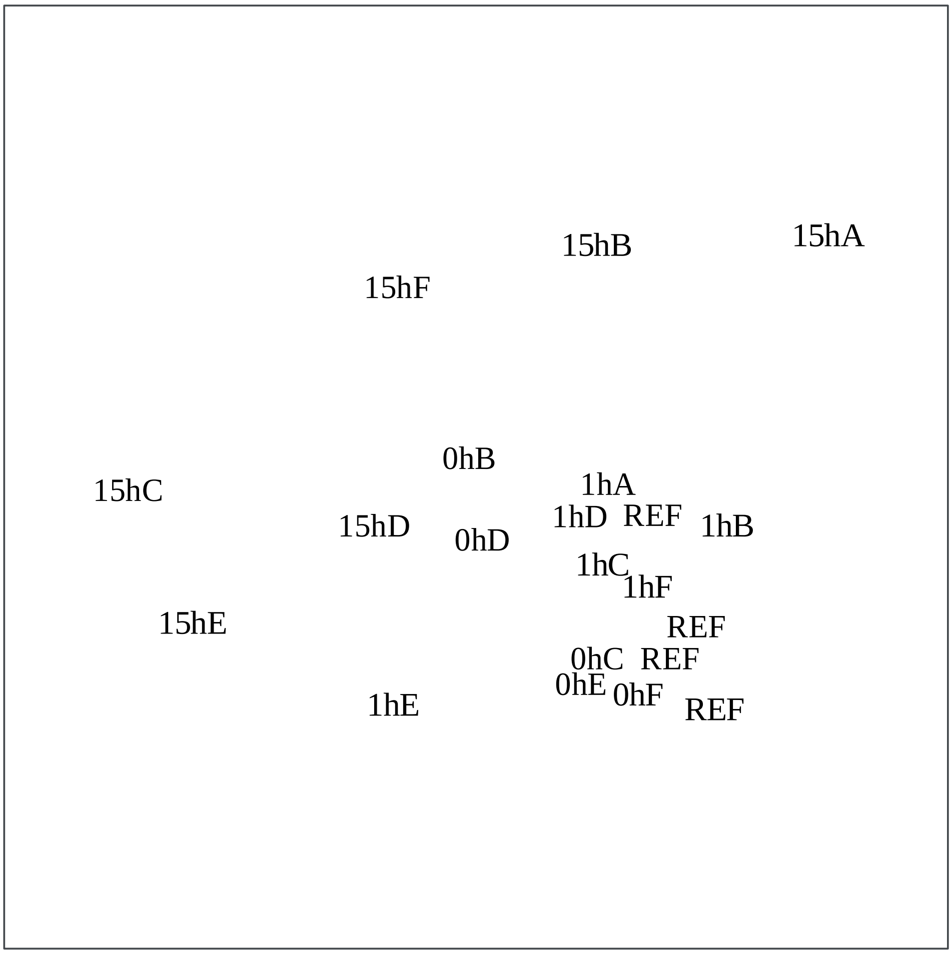
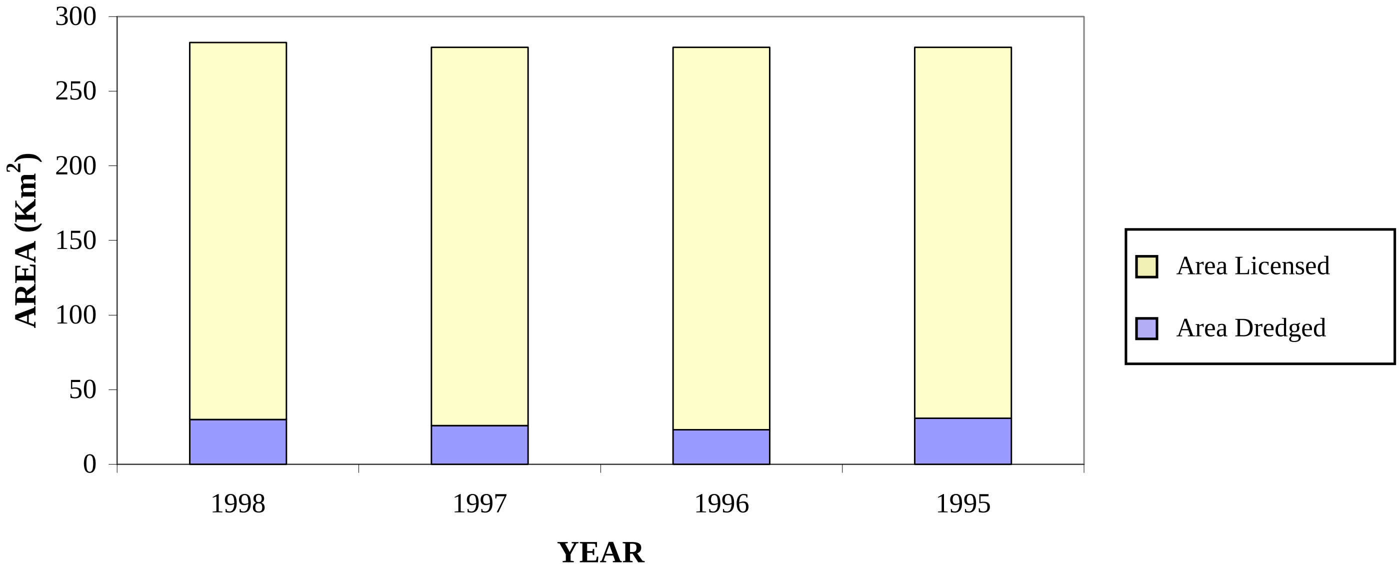


Figure 5 The area of seabed dredged in relation to the area licensed for sand and gravel extraction in the study region (derived from Crown Estate figures).



22 ANNEX X - GRAINSIZE VARIABILITY AND CREST STABILITY OF A NORTH SEA SAND WAVE IN SPACE AND TIME.

Paper presented at the Marine Sandwave Dynamics workshop, Lille, march 23-24, 2000

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ABSTRACT

A four-year study started in 1999 centers on grainsize variability and seafloor stability along the crest of a particular sand wave in Dutch offshore block S2. Most data from the literature suggest that due to higher current velocities and higher wave activity somewhat coarser grain sizes may be expected on a sand wave crest compared to a sand wave trough. However, the magnitude of the differences and their variability is a largely uncharted field as are the effects of moving bedforms and seasonal variations.

INTRODUCTION

Seafloor dynamics is part of the current research effort of NITG-TNO as seafloor stability is a recurrent theme in applied seabed activities. One of the projects is the DYNZEEB project which encompasses specific sand wave, longitudinal sand ridge and outer delta research. The present communication centers on the sand wave component of this project The input of Rijkswaterstaat, North Sea Directorate as regards surveying and data processing is gratefully acknowledged.

1.Sand wave crest dynamics and variability

Sand waves in the southern North Sea are an enigmatic result of a dynamic equilibrium between sand, tidal currents and wave energy. Currents and wave action lead to sand transport and bedform movement or bedform change. The crestal part of a sand wave is the most dynamic and unstable part of a sand wave, partly because under certain conditions smaller bedforms are present on and migrate over the sand wave crest, thereby changing the crest shape and/or symmetry. Otherwise, increased wave energy may lead to increased erosion and winnowing, resulting not only in an different (reduced) sand wave height but also in grain size changes. Sand wave crests in the area under study are generally not straight but curved and bifurcating instead. This probably will have an effect on current speed and direction and so, on grainsize.

As the shape of sand waves influences tidal flow velocity, grain size changes on a profile crossing a sand wave are to be expected. The increase in flow velocity near the crest results in coarser and well sorted sand over there. This has been measured by several authors, for instance Wells and Ludwick (1974). Other authors (e.g. Terwindt, 1971), however, note that because of migration of smaller bedforms the result is not straightforward. Wave activity over a sand wave crest also tends to increase winnowing of the finer particles resulting in a somewhat coarser grainsize. Storm activity may take the whole upper part of the sand wave crest away, further complicating matters.

Variability in time is based on amongst others movement of smaller bedforms during a normal tidal cycle. A spring tidal cycle not only enhances this bedform oscillation or migration but also changes (reduces) the shape (and the height) of a sand wave crest. See for instance Langhorne (1982). Most storms and even more so most severe storms occur in the winter season. Depending on inter alia the water depth storms affect especially the crestal part of sand waves, leading to a considerable reduction in sand wave height. See for instance Houthuys et al. (1994) and Langhorne (op.cit.).It is to be seen what the effect of a storm on the sand wave under study will be, not only as regards grain size but also regarding sand wave height. As to the latter, studies near the Goeree light platform suggest sand wave height reductions in the order of 0.5 to 1.2 m.

2.Outline of completed and planned research

A literature search for research results combining sand waves and grain size was carried out, followed by the selection of a suitable (part of a) sand wave. Two (out of five) envisaged surveys have been completed. Only the processed data and results of the first survey are now available for further study.

3.Particulars of the selected sand wave

The sand wave selected is situated in the SE corner of block S2, where water depth above the crest is 21-24 m. The sand wave height is 5-7 m. Some parts of the same sand wave are nearly symmetrical while other parts are clearly asymmetrical. The sand wave crest was surveyed in 1994 for potential coarse sand extraction purposes (Rijsdijk, 1995). The sand wave crest under study is part of a group of sand waves that show curved and bifurcating crest lines. These sand waves are situated on top of the broad and low Buiten banken linear sand ridge off the Zeeland coast.

4.Research results so far

Both in April (after the winter season) and September/October 1999 (after the summer) a short survey was successfully carried out over the selected sand wave in which 2 dozen short cores were collected as well as side scan sonar records and bathymetric profiles. On both surveys numerous megaripples were visible on the sand wave crest. Cores have been inspected and grain size subsamples at various levels taken. A first batch of Malvern particle sizer results is available. Processed side scan sonar records and 3D bathymetry are expected around the year’s end. A third survey, identical to the two previous ones, is planned after the stormy 1999-2000 winter season. Thereafter, a comparison of the data sets would be especially rewarding.

Conclusion

By the time of the Lille international sand wave workshop (March 2000) first results from the various characterization techniques of the first two surveys will be available for inspection and intercomparison. Subsequent survey results will lead to answers regarding the questions and uncertainties formulated in the first section.

References:

Houthuys, R.., Trentesaux, A. and De Wolf, P., 1994. Storm influences on a tidal sandbank's surface (Middelkerke Bank, southern North Sea). *Mar. Geol*., **v. 121**, p. 23-41.

Langhorne, D.N., 1982. A study of the dynamics of a marine sand wave. *Sedimentology*, **v. 29**, p. 571-594.

Rijsdijk, K.F., 1995. Onderzoek voorkomens industriezand zuidelijke Noordzee - Detailonderzoek op de kam van een zandgolf in het blok S2. (Study of the occurrence of industrial sand in the southern North Sea – detailed study on a sand wave crest in block S2). RGD Rept. OP6533, 17 p., figs, Rijkswaterstaat North Sea Directorate/Rijks Geologische Dienst.

Terwindt, J.H.J., 1971. Sand waves in the Southern Bight of the North Sea. *Mar. Geol*., **v. 10**, p. 51-67.

Wells, J.T. and Ludwick, J.C., 1974. Application of multiple comparisons to grain size on sand waves. *J. Sed. Petrol*., **v.44**, p. 1029-1036.

23 ANNEX XI TRIALLING ACOUSTIC SEABED MAPPING TECHNIQUES FOR MONITORING MARINE SAC'S: PLYMOUTH SOUND AND ESTUARIES CSAC.

Client: English Nature, UK.

Reporting: 2000.

Contractor: ABP Research.

Rationale

The UK marine SAC's project, funded under the EC LIFE programme, aims to develop demonstration schemes for management on 12 marine Special Areas of Conservation (SAC), one of which is Plymouth Sound and Estuaries cSAC, to inform management of marine SAC's elsewhere in the UK and Europe. To support this aim there are a number of tasks that seek to develop best practice and guidance on different aspects of managing marine SAC's.

Plymouth Sound and Estuaries cSAC has been chosen to assess the application and relative merits of different acoustic seabed mapping techniques, partly to maximise the results related monitoring trials, and partly because the site has been mapped previously using a RoxAnn ^{tm} acoustic ground discrimination system (AGDS).

Aims and Objectives

1. To evaluate the ability of different acoustic techniques to consistently discriminate between sublittoral habitats

2. To assess the repeatability of different acoustic techniques.

3. To evaluate the cost/benefits of the tested systems to meet the conservation objectives of English Nature.

4. To determine points of good practice and quality assurance (QA) to inform relevant Procedural Guidelines in the UK Maine SAC's project monitoring handbook (Hiscock and Murray, 1999).

Systems Evaluated

A survey was conducted over 7 days in January 2000 using, **i.** an interferrometric multibeam bathymetric system (Submetrix ISIS 200), **ii.** a digital dual frequency EG&G side-scan (Emu Environmental) and RoxAnn^{tm} (SeaMap, Newcastle University). A fourth system was also trialed at the same time, namely a multibeam bathymetric system (Simrad EM3000), but this was not officially part of the English Nature marine SAC contract.

The area surveyed is shown in Figure 1 and covers a north south leg 10 km by 500 metres and an east west leg 5 km by 500 metres. A calibration area measuring about 250 m by 250 m was used to investigate the stability of the systems at the beginning and end of each day. Ground truth sampling was conducted using an underwater camera, a Day grab and Anchor Dredge. The location of ground truth samples and existing ground truth data from previous surveys is shown in Figure 1. All survey positioning was performed using a kinematic DGPS which also provided 1cm accuracy elevation for bathymetric tidal level correction.

The results from the trials have yet to be fully analysed but an important consideration of the project is to ensure that the methods recommended consider the cost/benefits of each of the systems to meet English Nature's monitoring requirements. In particular, the project will investigate the practicalities of setting-up the equipment on relatively small (inshore) survey vessels and the data post processing requirements.

24 ANNEX XII - THE DISTRIBUTION OF MAERL ON THE IRISH COASTLINE

This report presents the findings of a desk study into the distribution of maerl beds in Irish waters. Records were extracted from a variety of sources including old Admiralty charts, published ecological and geological papers and personal communications from various people. Although every effort was made to include all records, undoubtedly some were undiscovered, especially older ones (i.e. pre-1900) and unusual occurrences. The latter ones are for instance where a small patch of maerl (< $10m^2$) occurs in close proximity to an extensive bedrock area (i.e. many parts of Bantry Bay, pers. obs. S. De Grave). In addition some records remain dubious as to their presence in a given area, while the exact location of other beds and most other ones in areas likely to contain maerl beds were consulted. In instances where duplicate records were found in a given area, the most comprehensive one was chosen and other ones left out of the report. The present report should thus be regarded in a general sense and should not be used to locate existing beds.

This report is a pure compilation of what has been reported as maerl in the ecological and geological literature and on the assumption that the chart notation 'crl' stands for maerl deposits. No effort has been made to verify the validity of any records and hence the distribution of maerl beds in Irish waters could potentially be significantly over- or under-estimated by this compilation. Thus caution should be exercised when perusing this report.

The report is geographically confined to the waters of the Republic of Ireland, excluding Northern Ireland, although it is known that maerl beds occur in certain locations in Northern Ireland (e.g. ERWIN et al., 1990; NUUN, 1993).

Three main sources were used in this compilation:

Old Admiralty charts, on which the notation 'crl' is used to denote maerl beds (see below)

published ecological and geological accounts

personal communications and observations

On the enclosed charts a distinction is made between locations derived from Admiralty charts (circles) and the other two sources (squares), the latter two sources are distinguished in the titles of the charts, with either a reference given to a publication or the notations pers. obs. (based on diving observations) or pers. comm. (based on other sources of information, i.e. confidential reports, local knowledge etc.) However, no distinction was made of chart annotations that show the bottom deposits to only partly consist of 'crl', these include amongst others: g.crl, s.crl, s.g.crl, This is justifiable, as it is known that maerl beds are frequently mixed with other types of bottom deposits (BOSENCE, 1980).

Caution has to be exercised in interpreting the old chart notations, as 'crl' does not always relate to maerl beds. In effect the notation 'crl' stands for any large fragment of calcareous material which is not definitively related to shells (SHEPARD et al., 1949). KEARY (1993) has further outlined the limitations of using chart notations to find maerl beds, in which he concluded that it would be reasonable to use chart data as an indication of the presence of maerl beds but not as a guide to its concentration, absence or exact distribution. However, chart notations indicated the presence of 'crl' in an area off Wicklow Head in the Irish Sea. When this area was sampled no maerl was encountered, extensive reefs constructed by the polychaete Sabellaria alveolata were found (DE GRAVE AND WHITAKER, in prep.). It thus appears that extreme caution has to be exercised in using chart notations to locate maerl grounds. Because of this, these charts were left out of the report.

As of course the old Admiralty charts do not give information as to the exact species of maerl forming the beds and as this information is also frequently left out of ecological and geological literature, a review of the main bed forming species and the rarer components in give below. In total 7 species are known to form free-living maerl beds, although one of these has not been found this century (Table 1). Presently, exact species distribution records of all species within Irish waters are confused, due to frequent mis-identifications. Only confirmed records are given below

Table 1. Maerl species, encountered in Irish Waters.

Genus	Species
Lithophyllum	Lithophyllym dentatum
	Lithophyllum faciculatum
	Lithophyllum hibernicum
Lithothamnion	Lithothamnion corallioides
	Lithothamnion glaciale
Mesophyllum	Mesophyllum licnenoides
Phymatolithon	Phymatolithon calcareum

25 ANNEX XIII NEW BELGIUM LEGISLATION ON EXPLORATION AND EXPLOITATION OF MARINE RESOURCES

WET VAN 13 JUNI 1969 INZAKE DE EXPLORATIE EN EXPLOITATIE VAN NIET-LEVENDE RIJKDOMMEN VAN DE TERRITORIALE ZEE EN HET CONTINENTAAL PLAT

(Staatsblad van 8 oktober 1969)

gewijzigd door:

(i) de wet van 20 januari 1999 tot bescherming van het mariene milieu in de zeegebieden onder de rechtsbevoegdheid van België, Staatsblad van 12 maart 1999, hierna genoemd, “de wet van 20 januari 1999” en door

(ii) de wet van 22 april 1999 betreffende de exclusieve economische zone van België in de Noordzee (Staatsblad van 10 juli 1999), hierna aangeduid als “wet van 22 april 1999”)

Boudewijn, Koning der Belgen,

Aan Allen die nu zijn en hierna wezen zullen,

Onze Groet.

LOI DU 13 JUIN 1969 SUR L’EXPLORATION ET L’EXPLOITATION DES RESSOURCES NON VIVANTES DE LA MER TERRITORIALE ET DU PLATEAU CONTINENTAL

(Moniteur du 8 octobre 1969)

modifiée par:

(i) la loi du 20 janvier 1999 visant la protection du milieu marin dans les espaces marins sous juridiction de la Belgique, Moniteur du 12 mars 1999, mentionnée ci-après, “la loi du 20 janvier 1999”

(ii) la loi du 22 avril 1999 concernant la zone économique de la Belgique en mer du Nord, (Moniteur du 10 juillet 1999), désignée ci-après comme « loi du 22 avril 1999 »

Baudouin, Roi des Belges,

A tous, présents et à venir,

Salut.

De Kamers hebben aangenomen en Wij bekrachtigen hetgeen volgt:

<u>Artikel 1</u> **[Het Koninkrijk België oefent zijn soevereiniteit uit over de territoriale zee en soevereine rechten over het continentaal plat ter exploratie en ter exploitatie van de minerale en andere niet-levende rijkdommen**.]

* Vervangen bij artikel 27 van de wet van 22 april 1999

<u>**Art. 2**</u> **[Het continentaal plat van België omvat de zeebodem en de ondergrond van de onder water gelegen gebieden die aan de kust aansluiten doch buiten de territoriale zee gelegen zijn en waarvan de buitengrens bepaald wordt door de lijn bestaande uit segmenten die de volgende, in coördinaten uitgedrukte punten, verbindt, in de volgorde zoals hieronder aangegeven:**

1. 51°16'09" N 02°23'25" O

2. 51°33'28" N 02°14'18" O

3. 51°36'47" N 02°15'12" O

4. 51°48'18" N 02°28'54" O

5. 51°52'34,012" N 02°32'21,599" O

6. 51°33'06" N 03°04'53" O

De ligging van de in dit artikel opgesomde punten is uitgedrukt in lengte en breedte volgens het Europees geodetisch systeem (1e vereffening 1950).]

* Vervangen bij artikel 28 van de wet van 22 april 1999

Les Chambres ont adopté et Nous sanctionnons ce qui suit:

<u>Article 1er</u> **[Le Royaume de Belgique exerce sa souveraineté sur la mer territoriale et des droits souverains sur le plateau continental aux fins de l'exploitation des ressources minérales et autres ressources non-vivantes]**

* Remplacé par l'article 27 de la loi du 22 avril 1999

<u>Art. 2</u> **[Le plateau continental de Belgique comprend le fond marin et le sous-sol des régions sous-marines, adjacentes aux côtes mais situées en dehors de la mer territoriale et dont la délimitation extérieure est constituée par une ligne composée de segments, qui relie, dans l'ordre où ils sont énumérés, les points ci-après définis par leurs coordonnées:**

1. 51°16'09"N 02°23'25"E

2. 51°33'28"N 02°14'18"E

3. 51°36'47"N 02°15'12"E

4. 51°48'18"N 02°28'54"E

5. 51°52'34,012"N 02°32'21,599"E

6. 51°33'06"N 03°04'53"E

Les positions des points énumérés dans le présent article sont exprimées en latitudes et longitudes dans le système géodésique européen (1er règlement 1950).]

* Remplacé par l'article 28 de la loi du 22 avril 1999

Zie ook: 1. Wet van 17 februari 1993 houdende goedkeuring van de Overeenkomst tussen de Regering van het Koninkrijk België en de Regering van het Verenigd Koninkrijk van Groot-Brittannië en Noord-Ierland inzake de afbakening van het continentaal plat tussen beide landen, ondertekend te Brussel op 29 mei 1991 (Staatsblad van 1 december 1993) (voor de in punten 3 – 4 uitgedrukte coördinaten);

Voir aussi: 1. Loi du 17 février 1993 portant approbation de l'Accord entre le Gouvernement du Royaume de Belgique et le Gouvernement du Royaume-Uni de Grande-Bretagne et d'Irlande du Nord relatif à la délimitation du Plateau continental entre les deux pays, signé à Bruxelles le 29 mai 1991 (Moniteur du 1 décembre 1993) (pour les points 3 – 4 définis par leurs coordonnées);

2. Wet van 17 februari 1993 houdende goedkeuring van de volgende Internationale akten: 1. Overeenkomst tussen de Regering van het Koninkrijk België en de Regering van de Franse Republiek inzake de afbakening van de territoriale zee en 2. Overeenkomst tussen de Regering van het Koninkrijk België en de Regering van de Franse Republiek inzake de afbakening van het Continentaal plat, ondertekend te Brussel op 8 oktober 1990 (Staatsblad van 1 december 1993) (voor de in punten 1 – 2 uitgedrukte coördinaten)

2. Loi du 17 février 1993 portant approbation des Actes internationaux suivants: 1. Accord entre le Gouvernement de Belgique et le Gouvernement de la République française relatif à la délimitation de la Mer territoriale et 2. Accord entre le Gouvernement de Belgique et le Gouvernement de la République française relatif à la délimitation du Plateau continental, signés à Bruxelles, le 8 octobre 1990 (Moniteur du 1 décembre 1993) (pour les points 1 – 2 définis par leurs coordonnées); (1 – 2)

3. Wet van 10 augustus 1998 houdende instemming met het Verdrag tussen het Koninkrijk België en het Koninkrijk der Nederlanden inzake de afbakening van het continentaal plat, en Bijlage, en briefwisseling en met het Verdrag tussen het Koninkrijk België en het Koninkrijk der Nederlanden inzake de afbakening van de territoriale zee, ondertekend te Brussel op 18 december 1996 (Staatsblad van 19 juni 1999, erratum 3 september 1999) (voor de in punten 5 – 6 uitgedrukte coördinaten)

3. Loi du 10 août 1998 portant assentiment à l'Accord entre le Royaume de Belgique et le Royaume des Pays-Bas relatif à la délimitation du Plateau continental, et Annexe, et échange de lettres et à l'Accord entre le Royaume de Belgique et le Royaume des Pays-Bas relatif à la délimitation de la Mer territoriale, signés à Bruxelles le 18 décembre 1996 (Moniteur du 19 juin 199, erratum 3 septembre 1999) (pour les points 5 – 6 définis par leurs coordonnées);

Art. 3 § 1. Voor de exploratie en de exploitatie van de minerale en andere niet-levende rijkdommen van de zeebodem en van de ondergrond is concessie vereist, die wordt verleend onder de voorwaarden en volgens de regelen welke de Koning bepaalt.

Art. 3 § 1. La recherche et l'exploitation des ressources minérales et autres ressources non vivantes du **fond marin** et du sous-sol sont subordonnées à l'octroi de concessions accordées aux conditions et selon les modalités déterminées par le Roi.

Hij bepaalt eveneens de procedure voor de gedeeltelijke of gehele intrekking of overdracht van de concessie.

Il détermine également la procédure à suivre pour le retrait ou le transfert partiel ou entier de la concession.

* Gewijzigd bij artikel 29 van de wet van 22 april 1999

* Modifié par l'article 29 de la loi du 22 avril 1999

Zie: koninklijk besluit van 7 oktober 1974 betreffende het verlenen van concessies voor de exploratie en de exploitatie van de minerale en andere niet-levende rijkdommen van het continentaal plat (Staatsblad van 1 januari 1975), gewijzigd bij het koninklijk besluit van 22 april 1983 (Staatsblad van 18 juni 1983);

Voir: arrêté royal du 7 octobre 1974 relatif à l'octroi de concessions de recherche et d'exploitation des ressources minérales et autres ressources non vivantes sur le plateau continental (Moniteur du 1 janvier 1975) et modifié par l'arrêté royal du 22 avril 1983 (Moniteur du 18 juin 1983);

Koninklijk besluit van 16 mei 1977 houdende maatregelen tot bescherming van de scheepvaart, de zeevisserij, het milieu en andere wezenlijke belangen bij de exploratie en exploitatie van minerale en andere niet-levende rijkdommen van de zeebedding en de ondergrond in de territoriale zee en op het continentaal plat (Staatsblad van 21 juli 1977);

Arrêté royal du 16 mai 1977 portant des mesures de protection de la navigation, de la pêche maritime, de l'environnement et d'autres intérêts essentiels lors de l'exploration et de l'exploitation des ressources minérales et autres ressources non vivantes du lit de la mer et du sous-sol dans la mer territoriale et sur le plateau continental (Moniteur du 21 juillet 1977);

Koninklijk besluit van 30 oktober 1997 betreffende het verlenen van uitsluitende vergunningen voor de exploratie en de exploitatie van koolwaterstoffen van het continentaal plat en in de territoriale zee (Staatsblad van 6 december 1997).

Arrêté royal du 30 octobre 1997 relatif à l'octroi de permis exclusifs de recherche et d'exploitation d'hydrocarbures sur le plateau continental et dans la mer territoriale (Moniteur du 6 décembre 1997).

[§ 2. Elke aanvraag tot concessie of machtiging omvat een milieueffectenrapport dat is opgesteld onder verantwoordelijkheid en op kosten van de aanvrager. De aanvraag wordt onderworpen aan een milieueffectenbeoordeling.

[§ 2. Toute demande de concession ou d'autorisation comprend une étude d'incidences sur l'environnement qui est établie sous la responsabilité et au frais du demandeur. La demande est soumise à une évaluation des incidences sur l'environnement.

Het milieu-effectenrapport wordt opgesteld en de milieueffectenbeoordeling wordt uitgevoerd overeenkomstig de door de Koning, op gezamenlijke voordracht van de minister die de Economische Zaken onder zijn bevoegdheid heeft en de minister die Leefmilieu onder zijn bevoegdheid heeft, vastgestelde regels in verband met de procedure, de inhoud en de vorm.

L'étude d'incidences sur l'environnement est établie et l'évaluation des incidences sur l'environnement est réalisée conformément aux règles relatives à la procédure, au contenu et à la forme établis par le Roi sur proposition conjointe du ministre qui a les Affaires économiques dans ses attributions et du ministre qui a l'Environnement dans ses attributions.

De exploratie en de exploitatie worden onderworpen aan een continu onderzoek naar de invloed van de betrokken activiteiten op de sedimentafzettingen en op het mariene milieu.

L'exploration et l'exploitation sont soumises à un examen continu de l'influence des activités concernées sur les déplacements des sédiments et sur le milieu marin.

§ 3. De minister die Leefmilieu onder zijn bevoegdheid heeft, brengt advies uit over het milieu-effectenrapport en de resultaten van de milieu-effectenbeoordeling.

§ 3. Le ministre qui a l'Environnement dans ses attributions émet un avis sur l'étude d'incidences sur l'environnement et sur les résultats de l'évaluation des incidences sur l'environnement.

Concessies, machtigingen, verlengingen of vernieuwingen kunnen slechts worden toegestaan mits het gunstig advies van de minister die Leefmilieu onder zijn bevoegdheid heeft.

Les concessions, les autorisations, les prolongations ou les renouvellements ne peuvent être accordés que sur avis favorable du ministre qui a l'Environnement dans ses attributions.

Bij aanvragen en aanvragen tot verlenging van een concessie of machtiging zal worden rekening gehouden met de resultaten van het continue onderzoek.

Lors de demandes et demandes de prolongation ou de renouvellement d'une concession ou autorisation, il sera tenu compte des résultats de l'examen continu.

Indien uit het continu onderzoek blijkt dat de betrokken activiteiten onaanvaardbare nadelige gevolgen voor de sedimentafzettingen of voor het mariene milieu hebben, kan de concessie of machtiging geheel of gedeeltelijk, opgeheven of geschorst worden.

Si l'examen continu fait apparaître des effets nuisibles inacceptables des activités concernées sur les déplacements de sédiments et sur le milieu marin, la concession peut être retirée ou suspendue en tout ou en partie.

§ 4. De exploratie en de exploitatie worden onderworpen aan een vergoeding volgens de modaliteiten die bepaald worden in de concessie-besluiten, voor de uitvoering van het continue onderzoek naar de invloed van de betrokken activiteiten op de sedimentafzettingen en op het mariene milieu.

§ 4. L'exploration et l'exploitation sont soumises à une redevance, selon les modalités prévues par les arrêtés de concession, pour l'exécution de l'examen continu de l'influence des activités concernées sur les déplacements de sédiments et sur le milieu marin.

§ 5. De Koning stelt op gezamenlijke voordracht van de minister die de Economische Zaken onder zijn bevoegdheid heeft en de minister die Leefmilieu onder zijn bevoegdheid heeft, een raadgevende commissie in om de coördinatie te verzekeren tussen de administraties die betrokken zijn bij het beheer van de exploratie en de exploitatie van het continentaal plat en de territoriale zee.

§ 5. Le Roi crée, sur proposition conjointe du ministre qui a les Affaires économiques dans ses attributions et du ministre qui a l'Environnement dans ses attributions, une commission consultative pour assurer la coordination entre les administrations concernées par la gestion de l'exploration et de l'exploitation du plateau continental et de la mer territoriale.

Om de drie jaar wordt een overzichtsrapport met de resultaten van het continue onderzoek aan de commissie voorgelegd.

Un rapport général sur les résultats de l'examen continu est soumis à la commission tous les trois ans.

De commissie heeft onder andere volgende specifieke opdrachten:

La commission se charge notamment des points spécifiques suivants:

- **het coördineren van de onderzoeken van de concessie-aanvragen en het formuleren van een advies over deze aanvragen;**

- **la coordination de l'examen des demandes de concession et la formulation d'un avis sur ces demandes;**

- **het opvolgen van de verschillende studies die uitgevoerd worden naar de invloed van de zandwinningen op het continentaal plat;**

- **le suivi des différentes études réalisées sur l'influence de l'extraction de sable sur le plateau continental;**

- **het onderzoek van het driejaarlijks rapport;**

- **l'étude du rapport triennal;**

- **het adviseren van corrigerende maatregelen indien een negatieve invloed zou worden vastgesteld en**

- **la recommandation de mesures de correction si une influence négative est constatée et**

- **het formuleren van beleidsvoorbereidende adviezen in verband met alle aspecten die verband houden met de zandwinningen.**

- **la formulation d'avis sur une politique concernant tous les aspects relatifs à l'extraction de sable.**

De Koning kan de werkingsmodaliteiten en werkingskosten van de commissie vaststellen].

Le Roi peut fixer les modalités de fonctionnement et les frais de fonctionnement de la commission].

** §§ 2 – 5: Ingevoegd door artikel 79 van de wet van 20 januari 1999

** §§ 2 – 5: Inséré par l'article 79 de la loi du 20 janvier 1999

[Art. 4 Voor het leggen van kabels of pijpleidingen

- die in de territoriale zee of het nationaal grondgebied binnenkomen

- of die geplaatst of gebruikt worden in het kader van de exploratie van het continentaal plat, de exploitatie van de minerale en andere niet-levende rijkdommen daarvan of van de werkzaamheden van kunstmatige eilanden, installaties of inrichtingen die onder Belgische rechtsmacht vallen

is een machtiging vereist die wordt verleend of ingetrokken volgens de regels die de koning bepaalt.

Voor pijpleidingen moet het tracé door de Koning goedgekeurd worden rekening houdend met de exploratie van het continentaal plat en de exploitatie van de minerale en andere niet-levende rijkdommen daarvan. De Koning kan bijkomende maatregelen opleggen om verontreiniging door pijpleidingen te voorkomen, verminderen of bestrijden].

* Vervangen bij artikel 30 van de wet van 22 april 1999

Art. 5 De **kunstmatige eilanden** installaties en andere inrichtingen, nodig voor de exploratie en exploitatie van de **minerale en andere niet-levende** rijkdommen van het continentaal plat alsmede de in artikel 6 bedoelde veiligheidszones mogen niet tot gevolg hebben dat op niet te rechtvaardigen wijze overlast wordt aangedaan aan de scheepvaart, de visserij of het instandhouden van de levende rijkdommen van de zee, noch dat het gebruik van de regelmatige scheepvaartroutes, die van wezenlijk belang zijn voor de internationale scheepvaart, of het fundamenteel oceanografisch of ander wetenschappelijk onderzoek, uitgevoerd met de bedoeling de resultaten ervan openbaar te maken, worden belemmerd

Te dien einde bepaalt de Koning de te nemen maatregelen en andere regelen voor hun uitvoering.

.1.1.1.1.1 [Art. 4 La pose de câbles ou de pipelines

- qui pénètrent dans la mer territoriale ou dans le territoire national

- ou qui sont installés ou utilisés dans le cadre de l'exploration du plateau continental, de l'exploitation des ressources minérales et autres ressources non-vivantes ou d'exploitation d'îles artificielles, d'installations ou d'ouvrages relevant de la juridiction belge

est subordonnée à l'obtention d'une autorisation qui est accordée ou retirée selon les modalités déterminées par le Roi.

Pour les pipelines, le tracé doit être approuvé par le Roi, compte tenu de l'exploration du plateau continental, de l'exploitation des ressources minérales et autres ressources non-vivantes. Le Roi peut imposer des mesures supplémentaires pour prévenir, réduire et lutter contre la pollution par les pipelines].

* Remplacé par l'article 30 de la loi du 22 avril 1999

Art. 5 Les **îles artificielles, installations et autres dispositifs,** nécessaires à l'exploration et l'exploitation des ressources **minérales et autres ressources non vivantes** du plateau continental, ainsi que les zones de sécurité visées à l'article 6 ne pourront gêner d'une manière injustifiable ni la navigation, la pêche ou la conservation des ressources biologiques de la mer, ni l'utilisation des routes maritimes régulières d'un intérêt essentiel pour la navigation internationale, ni les recherches océanographiques fondamentales ou les autres recherches scientifiques effectuées avec l'intention d'en publier les résultats.

A cet effet, le Roi fixe les mesures à prendre ainsi que leurs modalités d'exécution.

maatregelen en andere regelen voor hun uitvoering.

que leurs modalités d'exécution.

Hij stelt elke verplichting vast welke hij daartoe nuttig acht, inzonderheid inzake waarschuwingssystemen en inzake de middelen om verontreiniging van **de zee, de flora, de fauna en hun habitats alsook de** beschadiging van onderzeese kabels of pijpleidingen te voorkomen.

Il détermine de même toute obligation qu'il juge utile à cette fin, notamment en ce qui concerne la signalisation et les moyens d'éviter la pollution des eaux **de la mer, de la flore, de la faune et de leurs habitats** ainsi que la détérioration des câbles sous-marins et de pipelines.

Hij bepaalt de procedure voor gedeeltelijke of gehele intrekking van de machtiging of van de concessie.

Il arrête la procédure à suivre pour l'application du retrait partiel ou total de l'autorisation ou de la concession.

* Gewijzigd bij artikel 31 van de wet van 22 april 1999

* Modifié par l'article 31 de loi du 22 avril 1999

Art. 6 Een veiligheidszone zal, volgens door de koning bepaalde regelen, kunnen worden vastgesteld voor iedere in de territoriale zee of op het continentaal plat gelegen kunstmatig eiland installatie of inrichting.

Art. 6 Une zone de sécurité pourra être établie selon les modalités déterminées par le Roi pour chaque **île artificielle**, installation ou dispositif situé **dans la mer territoriale ou** sur le plateau continental.

Zij mag zich uitstrekken tot een afstand van vijfhonderd meter, gemeten van elk punt van de buitengrens van **het kunstmatig eiland**, de installatie of inrichting.

Elle peut s'étendre à une distance de cinq cents mètres mesurés à partir de chaque point du bord extérieur de ces **îles artificielles** installations ou dispositifs.

* Gewijzigd bij artikel 32 van de wet van 22 april 1999

* Modifié par l'article 32 de loi du 22 avril 1999

Art. 7 De **kunstmatige eilanden** installaties of andere inrichtingen, als bedoeld in deze wet, die blijvend **in de territoriale zee of** op het continentaal plat zijn aangebracht, alsmede de personen en de goederen die **op de kunstmatige eilanden**, installaties of inrichtingen bevinden, zijn onderworpen aan het Belgisch recht.

Art. 7 Les **îles artificielles, installations ou autres dispositifs** fixés à demeure **dans la mer territoriale ou** sur le plateau continental et visés par la présente loi, ainsi que les personnes et les biens qui se trouvent **sur les îles artificielles, installations ou dispositifs** sont soumis au droit belge.

* Gewijzigd bij artikel 33 van de wet van 22 april 1999

* Modifié par l'article 33 de loi du 22 avril 1999

Art. 8 **iedere persoon die op een in deze wet bedoeld kunstmatig eiland, installatie of andere inrichting een misdrijf begaat, dat door de belgische wet wordt beteugeld, kan in belgië worden vervolgd.**

Bij ontstentenis van andere bepalingen tot toekenning van bevoegdheid komt deze toe aan de rechtsmachten welke te Brussel zetelen.

* Gewijzigd bij artikel 34 van de wet van 22 april 1999

Art. 8 Toute personne qui aura commis une infraction réprimée par le droit belge **sur ces îles artificielles, installations ou dispositifs, visées par la présente loi** pourra être poursuivie en Belgique.

A défaut d'autres règles d'attributives de compétence, les juridictions qui siègent à Bruxelles sont compétentes.

* Modifié par l'article 34 de loi du 22 avril 1999

Art. 9 Handelingen of feiten die andere dan strafrechtelijke rechtsgevolgen hebben welke zich aan boord of ten aanzien van **een kunstmatig eiland** een installatie of een andere inrichting, als bedoeld bij artikel 7, voordoen, worden geacht zich in België te hebben voorgedaan.

Bij ontstentenis van andere bepalingen tot toekenning van bevoegdheid, worden deze handelingen of feiten geacht zich op het grondgebied van het vredegerecht van het tweede kanton van het rechterlijk arrondissement Brussel te hebben voorgedaan.

* Gewijzigd bij artikel 35 van de wet van 22 april 1999

Art. 9 Les actes ou faits ayant des effets juridiques autres que pénaux qui se produiront sur ou à l'égard **d'une île artificielle** d'une installation ou d'un autre dispositif visé à l'article 7, seront réputés s'être produits en Belgique.

A défaut d'autres règles attributives de compétence, ces actes ou faits seront réputés s'être produits sur le territoire du deuxième canton de justice de l'arrondissement judiciaire de Bruxelles.

* Modifié par l'article 35 de loi du 22 avril 1999

Art. 10 - De inbreuken op deze wet of zijn uitvoeringsbesluiten, worden bestraft overeenkomstig de artikelen 55 en 56 van de wet van 22 april 1999 betreffende de exclusieve economische zone van België in de Noordzee.

* Ingevoegd bij artikel 36 van de wet van 22 april 1999

Art. 10 Les infractions à la présente loi ou à ses arrêtés d'exécution sont punies, conformément aux articles 55 et 56 de la loi du 22 avril 1999 concernant la zone économique exclusive de la Belgique en mer du Nord.

* Inséré par l'article 36 de loi du 22 avril 1999

Nota: De artikelen 55 en 56 van de wet van 22 april 1999 luiden als volgt:

"Art. 55 Voor wat de hoofdstukken IV en V (6) van deze wet en hun uitvoeringsbesluiten betreft,

1° wordt gestraft met een gevangenisstraf van vijftien dagen tot een jaar en met geldboete van duizend frank tot een miljoen frank of met een van die straffen alleen, hij die zonder vergunning of concessie een activiteit uitoefent die onderworpen is aan een vergunning of ondergeschikt aan een concessie;

2° wordt gestraft met een gevangenisstraf van vijftien dagen tot een jaar en met geldboete van tweehonderd frank tot vijfhonderdduizend frank of met een die straffen alleen, hij die de voorwaarden of modaliteiten niet naleeft waaraan de hem verleende vergunning of concessie zijn verbonden;

3° wordt gestraft met een gevangenisstraf van vijftien dagen tot een jaar en met geldboete van tweeduizend frank tot honderdduizend frank of met een die straffen alleen, hij die de bij artikel 60 van deze wet voorziene toegang ontzegt aan een bevoegde ambtenaar of agent;

Note: Les articles 55 et 56 de la loi du 22 avril 1999 sont rédigés comme suit**:**

« Art. 55 Pour ce qui concerne les chapitres IV et V (7) de la présente loi et leurs arrêtés d'exécution,

1° est puni d'un emprisonnement de quinze jours à un an et d'une amende de mille francs à un million de francs ou d'une de ces peines seulement celui qui s'est livré sans autorisation ou concession à une activité soumise à autorisation ou subordonnée à une concession;

2° est puni d'un emprisonnement de quinze jours à un an et d'une amende de deux cents francs à cinq cent mille francs ou d'une de ces peines seulement celui qui ne s'est pas conformé aux conditions ou modalités définies dans l'autorisation ou la concession qui lui a été délivrée ou octroyée;

3° est puni d'un emprisonnement de quinze jours à un an et d'une amende de deux mille francs à cent mille francs ou d'une de ces peines seulement celui qui a refusé, à un fonctionnaire ou agent compétent, les accès prévus à l'article 60 de la présente loi;

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(6) Hoofdstuk IV: "Over niet-levende rijkdommen" en Hoofdstuk V: "Over kunstmatige eilanden, installaties en inrichtingen"

(7) Chapitre IV: "Des ressources non vivantes" et Chapitre V: "Des îles artificielles, installations et ouvrages"

4° wordt gestraft met een gevangenisstraf van vijftien dagen tot een jaar en met geldboete van duizend frank tot honderdduizend frank of met een die straffen alleen, hij die de veiligheidszones en –maatregelen niet naleeft, vastgesteld ter uitvoering van deze wet.

Indien de overtreding wordt begaan tussen zonsondergang en zonsopgang of bij herhaling binnen drie jaar na de vorige veroordeling wegens één der misdrijven bedoeld in het eerste lid, kunnen de hierboven voorziene straffen tot het dubbele van het maximum worden gebracht.

Art. 56 De rechtspersonen zijn burgerrechtelijk aansprakelijk voor de betaling van de schadevergoedingen, geldboetes en kosten, voortspruitend uit veroordelingen uitgesproken tegen hun organen of aangestelden wegens inbreuken op de bepalingen van deze wet en hun uitvoeringsbesluiten”

4° est puni d’un emprisonnement de quinze jours à un an et d'une amende de mille francs à cent mille francs ou d’une de ces peines seulement celui qui n'a pas respecté les zones et mesures de sécurité fixées en exécution de la présente loi.

Si l’infraction est commise entre le coucher et le lever du soleil ou en cas de récidive dans les trois ans qui suivent une condamnation pour une des infractions visées au premier alinéa, les peines prévues ci-dessus peuvent être portées au double du maximum.

Art. 56 Les personnes morales sont civilement responsables pour le paiement des dommages et intérêts, des amendes et des frais résultant des condamnations prononcés contre leurs organes ou préposés pour infraction aux dispositions de la présente loi ou de ses arrêtés d’exécution »

26 ANNEX XIV – NEW INVESTIGATION AND EVALUATION CONCEPT TO DETECT EFFECTS OF DREDGING AND DUMPING ON MACROZOOBENTHOS

Federal Institute of Hydrology, Germany

Presentation of the concept and first results: investigation of submarine disposal sites

Stefan Nehring & Heiko Leuchs, Federal Institute of Hydrology, Koblenz, Germany

Due to sedimentation of sand or mud within coastal waterways continuous maintenance dredging is necessary, to guarantee the legally fixed water depth. The sediment masses to be dredged in the different waterways on the German North Sea coast sum up every year to several million m³ (Elbe estuary, Ems estuary, Jade) with the exception Weser estuary (less than 1 million m³).
As a result of the transformation of international agreements (dredging guidelines from OSPAR and HELCOM), for the Federal Water and Shipping Administration the "manual for the handling of dredged material in the coastal areas (HABAK-WSV)" was developed. An important issue was the investigation of the impact of dumping activities on macrozoobenthos.

The typical dynamic abiotic parameters in estuaries are responsible for the great variability in aquatic coenosis, as well as in the number of species, the species composition and in the abundance and biomass. This strong "basic noise" complicates identification of anthropogenic disturbances on macrozoobenthos. To optimise the planning and evaluation of investigations, the following working hypothesis was formulated and on that basis a sampling concept was developed. With data sets of current investigations a new evaluation concept was tested and further developed. The consideration and evaluation of a number of statistical and ecological evaluation methods made it possible to receive by far a more detailed answer to the question "are there ecological effects on macrozoobenthos by dumping at sea?". By that, additional characteristics of the biocoenoses will increasingly be included. This will result in described effects being more quantifiable and more reconstructable.

General conditions while dumping

- a part of the dumped sediment sinks to seabed and deposits itself there.
- a part of the sediment goes into suspension, increases the concentration of suspended material and drifts with the current, within a given time and space in a limited manner. Partly higher particle concentration occurs close to the seabed (fluid mud).
- Sedimented material can be resuspended and transported by currents.

Working hypothesis

Sediment deposition and/or raised turbidity have effects on a different scale on benthic organisms. This is dependent on the tolerance of the species, the volume and the frequency of covering and/or increase of turbidity. Under these conditions, an initial assumption is that the zoobenthos community in the dumping area itself can become modified compared to reference areas, which are not influenced directly by dumping. Species and individual density of benthic invertebrates may be reduced compared to reference areas. Due to the recurring disturbances by regular disposal within the framework of maintenance measures, a zoobenthos community, which is characteristic for undisturbed sites, could possibly not develop itself. The number of adult individuals can be atypically low while juvenile stages dominate. For this reason, the relation number of individuals to biomass can also be modified compared to undisturbed sites.

The described effects on macrozoobenthos are most intense inside the dumping areas (centre of disturbance). Those areas, in which the suspended part of the dumped material drifts close to ground (plume area), can also be influenced. However, the effects are presumably to a lesser degree and will still decrease with distance from the centre. In the plume areas of dumping sites for mud, the level of concentration of suspended material is normally higher both in the water column and close to the seabed than in the zones of dumping areas for sand. It is expected that more intense effects will be observed at mud dumping sites. On the other hand, at sand dumping sites, an increased sand drift close to ground could potentially occur, which could mechanically damage benthic organisms (sand scour effect).

With increasing distance from the dumping area, the possibility of detecting the disturbance will decrease to a point, where no ecological effects of dumping at sea are discernable.

Sampling concept

On the basis of this working hypothesis, the following sampling concept was developed, which is designated as the 'c-p-r concept'. The sampling stations are sub-divided into three groups and positioned as follows:

- Strongly influenced stations in the center (c)
- Stations in the lesser influenced plume area (p)
- Undisturbed reference stations (r).

Figure 1 illustrates the approach, which is briefly described as follows. The effects of are expected to be most noticeable within the actual dumping area (cf. working hypothesis). Therefore the stations set up accordingly.

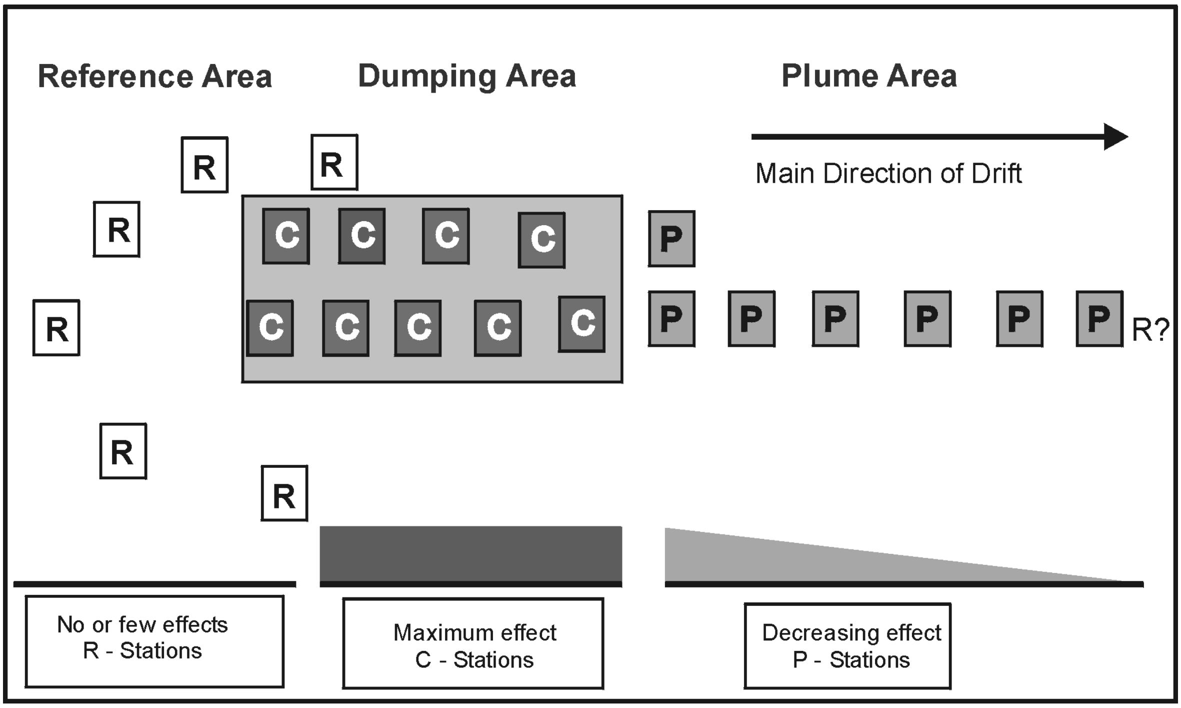


Fig. 1: Simplified representation of the working hypothesis (c-p-r concept) for the effects of dumping of dredged material on macrozoobenthos.

In the area of the main drift direction, there are potential effects of the plume on the macrozoobenthos. In this area, further sampling stations are positioned along a longitudinal transect (p). Stations P. were selected on the basis that the furthest station would presumably show limited effects on the benthic community since the potential for effects cannot be completely eliminated, the external plume stations not defined as reference stations (see below). Between the center and the external sampling station, the intervening stations were placed at more or less regular distance intervals.

Furthermore, sampling stations were positioned in direct proximity of the dumping area as well as in surrounding areas into which material was not expected to drift. The sampling stations outside the dumping area and outside the influence of the plume are defined – with restriction - as 'reference area' (r). The positioning of the reference stations is very difficult in a complex system such as an estuary where many natural and man-made gradients exist. It has to be considered that this sampling concept is adequate for dumping areas where strong currents exist and where the main direction of drift of material (plume) is approximately definable.

An important criterion for the quality of investigations about macrozoobenthos is, in addition to sampling method the underlying data record and particularly the number of stations and/or the number of replicate samples. The present biotope structure in the investigation area must be considered when fixing the position of the stations and the number of samples.

Evaluation concept

The described sampling concept was developed during a number of investigations of dumping areas carried out within the last few years. It has been used and further developed within ongoing HABAK investigations in the Weser and Ems Estuary. The data of several dumping areas have been analysed in each using a number of evaluation procedures (Table. 1). Both data of single samples and grouped samples were used as the basis for comparing dumping area (c), plume area (p) and reference area (r) (Table. 1). The more these procedures resulted in indications of effects (black rectangles in table 1), the clearer the general conclusion that differences exist between dumping and reference areas.

Evaluation process

Important descriptive parameters including number of species, diversity, abundance and biomass at different levels (all species, species group, single species) are used to biologically characterise the dumping site and allow a basis for the comparison of the different areas (c, p, r).

Species with rare occurrences may produce a less precise result within the analyses. Therefore a second evaluation which concentrated on regularly occurring species was carried out in order to eliminate the inaccuracies introduced by rarely occurring species. The definition of continuous species is based on the frequency of its occurrence and abundance (see. below).

A new ecological evaluation process developed by BioConsult, Bremen, Germany is being used to compare the biocoenosis with an internal reference and is based on the 'amoeba-approach' from COLJIN (1989). The abundance of single species is compared to a reference abundance (always 100%). In the 'internal reference approach' (developed by BioConsult, Bremen) the reference is the mean abundance for each continuous species in the whole set of data which is then compared to the mean abundance of the related species for the data set from the different areas (c, p, r). In this procedure a species is taken into account when the likelihood is not too low of detecting the species in the investigation with the given number of samples. The species is defined as a constant species when the frequency of occurrence is greater than 20% and additionally the abundance is greater or equal to 1 ind/m². The abundance of a species from one of the tested areas and the reference abundance are 'measured' against each other. The means from the whole dataset were compared with means from a part of the set. The result is presented graphically in deformations of a circle diagram (Fig. 2).

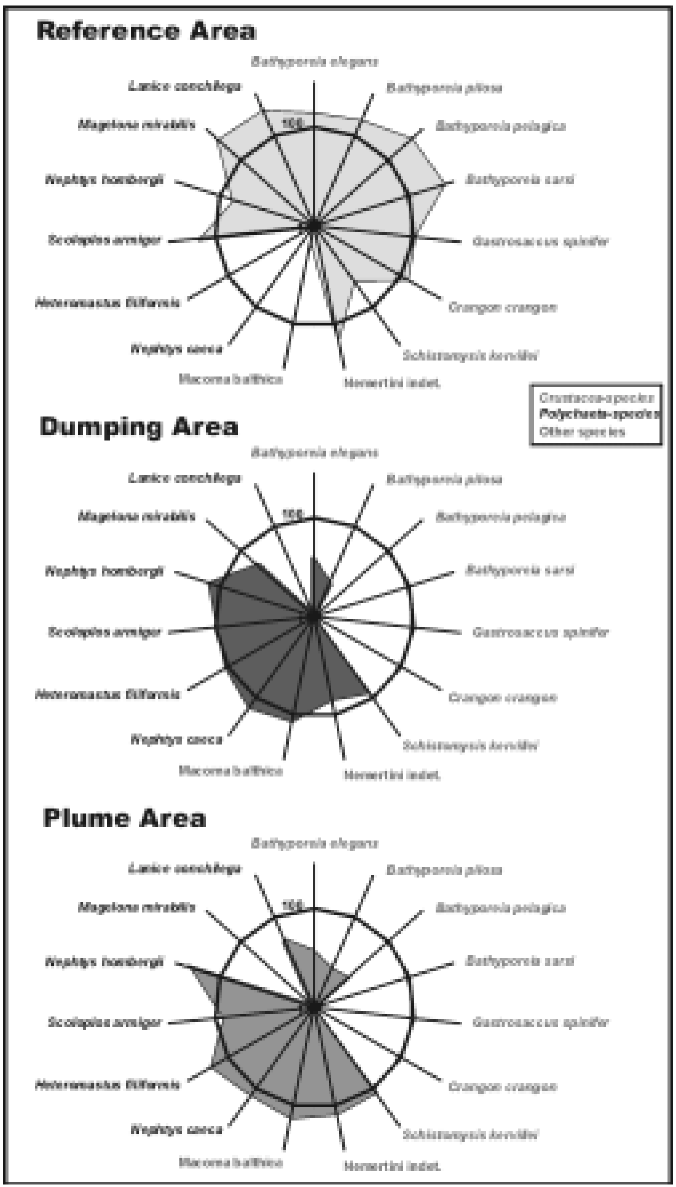


Fig. 2: Evaluation method "internal reference":

Arrangements of dumping, plume and reference areas are on the basis of the abundance of continuous macrozoobenthos species (HABAK EMS, dumping area 6).
Explanation: The similarity of the species compositions between dumping and plume area (dominated by Polychaeta) is by far higher than its similarity to the reference area (dominated by Crustacea), This is an indication of modification due to dumping. Black ring = reference value 100%.

In order to assess the differences statistically between the several groups of stations with respect to abundances and biomass, a set of statistical tests were carried out: cluster analyses, univariate significance tests (median and Wilcoxon tests) and a multivariate significance test (ANOSIM). In addition, ordination procedures represent an essential complement. The Principal Component Analysis (PCA) and Correspondence Analysis (CA) assess the variation of the structures of species abundances without taking into account different measured environmental parameters (which could be used for interpretation). In contrary the Canonical Correspondence Analysis (CCA) permits an estimate, at which degree specific environmental parameters can explain the width of variation of the benthos data. Therefore, combinations of environmental parameters can be computed and the ordination axes mounted (=axes of artificial factors). The analysis represents a multivariate form of regression by which the data of species abundance are modelled as a function of the environmental parameters. The CCA serve to explain the possible influence of the identified environmental parameters (type of sediment, loss of ignition from sediment, depth of water) onto the macrozoobenthos communities. The points representing species on the graph reveal their optimum level in the context of the presented environmental parameters. Additionally the situation of the stations in dependence of the environmental parameters and the structure of species abundance is presented in this ordination (Fig. 3).

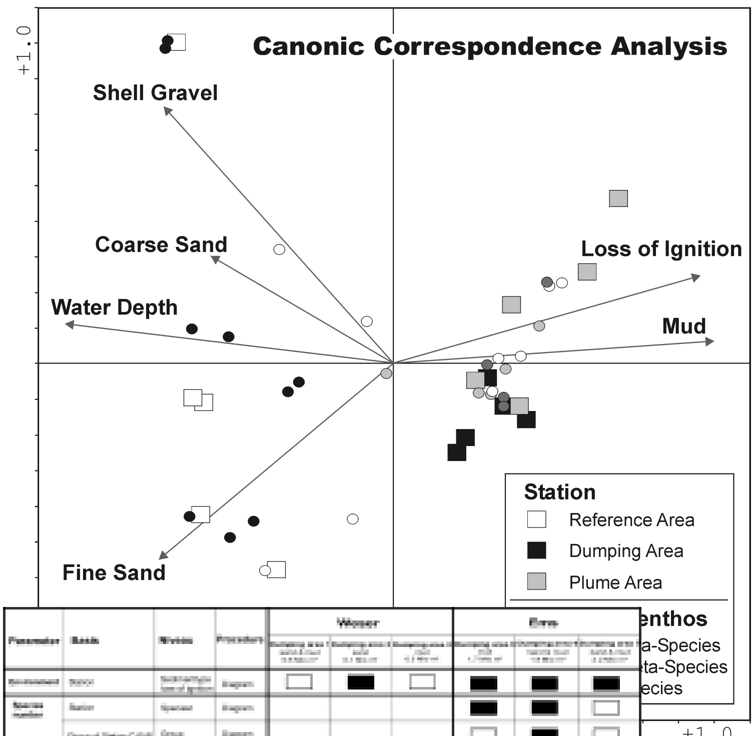
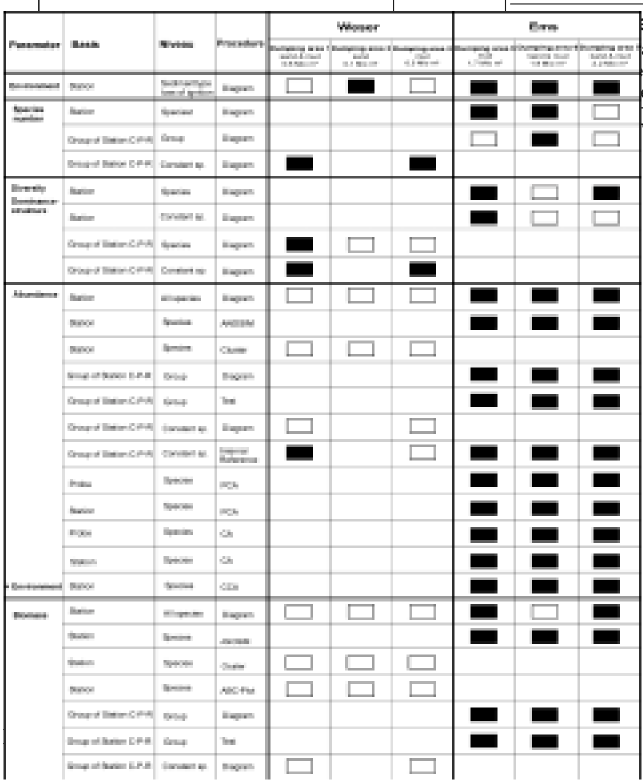


Fig. 3: Evaluation method "canonic correspondence analysis": Link between species composition of macrozoobenthos and environmental parameters, ordination of stations based on abundance data (HABAK EMS, dumping area 6).
Explanation: In the ordination, differences of species and stations are performed in accordance with the prevailing environmental parameters. The reference stations are marked by fine sandy, partially shell gravel containing and coarse sandy sediments, plume and especially stations within dumping area show higher mud contents and losses of ignition, both are results of continuous dumping activities. On the represented axes (X- and Y-axis) 70,5% of variation in variances of species abundance are traced back to the given environmental parameters and consequently, can be evaluated as a indication of modifications by dumping at sea.



Initial results

Within the framework of the investigations to the **HABAK Weser** estuary in 1997, at three dumping areas the presented sampling and evaluation concept with different statistical procedures were used (Tab. 1). This investigation in conjunction with older data sets confirmed the known high natural biotic variability in the Weser estuary on different scales of space and time. This not only applies to abundance and biomass but especially to the species composition. Only in the dumping area with 0,6 million m³ sand and mud some evidence of effects by dumping on the biocoenosis could be detected despite of the high natural variability in the biocoenosis. Effects could be detected by the slight decrease in species number and abundance, but there was no clear reduction. For the dumping area three results were even less clear. Since the internal reference analyses showed no effect, the slight differences are probably not linked to the dumping activities.

Table. 1: Survey for the results of different statistical evaluation methods for elucidation of effects by dumping of dredged material on macrozoobenthos (HABAK Weser 1997, HABAK Ems 1999; Dumping areas with information of type and quantity of dumped sediments within a year each before sampling of macrozoobenthos). Differences between reference stations and stations within dumping and plume area:

black - rectangle: clear modifications in macrozoobenthos by dumping

white – rectangle: no recognizable indications of effects on macrozoobenthos by dumping
Field without rectangle: no statistical analysis carried out

During the investigation ‘**HABAK-Ems’**, carried out in 1999, the evaluation concept was applied and further developed in conjunction with several statistical procedures. During the evaluation of the results from the dumping areas 5, 6 and 7 clear differences between the dumping-, plume- and reference areas could be detected with respect to number of species, number of individuals, diversity, biomass and community structures (Table. 1). Very clear differences could be seen between the reference area on one hand and the dumping- and plume area on the other hand (Fig. 2). The results of the Canonical Correspondence Analysis (CCA) showed that the difference was caused by the difference in the grain size in the 3 investigated areas. The reference area was characterised by low mud content, dumping and plume area showed a higher mud content, which was caused by the dumping of mud and sand (Fig. 3).

A comparison of the two HABAK investigations shows that the quality and quantity of the material deposited in dumping areas essentially influences the kind and scale of the effects on the benthic coenosis. On the basis of these results initial effects on the macrozoobenthos in the investigated region can be predicted, if dumping activities exceed more than ½ million m³ sand and mud a year.

Conclusion

In order to economically manage dredged material in the future with consideration of ecological issues, it is necessary to document the effects of dumping of dredged material of different origins, different quantities and in different frequencies in different regions. When carrying out this work it is essential to have an optimised tool of investigation and evaluation procedures as their quality influences the possibilities and limitations of detecting disturbances on benthic coenosis.

Due to the concepts used within the HABAK investigations, it was possible to detect relatively small anthropogenic, time limited disturbances within a system with high natural variability like the investigated estuaries. Using a number of ecological and statistical evaluation procedures enables a separation of essential ecological effects from disturbing signals and a selective interpretation of the data correspondingly.

It is the aim by checking and further developing of ecological and statistical tools to provide an extensive set of procedures which will allow consideration of the question; “are there ecological effects caused by dumping (and also caused by dredging, extraction, etc.)?” The knowledge obtained will enable an ecologically optimised management of dumping areas.

COLIJN, F. (1989) Gewässergütekriterien und naturbezogene Zielsetzungen in den marinen und brackigen niederländischen Gewässern. In: Niedersächsisches Umweltministerium (Ed.), Statusseminar - Gütekriterien für Küstengewässer. Hannover, pp 36-42.

27 ANNEX XV – EXECUTIVE ORDER ON ENVIRONMENTAL IMPACT ASSESSMENT OF RAW MATERIAL EXTRACTION FROM THE SEABED EIA (DRAFT TRANSLATION)

Executive Order No. 126 of March 4, 1999

Pursuant to sections 23, 34 and 38 of the Danish Raw Materials Act cf. Consolidated Act No. 569 of June 30, 1997, the following has been established:

§1. This Executive Order shall apply to applications for permits pursuant to section 20(1) of the Danish Raw Materials Act with regard to:

1) Raw material extraction in international nature conservation areas (EC bird protection areas, EC habitat conservation areas and Ramsar sites).

2) Raw material extraction of more than 1 million cubic metres per year or more than 5 million cubic metres in all.

3) Raw material extraction which in other respects must be regarded as potentially having a significant impact on the environment. In assessing this point the criteria stated in schedule 2 must be taken into consideration.

Subsection 2. This Executive Order does not apply to the extraction of materials occurring in connection with dredging and deepening, and which are utilised as raw materials.

Subsection 3. This Executive Order does not apply to raw material extraction in the Wadden Sea (EC bird protection area no. 57) whose purpose is the repair of sudden damage to dykes and adjacent foreland.

§2. Decisions pursuant to section 1(1) item 3 to the effect that extraction may not be regarded as potentially having a significant impact on the environment shall be published no later than the time at which extraction permits are issued. Such information shall be communicated via the National Forest and Nature Agency in one or more local (or possibly national) newspapers.

§3. Applications for permits to extract raw materials which are covered by section 1(1) shall be accompanied by an environmental impact assessment (EIA) drawn up by the applicant. This assessment shall contain the information stated in schedule 1 as a minimum.

Subsection 2. The National Forest and Nature Agency may decide that additional material is required with a view to assessing the environmental impact.

§4. Information about applications and the assessment mentioned in section 3 shall be published via the National Forest and Nature Agency in one or more local (or possibly national) newspapers. Applications and assessments will be available to order. Publication shall also contain information about:

1) the nature of possible decisions,

2) the length of the publication period and the name of the person(s) to whom comments should be submitted, and the name of the organisation(s) to which questions should be submitted during the period of publication, and

3) where any reports, background notes etc. drawn up in connection with the EIA are available for public inspection.

Subsection 2. The application and EIA shall be submitted to a hearing by the authorities and organisations affected.

1)

Subsection 3. The deadline for submission of comments by the public, authorities and organisations shall be at least 8 weeks.

§5. Information concerning decisions shall be communicated via the National Forest and Nature Agency in the newspapers in which communication pursuant to section 4(1) has occurred. The decisions passed, as well as any terms applying, the most important reasons and considerations on which decisions are based, and if necessary a description of the most important measures to be taken with a view to avoiding, limiting and if possible remedying significant negative impacts will be available to order.

§6. This Executive Order comes into force on March 14, 1999.

Subsection 2. At the same time, Executive Order no. 1166 of December 16, 1996 on the environmental assessment of raw material extraction on the seabed (EIA) shall be repealed.

Subsection 3. Applications for permits covered by the stipulations of section 1(1) which are received by the National Forest and Nature Agency by March 14, 1999 shall be processed in accordance with the regulations applying previously.

Ministry of the Environment and Energy, March 4, 1999

SVEND AUKEN

/ Ole Christiansen

Schedule 1

Information which must be submitted pursuant to section 3(1).

1. A description of the extraction planned, including in particular:

1.1 The quantity, composition and quality of the raw material to be extracted.

1.2 Charts or UTM maps in original scale, showing the area applied for clearly and attaching a list of the positions demarcating the area in question.

1.3 Documentation of the extent, quantity, quality and composition of the raw materials in question occurring in the area applied for.

1.4 A description of the extraction method and extraction equipment planned, including its capacity, maximum working depth, expected production and extraction period.

1.5 Documentation of the physical status of the area, including surface sediment distribution and depth conditions in and around the extraction area.

1.6 Information about market conditions and raw material and environmental factors which are deemed to be relevant in connection with the Agency's evaluation, including information about the potential for completely or partially replacing the raw material resource for which an application is being submitted by dredging and deepening materials (dumped materials).

1.7 Proposals for an extraction and after-treatment plan.

2. A list of the most important alternatives and alternative extraction areas which the applicant has examined, a description of the consequences if extraction is not performed (the so-called "zero alternative"), and information about the most important reasons for choosing the extraction area in question with due regard for the impact on the environment.

3. A description of the area and the surroundings which may be affected significantly by the extraction in question. A description of the significant impact of extraction on the area and the surroundings, including in particular the effects on the fauna, flora, seabed, marine environment, air, archaeological cultural heritage, coastal protection, fishing, marine traffic and recreational interests.

4. A description of the short-term and long-term effects of extraction on the environment due to:

4.1 The physical measures taken.

4.2 Air pollution.

4.3 Noise.

4.4 The use of natural raw materials.

4.5 Sediment waste and the distribution of substances, and oil spillage (if relevant).

4.6 A description of the methods used to pre-calculate the effects on the environment.

5. For extraction in EC bird protection areas, Ramsar sites and EC habitat conservation areas the assessment must also meet the requirements of consequence assessment pursuant to article 6 points 2-4 of the habitat directive.

6. A description of the measures envisaged to avoid, reduce and, if possible, remedy the adverse effects on the environment, including any proposals for a monitoring programme.

7. A non-technical summary based on the information above.

8. A list of any information lacking and an assessment of the environment effects.

Executive Order No. 1167 of December 16, 1996 issued by the Danish Ministry of the Environment and Energy

Executive Order on applications for exploration and extraction of raw materials from the seabed and reporting about the raw materials extracted

Pursuant to sections 29, 34, 38 and 44(3) of the Danish Raw Materials Act cf. Consolidated Act No. 1007 of November 28, 1996, the following has been established:

Applications for approval of equipment for exploration and extraction of raw materials

in territorial waters and on the continental shelf

§1. Applications for approval of equipment for exploration and extraction of raw materials in territorial waters and on the continental shelf under section 19(1) of the Danish Raw Materials Act shall be submitted in writing to the National Forest and Nature Agency.

Subsection 2. Applications shall contain information about the name, registration and ownership of the equipment concerned.

Subsection 3. Applications for approval of exploration shall also contain information about exploration and navigation equipment.

Subsection 4. Applications for approval of extraction shall also contain information about extraction equipment, capacity, maximum working depth and navigation equipment.

Applications for permits for exploration of

raw materials in territorial waters and on the continental shelf

§2. Applications for permits to explore for raw materials in territorial waters and on the continental shelf under section 20(1) of the Danish Raw Materials Act shall be submitted in writing to the National Forest and Nature Agency.

Subsection 2. Applications shall contain the following information:

1) Information concerning the purpose of the exploration, including a statement of the raw material types for which exploration is planned.

2) Information concerning the geographical areas in which exploration is to be performed. The area for which applications are submitted shall be marked on a chart or UTM map in original scale, showing the area concerned clearly and attaching a list of the positions demarcating the area in question.

3) A report on implementation of the exploration, including all the explorations planned, a timetable and the equipment used.

4) For trial dredging the available information shall be stated concerning: geographical location of dredging, drilling method and drilling depth.

5) For trial dredging the available information shall be stated concerning: trial dredging method, number of dredgings, geographical location of dredging, expected quantity extracted at each location, and dredging depth. The expected effects of trial dredging on the environment and the natural surroundings must also be explained, including information about factors relevant for other interested parties, expected seabed type at trial dredging locations, seabed area affected by dredging, expected spill and disposal of dredged material.

6) Information about any wishes for the prior right to perform subsequent extraction.

7) The planned reporting of the progress and results of exploration.

8) The name of the exploration equipment. If equipment is to be used which has not been approved under section 19 of the Danish Raw Materials Act (or which has not been given a similar permit under previous legislation) approval shall also be applied for under section 1 of this Executive order.

Applications for permits to extract

raw materials in territorial waters and on the continental shelf

§3. Applications for permits to extract raw materials in territorial waters and on the continental shelf under section 20(1) of the Danish Raw Materials Act shall be submitted in writing to the National Forest and Nature Agency.

Subsection 2. Applications shall contain the following information:

1) The quantity, composition and quality of the raw materials for which an extraction application is being submitted.

2) Charts or UTM maps in original scale, showing the area concerned clearly and attaching a list of the positions demarcating the area in question.

3) Information about the extent, quantity, quality and composition of the raw materials concerned in the area for which an application is being submitted.

4) A description of the extraction method and extraction equipment planned, including maximum working depth, expected production and extraction period.

5) Available information about the physical and biological status of the area, including hydrographical and topographical factors, surface sediment distribution and dominant flora and fauna communities.

6) A description of the possible effects of extraction on the area and its surroundings, including in particular the effects on the flora, fauna, seabed, water quality, air, marine archaeology, geology, coastal protection, fishing, marine traffic and any recreational interests.

7) A description of the measures envisaged in order to avoid, reduce and, if possible, remedy adverse effects on the environment in the short term and the long term, including any proposals for a monitoring programme.

8) Information about the use of the raw materials, market conditions and raw material factors in general which are deemed to be relevant in connection with the Agency's evaluation, including information about the potential for completely or partially replacing the raw material resource for which an application is being submitted by materials from maintenance and capital dredging.

9) Proposals for an extraction and possible after-treatment plan.

10) The name of the extraction equipment. If equipment is to be used which has not been approved under section 19 of the Danish Raw Materials Act (or which has not been given a similar permit under previous legislation) approval shall also be applied for under section 1 of this Executive Order.

Subsection 3. The stipulations in subsection 2 shall not apply to the extraction of

materials occurring in connection with maintenance and capital dredging, and which are utilised as raw materials pursuant to section 4.

§4. Applications for permits to utilise materials occurring in connection with maintenance and capital dredging shall contain the following information:

1) The location of maintenance/capital dredging marked on a chart showing the area concerned clearly and attaching a list of the positions demarcating the area in question.

2) Information about the quantity and composition of the materials which are to be utilised, including the results of any available analyses, grain size distribution curves, drilling samples etc.

3) The extraction method, including information about any expected spill and the possible environmental effects of extraction.

4) A description of any measures envisaged to avoid, reduce and, if possible, remedy any adverse effects on the environment.

5) The planned use of the materials concerned.

6) The name of the extraction equipment. If equipment is to be used which has not been approved under section 19 of the Danish Raw Materials Act (or which has not been given a similar permit under previous legislation) approval shall also be applied for under section 1 of this Executive Order.

§5. The National Forest and Nature Agency may require additional information for use in evaluating applications under sections 1, 2, 3 and 4.

Reports on raw materials extracted

§6. Anyone extracting raw materials in territorial waters and on the continental shelf shall submit a report to the National Forest and Nature Agency once a quarter. Reports shall be submitted for each extraction vessel using special forms issued by the National Forest and Nature Agency. These forms shall be filled in with general information about the vessel and extraction area concerned; and information for each ship load stating the position at which extraction took place, the nature and quantity of the raw materials extracted, and the point of unloading.

Subsection 2. If extraction is performed in connection with capital or maintenance dredging in a harbour or a navigation channel, or in connection with dredging for construction work, reports may be submitted each working day instead. The same applies if extraction is performed using direct pumping or excavation of seabed material to a reclamation area.

Penalties and entry into force

§7. Infringement of section 6 of the Executive Order shall be punished by a fine.

Subsection 2. Companies (legal persons) may be subject to criminal liability under the terms of chapter 5 of the Danish Criminal Code.

§8. This Executive Order comes into force on January 1, 1997.

Subsection 2. At the same time, Executive Order No. 916 of December 18, 1991 on applications and reporting on extraction under the Danish Raw Materials Act and on the authority of the county councils to fix the terms of registered rights shall be repealed.

Ministry of the Environment and Energy, December 16, 1996

SVEND AUKEN

/ Ole Christiansen

Schedule 2

Selection criteria mentioned in section 1 item 3.

1. Project characteristics

The project characteristics must be considered in particular in relation to:

- the project dimensions

- accumulation with other projects

- the use of natural resources

- waste production

- pollution and irritation

- the risk of accidents, particularly in view of the materials and technologies used.

2. Project location

The environmental vulnerability of the geographical areas which may be affected by projects must be taken into consideration, in particular:

- the current use of the area

- the relative wealth, quality and regeneration capacity of the natural resources in the area concerned

- the natural environment's capacity, with particular focus on the following areas:

a) wetlands

b) coastal areas

c) reserves and national parks

d) areas which are registered or protected under national legislation

e) areas for which there are intensified objectives in regional planning

f) areas in which fixed environmental quality standards have already been exceeded

g) densely populated areas

h) important landscapes from a historical, cultural, archaeological or recreational point of view.

3. Characteristics of the potential environmental effects

The potential significant effects of projects shall be viewed in relation to the criteria stated under 1 and 2 above, in particular with regard to:

- the extent of such effects (geographical area and number (extent) of people affected)

- the extent to which such effects exceed any defined limits

- the degree and complexity of such effects

- the likelihood of such effects occurring

- the duration, frequency and reversibility of such effects

28 ANNEX XVI - SEABED CHARACTERISATION IN THE CONTEXT OF BIOTOPE MAPPING (PAPER PRODUCED BY MEMBERS OF WGEXT)

Report prepared by members of the ICES WGEXT for its Annual Report, and as the basis for a paper for the ICES Annual Science Conference: Theme Session on Habitat Mapping and Classification.

28.1.1.1.1.1.1.1.1 APRIL 2000

28.2 1 RATIONALE

Techniques described in this paper are used to map the shape of the seafloor and physical properties of surficial sediments upon which habitats (mainly physical attributes) and biotopes (habitat and community) mapping classification can be developed. There are many complimentary benthic 'ground-truthing' sampling methods such as grabs, corers and underwater photography, which are beyond the scope of this report for detailed appraisal.

28.3 2 REMOTE ACOUSTIC SENSING TECHNIQUES

To manage the marine environment effectively maps which reveal the geophysical characteristics of the seabed are essential, since they allow the wide-scale geology and modern day (Holocene) sedimentary processes to be determined and understood. This is important because an understanding of the sediment dynamics and geological structure of the seabed allows scientists to accurately predict the impacts of mans activities on the seabed and in particular impacts on those habitats which may be of high nature conservation or ecological value. In addition, offshore sediment dynamics play an important role in the long term stability and geomorphology of the coastline which is an important consideration when planning flood and coastal sea defence schemes.

Imaging of the seabed was revolutionised in the 1940's when, for the first time, relatively high frequency echo-sounders were positioned in such a way so as to insonify[8] a swath of seabed (Fish and Carr, 1990). These early systems gave rise to the first side-scan sonar sonographs[9]. The first sonographs were rather crude having low resolution and could only reliably be used to detect large physical targets such as shipwrecks. However, the 1970's and 80's witnessed rapid developments in acoustic electronics which, importantly, allowed the phase and amplitude properties of the acoustic signal to be precisely controlled thereby allowing high resolution (almost photographic quality) images of the seabed to be obtained. Most of the recent developments (during the 1990's) in acoustic mapping have been associated with the increase in digital processing power offered by modern computers. This in turn has enabled acoustic engineers to incorporate digital electronics within the sonar transducers making them more efficient. In addition, software applications are continually being developed, offering greater data control and visualisation functions, with most systems now supporting *real-time* visualisation of sonar data as true (geo-corrected) mosaic seabed maps.

There are nevertheless some important differences between the various sonar devices, irrespective of the post processing which may be used, and these need to be highlighted in order that the reader can judge which sonar device is most suited to their needs.

The many sonar devices that are currently on the market generally fall into one of the following categories, namely; **i.** broad-acoustic beam (swath) systems such as side-scan sonars used for seabed mapping and geophysical surveys (Fish and Carr, 1990; Newton and Stefanon, 1975; Kenny, 1998), **ii.** ground discriminating single beam echo-sounders (AGDS) such as RoxAnn® and QTC-View® (Foster-Smith and

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8 Insonify is the term used to describe an area of the seabed which is exposed to sonar energy.

9 Sonographs are hard copy displays of the sonar data generated either in real time or from recorded data.

Gilland, 1997; Magorrian, *et al.*, 1995) and fish finding echo-sounders, predominantly used for seabed sediment dicrimination, **iii.** multiple narrow-beam swath bathymetric systems (Loncarevic *et al.*, 1994; Hughes Clarke, 1998) which have been used to generate high resolution topographical images of the seabed and, **iv.** multiple beam (interferometric) side-scan sonar systems (Green and Cunningham, 1998).

The most commonly used, highly developed and versatile systems are the sidescan sonars and multibeam swath bathymetric devices. These systems are described in more detail below and a tabulated comparison with other devices such as single beam echosounders (AGDS) is provided highlighting their advantages and disadvantages for various seabed mapping applications.

28.3.1 2.1 Side-Scan Sonar

Side-scan sonar has been defined as an acoustic imaging device used to provide wide-area, high resolution pictures of the seabed. The system typically consists of an underwater transducer connected via a cable to a shipboard recording device. In basic operation, the side scan sonar recorder charges capacitors in the tow fish through the cable. On command from the recorder the stored power is discharged through the transducers which in turn emit the acoustic signal. The emitting lobe of sonar energy (narrow in azimuth) has a beam geometry that insonifies a wide swath of the seabed particularly when operated at relatively low frequencies e.g. < 100 kHz. Then over a very short period of time (from a few milliseconds up to one second) the returning echoes from the seafloor are received by the transducers, amplified on a time varied gain curve and then transmitted up to the recording unit. Most of the technological advances in side scan sonar relate to the control of the phase and amplitude of the emitting sonar signal and in the precise control of the time varied gain applied to the return signals. The recorder further processes these signals, in the case of a non-digital transducer it will convert the analogue signal in to digital format, calculates the proper position for each signal in the final record (pixel by pixel) and then prints these echoes on electro-sensitive or thermal paper one scan, or line at a time.

Modern high (dual) frequency digital side-scan sonar devices offer very high resolution images of the seabed that can detect objects in the order of tens of centimetres at a range of up to 100 metres either side of the tow fish (total swath width 200 metres), although the precise accuracy will depend on a number of factors. For example, the horizontal range between the transducer and the seabed is affected by the frequency of the signal and the grazing-angle of the signal to the bed which is itself determined by the altitude of the transducer above the sea floor. Some typical limits associated with side-scan sonar are as follows, operating at 117 kHz under optimal seabed conditions and altitude above the bed, a range of 300 metres (600 metre swath) can be obtained and typically 150 metres at a frequency of 234 kHz. Accuracy, increases with decreasing range, for example, 0.1 metre accuracy is typically obtained with a range of 50 metres (100 metre swath) where as ‘only’ 0.3 metre accuracy is obtained at a range of 150 metres.

A major advantage of side-scan sonar is that under optimal conditions it can generate an almost photo-realistic picture of the seabed. Once several swaths have been mosaiced, geological and sedimentological features are easily recognisable and their interpretation provides a valuable qualitative insight into the dynamics of the seabed. However, the quality (or amplitude) of the data is variable, for example the grey-scale (signal amplitude) between swaths covering the same area of seabed is often noticeably different. The variation in signal amplitude for the same area or type of seabed causes problems when trying to classify the sonograph, since ground truth samples (grabs and underwater cameras) may reveal the seabed to be the same but the sonograph indicates differences. Sidescan does not normally produce bathymetric data. However, side-scan sonar provides information on sediment texture, topography, bedforms and other discrete objects.

28.3.2 2.2. Multibeam Swath Bathymetry

Multibeam bathymetry is a relatively new seabed mapping technology that can be applied to an understanding of marine habitats, aggregate resources and seabed processes. Through digital processing techniques, the data can provide shaded-relief topographic maps. Echo strength data (reflectance) can be extracted and presented as seabed back-scatter maps that display information on sediment types. Slope maps can also be provided. From a combination of both shaded-relief bathymetry, slope analysis and back-scatter maps, the seabed can be interpreted in terms of both relict and modern processes. Multibeam data processing can also enhance subtle aspects of relief elements through shading techniques for an understanding of erosive and depositional processes.

There are many manufacturers of multibeam bathymetric systems for operating in water depths of a few meters to full ocean depths. Higher resolution systems for continental shelf depths provide resolution in decimetres. Interpreted maps of seabed geology, relief and processes, from these systems help to provide the foundation for assessment and mapping of seabed habitats.

A major advantage of multibeam systems over side-scan sonar is that they generate quantitative bathymetric data that is much more amenable to classification and image processing.

28.3.3 2.3 Acoustic Ground Discrimination Systems (AGDS)

Nominal incidence single beam echo-sounders may be used to obtain a variety of information about the reflective characteristics of the seabed. They send a pulse of sound at a particular frequency (usually between 30kHz and 200kHz) that reflects from the seabed and the echo is picked up by the transducer. RoxAnn tm is an AGDS that has been most frequently used for environmental studies round the UK. The system uses echo-integration methodology to derive values for an electronically gated tail part of the first return echo (E1) and the whole of the first multiple return echo (E2). While E2 is primarily a function of the gross reflectivity of the sediment and therefore hardness, E1 is influenced by the small to meso-scale backscatter from the seabed and is used to describe the roughness of the bottom. By plotting E1 against E2 various acoustically different seabed types can be discriminated (Chivers *et al*, & Heald and Pace). With appropriate ground truth calibration, acoustic discrimination systems can be remarkably affective at showing where changes in seabed characteristics occur. However, great caution should be exercised in trying to directly compare readings taken on different surveys as it is very difficult to be sure that the sounder is delivering the same power level into the water column, especially when there may be intervals of months or years between the surveys. This problem has been addressed in the design of the Echoplus seabed discrimination system accurately, a greater consideration should be given to using narrow beam geometry.

Although AGDS is relatively simple to use, the output requires considerable interpolation in order to generate a broad scale map of the seabed with 100 % coverage. In addition the area insonified by the echo sounder directly under the vessel depends on the beam angle and depth of the seabed. For example, an echo sounder with a beam angle of 15^o with a depth under the boat of 30 m would insonify an area with a radius of about 7 m. This limits the ability of the system to discriminate accurately. For example, a 7 metre track of the seabed that is composed of sand with 1 or two cobbles would have a different E1/E2 value compared to an adjacent 7 m track of sand with say 5 or 6 cobbles. However, the habitat in both cases would be the same, that is a sandy bottom with cobbles. For a summary description of AGDS – see Table 1.

Table 1. The three most commonly AGDS systems

System	**Remarks**
QTC - View	Analysis of first echo signals using PCA analysis.
RoxAnn	Uses the backscatter information from the first echo to characterise seabed roughness and reflection of second echo to characterise hardness.
EchoPlus	Dual frequency digital signal processing system using first and second echo analysis technique, including compensation for changes in frequency, pulse length and power levels. Unprocessed baseband signals are also obtained.

28.3.4 2.4 Sub-Bottom Profilers

These devices provide high-resolution definition of the seabed sediments down to about 50 metres beneath the seafloor. The sound source is generally a pressure compensated boomer or sparker which generates a high intensity, short time duration pressure pulse with well defined directional characteristics.

These devices offer the potential to map sediment thickness, infaunal communities and to examine the interactions between the benthic fauna and sediments.

A detailed appraisal of these systems is not within the remit of this report.

28.4 3 UNIT AREA COVERED ($Km.h^{-1}$) *versus* SEABED RESOLUTION FOR DIFFERENT SYSTEMS

An overview of the area covered (mapped) and the resolution which can be achieved under optimal conditions is provided in Table 2. It is evident from Table 2 that there is generally a trade-off between the extent of seabed which can be mapped in a given time and the resolution of seabed features.

28.5 4 COMPARISON BETWEEN THE TECHNICAL ASPECTS OF MULTIBEAM BATHYMETRY SONAR AND SIDE-SCAN SONAR

The following tables summarise the technical aspects of side-scan sonar and multibeam bathymetric systems. Table 3 serves to highlight the increased efficiency of the ‘chirp’ side-scan sonar over other side-scan sonar systems due to the increased swath width and high resolution that chirp provides. The increased power output of the chirp sonar also provides better resolution towards the outer portions of the sonograph.

Table 3. Side scan sonar performan comparison

Sonar	Type	Pulse length	Horizontal Beam	By experience approx. Useful range at average conditions		Total swath	By experience "optimum" survey speed	Maximum Coverage	Detectability at good conditions					
									Cable	Wreck	Contain	Barrel	Mine	Bottle
KHz		m/s	Degrees	sec.	m	m	Knots	Km²/h						
500 (380)	c.w.	0.02	0.2°	0.1	75	150	3	0.8	X	X	X	X	X	X
100	c.w.	0.1	1.0°	0.25	187	375	5	3.5	X	X	X	X	(X)	

50	c.w.	0.2	1.5°	0.5	375	750	6	8.3	X	X	X			
Chirp 110	f.m. "chirp"	<24	0.5°	1	750	1500	4.5	12.5	X	X	X	X	(X)	

Table 4 (below) considers the application (or utility) of two multibeam bathymetric systems under different operational conditions of line spacing and depth of water. It should be noted that the higher resolution system (EM3000) is not applicable for applications in deep water (>400 m). The maximum resolution reliably achievable using multibeam is about 1 m in depths of 50m or less.

Table 4. Footprints of multibeam mapping systems

Water depth m	Spacing between soundings @ 12 kts m	EM1000 3.3° beam width			EM3000 1.5° beam width		
		Footprint (m) nadir	Footprint (m) 30°	Footprint (m) 75°	Footprint (m) nadir	Footprint (m) 30°	Footprint (m) 75°
50	1.6	2.9	3.3	12.0	1.3	1.5	5.0
100	3.2	5.8	6.6	24.0	2.6	3.0	10.0
200	6.4	11.6	13.2	48.0	5.2	6.0	n/a
500	16	29	33	n/a	n/a	n/a	n/a
1000	32	58	66	n/a	n/a	n/a	n/a

(from ICES 1999, with additional data from Ron McHugh)

Table 2.

Overview of Seabed Mapping Tools

System	Coverage	Resolution (horizontal)								Remarks
	km²/h	km	100m	10m	m	dm	cm	mm	<mm	
Remote Sensing, Satellite	> 100	x	x	x						Restricted to satellite operation coverage and to shallow areas (not more than 6 m water depth)
Remote Sensing, Aircraft	> 10	x	x	x	x					Only for shallow areas (not more than 6 m water depth)
Multi Beam	3 - 6	x	x	x	x	x				Allows the use of backscattering data for analysing bottom substrate
Single Beam	1 - 2	x	x	x	x	x				Narrow surface coverage
Side Scan	1 - 8		x	x	x	x				Size of surface coverage (swath) depends on the frequency used
Synthetic Aperture Sonar	1 - 10					x	x			Optimal operation at 50 - 100 kHz
Subbottom Profiler	0.5 - 1	x	x	x	x	x				Narrow sub-surface coverage
Video Camera	0.1 - 0.2				x	x	x			Allows epibenthos identification and provides ground truth for acoustic survey mapping technology.
Sediment Profile Camera	< 0.001						x	x		Only site inspections
X-ray photography	< 0.001						x	x		Only site inspections, allows more detailed analysing than the profile camera (watercontent, density, etc.)
Macro Grab/Corer Sampling	< 0.003					x	x	x		Quantitative data on the macro and meiofauna requires additional analysis in a laboratory

SAS prototype figures are based on 100 m range at 400 kHz with a traverse rate of 10 m/sec. If designed for 50 kHz, and only using a longer array, it would be possible to get 1 km range at a higher traverse rate

Table 5 (below) considers the application (or utility) of two side-scan sonar systems under different operational conditions of spacing between soundings and range (swath width). The maximum resolution reliably achievable using high frequency side-scan sonar is about 20 cm.

Table 5. Footprint (meters) of sidescan sonar systems

Range (m)	Spacing between soundings (m) @ 4 knts	MS992 120kHz Sidescan 75° beam width	MS992 330kHz Sidescan 0.3° beam width
25	0.07	0.33	0.13
50	0.13	0.65	0.26
100	0.26	1.30	0.52
200	0.52	2.60	1.00
500	1.30	6.50	n/a

Table 6 compares the resolution of each system and the unit area covered ($km.d^{-1}$) under a range of different depths. It is clear that the multibeam bathymetric systems are greatly influenced by water depth. For example, as the water depth increases and the area covered increases the resolution decreases. The side-scan sonar is not affected by water depth, but the innate instability of the sonar fish, gives rise to qualitative data compared to the multibeam bathymetric system.

Table 6. Coverage comparison between survey systems

Water depth (m)	EM1000 multibeam @ 12 kts			MS992 330 kHz Sidescan @ 4 kts		
	Horizontal width (m)	Maximum footprint (m)	Coverage (km² per day)	Horizontal width (m)	Maximum Footprint (m)	Coverage (km² per day)
10	70	2.4	40	400	1.0	67

50	350	12	195	400	1.0	67
100	700	24	390	400	1.0	67
200	1400	48	780	400	1.0	67

28.6 5 GEOPHYSICAL ATTRIBUTES OF IMPORTANCE WHEN BIOTOPE MAPPING MARINE AGGREGATE DEPOSITS

A 'brain-storming' sub-group of WGEXT in 1999 was convened during the meeting to discuss which of the seabed geological attributes (which can be measured) are most important in determining the type of seabed benthic assemblages.

The geological attributes identified and considered were; micro-relief (centimetres to decimetres), macro relief (metres to 100s of metres), grain size (gravel, sand, silt and clay), lithology (rock composition, carbonate), patchiness (local variability, shape, spatial patterns), sediment distribution, sediment sorting, porosity (pore spaces and packing), shear strength, grain shape, stratigraphy, dynamic processes (relict to modern and combinations thereof), bedforms, sediment transport pathways, sediment thickness, regional setting (e.g. sandbank, moraine, beach ridge, basin), geological history (origin), anthropogenic features (shipwrecks, anchor marks, extraction pits, dredging furrows, dredge material mounds and trawl marks)

The above list was evaluated against available monitoring techniques such as, underwater cameras, side-scan sonar, seismic sonar, multibeam bathymetry, traditional echosounders, grab sampling and sediment probes (various seabed landers). The aim of this was to find which method of detection (at varying spatial scales) best suites the mapping of the 'key' attributes thought to be responsible for determining the status of benthic assemblages. Of the identified geological attributes it was concluded at the WGEXT 2000 meeting that sediment grain size, porosity or shear strength, and sediment dynamics were particularly important in regulating the biology of marine sands and gravels.

The relationship between sediment substrate, its stability and relevant processes of physical disturbance is given in Table 7. All these processes may have an impact on the ecology of the benthic fauna and flora. Table 7 also indicates which technique is best suited for identifying each of the conditions described.

For the broad-scale mapping of aggregate biotopes (>1 km^2) either 'chirp' based side-scan sonar or multibeam swath bathymetry were considered to offer the most cost effective means of discriminating different sediment types and dynamic processes (see table and figure in previous section). For small-scale biotope classification over relatively small areas (<1 km^2) high resolution side-scan sonar, underwater cameras and grab sampling methods are considered to be the most appropriate mapping tools.

The sub-group concluded that further work should be undertaken to investigate and review the most appropriate mapping techniques for discriminating various habitats (seabed attributes and dynamics) at different spatial scales.

Table 7. Relationship between rapid continental shelf seabed processes, seabed textural characteristic and marine mapping systems for habitat delineation

.1.1.2	**28.6.1.1.1.1.1.1 Seabed Nature**																				.1.2
	outcropping bedrock				gravel				clean sand (non-cohesive <8-10% mud)				cohesive sediments				Bioherms (shells, maerl, mussel-beds)				
	Tidal	Wave	Other	Storm	Tidal	Wave	Both	Storm	Tidal	Wave	Other	Storm	Tidal	Wave	Other	Storm	Tidal	Wave	Other	Storm	Mapping systems
Bedform migration	–	–	–	–	+	Shallow water only	+	+	+	+	+	+	–	–	–	–	+	+	+	+	Repeated surveys with side-scan sonar, multibeam & time-lapse photography
Scour	–	–	–	–	+	Shallow water only	+	+	+	+	+	+	–	–	–	Slow +	slow +	slow +	slow +	+	Side-scan sonar, multibeam & time-lapse photography
Liquefaction (wave loading)	–	–	–	–	–	–	–	–	–	Shallow water only	Shallow water only	+	–	–	–	–	–	Shallow water only	Shallow water only	+	Lab measurements Field investigations
Gravity sinking (under its own weight)	–	–	–	–	–	–	–	–	–	–	–	–	+ for low shear strength sediments				–	–	–	–	Side-scan sona & multibeam Field investigations
Other sedimentation (rapid events)	–	–	–	–	–	–	–	–	–	–	–	storm deposits	–	–	–	+	–	–	–	–	Very high resolution seismic reflection profiling. Core inspection
Anthropogenic activities	minimal effects				moderate to severe effects				moderate effect				potentially severe effects				potentially severe effects				SSS & multibeam
Gas venting	habitat enhancer				habitat enhancer				habitat enhancer seabed stabilizer				habitat enhancer erodes + stabilizes				product of				SSS & multibeam Very high resolution seismic reflection profiling

	Nearbed density flows on the shelf	–	–	–	–	–	–	–	–	–	–	–	–	Fluid + mud	–	Fluid + mud	Fluid + mud	–	–	–	–	Multi-frequency echosounders	
	Slope failure	–	–	–	–	–	–	–	+	–	–	–	+	–	–	–	+	–	–	–	+	SSS + multibeam very high resolution seismics	

\+ Denotes that a **seabed process** occurs under the specified **seabed nature** conditions, and can be detected with the prescribed **mapping system**

28.7 6 BIOGENIC REEF STRUCTURES

Numerous cold water reefs occur on the Mid-Norwegian shelf. The knowledge of these reefs is based on reports from fishermen, from mapping related to pipeline laying and from scientific investigations using ROV and other techniques. In order to increase the knowledge of the reefs, a pilot project involving multibeam swath bathymetry mapping of two areas was initiated in 1999 using SIMRAD EM1002. These are the Sula Reef, one of the worlds largest known cold water Lophelia reef complexes, and the Horseshoe Ridge.

The Sula reef is located at 64°N, 8°E, on the Mid-Norwegian Continental shelf, 50 km off the Norwegian coast at about 300 m water depth. The reef is 13 km long, up to 400 m wide, The multibeam mapping shows that the reef comprises about 500 individual coral mounds (Figure 1). The individual coral mounds are often grown together to form a ridge. Within the reef complex, the density varies between 40 and 200 coral mounds per km^2. The individual coral mound has a diameter between 50 and 100 m at the base, and reaches up to 30 m in height. The reef is located along the northern flank of the Sula depth, a glacially eroded trough, eroded in soft jurassic schists outside the crystalline basement. The major part of the reef complex is situated on a bedrock ridge of more resistant sedimentary rocks. The ridge has been exposed to glacial erosion, where extensive glacial lineaments, primarily magaflutes and drumlins, show the main ice movement direction towards west-southwest across the area. Several of these glacial lineations cross the major reef complex, indicating that the location of the reef is not controlled by glacial surface forms on a regional scale, even though local control is evident. We believe that the major reef is located on the ridge primarily due a combination of strong currents and hard substrate. The subsurface bedrock comprises sandstones of high porosity, which may concentrate seeping of gas from the underground.

The Horseshoe Ridge is a 100 m high, horseshoe-shaped arcuate moraine ridge situated at 300 m water depth (66°N, 11°E). No cold water reefs have been reported from this area previously, but the multibeam data clearly indicates the possible existence of large cold water reefs. These structures are found on the flanks of the moraine ridge, with a size comparable to the mounds found at the Sula Reef. No potential reef structures are found on the main moraine ridge or at the flat seabottom surrounding the Horseshoe Ridge. Investigations with ROV are needed to confirm that the potential reef structures indeed are reefs. If confirmed, this case study illustrates a close connection between the seabed conditions (moraine structures formed more than 10 000 years ago) and present distribution of cold water reefs.

In this example, and others, such as mapping *Modiolus modiolus* bioherms in the Bay of Fundy, the application of multibeam bathymetry and side-scan sonar are useful in identifying their presence and distribution. It should be noted, however, that the status of the bioherm, namely if it is living or dead, can not be determined by these techniques.

28.8 7 SUMMARY AND CONCLUSIONS

A summary of the advantages and disadvantages of the ‘key’ acoustic systems currently available is provided in Table 8. Essentially, there is a significant difference between *swath* systems which include side-scan sonar (qualitative data), multiple narrow beam swath bathymetry (quantitative data), seismics; and *single beam* ‘echo-sounder’ systems.

The swath systems offer the ability to discriminate small habitat (seabed) features (0.3 to 1 m) together with providing information on sediment dynamics and geological evolution makes them most suited for detailed biotope mapping and professional geophysical surveys. By contrast, single beam systems such as fish finder echo-sounders, RoxAnn® and QTC-View® are useful for detecting reliably (without frequent ground truthing) gross differences in substrate type, i.e. between rock, sand and mud. However, the repeatability and level of discrimination is difficult to define and often requires intensive ground truthing which lessons their utility as a tool for broad-scale biotope mapping. Further details are provided in Rumohr.

Table 8. Pros & cons of swath and single beam systems

SWATH SYSTEMS (Side-scan Sonar & Multibeam)	**SINGLE BEAM SYSTEMS** (AGDS)
Advantages	**Advantages**
Self Calibrating	Low Cost (typically £5 – 15 k)
High Resolution	Ships Echo-Sounders
Wide Coverage	Easy to Operate
Sediment Texture	
Bedforms	**Disadvantages**
Sediment Dynamics	

A number of conclusions may be made in relation to the technical advantages and disadvantages of the various devices for biotope mapping. The swath systems are most likely to provide the best high resolution maps of sea-bed, particularly over a wide area (swath widths that vary between 30 to 500 metres). They provide information on sea-bed sediment texture and bedform structure which allow dynamic process (eg. sediment transport) to be defined. The disadvantages associated with swath systems are their high costs and the need to have skilled interpretation. In addition, the output often requires considerable post-processing time and expense to derive the best images. On the other hand single beam systems cost much less and are generally simple to operate. The disadvantage of single beam sounders is they require intensive calibration (ground truthing) when being used to discriminate sea-bed biotopes. The 'echo' beam often has a large acoustic footprint (typically $4m^2$) which results in low resolution of sea-bed features. The lack of swath coverage of the bed results in the need to undertake extensive spatial interpolation in order to provide full-coverage maps of the sea-bed.

The value of one system *versus* any other will depend on the objectives of the survey, but as a general guide the high resolution capability of side-scan sonar systems and their ability to discriminate small scale habitat features (0.3 m – 1 m) together with providing information on habitat stability makes them most suitable for most detailed biotope mapping applications.

The single beam sediment discrimination systems (e.g. RoxAnn) are useful for detecting gross differences in substrate. Whilst they can discriminate much more subtle differences in habitat the repeatability and level of discrimination is difficult to define often resulting in unexplained variability between surveys.

28.9 8 REFERENCES

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29 ANNEX XVII - DRAFT AGENDA FOR THE WGEXT MEETING AT PGI.

Host Institute for WGEXT2000:

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THE WORKING GROUP ON THE EFFECTS OF EXTRACTION OF MARINE SEDIMENTS ON THE MARINE ECOSYSTEM (WGEXT)

Draft Agenda for the WGEXT meeting at the Polish Geological Institute (PGI) in Gdansk, Poland, 11 -14 April 2000

(This draft of 21 March 2000)

Monday 10 April	*If arriving before tea note Szymon's offer of a drink at PGI at 17:00*
Tuesday 11 April	
10.00 - 10.10	Coffee
10.10 - 10.30	Welcome by representative(s) of the Polish Geological Institute
	Welcome by WGEXT Chair
	Appointment of Rapporteur (Siân Boyd has indicated she is willing to take this on this year)
	Terms of Reference (*see ICES Res. 1998/2E07 attached*)
	Adoption of Agenda
10.30 - 12:00	Terms of reference item (a) – please supply national reports on disk
12.00 - 13.00	Lunch
13.00 - 14.30	Terms of reference item (a) – please supply national reports on disk
14.45 - 15.00	Coffee

15.00 - 17.00	Terms of reference item (c) – see note attached to Terms of Reference – further information will follow, but please advise if you have material to contribute.
17.00	Guided tour of the old city of Gdansk

Wednesday 12 April

09.00 - 10.30	Terms of reference item (c) – production of draft report for comment by SGMHM
10.30 - 10.45	Coffee
10.45 - 12.00	Terms of Reference item (c) continued and review of draft report from SGMHM
12.00 - 13.00	Lunch
13.00 - 14.45	Terms of reference item (e)
14.45 - 15.00	Coffee
15.00 - 18.30	Parallel groups Terms of Reference items (d) and (f) – please advise if you have material to review/contribute
18:30	*Reception organised by PGI*

Thursday 13 April

09.00 – 10.30	Continue (and Report back) items (d) and (f) and formulate report on these
10.30 – 10.45	Coffee
10.45 – 13.30	Terms of Reference item (b): Sessions on updating Code of Practice and EIA Guidelines – perhaps parallel sessions.
13.30 – 14.15	Lunch
14:30	Excursion to the Hel Peninsula (artificially nourished beaches) and other parts of the Gulf of Gdansk

	the Gulf of Gdansk

Friday 14 April

09.00 – 10.30	Continue Work on Code of Practice and EIA Guidelines – item (b)
10.30 – 10.45	Coffee
10.45 – 12.00	Work on outstanding agenda items/new agenda items
	Presentation on EU research project SUMARE
12.00 – 13.00	Lunch
13.00 – 14.45	Final
14.45 – 15.00	Coffee
15.00 – 17.00	Agree text of Working Group Annual Report for 2000.
	Review and agree Recommendations for next Annual Meeting.
	Date and place of next Annual Meeting
	Close of Annual Meeting
Saturday 15 April	*Final session for work on ICES Theme Session contribution*
9:30 – 15:00	Discussion on future research projects and related technologies.