COOPERATIVE RESEARCH REPORT

No. 64

SECOND REPORT OF THE ICES WORKING GROUP ON EFFECTS ON FISHERIES OF MARINE SAND AND GRAVEL EXTRACTION

(IJmuiden, 9-10 December 1975)

https://doi.org/10.17895/ices.pub.7994

ISBN 978-87-7482-692-7

ISSN 2707-7144

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April 1977

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1. TERMS OF REFERENCE

Resolution C.Res.1973/2:9 which was passed at the 61st Statutory Meeting of ICES set up a Working Group to consider the various effects of sand and gravel extraction on fisheries. The first meeting of this Group recommended that member countries should: (i) be encouraged to seek the view of the Council on the fisheries aspects of proposals to extract sand and/or gravel in their sectors of the continental shelf whenever such proposals are considered likely to affect international fisheries; and (ii) to submit to the Council on an annual basis details of marine sand and gravel extraction within their respective sectors.

In accordance with (i) the United Kingdom submitted details of a proposal to extract gravel from eight localities in the North Sea. After consideration of this proposal at the 63rd Statutory Meeting it was decided (C.Res.1975/2:12) to call a meeting of the Working Group on the Effects on Fisheries of Marine Aggregate Extraction to study the implications of dredging in the North Sea on international fisheries. The resolution reads as follows:-

"(i) The Working Group on the Effects on Fisheries of Marine Aggregate Extraction should meet for three days, 9-11 December 1975, in IJmuiden in order to:

(a) advise on the effects on fisheries of recent proposals for marine aggregate extraction in the North Sea and English Channel;

(b) advise on how the Council should deal with such proposals in future;

(c) advise on whether the Council should propose a ban on dredging activities in certain areas of fisheries importance.

(ii) The report of the meeting should be made available to the Advisory Committee on Marine Pollution at its mid-year meeting;

(iii) The Working Group should also examine the recent results obtained by national programmes of research into the effects on fisheries of marine aggregate extraction."

The Working Group met at the Netherlands Institute for Fishery Investigations on 9-10 December 1975, with Mr A J Lee as its Chairman.

1.1 Working Group Members

Belgium

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Denmark

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Norway	
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United Kingdom	
Mr A J Lee, Chairman	Fisheries Laboratory, Lowestoft
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Dr A D McIntyre	Marine Laboratory, Aberdeen
U.S.A.	
Mr A Lane	Office of Minerals, NOAA, Rockville, Maryland.

2. INTERNATIONAL IMPLICATIONS OF SAND AND GRAVEL EXTRACTION

The possibility that the dredging activities of one nation may harm the fishery of another country was recognised in the resolution which was passed at the 62nd Statutory Meeting of ICES (C.Res.1974/4:24) which stated that member countries should "be encouraged to seek the view of the Council on the fisheries aspects of proposals to extract sand and/or gravel in their sectors of the continental shelf whenever such proposals are considered likely to affect international fisheries".

There will be little need for concern in those cases where the national fishery is sufficiently important to prevent dredging taking place. However, problems are likely to be more acute when the national fishery is small compared to the fishing effort of other countries or where the requirement for aggregate is urgent, for instance to supply a special constructional need. In these cases there is a special need to consult the interests of countries which may be affected by the proposed dredging.

2.1 Outer Dowsing Proposal

The submission by the United Kingdom of the details of licence applications to dredge for sand and gravel from the vicinity of the Outer Dowsing Shoal off the east coast of England typifies the problems likely to be encountered.

The Dowsing area (Figure 1) has been under pressure from dredging interests for many years and has been the subject of no less than five separate surveys and four production licence applications. Requests for the two areas shown hatched in Figure 1 were received in 1972. The triangular area alone was thought to contain some 10 million tonnes of workable aggregate and an extraction rate of 500 000 tonnes per annum was proposed. Although production licences were refused, six further licence applications covering much the same area were received in 1975.

Those fish stocks which support international fisheries are considered to be vulnerable to the dredging proposals. The first is the herring stock fished in deeper water to the east of the Outer Dowsing Shoal. In 1974 Dutch and French vessels caught nearly 6 000 tonnes of herring each from this area. Although the adult fish are not at risk from dredging, three of the proposed dredging sites are thought to include some of the few remaining herring spawning grounds still in regular use. The need to protect spawning grounds as part of the overall measures to conserve herring stocks is discussed further in Section 2.2. The second is the important fishery for cod carried out by Belgian trawlers; during 1974 just under 9 000 tonnes were caught on and around the Outer Dowsing Shoal.

The other major fishery at risk is the industrial fishery for sandeels which is centred on the Outer Dowsing Shoal. Fishing is seasonal extending from April to July or August but peak catches are taken in June. Only Denmark and the United Kingdom fish for sandeels on the Dowsing ground with Danish vessels taking the larger share of the catch (Table 1).

Table 1. International catch of sandeels from the Outer Dowsing area.

Year	Danish		United Kingdom		Total	
	Weight ('000 tonnes)	£ ('000)	Weight ('000 tonnes)	£ ('000)	Weight ('000 tonnes)	£ ('000)
1973	10.26	307.8	2.01	56.3	12.27	364.1
1974	9.10	273.0	1.50	42.0	10.60	315.0
1975	13.50	405.0	0.09	2.5	13.59	407.5
Average 1971-75	16.20	486.0	1.65	46.2	17.85	532.2

Notes (a) Catches are from ICES statistical rectangle 35 F1

(b) Values (£) are based on 1973 prices for raw material which were £ 28 per tonne on the Humber and £30 per tonne in Esbjerg.

The behaviour of the sandeel makes this animal particularly sensitive to interference from dredging. The main species caught on the Shoal is Ammodytes marinus which spends between four and six months completely buried in the sand. Even during periods of activity, the fish remains buried at night and leaves the sea bed only during daylight hours to feed. It is thus dependent during much of its life cycle on the free movement of water through the surface layers of the sediment in which it lives. Interference with the surface layers of the sediment or the deposition of out-wash material may alter the characteristics of the sediment sufficiently to affect the survival of the buried fish.

A similar situation exists with the development of sandeel eggs. These are laid in the sand during spawning where they adhere to sand grains. Satisfactory development is related to the oxygen concentration of the water in contact with the eggs and although the eggs may be able to withstand short periods of burial, prolonged smothering by, for instance, out-wash material from dredgers would seriously affect growth of the embryos.

If it is accepted that dredging will harm the sandeel stocks, the licensing authority then has to consider whether the size of the fishery justifies the refusal of an extraction licence. The small size of the United Kingdom catch of sandeels would in the short term compare unfavourably with the value of aggregate which could be removed annually, and if this was used as the sole criterion for assessing licence applications, there would not be a strong argument for refusing the application if the decision were to be taken on a national basis. However, the United Kingdom fishery cannot be considered in isolation since if dredging reduces the UK catch by damaging the fish stocks, it will also affect the catch of all nations fishing in the area. The most important criterion is not therefore the size of the catch taken by an individual country but the maximum sustainable yield which can be obtained from the fish stock if unaffected by dredging.

One other factor should be considered when comparing the value of the sandeel stocks with national requirements for gravel. This is the importance of the species as a food source for other more valuable fish such as cod and whiting (see, for example, Nagalhuskanan, 1964; Jones, 1954; Rae, 1967; Daan, 1973).

A unilateral decision to allow dredging on the Outer Dowsing, based on the assumption by the licensing country that their own catches in the area are small, could therefore have considerable repercussions on at least two important international fisheries. In order to avoid this situation the Working Group recommends that an intergovernmental organisation be set up to deal with any conflict of interest between the dredging industry and the international fisheries (see recommendations).

In addition the Working Group feels that a more satisfactory position could only be reached when the most important fisheries grounds had been mapped in detail and could be considered alongside the charts of the most valuable gravel deposits. For this reason it also recommends that the information necessary to prepare suitable charts should be obtained from member countries and if necessary a coordinator be appointed by ICES to deal with the material received (see recommendations).

Since by their nature fishing grounds are not static, the charts would require periodic updating, but would nevertheless provide a working basis on which to assess proposals to extract sand and gravel.

2.2 Herring Spawning Grounds

Measures introduced to conserve herring stocks in the North Sea, by limiting the numbers of fish caught, cannot be successful if the spawning grounds are themselves liable to be damaged by dredging. The possibility that some of the grounds may be at risk is indicated by the close correspondence, shown in Figure 2, between spawning beds and gravel deposits in the North Sea. Since the dredging technology necessary to exploit these deposits is available, all that will be required to revive interest in them will be an increasing demand for gravel and a profitable return on the operation.

In order to protect and study spawning grounds their location needs to be determined as precisely as possible. As a result of the recommendation from the first meeting of the Working Group an effort was made to bring together all available information which would help to delineate spawning grounds in the North Sea (Postuma, Saville and Wood, 1975). Four types of data were used:-

1. Observations of spawn either by dredging or grabbing techniques or by visual observation.
2. Records of the position of capture of herring which are, or on the point of, spawning.
3. Position of capture of other fish species which are feeding on herring spawn.
4. Position of capture of recently-hatched herring larvae.

By combining this information the authors were able to draw up a chart of spawning grounds which they designated as zones from which dredging should be banned (see Figure 2). The size of these zones is considerably larger than the actual area on which herring spawn and reflects the need to be over-cautious until the grounds can be more precisely delineated.

Two approaches can be made to achieve this. Firstly, using the approximate positions of the spawning grounds which have been outlined, attempts can be made to obtain samples of eggs and bottom substrate. In the past this technique has proved unsuccessful on offshore grounds in the North Sea, with the exception of the work of Bolster and Bridger (1957), but has been relatively successful on sites such as those off the coast of Norway (Runnström, 1941), Iceland (Fridriksson and Timmermann, 1951), Ballantrae Bank off the west coast of Scotland (Parrish et al., 1959) and off the Isle of Man (Bowers, 1969).

The main difference between the successful and unsuccessful surveys has been the size of the area to be covered. Bowers (1969) pointed out that a sampling grid of less than 0.5 km between stations would have been necessary to delineate the small spawning grounds which he studied. Although offshore beds may be expected to be larger than these, Bowers' work does give some idea of the scale of the problem. Furthermore, knowledge of the inshore grounds is usually more complete and may include details of the local sediments and precise information from fishermen on the position of the shoaling herring. In contrast, little may be known of the offshore grounds, with the result that the survey may need to cover a very wide area.

A second approach would be to determine the sediment types within the suspected spawning zones and concentrate only on those sediments which are likely to be used by herring for spawning purposes. Sufficient evidence has been obtained from samples and by direct observation to indicate that herring spawn preferentially on clean coarse gravel in the North Sea. By mapping these areas within the main spawning zones, it would be possible to eliminate the remaining, unsuitable areas from further investigations.

Considerable information is already available on North Sea sediments, although much of it is scattered throughout the literature. In addition, extensive surveys have been carried out by private companies with interests in the sea bed and this could be extremely useful if it could be made available. For example, Figure 3 illustrates the area of the sea bed around the United Kingdom which has been surveyed by dredging companies. Although much of the ground would have received only slight attention, those areas containing gravel and therefore of interest as potential spawning grounds will have been surveyed in greater detail. This information would form part of the input to the coordinator appointed by ICES with the responsibility for drawing up charts of bottom deposits (see recommendations).

A number of grounds on the east coast of England and in the eastern Channel are already under pressure from dredging companies or may be threatened by increasing dredger activity. In these areas it may not be sufficient simply to delineate the spawning grounds more precisely, and further research will be needed to determine why herring return repeatedly to specific areas. If visual or olfactory imprinting is used, what effect will changes in the immediate vicinity or on the spawning grounds themselves have on the fish? Similarly, how will the deposition of outwash material affect the recognition of spawning banks and the development of the eggs?

Until close delineation of the grounds is available and the effects of dredging on spawning grounds is better understood, it is recommended that no dredging should be allowed on spawning grounds (see recommendations).

2.3 Nursery Grounds

The importance of preventing interference to fish nursery grounds does not need to be emphasized and it appears to be generally accepted that dredging should be excluded from all such areas. However, only Belgium and the Netherlands have legislation specifically prohibiting dredging from an inshore zone which includes all major nursery grounds.

The Dutch exclusive coastal belt extends for 20 km from the shore, or to a depth of 20 m if this is further. Only in exceptional cases is dredging allowed inside the 20 m isobath. Figure 4 shows the area off the Belgian coast in which dredging is prohibited. The ban in this area is to protect all important fisheries including nursery and spawning grounds, although it contains a large section which is protected for navigational reasons.

There is no common code of practice amongst the remaining ICES countries, although grounds may often by protected as a result of bans implemented for some other reason. For instance, on the North Sea coast of the Federal Republic of Germany dredging is not permitted in the area outlined in Figure 5. The basis for this restriction is the protection of the coastline, but it also serves to exclude dredging from sensitive fisheries grounds within the zone. A similar situation exists in the United Kingdom where dredging is not normally allowed to take place within 3 miles of the shore, in order to prevent erosion of the coastline. However, this ruling has been challenged and there is the possibility that in the future dredging activity may move closer inshore. This situation has already occurred off the coast of Scotland where it has been decided that the removal of 20 million m^3 of sand from the Firth of Forth and 11 million m^3 of sand from the Firth of Clyde would not affect the adjacent coastline. As a result two important plaice nursery grounds could be placed at risk if dredging is permitted.

A proposal to exclude dredging from the inshore area shown in Figure 6 has been put forward by the French scientific organisations who have been studying the environmental effects of dredging in the Baie de Seine. The zone which is outlined includes the highly productive sea bed areas characterised by the bivalve Abra alba, as well as nursery grounds and spawning areas. In general, it is hoped to concentrate sand and gravel extraction on those sectors of the Baie de Seine which have little fisheries importance.

Since the general principle of excluding dredging from the coastal zone has been accepted by many countries, whether for coast protection or for other reasons, it is recommended that it should now become the accepted practice in order to ensure adequate protection for nursery grounds (see recommendations).

3. REVIEW OF CURRENT RESEARCH PROGRAMMES

3.1 France: Baie de Seine Project

A detailed study of an experimental dredging site has been carried out by a number of scientific organisations with the "Centre National pour l'Exploitation des Océans" (CNEXO) acting as the co-ordinating body (Bouchot et al.,1975; Debyser, 1975). The study has three main aims: (1) to assess the effects of dredging on a selected test area, (2) to define the criteria and develop the methods needed to examine these effects, (3) to develop a theoretical basis which could be used to judge the effects of aggregate extraction in other areas in the future.

The area chosen for the study was the Baie de Seine (Figure 6) which is likely to be the centre of a large dredging industry and consequently would be typical of the sites selected for full-scale dredging operations. The test site, which is located on a deposit of sand overlying gravel, consisted of a dredged channel, 1 700 m long by 70-150 m wide and between 4 and 6 m deep. In all approximately 1.2 million m^3 of material was removed in three periods between January 1974 and July 1975.

There are two main areas in which results have so far been obtained. One is the field study of the dispersion of outwash 'fines' and the other is the recolonization of the sea bed after dredging.

3.1.1 Effect of outwash material on water turbidity

The radioactive labelling of sediments was used to trace the dispersion of material washed overboard during the dredging operation. Increased turbidity was measured throughout an area of 50-70 km^2 around the dredger, although particles larger than 40 µm were found to settle out within 1.5 km of the test site. Sediment smaller than this - classified as 'fines' - remained in suspension for longer periods and the rate of sedimentation of these small particles was influenced more by wave action than by current velocity in water depths of up to 20 m. Thus, it was observed that 10 per cent of the fines may still be held in suspension 6-12 km from their point of origin. There was a clear indication from these results that the suspended sediment load in the water would be increased by dredging, but the biological significance of this conclusion has not yet been examined.

3.1.2 Assessment of biological effects

A four-year study of benthic communities in the Channel was used as a base-line from which to monitor changes caused by dredging of the test site. In the Baie de Seine the main benthic communities and their association with the substrate type are as shown in Figure 6.

The experimental trench is situated in an area of medium sand overlying gravel. The dominant animal in the benthic community is the polychaete worm *Ophelia borealis.* The removal of the overlying sand during dredging has resulted in the development of a completely different animal community associated with the newly exposed gravel substrate. Two months after dredging had finished the pebbles in the trench were thickly covered by two species of hydroid, and a single species of polyzoan had begun to colonize the gravel. After a further four months many other species had recolonized the area including both attached sessile animals and members of the mobile epibenthos. The most important source of recolonization appears to have been by larvae from the plankton rather than the movement of adult animals into the area.

The importance of the benthos as a food source to commercial fish species in the area has been examined by analysing the gut contents of fish caught in the region of the dredged channel. It has been shown that of the 30 most commonly encountered animals, 26 are found regularly in fish stomachs. However, it is not yet clear how far the change from an animal community associated with a sandy sea bed to one associated with gravel and stones will affect the behaviour and feeding of fish in the area.

3.1.3 Future work

In addition to completing the work programme on the present experimental site, there are plans to carry out a study in an area in which the gravel deposit lies at the surface. Suitable locations in the Baie de Seine are characterised by a varied animal community dominated by the brittle star *Ophiothrix fragilis.*

3.2 United Kingdom: Southwold-Thorpeness Project

The aims and methods of study of a licensed dredging ground off the east coast of England are in many ways similar to those in the French study. However, the problems which are likely to arise as a result of the dredging activities differ in two important respects. Firstly, because of the shallow nature of the gravel deposit, dredging is not confined to a deep narrow channel as in the Baie de Seine but occurs to an average depth of about 2 m over most of the licence area. Secondly, the nature of the sediment which is left after dredging is likely to be fairly similar to that present before, except where the underlying clay base has been exposed.

The main elements of study have been described previously (ICES, 1975) and a number of surveys have now been conducted.

3.2.1 Effects on the sea bed and on water quality

Changes in the sea bed as a result of dredging have been monitored using the MAFF sector scanning sonar. Two surveys were carried out before dredging began and a further survey took place during intensive dredging activity. Tracks resulting from the trailing suction pipe were clearly outlined on the scanner display and by linking the display with a centre channel chart recorder a permanent record of the sea bed was obtained. As extraction continues it will be possible to build up a record of the changes taking place on the ground and this information will provide a useful basis for interpreting the biological data obtained over the same area.

The persistence of trailer dredged furrows as distinctive features in the sea bed has been studied by measuring the shear stress acting on the bottom. The maximum particle size capable of being moved by the peak tidal currents was found to be about 5 mm. Gravel on the bottom is never moved by tidal currents and only slight infill of the tracks is therefore likely to take place.

The measurement of high natural turbidity levels on the dredging ground indicated that the problem of outwash material could be disregarded in this area.

3.2.2 Biological monitoring

Surveys of the animals living in the sediment as well as the mobile epibenthos living freely on the bottom were made before dredging began and at the start of dredging operations. In addition, the stomach contents of bottom-feeding fish caught in the area have been analysed and related to the animals obtained during the surveys. All the most important members of the epibenthos with the exception of the echinoderms were found to contribute to the food of the fish sampled. (This background information will be used to assess the changes which may take place as the area covered by the dredgers increases.) Although destruction of the benthos occurs in the path of the dredge, no effects on the animal community were noticed in the area as a whole at the level of dredging encountered.

3.2.3 Future work

A trailer dredging operation of the type being carried out on the Southwold ground tends to result in some areas receiving considerable dredging activity while other sectors remain virtually untouched. It is hoped to compare the effect on the benthos of this type of activity with the effect at an intensively dredged site on the same licensed ground.

3.3 Belgium

Preliminary surveys are to be undertaken of selected areas off the Belgian coast in 1976. The three main lines of study which have been proposed are: (1) to survey the diversity and density of fish, shellfish and benthos, (2) to study water quality, (3) to study water movement, wave action, etc. Once this background information has been obtained, dredging will be allowed to take place in some areas and these will be monitored at regular intervals.

3.4 Sweden

Two studies which relate to marine extraction are being undertaken. The first, carried out by the National Industrial Board, involves a study of the effects of increasing extraction of sand and gravel from the sea bed. The terms of reference of the Group concerned require that it pay particular attention to the environmental effects of extraction and identify any obstacles to exploitation, such as the presence of spawning grounds.

The second project is related to the effects of the construction of a steelworks on the environment and is only partly concerned with marine extraction and dredging. The project will however include a biological study of sufficient detail to enable the ecological effects of dredging to be monitored.

3.5 Norway

The University of Bergen has begun a study on the effects on benthos of gravel extraction in fjords. This reflects the interest that has been shown in mining for gravel in the shallow water around the edge of fjords.

4. CURRENT LICENSING REGULATIONS

The current licensing procedures for most ICES member countries were outlined in ICES (1975). The fact that some changes have occurred since then is indicative of the rapid growth in mining activity which is taking place.

Detailed regulations regarding prospecting for certain minerals, including sand and gravel, have been introduced by Norway. Among the more significant clauses are the following: (1) Licences are granted for two years, (2) the right to survey does not give any precedence or right to exploit, (3) accurate data including results of all surveys, samples, etc. must be supplied to the Ministry of Industry within six months of the end of the survey, (4) the exploration must as far as possible not interfere with (amongst other things) fishing and marine fauna and flora.

The importance of minimising effects on the environment appears to be generally recognised in legislation, and a number of countries require environmental surveys to be conducted before licences are granted. In the U.S.A. an environmental impact statement must be produced before a licence is issued and the firm must then comply with the strict guidelines laid down.

In Sweden a government survey is required before a licence is granted. If no adverse effects are expected, dredging is permitted but regular monitoring surveys are carried out. The cost of all necessary studies is borne by the dreding company, even if no licence is forthcoming. A similar situation exists in Belgium where biological surveys are organised by the Rijksstation voor Zeevisserij, Ostende, and paid for by the company.

The principle that the licencee pays for environmental surveys before a licence is issued is one of the features in the comprehensive list of conditions which has been adopted by France. The main regulations are similar to those proposed as a common code of practice by the Netherlands (ICES, 1975). Each applicant is required to fill in a detailed questionnaire or 'check-list' which deals with every aspect of the dredging operation. The main points of the 'check-list' are summarised in some detail below because they provide a useful basis for the formation of a common 'European' code of practice:

Section A	Identification of applicant. Name, firm, etc. Includes details of any other dredging operations
Section B	Position of the extraction site Latitude and longitude of location; area, depth and distance from the shore; chart of location
Section C	Nature of the deposits to be exploited Type of surface sediment; depth and nature of sediment required; granulometry of sediment

Section C (ctd) required, particularly the composition of material less than 63 microns

Section D Exploitation

(1) Total volume to be extracted; total period of work and the rate of extraction; 5 year plan of extraction

(2) Method of dredging, names and capacities of ships, etc. Method of position-fixing

(3) Rejected material
Quantity and location of outwash material; granulometry of outwash

Section E Discharge

Port of discharge and treatment facilities

Section F Economic aspects

What is the material to be used for? Does it have a specific market?

Section G Environmental impact

The applicant should attach to his licence request details of his study of the environment which should include (1) a precise description of the environment, (2) an assessment of the consequences of dredging activities

At least the following areas should be covered:

Currents
Surface and bottom velocities and direction

Bottom communities
Define the benthic community
List the main species exploited commercially
Give their annual production

Commercial fish species
Give period of spawning
Abundance of young fish
Composition of food compared to benthos in the area

Commercial bivalve species
State distance to the nearest exploited beds

Other activities
Is the extraction zone situated across navigation routes or access to ports?
Is it close to buoys, submarine cables, etc.?

This questionnaire is designed for firms extracting more than 500 tonnes per day or 100 000 tonnes per year. A similar type of questionnaire is also given to smaller firms but less detailed answers are expected of them. The use of this list ensures that the licensing authority and other interested government departments have a detailed knowledge of all aspects of the proposed exploitation.

5. THE EXPLOITATION OF Lithothamnium (Maërl)

The commercial exploitation of marine calcareous algae for use as fertilizers and soil conditioners is based on deposits of the rhodolithforming members of the Corallinaceae which are collectively known as maërl. Interest is centred on deposits off the coast of France, England and Ireland where the algae are found in sufficient quantities to make commercial utilisation worthwhile.

Small quantities of maërl have been dredged off the coast of France since at least the 19th century and in 1974 the amount had increased to 648 000 tonnes. No large-scale extractions have taken place off the coasts of either England or Ireland, although proposals to dredge for maërl have been considered in both countries.

5.1 Systematics and Structure

The two species which predominate in maërl deposits in southern boreal waters are *Lithothamnium corallioides* Crouan and *Phymatolithon calcareum* (Pallas) Areschoug. *P. calcareum* was until recently included in the genus *Lithothamnium* but recent studies by Adey and McKibbin (1970) have shown that it is structurally and reproductively closer to other members of the genus *Phymatolithon* in which it is now included.

Both species have a branching calcareous thallus or rhodolith which can vary considerably both in size and shape depending on age and exposure to water movement. Examples of the range of shapes which occur naturally are given in Cabioch (1970) and Blunden *et al.* (1975). The characteristic coloration of living maërl is a reddish-purple but the dead algae which form the basis of the material extracted for fertilizers turn a yellowish or greyish-white colour after they have been broken down and abraided by the sea.

5.2 Distribution

Maërl-forming species of algae are widely distributed throughout the North Atlantic (Adey and Adey, 1973) although they only occur abundantly in a rather limited number of areas where the environmental conditions are suitable. The main requirements for satisfactory growth would appear to be protection from heavy swell, relatively strong currents to prevent smothering by silt and lack of abrasion from waterborne particles (Cabioch, 1968; Adey and McKibbin, 1970). The limiting factor to depth distribution is the penetration of light for photosynthesis. As a result, in the relatively clear water of the Mediterranean deposits of maërl occur down to depths of 70 m or greater (Jacquotte, 1962), whereas in the more turbid waters off the coast of Brittany maximum depths appear to be about 20 m (Gautier, 1971).

The distribution of maërl banks around the Brittany coast of France is given in Figure 7, which is based on the more detailed map of Gautier (1971). These banks constitute the most important deposits in terms of commercial exploitation of maërl. More detailed surveys of certain deposits around the coast of Brittany are given in Boillot (1961, 1964), Cabioch (1968) and Retière (1975).

The distribution of maërl sediments around the United Kingdom has not been studied in any detail except for the deposits in the Falmouth area of the English Channel where commercially exploitable quantities have been found.

Maërl is only found on the west coast of Ireland (Figure 8) and licences to dredge for the material have been submitted for areas around Galway Bay. The distribution of calcareous sediments in Kilkieran Bay on the north shore of Galway Bay has been studied in some detail by Deeny (1975).

5.3 Fauna of Maërl Beds

The dominating factor which affects the animal community associated with maërl deposits is the natural condition of the algae. Deposits of dead material are in general much poorer both in numbers of species and numbers of individuals than the living maërl.

Cabioch (1968) in his study of the Channel fauna and their association with different sediment types suggested that the fauna of living maërl beds was sufficiently different from animal communities of other sediments to be considered as a separate and extremely rich biocoenosis. However, two communities were distinguished in maërl beds off the north Brittany coast and these bore resemblances to communities from other deposits in the western Channel. Deposits of _Lithothamnium corallioides_ var. _corallioides_ were associated with an endofauna typical of the _Venus fasciata_ community whereas banks made up of _L. corallioides_ var. _minima_ contained a community typified by the _Pista instata_ community of heterogeneous muds.

Keegan (1974) found a considerable variety of animal groups in association with deposits of _L. corallioides_ var. _corallioides_ in Galway Bay on the west coast of Ireland. The local characteristics of the deposit, that is the percentage of living or dead material, position in relation to currents and associated material such as mud, sand or shell, were important in determining the faunal community. However, the general pattern was consistent with the findings of Cabioch.

Rolfe (1976) in a brief survey of the Falmouth Bay maërl beds found the living material to be rich in animal life with over 3 814 individuals of 25 species being obtained from the crevices of rhodoliths collected in a single 0.1 m^2 box sample. Crustaceans and small bivalves dominated the samples examined.

In contrast the dead maërl was relatively poor in numbers of species, although the coarse open matrix and varying amounts of 'fines' trapped within it was considered to demonstrate the 'specialised ecological habitat that maërl deposits provide.'

5.4 Effects of Exploitation

The extensive banks of dead algae which form the commercially exploitable deposits are either formed beside the actively growing maërl, as off the coasts of Brittany and Ireland, or appear to be quite separate from the present-day growing areas, as in Falmouth Bay. In both cases the banks require strong currents for their formation and are the result of the collection of dead material over very considerable periods of time.

Replenishment of the banks is likely to be very slow, since maërl species have been observed to grow only about 1-2 mm per year (Adey and McKibbin, 1970). Similarly, the formation of new plants occurs largely by the release of reproductive spores, in itself an infrequent and slow process.

In the long term the effect of dredging will be to exhaust all supplies of maërl within the extraction zone. When living maërl is closely associated with dead material, a rich and productive animal community will also be destroyed. The slow growth rate of the species means that replacement of the banks could not be expected in the foreseeable future.

An alternative source of supply is however available in the enormous calcareous sand deposits which occur in many areas. Not only are these sediments a renewable resource, but in many cases they are also associated with an impoverished faunal community.

6. RECOMMENDATIONS

The Working Group recommends that:-

1. Member countries encourage collaborative work on a national basis between fisheries biologists and marine geologists with respect to the effect on fisheries of marine sand and gravel extraction, and that these scientists be encouraged to study:

   (a) the effects of dredging on a seasonal basis,

   (b) the differing effects of extracting material of various grain sizes (fine sand, medium sand, etc.).

2.* The Council takes steps to obtain from member countries and appropriate international scientific bodies for all areas of potential dredging activity, maps, etc. showing:

   (a) the distribution of different types of sediment, bathymetry, etc.,

   (b) fishery grounds, spawning areas, nursery areas, etc.

   The Council should appoint a co-ordinator(s) to synthesize the material.

3. Member countries intensify their research programmes in order to obtain much more detailed knowledge concerning the location of herring spawning grounds in areas of potential dredging activity and of the actual distribution of gravel.

4. The information obtained under 1-3 above should be used by member countries to determine the strategies (use of deep trenches, surface dredging, etc.) with which to exploit sand and gravel and at the same time to reduce harmful effects on the marine environment and fisheries to a minimum.

5. The practice already adopted by some countries of prohibiting sand and gravel dredging in the coastal zone and in fish nursery areas be brought to the notice of the appropriate authorities in other member countries with a view to making it generally recognised practice.

6. The appropriate bodies in member countries be made aware of the need for an environmental impact assessment to be made before a prospecting or production licence for marine aggregate is issued. Such an assessment should be made either by a governmental body or by the dredging company concerned, but in the latter case the assessment will need to be overseen by a governmental body.

7. With respect to the request for advice, received from the United Kingdom, the relevant authority should be informed of:-

   (a) countries' catches in the proposed extraction zone, the importance of the area to the Belgian cod fishery, the French and Dutch herring fisheries

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* See C.Res.1976/4:14 adopted by the Council at its 64th Statutory Meeting (Procès-Verbal de la Réunion 1976, p.137).

etc. and the fact that the proposed extraction zone is the scene of an important Danish sand-eel fishery and that Denmark would not wish to see the United Kingdom take any action that might harm that fishery;

(b) the Council's views of the undesirability of dredging in herring spawning areas (see Recommendation No.8); the proposed extraction zone incorporates such an area;

(c) the fact that the sand-eel species play a very important part in the food chain of the cod, haddock, turbot, etc.

The Working Group notes, that:-

(i) herring spawning grounds are located in certain areas of gravel deposits and that extraction of gravel in such areas, even on a prospecting basis, would cause serious harm to the herring stocks in the ICES area;

(ii) with the ever-increasing demand for marine sand and gravel and the existence of the technology with which to obtain it, pressure to exploit sand and gravel in certain critical fisheries areas will increase;

(iii) whilst fishing in the ICES area is international, decisions to dredge sand and gravel on the continental shelf are taken on a national basis;

(iv) there is no intergovernmental organisation with the necessary authority to harmonize the respective requirements of the fishing industry and the sand and gravel industry

and therefore also recommends, that:-

8.* The Council should as a matter of urgency draw the attention of the governments of its member countries and of the North-East Atlantic Fisheries Commission to this state of affairs and should request them to set up the appropriate intergovernmental machinery to deal with it. In the meantime it should also request the governments of its member countries not to proceed with any dredging on herring spawning grounds and in other critical fisheries areas.

* See C.Res.1976/4:15 adopted by the Council at its 64th Statutory Meeting (Procès-Verbal de la Réunion 1976, p.138).

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APPENDIX

Resolution C.Res.1974/4:24 called for member countries to submit on an annual basis details of marine sand and gravel extraction within their respective sectors. The information received with respect to year 1974 is given in the table below:

Country	Amount extracted (million m^3) (1974)	Future production
Belgium	0	6 million m^3 between 1976-77
Denmark	-	-
France	Small amount	Increase
Federal Republic of Germany	3.3 - 3.4	1.2 million m^3 between 1973-76 from Gabelsflach. Unlimited quantities between 1973-76 from Kiel Bight
Ireland	0	Increase
Netherlands	0.13	Licences for up to 10.6 million m^3 granted in 1974
Norway	0	Licences for 0.46 million m^3 granted
Sweden	-	-
United Kingdom	12.44	Approx. same as for 1974
United States	0	Prototype lease to be issued

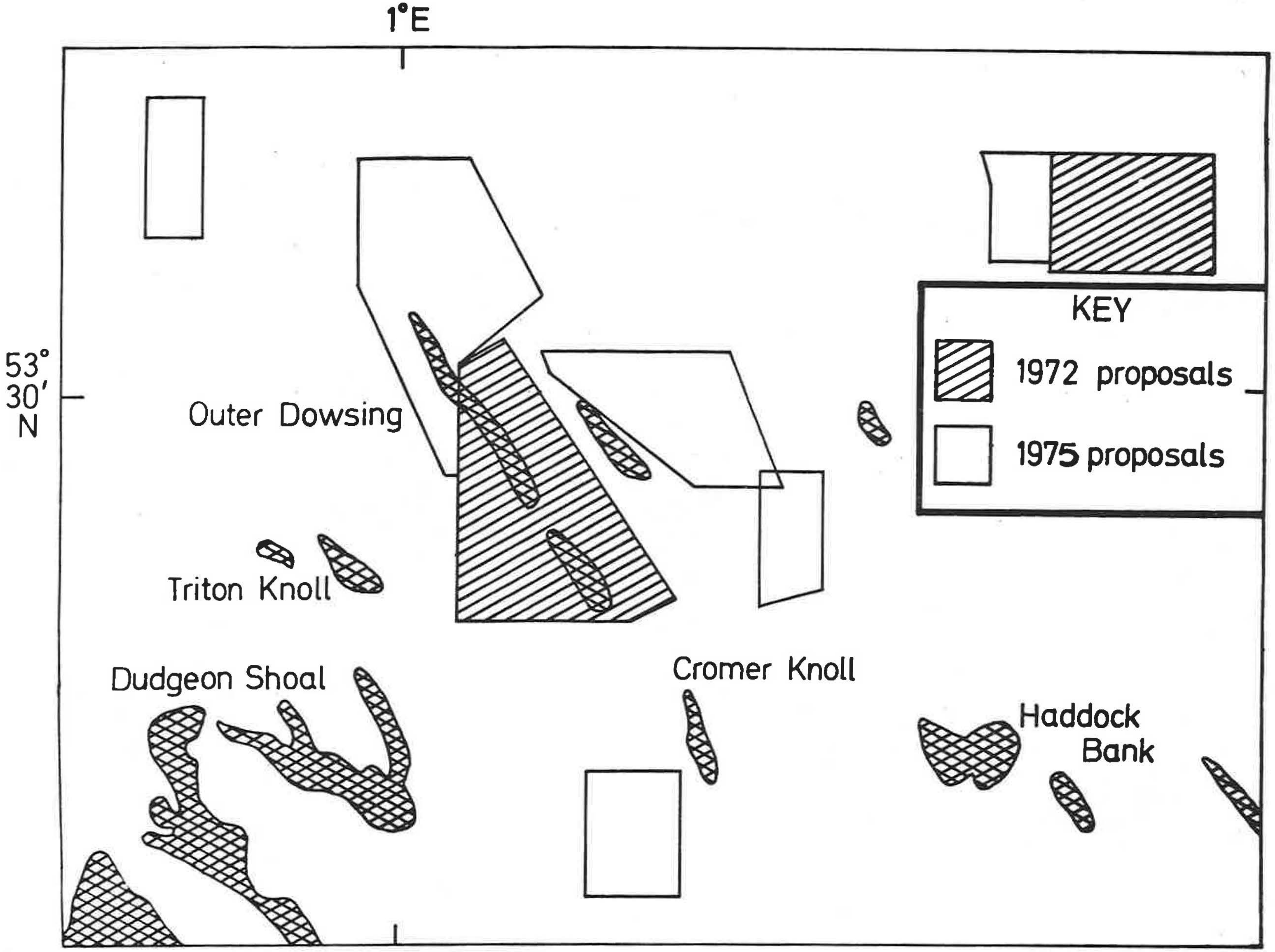
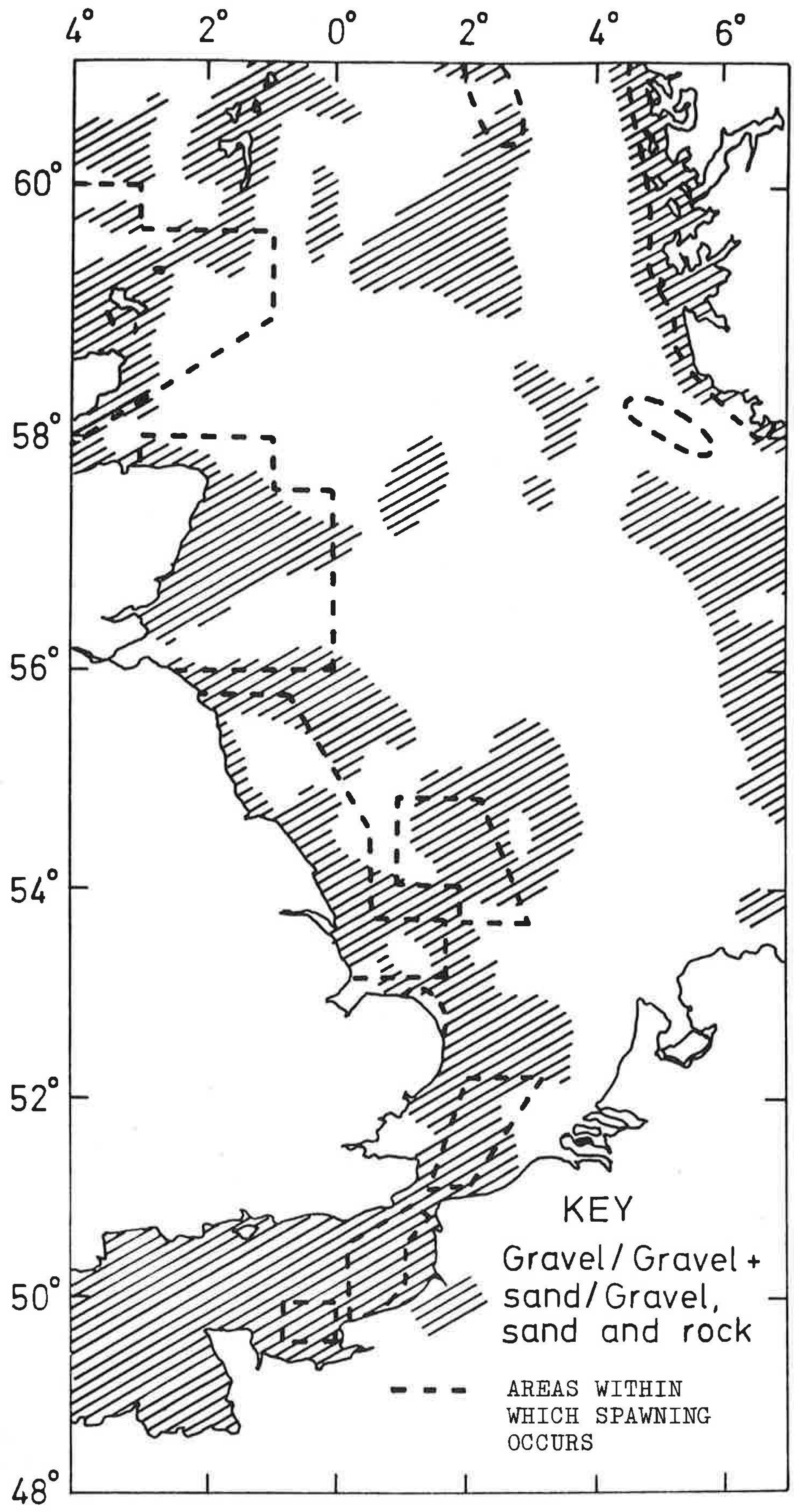


Figure 1. Proposed sand and gravel extraction sites in the Outer Dowsing area of the North Sea.



<u>Figure 2.</u> Distribution of herring spawning grounds and gravel deposits in the North Sea (from Postuma <u>et al.</u>, 1975 and Lee and Ramster, 1976).

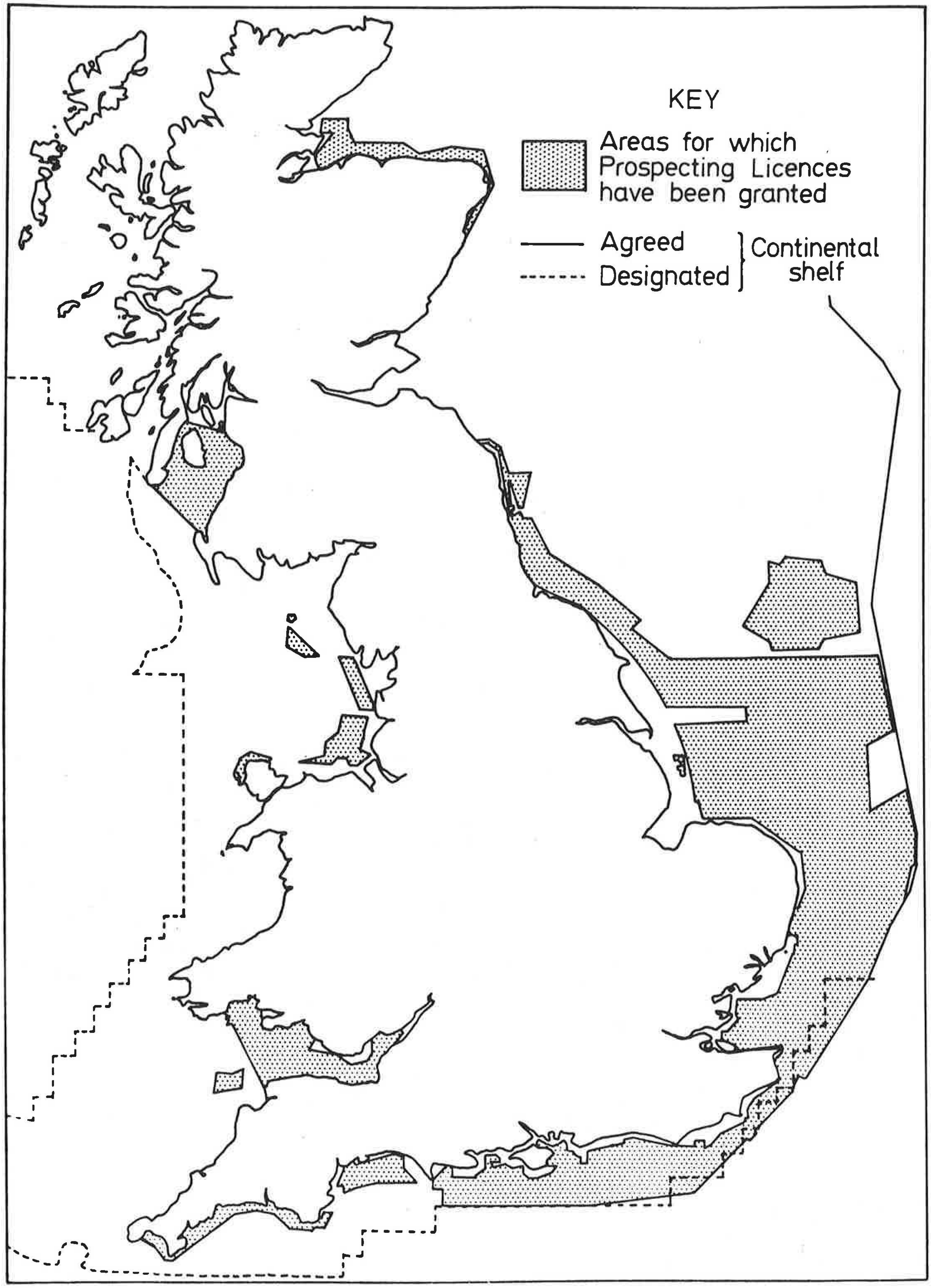


Figure 3. Licensed prospecting areas around the United Kingdom. (Department of the Environment, 1976).

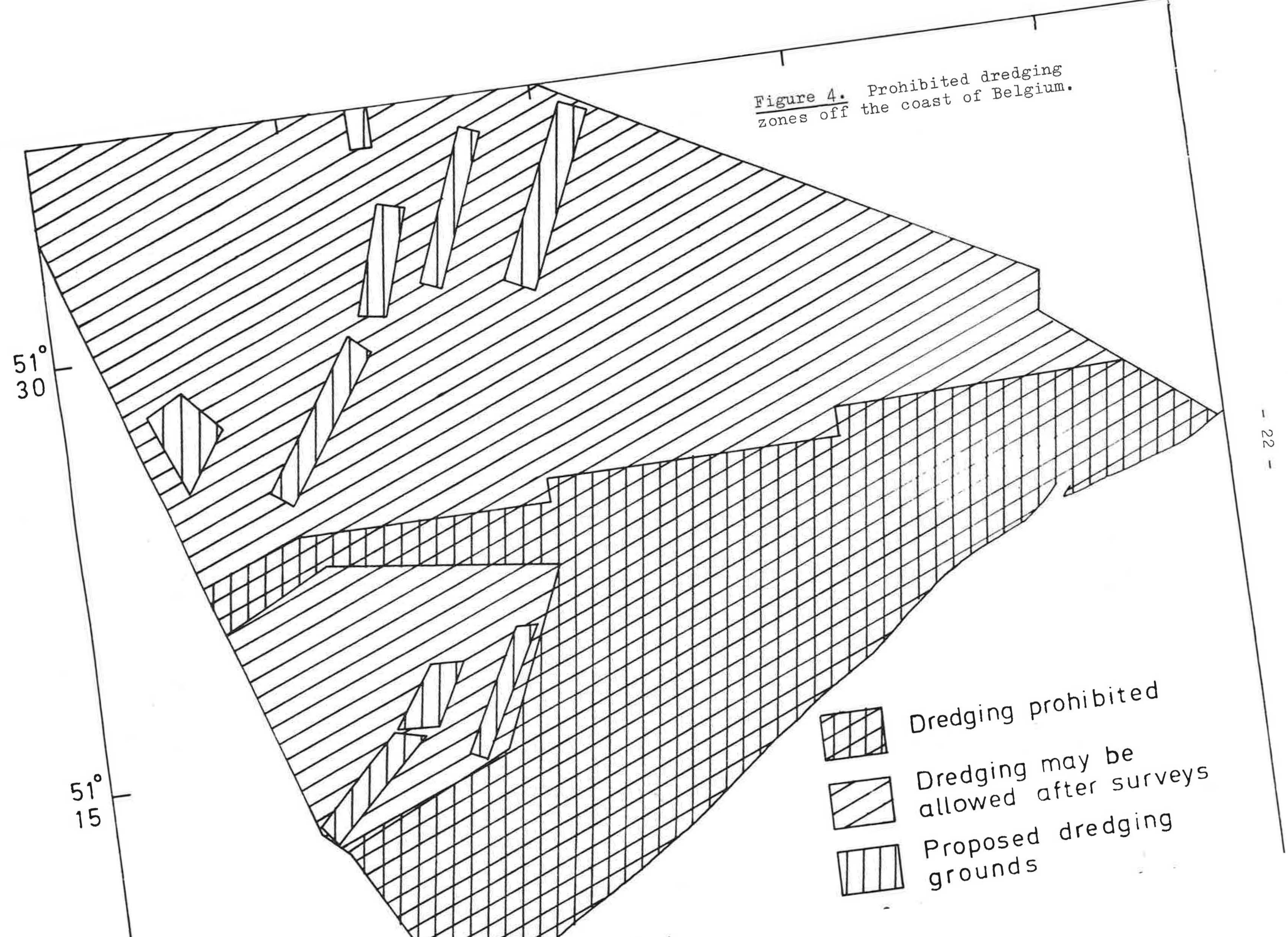


Figure 4. Prohibited dredging zones off the coast of Belgium.

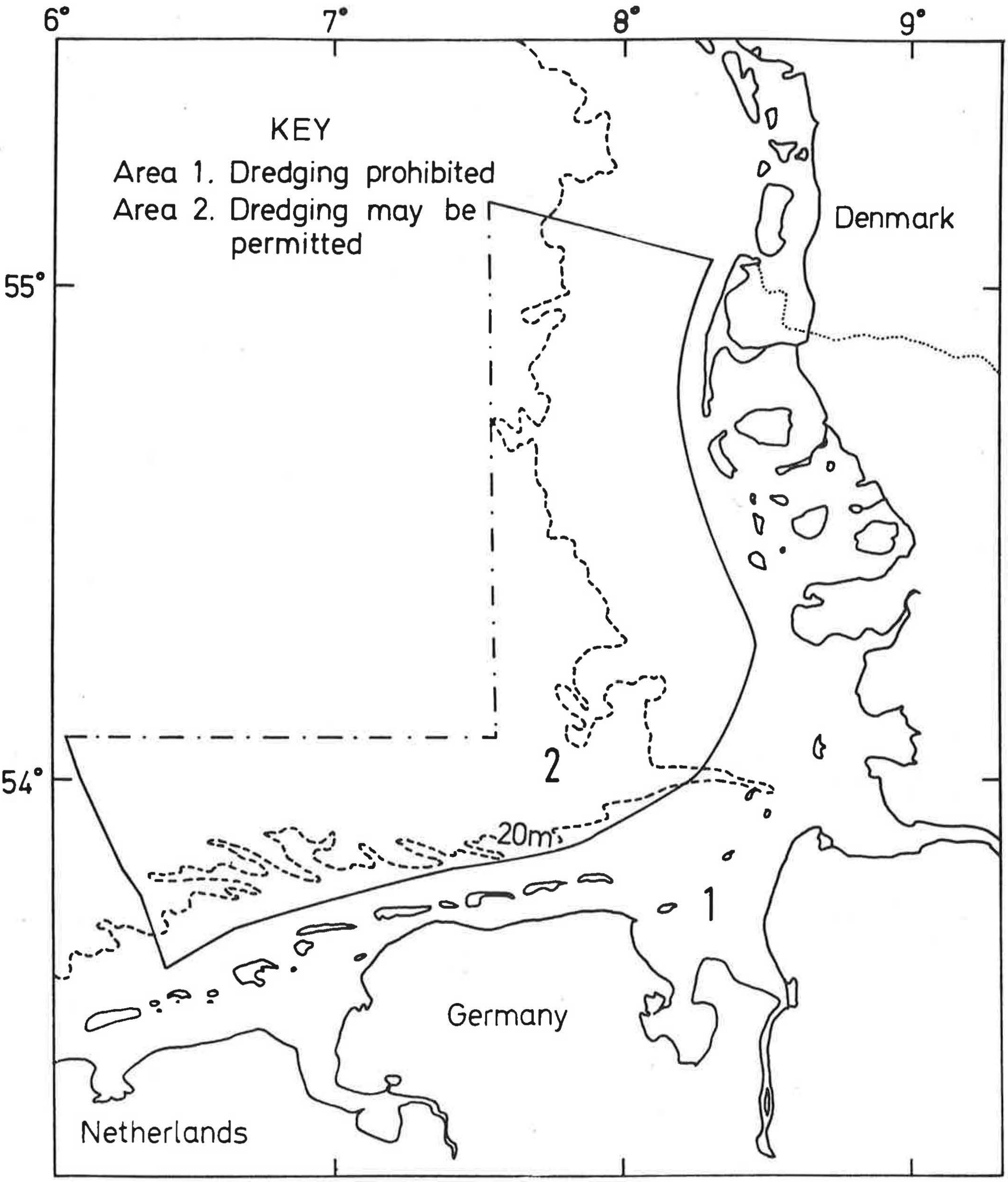


Figure 5. Prohibited dredging zones off the coast of Federal Republic of Germany.

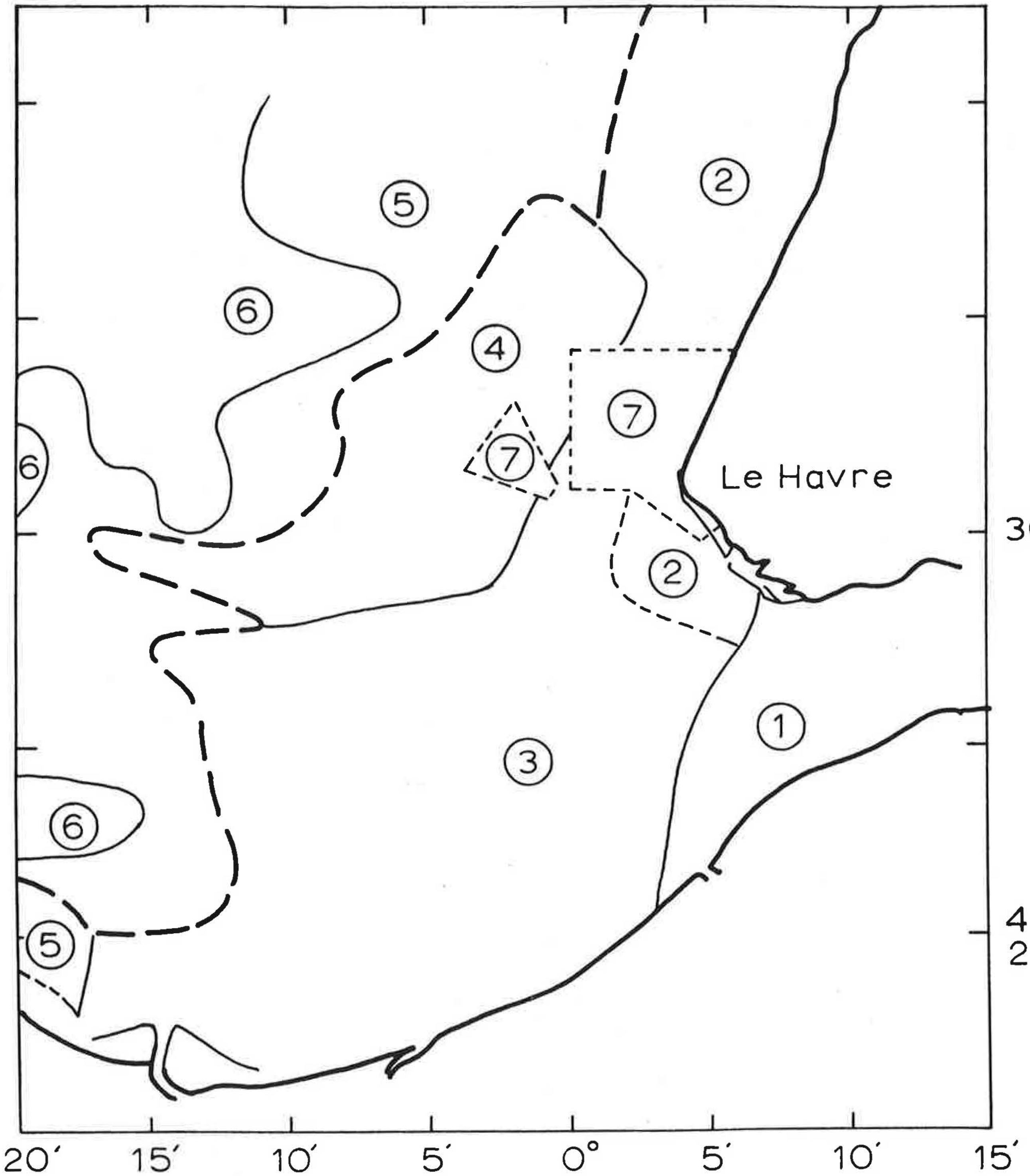


Figure 6. Benthic communities in the Baie de Seine.

1 Macoma baltica/mud
2 Abra alba/heterogeneous muds
3 Abra alba/fine muddy sand
4 Ophelia borealis/medium sand
5 Sessile epibenthos/sandy gravel
6 Ophiothrix
7 Prohibited zone

Region of less important biological interest: slight covering of sand

Biologically important region which must be protected

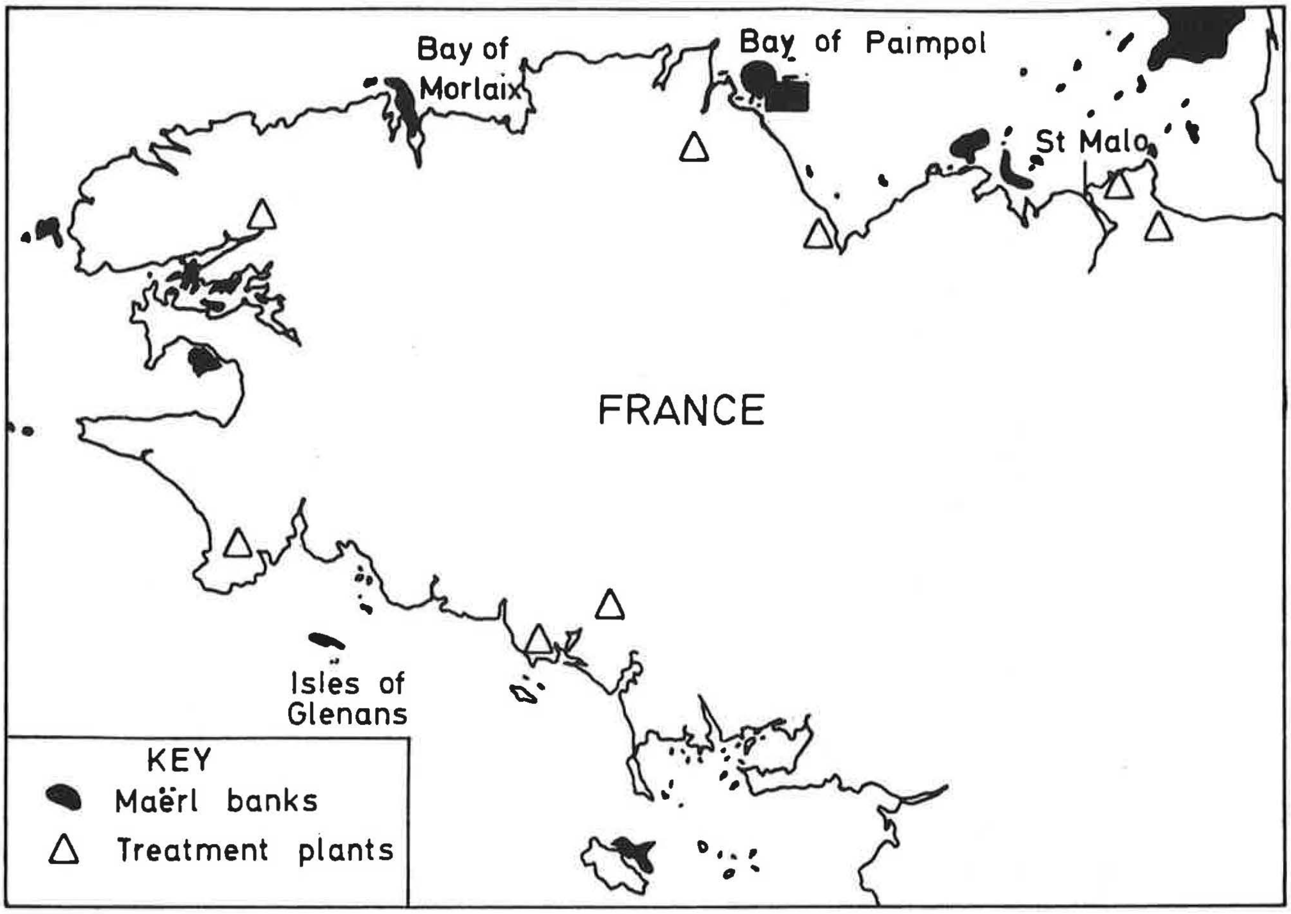


Figure 7. Distribution of maërl banks around the coast of Brittany, France (simplified from Gautier, 1971).

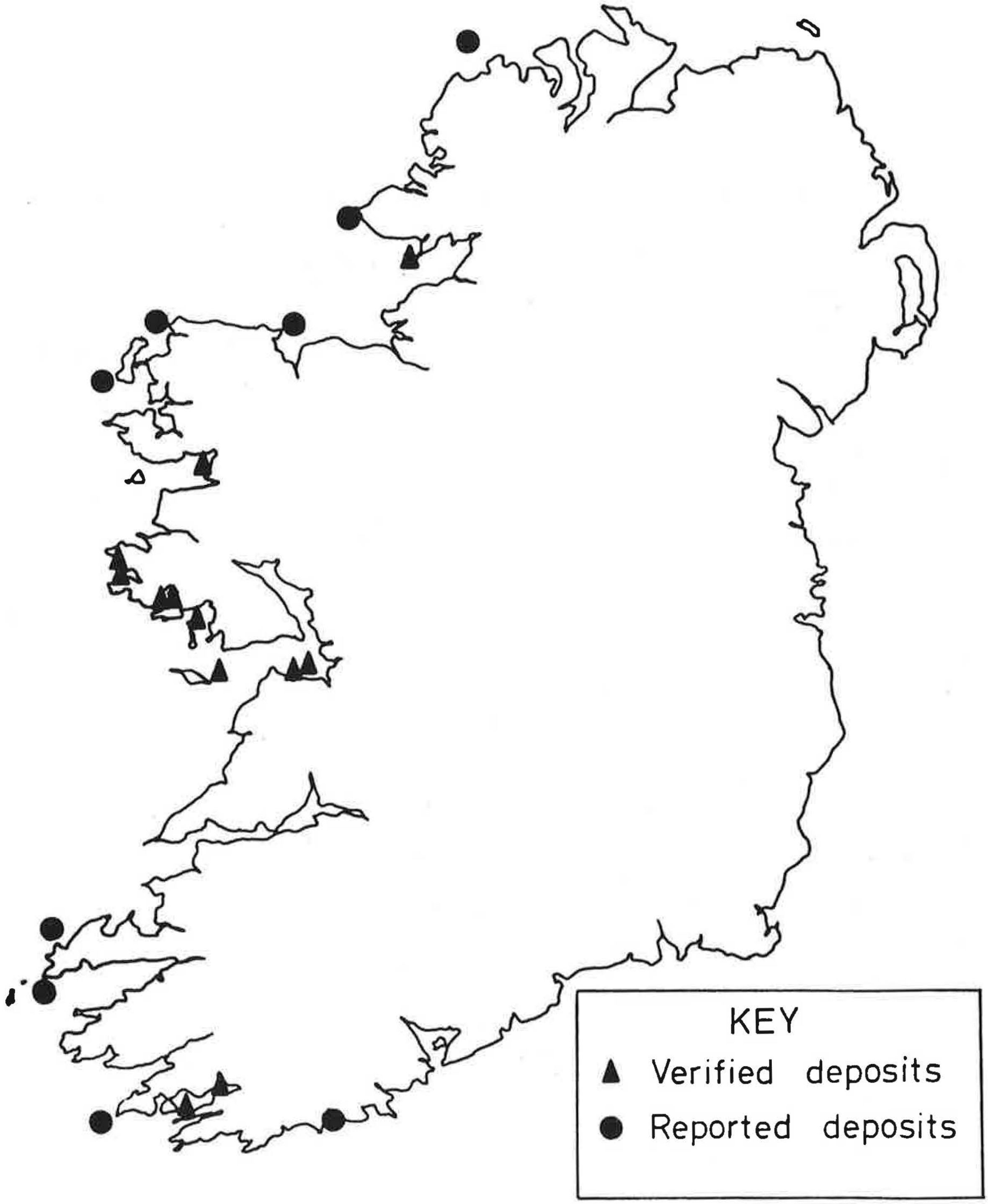


Figure 8. Distribution of maërl deposits around Ireland.

Indication of spine colours

Liaison Committee Reports	Red
Reports of Advisory Committee on Marine Pollution	Yellow
Fish Assessment Reports	Grey
Pollution Studies	Green
Others	Black