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Sea Fish Technology

BRITISH PETROLEUM DEVELOPMENT LIMITED

ARTIFICAL LOBSTER HABITATS - A REVIEW

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Consultancy Services Report No. 25 December, 1990
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CONTENTS

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Summary

This paper reviews current knowledge on lobster (Homarus sp) life cycle and habitats. The information is intended to assist in the planning of an artificial island in Poole Bay with a view to ensuring that the habitat would be suitable for lobster habitation.

In European lobsters, mating takes place after moulting. The eggs incubate for up to ten months on the female's abdomen after which young lobsters are released into the plankton. Knowledge of the planktonic and early juvenile stages of the young lobsters is sparse. Laboratory observations indicate that juvenile lobster's preferred habitat appears to be cohesive sediments in which there is a high level of suspended organic matter upon which they can feed and a number of boulders which provide surfaces against which they can burrow.

Adult lobsters are not normally migratory, tagged animals remaining within 1 - 2 nautical miles of their release point, although longer migrations have been reported. The adults inhabit crevices in rocks and under stones and boulders. Shelter is required for protection against predators particularly after moulting and the action of tidal and wave induced currents.

The location and abundance of the various size groups of lobsters in an adult lobster population is dependent upon shelter size; in areas of small shelters the modal size of the lobsters has been shown to be smaller. A relationship between adult lobsters size and shelter size is presented although it must be used with caution.

Suggestions are made in which may improve the artificial island's ability to support a lobster population. An array of cobbles (64 - 256mm diameter) and boulders (<256mm diameter) could be added around the outside of the island; exactly what mixture of boulders is required should be subject of further research and discussion.

Before the stocking of the island with juvenile lobsters is contemplated a survey of the artificial island should be undertaken to ascertain a suitable area for stocking, with the habitat requirements of young lobsters taken into account.

INTRODUCTION

This review provides information on lobster (*Homarus* sp) biology, and habitats. The intention is to give an overview of the current knowledge of lobster habitat requirements in order that an artificial island which is to be constructed in Poole bay for the purpose of oil extraction can be designed in a manner suitable for lobster habitation.

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1. Taxonomy

Two species of lobsters are discussed in this report. The European lobster (Homarus gammarus) which inhabits European waters and North American lobster (Homarus americanus). These two species are morphologically very similar, and some authorities believe that they are the same species (Ingle, pers comm). For the purposes of this report it has been assumed that there is no substantial difference in terms of habitat requirements. However if data from H. americanus are to be used then they should be treated with caution since it is H. gammarus which would have to be used in a lobster stocking programme in the U.K.

2. Life Cycle of Lobsters

The breeding of European lobsters (Homarus gammarus) is initiated after ecdysis, or shell casting, of the female. The timing of ecdysis varies between individuals and between different parts of the coast. On the south coast spring and summer are normal times but this can be influenced by water temperatures. The male lobster deposits sperm in pockets on the underside of the females immediately after ecdysis (Spence 1989). The eggs are then fertilised and remain on the underside of the female's abdomen for up to 10 months. Hatching takes place in response to rising water temperatures the summer after moulting. It has been observed that the current of water generated by the pleopods (swimming legs) of the female is important in maintaining the best possible conditions for incubation (Appellof 1909)

Knowledge of the early life of lobsters in their natural habitat is still relatively uncertain. Extensive searches by MAFF scientists failed to yield substantial field data (Howard and Bennett 1979). It is known that the animals are pelagic as larvae and undergo vertical migration until they metamorphose at stage IV. Stage IV is the first post larval stage and the lobsters, whilst resembling adults are semi benthic in habit. From stage V onwards the animals are considered truly benthic. These animals appear to live in burrows under small rocks or in small rock crevices for a number of years until they attain adult size (see section 4). In order that growth can take place the lobster has to shed its hard exoskeleton periodically, during the process known as ecdysis. This occurs frequently in young animals but it occurs annually or less frequently in larger animals, occurring at different times in different parts of the coast dependant on water temperatures. The adult lobster retreats into a hiding place before ecdysis. Ecdysis then occurs in the safety of the hiding place and the animals emerge once their shells have hardened sufficiently (Cobb and Phillips 1981). Adult lobsters inhabit crevices in rocks (section 4.2) or underneath rock outcrops and can grow up to 7.1 kg (16 lb.) in European waters. The closely related American lobster has been known to occur as specimens of up to 18.9kg (42.5 lb.) (Burgess 1981).

3. Migrations

A three year study in which 4,490 lobsters were tagged in French waters off Blanville sur Mer (adjacent to the Channel Islands) showed that there was very little movement of adult lobsters. The majority of the 294 lobsters returned were recaptured within 1-2 nautical miles of the location where they were tagged (Table 1) (Reveche 1981). American lobsters have been shown to migrate offshore during the winters (Hruby 1979) but this could be related to cold weather conditions encountered inshore during the winter. Some workers consider that this phenomenon occurs in U.K. waters (see Seafish Consultancy Report No. 20). The lobster cannot be described as a migratory species in the same sense as crabs are; once settled into an area they tend to stay within five miles. There have been examples of movements between sites in one locality (Burton pers. comm.) and of longer distance migrations but, judging by Reveche's (1981) work, longer distance migrations of more than ten miles are exceptional rather than normal behaviour, assuming that the mortality of lobster migrating ten or more miles is the same as those staying near to where they were released (Table 1).

Distance travelled by Lobsters (Nautical Miles)	Total	(%)	Numbers Male	Numbers Female
0 - 1	179	(61)	109	70
1 - 2	51	(17)	37	14
2 - 5	33	(11)	22	11
5 - 10	20	(7)	13	7
10 - 15	4	(1)	4	0
15 - 20	4	(1)	3	1
20 - 25	2	(0.7)	1	1
25 - 27	1	(0.3)	1	0
Total re-captured	294	(100)	190	104

Table 1.

Distance travelled by lobsters in a mark and recapture study off the French coast around Blanville sur Mer, Northern France. (Reveche 1981).

During this study 4490 lobsters were released over a three year period from 1977 - 1979.

4. Critical Factors Affecting Lobster Habitats

4.1. Juvenile Lobsters

4.1.1. Habitats and Food

Lobsters maybe regarded as "juvenile" when they are smaller than the size of maturity. This varies around the coast. Lobsters of less than 65mm carapace length are not found in commercial traps (Spence 1989) and may therefore be regarded as pre-recruits. Considerable diving effort has been put into trying to find these pre-recruits or "juvenile" lobsters in U.K. waters without finding statistically valid numbers (Howard and Bennett 1979).The juvenile of the American lobster has been found in "peat reef" habitats; these are areas of *Spartina alterniflora* "peat" which is soil which *Spartina* has been rooted and which have become separated from the marsh surface and fallen into adjacent sub-tidal marsh channels (Able et al 1988). *Spartina alterniflora* occurs in the U.K. although its distribution is limited to southern Britain where it is considered a pest in some areas. A "peat reef" type habitat exists in some areas, but it is not common. It seems likely that in the U.K. most of these "peat reefs" are inter-tidal rather than sub-tidal. Thus they would not be likely to form a suitable habitat for young lobsters which would require sublittoral conditions. The low salinity of the habitat would probably limit the usefulness of these conditions to young lobsters.

Knowledge of the juvenile stages is therefore limited to observations of laboratory reared individuals. Howard and Bennett (1979) offered young lobsters (Stage VII *Homarus gammarus*) a choice of substrates under constantly lit conditions and found that lobsters preferred either stones >7<20mm or unsieved mud conditions. When given a choice between stones and mud the young lobsters chose the stones under lighted conditions, but under dark conditions after 24 hours one third were still uncommitted, one third had chosen rocky conditions and one third had dug burrows in the mud. These burrows were quite complex, including shafts linked by lateral tunnels. There seemed to be a preference for burrowing alongside a hard surface, such as the glass walls of the tank. The lobsters could build these initial shafts within 8 hours and most had produced a complex burrow system within three days. Wickens (pers. comm.) suggests that a good environment for young lobsters would be a cohesive sediment such as muddy sand with hard surfaces against which they can burrow.

Studies on the behaviour of juvenile American lobsters on gravel substrate (Cobb 1971) indicated that a juvenile lobster's ability to move gravel is related to the animals size. Table 2 shows this relationship.

In longer term experiments by Barshaw and Bryant Rich (1988), American lobster (H. americanus) were kept in three substrates, eelgrass, mud and rocks in the laboratory. They found that the lobsters could survive and grow in any of these habitats.

There was no significant difference between the mean final weight of the animals in each habitat. However those kept in eel grass were slightly larger and survived significantly better. This was ascribed to improved food availability in this habitat. The authors observed very little time spent feeding in any of the habitats. The animals appeared to derive their nutrition by fanning their pleopods which was seen to create a water current through their burrows drawing plankton into the burrow.
The lobster stood with its clawed limbs held up and apart with is mouth parts working rapidly occasionally jerking forward and snapping its claws. The authors concluded that the young lobsters were able to filter feed and that most of their nutrition maybe derived from this source.
Feeding using the animal's claws only occurred when an edible object landed close enough to the burrow so that the lobster could reach it without entirely leaving its burrow. It is therefore essential that the area which young lobsters are released into contains a sufficient quantity of organic matter for the young lobsters. Thus areas of muddy sand with a mature bacterial flora and containing hard surfaces against which they can burrow are required.

4.1.2 Predation

Apart from observations of cannibalism amongst the young lobsters (Appellof 1909) there does not appear to have been any systematic study of the predators on the juvenile lobsters. Their normal habit of remaining hidden or buried suggests that they are very vulnerable to all types of predation. Burton (pers comm) has observed predation by velvet crabs, green crabs, gobies, wrasse, codling,

Carapace Length (mm)	Digging Ability Gravel size (mm diameter)
15	3.7 - 11.2 able to dig
	11.2 - 31.5 unable to dig
80	11.2 - 31.5 able to dig
	31.5 - 63.6 unable to dig

Table 2 Size of lobsters/ability to dig gravel of specified sizes.

squat lobsters, saithe, butterfish (frequently), on released juvenile lobsters. In the plankton there would be expected to be many more predators taking the larvae.

4.2. Adult Lobsters

4.2.1. General

Adult lobsters live in rock crevices and under stones and boulders. The size, accessibility and number of shelters are important factors which determine the composition and size of the population of lobsters. Intuitivly, shelters are required by lobsters primarily as shelter from predation, and for shelter from wave and tide induced currents. Lobsters would be expected to require a certain amount of territory; the size of territory required may be related to lobster size but remains undetermined. Some unpublished work carried out in Scotland by the SMBA (see Seafish Consultancy Report No. 20) suggested that lobsters can live at densities of 0.5-1 lobster per linear meter along a crack system. Another feature which maybe important is the presence or absence of macro algae.
Although macro algae may provide cover for lobsters moving around on rock surfaces, very thick growths, may inhibit adult lobster movement (Wickens pers. comm.).

These factors, together with food supply, appear to be important in determining the distribution of adult lobsters.

4.2.2. Shelter Size

Early experiments in lobster habitat enhancement were carried out in Canada (Scarratt 1968) using terracotta drainage tiles. However it was found that these tiles were only occupied by animals of a uniform size. Studies by Cobb (1971) showed a statistical relationship between lobster (H. americanus) size and shelter dimensions.
Larger lobsters were found in larger shelters. Table 3 shows the shelter dimensions requirements for a range of lobster sizes derived from Cobb's equations. Some caution should be exercised when using these results since the observations were on North American lobsters and relate to a sample of 46 lobsters whose length range was not stated.
In a further study Scarratt (1968) used flat blocks of up to 15cm thick and 5-100cm in diameter dumped onto a flat seabed. The size range of American lobsters found on this

Carapace Length	Shelter Height mm	Dimensions Width mm	Area of Opening mm	Length of opening mm
36	18	40	2,022	213
85	130	205	32400	416
170	300	472	168,100	769

Table 3 Shelter size requirements as derived from Cobb (1971).

This data was derived from measurements of 46 lobsters which were removed from their shelters.

The lobsters and the shelters were measured and equations were derived relating lobster size to the size of their shelters. The correlation coefficents were as follows:

$\sqrt{\text{Area}}$ = 0.71
Height = 0.66
Width = 0.66
Depth = 0.40

reef was 41-153cm carapace length. Jensen (pers comm) states that European lobsters have successfully colonised artificial reefs consisting of blocks 40cm x 20cm x 20cm. Whether crevice sizes should be mixed or in separate areas should be considered. Lobsters are cannibalistic and larger lobsters dominate small lobsters (Lawton 1987). Thus keeping the size groups separate by separating shelter sizes could perhaps reduce intra specific competition. However it would be equally feasible to mix the size ranges, since large lobsters cannot follow small lobsters into a small crack. A small lobster confronted with a large lobster in an area of mixed shelters would not have as far to go to safety as one confronted with a large lobster in a "large shelter" area.

Other features of lobster shelters are important. Shelters with oblong shaped openings with the long axis parallel with the floor of the tank were preferred to square openings of the same area (Cobb 1971). Reveche (1979) suggested that lobsters prefer shelters with another, smaller exit other than the main exit and shows diagrams of suggested layouts for lobster shelters for different sized lobsters. (Figure 1). Observations of lobster burrows (Burton pers comm.) indicates that they usually have more than one exit.

Studies of two lobster fisheries, off Norfolk and Whitby respectively, suggested that current speed and boulder size are factors limiting the size of individuals in lobster populations. The area off the Norfolk coast contained lobsters of a 60-70mm carapace length modal size and small boulders and outcrops with dimensions of less than 5cm x 5cm x 5cm. Off Whitby larger outcrops greater than 50cm x 50cm x 50cm were found, and the modal size of the lobsters was also larger at 90mm carapace length. The author (Howard 1979) suggests that the larger lobsters were unable to live in the area of Norfolk because the relatively small boulders there provided inadequate shelter from the tidal currents. In contrast the area off Whitby had larger boulders and hence larger areas sheltered from the tidal currents.

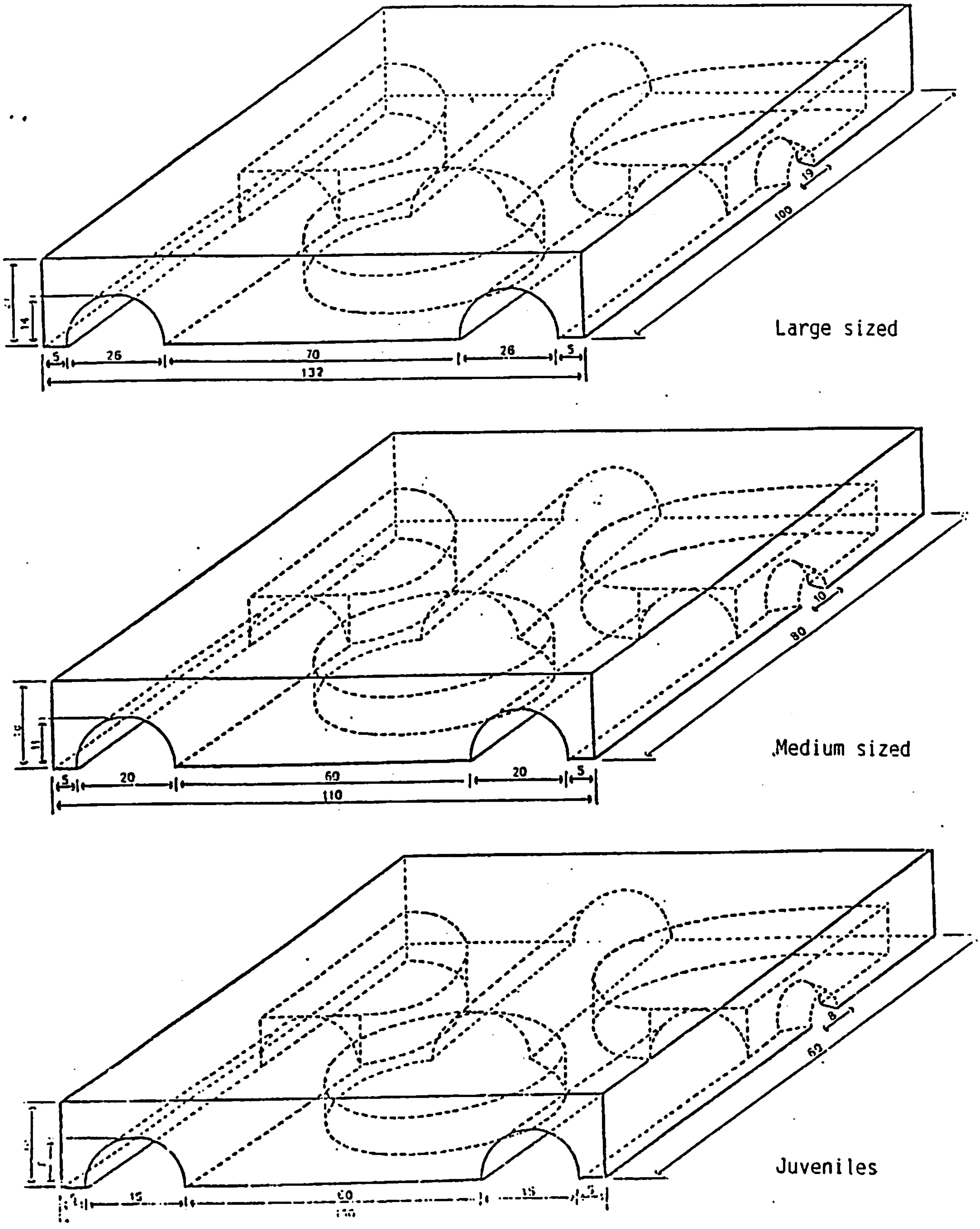

Figure 1 Artificial habitats for Lobsters (Reveche 1981)

Dimension in cm

Flume experiments (Howard and Nummy 1983) showed that juvenile lobsters (12 - 25mm carapace length) were able to shelter behind a block 22 x 21 x 13mm high in current speeds of 0.55m/second whilst adults were unable to do so. It was also found that seabed current speeds exceeding 0.25m/sec inhibited lobster mobility on the open seabed.

Shelton (1981) observed that lobsters tend to prefer the lee sides of pinnacles and Spence (1989) notes that catches maybe improved if pots are shot on the side of the reef which is the downstream side of the reef during darkness, the lobsters' most active period. This suggests that lobster behaviour is influenced by current velocities, but their distribution is limited by shelter size.

It appears that the location of the various size groups in a lobster population would be expected to depend upon the shelter size. Lobsters would be expected to outgrow their shelters as they got bigger and search, during slack water, for larger shelters

4.2.3. Food Supply

The relationship between samples of the stomach contents of lobsters and their diet is difficult to establish. The results are likely to be distorted owing to the way in which lobsters fragment and selectively ingest their prey (Elner and Campbell 1987). The fragments found in lobsters' stomachs are usually indigestible skeletal elements, which may be over represented relative to other elements of the diet. Mussels were invariably the most important identified prey of American lobsters studied by Elner and Campbell (1987). However other taxonomic groups are also important including echinoderms, polycheates, crustacea (including lobsters), and a significant quantity of macro algae. In comparing two habitats; a comparatively barren zone, and an area with a diverse fauna including macroalgae covered zones, the above authors found remarkable consistency in the diets of the lobsters inhabiting the two zones.

4.2.4. Predation and Competition

Lobsters are more active during the hours of darkness (Lawton 1987, Spence 1989). This may ensure that they are not detected by their prey, it would also prevent them from being detected by predators.

Conger eels and seals are considered to be the main predators of mature or fishery sized lobsters other than man, but octopii which are able to kill and suck out the flesh of lobsters and codling are also named as predators (Spence 1989). It would be expected that adult lobsters are at their most vulnerable after moulting when the exoskeleton is soft.

Lobsters' closest potential competitors would appear to be crabs. Studies do not appear to have been done in U.K. waters. However studies in America by Hudon and Lamarche (1989) and Richards and Cobb (1986) studied interactions between *H. americanus*, *Cancer irroratus* and *Cancer borealis* in North American waters. They found that lobsters of greater than 36mm carapace length could competitively exclude *Cancer borealis* of all sizes up to 158mm carapace width from shelter. The requirement for shelter was considered to be of more importance to lobsters than to crabs which were capable of digging holes in soft substrata. Diet in lobsters and *Cancer irroratus* was also found to be sufficiently different to avoid competition between the species. (Hudon and Lamarche 1988). Investigations of underwater cliff habitats in Lough Hyne, Southern Ireland by Turner and Warman (1990) showed that a variety of organisms could "time share" crevices in a habitat. Organisms moved in and out of the crevices according to the time of day. However lobster holes were rarely shared by other crustacea, even when left vacant, possibly because the return of a lobster to its hole is unpredictable.

5. Natural Disasters

Spence (1989) describes an occasion in early 1986 when a prolonged cold spell in the south east of Scotland and Northumberland caused snow to fall on the high ground inland resulting in a large fresh water discharge into the sea from the rivers in the area when the snow melted. Subsequently during late May and June divers found large numbers of dead lobsters in the area of the Farne Islands.

The animals were examined but, not being found diseased, several factors could have been responsible for this phenomenon. The cold temperatures would have resulted in the animals being less active and so not have emerged to feed; the animals might have starved to death.
Alternatively the reduced salinity could have affected the lobsters osmotically. Without temperature and salinity data it is difficult to be certain of the cause.

6. Effect of Drilling Muds Upon Survival of Lobsters

This review of the literature appertaining to lobster habitats did not include a review, *per se* of pollution.
However one paper on the effects of drilling muds on the settlement and burrow building of post larval lobsters (stages IV and V) was found in the course of the review and may be important. These results (Atema *et at* 1982), showed that 36 day exposure of post larval lobsters to 7mg/litre of drilling mud in aquaria and to a 1mm layers of drilling mud covering the substrate resulted in toxic effects including delays in moulting and in shelter construction, increased walking and swimming, unprovoked tail flipping, and lethargy. Natural mud used as a control had no such effects. Adult lobsters were severely affected by acute exposure to drilling muds; exposure resulted in death, although it is difficult to quantify from these experiments the exact level of exposure.

The drilling muds used were taken from rigs already operating; thus they had an unquantified composition. It seems clear that steps would have to be taken to avoid contact between the lobster growing area and drilling muds.

7. Discussion

7.1 Juveniles

Considerable uncertainty still exists on the natural distribution of young lobsters. Currently during re-stocking exercises young lobster are released amongst areas of mixed rocky substrates. The best method for allowing sufficient space for young lobsters is to construct the island with a mixed size range of cobbles and boulders around a central core. This may provide adequate small shelters amongst the smaller stones, particularly where the basic substrate is organic rich muddy sand. Searching for *Spartina* "peat reefs" in Poole harbour or surrounding areas may not be considered worthwhile.

7.2 Adult Lobsters

There appears to be a relationship between shelter size and lobster size. When designing the surface of the artificial island it would be worthwhile taking this factor into account. It seems likely that a random array of different sized crevices from those small enough for post larval lobsters to larger shelters for very large lobsters would be appropriate. Table 3 may be used as a guide. This could be achieved by adding a thick layer of cobbles and boulders, around the inner core. Cobbles are defined on the Wentworth scale of sediment classification as being of between 64 and 256mm diameter whilst boulders are larger than 256mm diameter. The slope of the sides of the artificial island is also of importance because it affects the lobsters ability to gain access to the crevices. If it is too steep the lobsters cannot climb up to the shelters (Turner perscom). The exact composition of this layer is best decided upon by observations of a range of lobster habitats. As an alternative scenario sizes of boulders might be varied around the perimeter of the island. The effects of such differences could be monitored. This might help give an insight into colonisation of artificial reefs by lobsters.

The most important recommendation is that there should be some form of boulder cover surrounding the internal core.

7.3 Food Supply

This appears to be more crucial to young lobsters which can filter feed than to larger lobsters which appear to be able to find food even in so called barren habitats (Elner and Campbell 1987). It is unlikely that any attempt at artificial enhancement of food supply of the juvenile lobster in the wild would be successful because of their filter feeding habit. However their survival might be best optimised by finding an environment in which there is likely to be plenty of particulate organic matter. Thus if stocking of the reef with juvenile lobsters were contemplated it seems essential to allow the sediments around the reef to settle and the bacterial flora on them to mature after the island has been constructed. A survey of sediment type, including investigation of cohesiveness and organic matter content could then be undertaken to establish suitable areas for release of young lobsters.

Since adult lobsters feed on bivalves, particularly mussels, it might be considered feasible to encourage mussels to grow on areas of the reef. There does not appear to be a local settlement of mussels (Seafish Consultancy Report No. 20) so seed would have to be brought in from outside. Bringing in mussels may alter the ecology of the area. However introducing mussels and monitoring their effects in localised areas of the reef may given an insight into the development of the benthic community structure.

7.4 Environmental Hazards

It appears that lobster can suffer mortalities after sustained periods of low temperatures and/or salinity. However the environment where this phenomenon has been reported (off Northumberland) is different from the Poole bay habitat; Poole bay is further south, and the surrounding area is not mountainous thereby reducing the possibility of large amounts of snow melt waters which was considered critical in the above incident (section 5).

Disease is not a problem in U.K. lobsters provided that the bacterial disease gaffkaemia (Aerococcus viridens) is not imported from America (Spence 1989).

Since the island is to be used for oil extraction, consideration should be given to the effects of discharges from this activity. Whilst a comprehensive survey on the effects of such discharge was not carried out one paper was found which shows the sensitivity of lobsters to drilling muds. Steps should therefore be taken to minimise the likelihood of such discharges.

8. Recommendations

The principle recommendations of this review are:

8.1 Structure of the Reef

The substrate should allow sufficient space for colonisation by lobsters of all size groups. This could be achieved by surrounding the internal core with a mixture of cobble and boulders in order to provide a diverse range of cracks and crevices.

8.2 Stocking with Juvenile Lobsters

The sediments around the reef should be allowed to settle and a bacterial flora allowed to mature before the stocking of the island with juvenile lobsters is contemplated. A survey should be carried out in order to establish which area of the reef would be most suitable in terms of organic matter content and crevice availability.

8.3 Precaution with Drilling Muds

Drilling muds are highly toxic to lobsters. All precautions should be taken to prevent contamination of the habitat.

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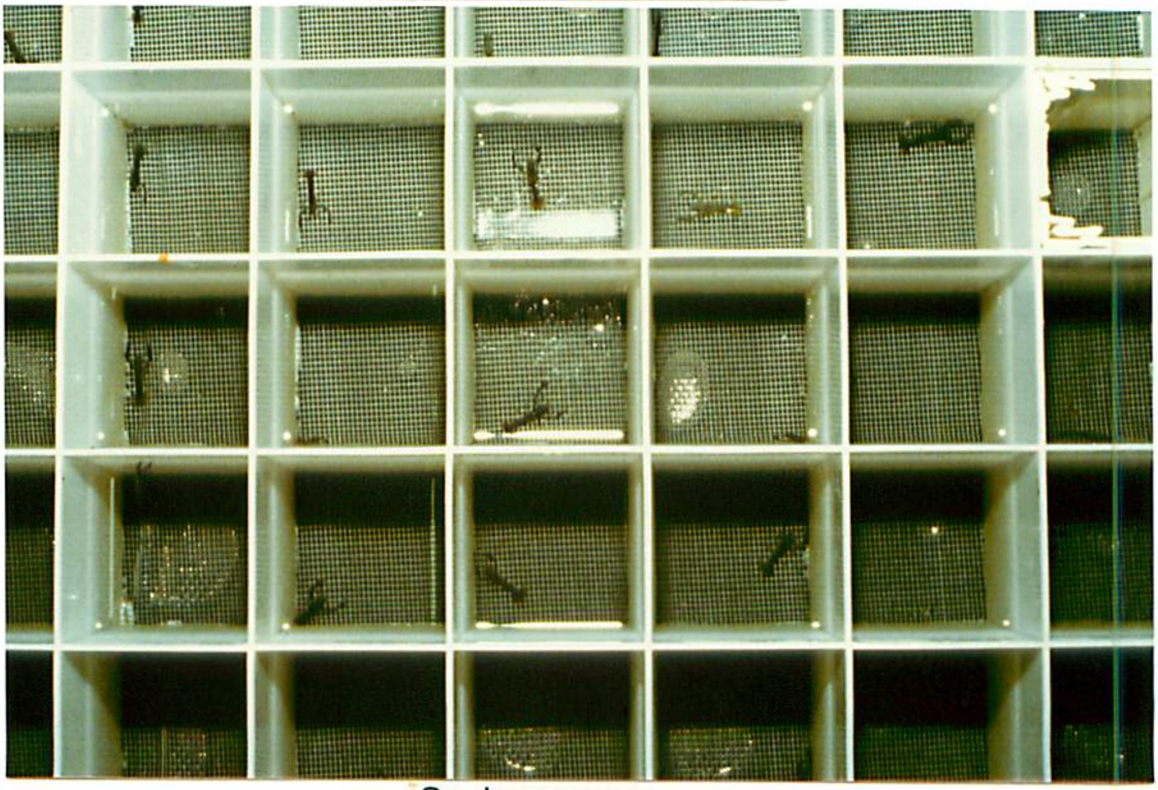
Appendix
Photographs of Lobsters



Scale: 50 mm

Scale: 50 mm

Juvenile Lobsters reared at Seafish, Ardtoe.

Adult Lobster.
Scale: 88 mm