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CUMULATIVE EFFECTS OF MARINE AGGREGATE EXTRACTION IN AN AREA EAST OF THE ISLE OF WIGHT - A FISHING INDUSTRY PERSPECTIVE

K.M. Cooper

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ABSTRACT

The purpose of this study was to document the nature and distribution of local fisheries and associated effort, and to report the views of the fishing industry in relation to perceived impacts of aggregate dredging on their activities. As such this study does not to seek to address questions over the relative impacts of the two industries, merely to provide a perspective from those engaged in fishing in the area, so as to contribute to informed debate and the sustainable use of resources. Relevant information was obtained by interviewing a representative sample of local fishermen, with experience deploying gear in the vicinity of areas of aggregate extraction. This was accompanied by a review of published information, discussions with the Sea Fisheries Inspectorate, Sea Fisheries Committees and CEFAS fisheries scientists. The findings were examined in relation to the known extent of dredging operations in recent years, determined through an analysis of Electronic Monitoring System (EMS) data.

Results indicate a general avoidance of licensed areas by static gear fishermen due to the potential for gear damage. This area avoidance has the effect of increasing fishing pressure in alternative grounds remote from dredging and has led to increasing concerns amongst fishermen over the sustainability of already heavily exploited stocks in these areas. A further issue highlighted by this study concerns vessel safety in relation to the increased distances offshore that some of these relatively small vessels (<14 m) are working and this was attributed by fishermen to be a direct consequence of displacement from extraction areas. Declines in brown crab *(Cancer pagurus)* stocks were also reported by interviewed fishermen to the south of the Isle of Wight and possible factors which may explain this observation are discussed, including over-fishing and the potential interference of dredging operations in the movement of crab populations into fishing grounds.

The study also identified previously fished areas that are now avoided by trawlers due to perceived changes in the nature of the seabed. The hydrographic conditions in the area suggest that these features (e.g. dredged tracks and depressions) may persist for several years. The potential loss of grounds for trawl fisheries may also result in the displacement of vessels into other areas leading to conflicts with other gear types. Finally, this study identified charter angling grounds in which anglers have observed significant declines in catches of smooth hound (*Mustelus mustelus*). A large proportion (75%) of this area was dredged in 2001 and therefore dredging cannot be ruled out as a causative factor.

It is recommended that, in order to ensure the sustainability of local fishing interests, consideration is given to potential repercussions resulting from the exclusion of fishermen from certain areas. A suggested approach to help with these assessments is through the use of a Geographic Information System (GIS) which can be used to map fishery and fishery resource areas, allowing for a more quantitative assessment of the potential impacts from future dredging licences and other human activities.

1. INTRODUCTION

Fisheries management aims to ensure the sustainable exploitation of stocks. However, in addition to fishing pressure, other factors have the potential to affect the sustainability of fisheries, on various spatial scales. One such concern is that of marine aggregate dredging, an activity which has expanded in recent years as a result of the increasing demands of the construction industry and the tightening of legislation governing the use of land-based resources (Lart, 1991).

Marine aggregate extraction activities are known to impact the marine environment in a variety of ways, some of which have the potential to affect fisheries. These impacts include: restriction of access to fishing grounds; local destruction or damage to benthic organisms as a direct result of the passage of the drag-head (Lees *et al*., 1992), and the potential for wider area effects due to the re-distribution of finer material. Dredging may also, in time, alter the physical characteristics of sediments and the seabed (Millner *et al*., 1977 and Dickson and Lee, 1973), with potential longer-term consequences for dependent benthic organisms (Boyd *et al*., 2003; Boyd *et al*., 2005), including fish/shellfish populations. As a result, marine aggregate extraction activities have been a cause of concern to the fishing industry, although separating perception from reality can be problematic, as in many other coastal issues involving the potential for conflict between overlapping commercial interests. (See, for example, Fishing News, 1991, 1992, 2000, 2001a, 2001b, 2001c, 2001d, 2001e, 2001f; BBC Wildlife, 1999, as expressions of the high public and political profile of this issue).

The fishing industry has expressed particular concern over the potential for cumulative effects in areas where there are local concentrations of marine aggregate extraction licences. The impacts from one licence may be minor but, when added to the effects of other nearby licences or other man-made activities, they may be more severe.

As part of the current licensing process in UK waters, Environmental Statements are prepared in order to identify potential impacts from proposed extraction activities, and to evaluate their acceptability. In order to assess potential impacts on local fisheries, information is often gleaned from interviewing local fishermen, as reliable quantitative information is commonly not available on the localised scales that are associated with licence applications. This source of information has proved valuable, particularly when

observations can be corroborated by available scientific information (Neis *et al*., 1999). In order to objectively address the concerns of fishermen, it is necessary to have a proper understanding of the extent of both fishing and the impact of dredging operations. The former may be established from a variety of sources (see below) although the outcome is often relatively inconclusive. In contrast, the latter may be precisely determined (at least in recent years) through Electronic Monitoring System (EMS) data, which provide information on the location and intensity of dredging over time.

This study examines an area to the east of the Isle of Wight (Figure 1) where there are a number of dredging licences which coincide with various fishery interests. The aims of the study are to:

1. Identify the location of fishing activity.
2. Identify issues of concern in relation to marine aggregate extraction through interviews with fishermen.
3. Determine the spatial and temporal extent of dredging operations on the seabed using annual Electronic Monitoring System (EMS) data.
4. Assess the relationships between 1-3, above.
5. Draw conclusions regarding the presence and significance of any (cumulative) impacts of aggregate dredging on local fisheries.

Inter-relationships between aims 1-3 were addressed through combining the outcome of interviews with a representative selection of local fishermen, with existing information on the distribution of commercial species, other relevant historical information and patterns in the exploitation of the marine aggregate resource. The limited resources available for the conduct of the investigation determined that it could not be comprehensive. Thus, for example, it is recognised that attempts to better quantify historical trends in local catches (insofar as information of sufficient accuracy exists), or to initiate log-book schemes for evaluating current performance may, in future, usefully augment the findings of the present study.

2. METHODS

2.1 Location of fishing effort and concerns of fishermen

The location of fishing activity in this area has been investigated, at different times, by various authors (For example, Plumb, 1996; EMU 1998, 1999a, 1999b; METOC, 1997). However, the results of these investigations cannot be taken to be representative of the current situation and hence it was necessary to obtain up-to-date information. The main species targeted and the commercial and charter fishing interests were identified by reference to the literature (Pawson, 1995; Gray, 1995), Defra landing statistics and advice from the local officers of the Sea Fisheries Inspectorate and Sea Fisheries Committees. Within the area of study, there are a very large number of fishermen, many of whom are part time. It was therefore necessary to identify key fishermen from each port and fishery to obtain representative coverage.

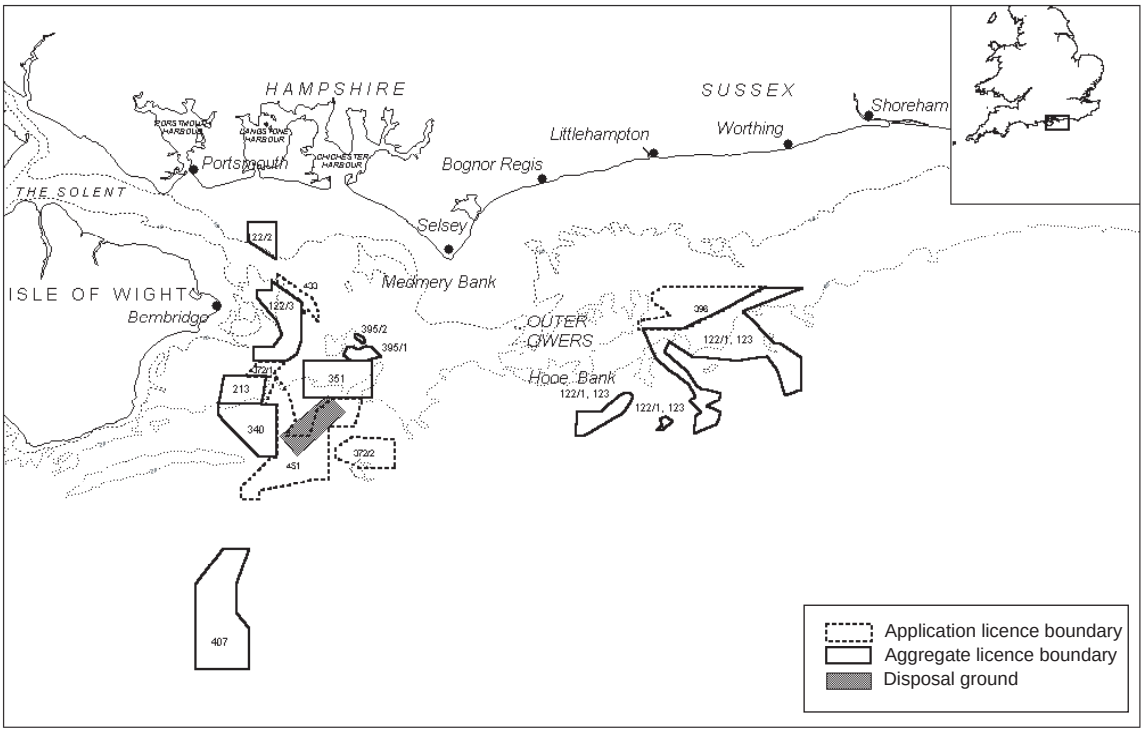

Figure 1. Study area and location of current and proposed marine aggregate extraction licences

Interviews were conducted between 7th September and 21st December 2001. Fishermen were invited to give an overview of their activities, including the location, extent and success of fishing operations. They were also invited to offer their views on any relationship between their activities and those of the aggregate extraction industry in the locality. Where possible, individuals were interviewed separately and have not been identified by name, at their request, in order to respect confidentiality. The precise location of certain individual's fishing grounds have also not been identified for reasons of confidentiality. Therefore, maps of fishing grounds shown in Figures 2-8 may comprise contributions from a number of individuals.

2.2 Extent of dredging activity

The extent of the direct impact of dredging activity on the seabed was determined using Electronic Monitoring System (EMS) data collated by the Crown Estate. Maps were prepared from these data for the period 1993-2001 in order to identify the location and intensity of dredging in individual years. These were imported into MAPINFO™, a Geographic Information System (GIS) package. Data from individual years were also combined to produce maps showing the cumulative extent of dredging in the region to the east of the Isle of Wight, since 1993.

2.3 Evaluation of fishery concerns using EMS data

Maps showing the extent of dredging operations were used to calculate the area of seabed potentially affected by dredging and to estimate the overlap between dredging and fishing activity.

3. RESULTS

These are presented by port. Each account is then divided into a 'fleet summary', which attempts to provide an overview of the different fisheries and the number of boats involved, followed by the results of interviews with individuals from each of the fisheries. The main effort was directed at individuals fishing either within or in close proximity to marine aggregate extraction areas. At ports where it was considered that fishermen were unlikely to fish in or around the extraction areas, no interviews were conducted.

3.1 Location of fishing effort and concerns of fishermen

3.1.1 Bembridge

Fleet Summary

Most of the vessels fishing from Bembridge are dedicated potters targeting brown crab (*Cancer pagurus*) and lobster (*Hommarus gammarus*). Presently, one vessel also mainly uses set nets to target various seasonally abundant species including dover sole (*Solea solea*), plaice (*Pleuronectes platessa*), brill (*Scopthalamus rhombus*) turbot (*Psetta maxima*) and bass (*Dicentrarchus labrax*). Local fishermen report that the number of full-time vessels fishing from Bembridge has fallen from thirteen to six in the last ten years, a decline which they attribute to the general decline in the brown crab stock. Interviews were conducted with seven potters (six based in Bembridge and one from Ventnor) and one netter (also based in Bembridge).

Potters

The main potting grounds used by Bembridge vessels are to the south of the Isle of Wight and are subdivided, with individual fishermen occupying a specific area (see Figure 2). Pots are laid across the tide in a north-south direction and a ¼ mile is left between strings to prevent entanglement. This arrangement is agreed between the fishermen from this port and ensures an equitable distribution across the grounds. The arrangement is also important for vessel safety as it reduces the risk of pot strings set by different vessels becoming tangled. This is of particular concern to local fishermen as vessels of different sizes are able to set different length strings. The majority of these fishermen work alone and are therefore keen to avoid dangerous situations as far as possible. However, instances have arisen where strings have become tangled, particularly at the eastern end of the grounds where a larger vessel from the mainland has moved into this area, reportedly as a result of losing grounds within the cluster of marine aggregate extraction licences. The arrival of this individual has also had the inevitable effect of decreasing the space available for the fishing activities of others.

Bembridge potters have expressed concern over what they view as a 'massive decline' of the crab fishery in the area. This decline is held responsible for a number of boats leaving the fishery in recent years. Despite the decline, fishermen report that the total number of pots deployed now is greater than that deployed historically. Fishermen explained that the increase in the quantity of pots used by individuals is due to the decline in catches of brown crab. For example, one interviewee suggested that a good haul used to yield around 150 kg of brown crab from 50 pots, whereas currently hauls are more likely to yield 50 kg from 200 pots. Fishermen have also noticed a decline in the lobster fishery which they consider an effect of overfishing. However, they were also of the opinion that this was not the cause of the decline in the crab fishery. The consensus amongst fishermen is that the numbers of crab moving into their grounds from the east has 'drastically declined'. They have also noticed a decline in the number of juvenile crabs. Their concern is that dredging to the east may be affecting their crab fishery. Additionally, it is considered that the food source (benthic organisms) is being removed from the shingle upon which hen crabs are found, as a direct result of dredging in the licensed areas.

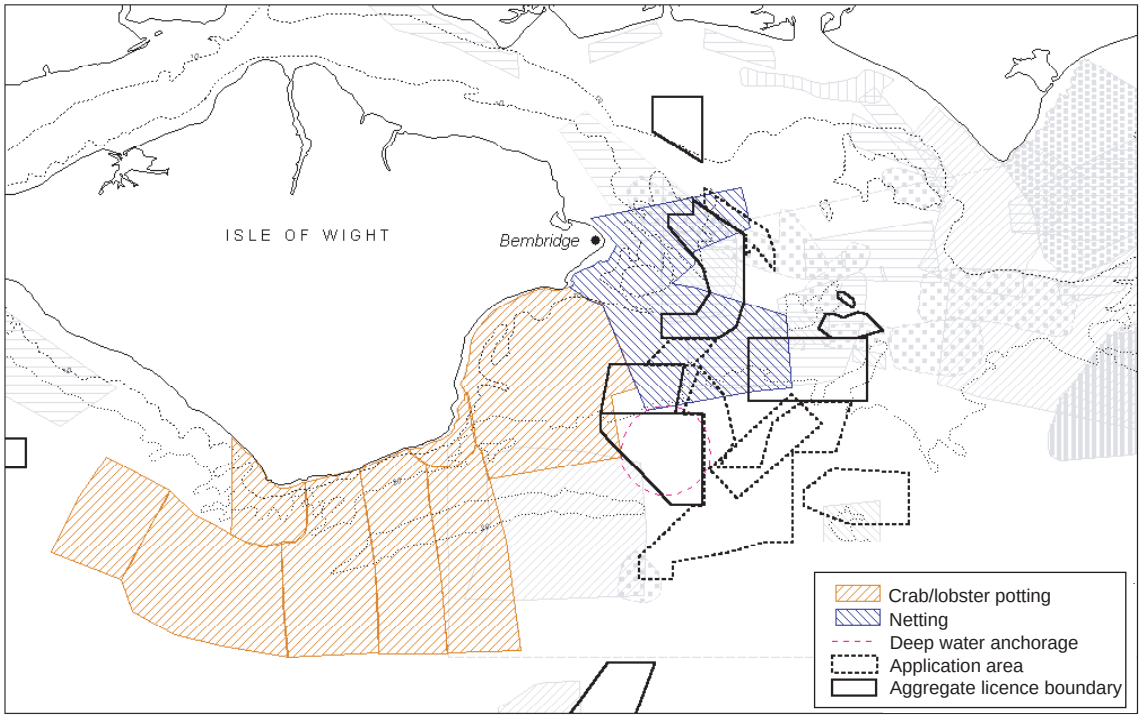

Figure 2. Location of fishing effort, using different types of gear, for vessels fishing from Bembridge in 2001 in relation to the boundaries of current and proposed dredging licences. The map also shows the location of effort from other ports (shaded grey)

Netters

Potting accounts for most of the fishing effort from Bembridge. However, a set net fishery is also exploited by one individual in pursuit of a variety of species. The main grounds are shown in Figure 2, to the east of Bembridge. Some of this area overlaps with a number of extraction licences. Nets are set with the tide and species targeted include sole, plaice, brill, turbot and bass. This individual reported that the one hour notice given prior to the commencement of dredging operations commencing did not give sufficient time to allow nets to be moved out of an extraction site. For this reason, nets are unlikely to be set in areas known to be actively dredged, based on previous experience.

3.1.2 Portsmouth/Gosport

Fleet Summary

Portsmouth Harbour is home to an inshore fleet of around 30 boats of length 6-12 m. Vessels use a variety of fishing methods including trawling, netting, long-lining, dredging (for oysters, *Ostrea edulis*), potting for whelks (4 vessels), potting for lobster and crab (1 full-time) and rod and line fishing (charter and one commercial bass angler). Some vessels from Portsmouth will also target the scallop (*Pecten maximus*) fishery located in the vicinity of the Owers Bank (see Figure 8). Many of the vessels are capable of using a variety of gears and may switch according to local abundance and market prices. There has been a trend for an increase in the number of <10 m vessels and a fall in the number of >10 m vessels. Interviews were carried out with a commercial bass angler, two trawler fishermen and four netters.

Trawler (<10 m)

One individual trawler employs mainly stern and beam trawls, but will also deploy nets, long-lines and whelk pots. He reported that traditional trawling grounds have been damaged or lost in a number of areas, both as a result of aggregate extraction and other activities. A number of examples were given including the creation of a sewage outfall discharging to the main channel to the east of Portsmouth Harbour (see Figure 3). This he considers to have resulted in damage to an area of mussel bed, a habitat that is viewed to be responsible for the abundance of plaice which previously frequented this area. He has also damaged fishing gear in areas where there had previously been good tows within the boundaries of aggregate extraction licences. Damage has resulted from the cod end filling with large cobbles and the skipper attributes this to exposure and then rejection of oversized material by the draghead of dredgers. As a result of such experiences, this individual believes that many trawler fishermen avoid fishing within marine aggregate extraction areas.

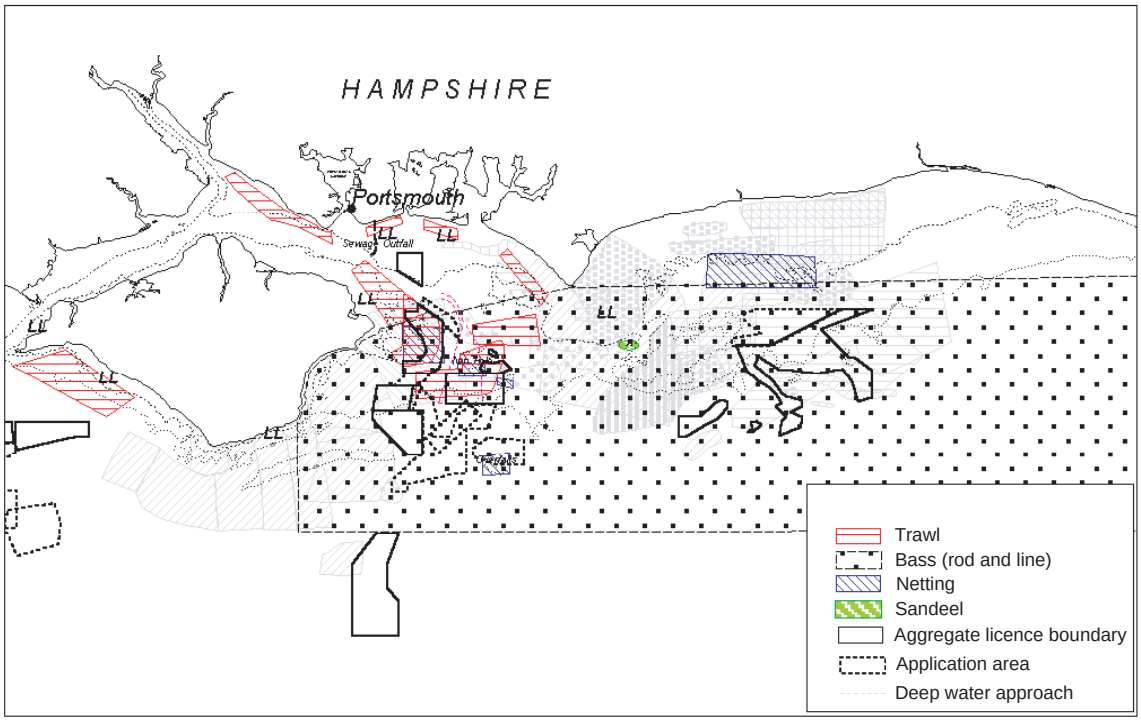

Figure 3. Location of fishing effort, using different types of gear, for vessels fishing from Portsmouth in 2001 in relation to the boundaries of current and proposed dredging licences(LL indicates areas where long-lining takes place). The map also shows the location of effort from other ports (shaded grey)

A reported decline in the accumulation of sole in the vicinity of Area 122/2 was also attributed to the effects of dredging.

This individual also highlighted the problem of 'first sale' fish prices, with the price for sole having remained the same for the last 10 years and plaice having remained largely unchanged for 25 years. Furthermore, problems associated with vessel anchorages (e.g. St Helens Roads), ferry traffic across the Solent, yacht mooring buoys at Wootten placed on a trawling ground and yachting traffic were all highlighted as contributing to interference with fishing or causing the loss of fishing grounds.

Potters

One trawler skipper was of the opinion that potters were being displaced further offshore as a result of losing grounds within the extraction areas. Due to the small size of these vessels, he considered that working further offshore raised some important safety concerns.

Netter

Of the four netters interviewed, three were unwilling to give details of the location of their netting grounds. The fourth individual has recently abandoned this method of fishing. He stated that the risk of damage to nets from marine aggregate dredgers or trawling vessels were major contributory factors. The locations of these netting areas are shown in Figure 3. This individual used to set nets on an area known as the Overfalls which can only be fished, using nets, on neap tides (5 days in every 2 weeks). For the remaining time, these nets were moved to an area known as the Nab Hole, but the presence of aggregate dredgers and trawlers meant that this was no longer feasible due to the risk of losing gear. He did attempt to move to an area off Littlehampton but the presence of local fishermen made this very difficult, particularly as this area overlaps with whelk grounds where pots are set across the tide. Static nets are laid with the tide and hence the two gear types are incompatible within the same area.

Bass Fishing

This interviewee targets bass, using rod and line on a commercial basis. He explained that he does have spots within and around the licensed areas, but that when the dredging operations are taking place he is unlikely to catch any fish. He also stated that these fish are unlikely to return until between 12-18 hours after the dredger has left. He has invested in a fast boat and tries to avoid dredgers by moving to alternative sites. The skipper of this vessel did not wish to reveal the exact location of his angling sites for fear that this information may be used by other anglers as, in his experience, the chances of catching bass rapidly decline

at a site after the arrival of additional boats. However, he fishes in spots in the area indicated in Figure 3. This individual expressed concern about the damage caused to the seabed from trawling and aggregate extraction activities and considered that the impacts of these activities may be making the ground less attractive to bass. An example was given of the trawl grounds around Beachy Head which have been intensively trawled and are no longer productive for bass. He expressed concern that dredgers may be adversely affecting the physical and biological characteristics of the seabed, which he considers are important for attracting commercially fishable numbers of bass. Sandeels are used for bait for this fishery and the area used to catch these fish is shown in Figure 3.

3.1.3 Langstone Harbour

Fleet Summary

There are around 60 vessels fishing from Langstone Harbour, although only ten operate on a full time basis. The majority of vessels are involved with charter angling although there are two full-time potters and a number of vessels that use set nets and trawls. A large percentage of these vessels are known to work in and around licensed extraction areas. There is also a sandeel fishery within the harbour, which is exploited for bait. A representative of the Langstone Harbour Licensed Boatmen Association, which represents the interests of charter anglers, was interviewed.

Charter Anglers

There are approximately 40 charter vessels working from Portsmouth, Langstone and Chichester. The interviewee estimated that these vessels take an average of eight paying passengers each and will undertake trips on around 160-170 days per year. Many of the people on these charters come from outside the local region and provide an important source of income to the local economy. In addition to the charter anglers, there are a significant number of privately-owned boats used by sport anglers. The number of these vessels in the region of study was estimated at around four hundred. Indeed, a local Sea Fisheries Committee officer estimates more finfish are caught by anglers than commercial fishermen. Anglers will fish in a variety of localities but the most important areas are detailed below and are shown in Figure 4.

Smooth hound (Mustelus mustelus)

Smooth hound is targeted from mid April to the end of August/beginning of September. Area 1 in Figure 4 was previously an important area for Smooth hound. Catches of this species have reportedly fallen since dredging commenced in this area and, as a consequence, anglers have been displaced to an alternative location to the east (see Figure 4, area 2). This has particularly affected anglers from Portsmouth who have to travel further to reach these grounds, resulting in a slight increase in fuel costs and results in marginally less time available for fishing.

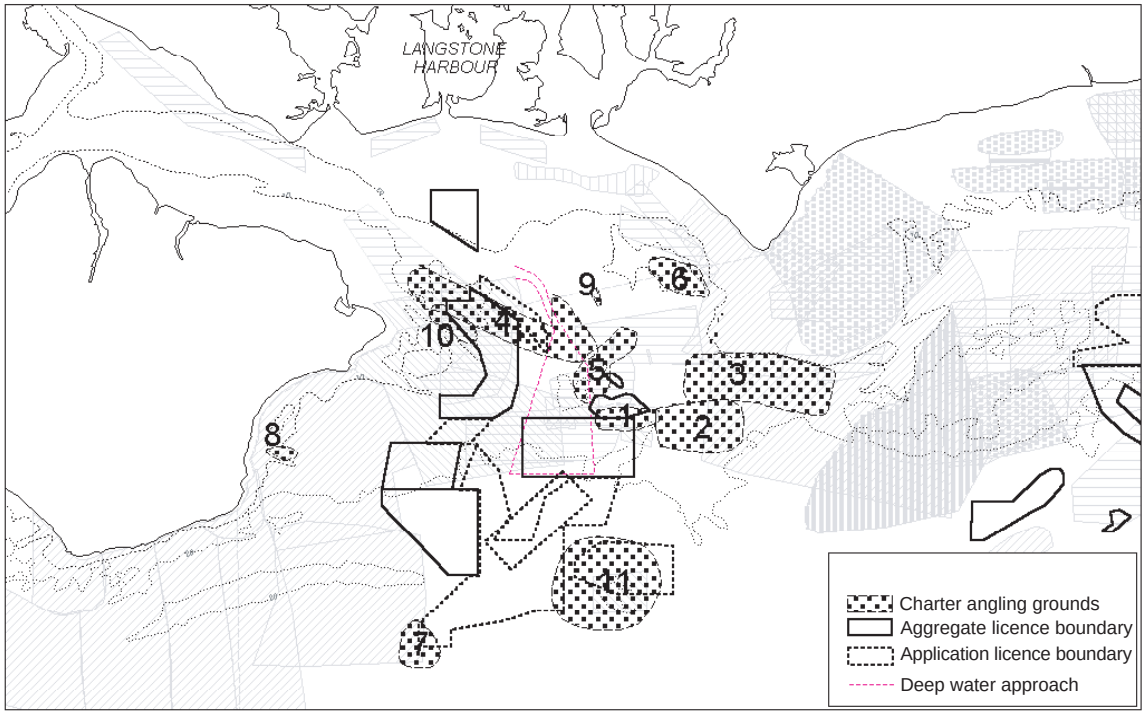

Figure 4. Location of important fishing grounds for charter and hobby angling vessels fishing from Langstone Harbour in 2001 in relation to the boundaries of current and proposed dredging licences. The map also shows the location of fishing effort from other ports (shaded grey)

Tope (Galeorhinus galeus)
Area 3 in Figure 4 is an important angling area for tope. Fishing for this species takes place in May and June when large fish come inshore to give birth, after which time they disperse. It is thought by the interviewee that this area may coincide with a spawning ground for this species.

Rays (Raja spp.)
Rays are caught by anglers, all year round, in Areas 5, 6 (Medmery Bank, an area of sand), 7 and 8.

Whiting (Merlangius merlangus)
Cod and Whiting are caught in Area 4, an area of gravel, from November to January. This area was considered particularly important as, unlike many of the other locations used by anglers, it offers some protection from strong south-westerly winds.

Black Bream (Spondyliosoma cantharus)
Areas 9 (Bullock Patch) and 10 (Nab Rock) are both targeted by anglers for black bream in May and June.

Bass
Area 11 (known locally as the Overfalls) is the location of angling for bass from March to November.

3.1.4 Chichester

Fleet Summary
The majority of the 18 vessels based at Chichester target oysters in Chichester Harbour and in the Solent, between November and April. Only six of these vessels are full-time. After the end of the oyster fishery, some fishermen will switch to other gears. These include trawls and nets, used to target white fish and cuttlefish in Bracklesham Bay, and potting for brown crab, lobster, whelks (*Buccinum undatum*) and cuttlefish (*Sepia officinalis*). As a high value non-quota species, cuttlefish provides an important source of income. Fishing for bass also occurs within the Harbour using a variety of fishing gears. One full-time potter was interviewed from Chichester.

Potter
In common with other crab fishermen in the region, this skipper reported a decline in the brown crab fishery. Due to the density of potting off Selsey, this individual mainly fishes the potting grounds located to the south of the Isle of Wight and targets both edible crab and lobster. This necessitates a 2½-hour journey to and from the grounds. Although, by potting standards, his 40-foot vessel is large, he did express concern about working so far offshore, particularly in marginal weather. He also fishes between Chichester and his main grounds to the south of the Isle of Wight (see Figure 5). These grounds are particularly important when weather conditions prevent him reaching the grounds to the south of the Isle of Wight. The areas fished by this individual to the south of the Isle of Wight overlap with areas given by two potters from Bembridge. Furthermore, this individual has lost some potting ground in the north of Area 407 and is

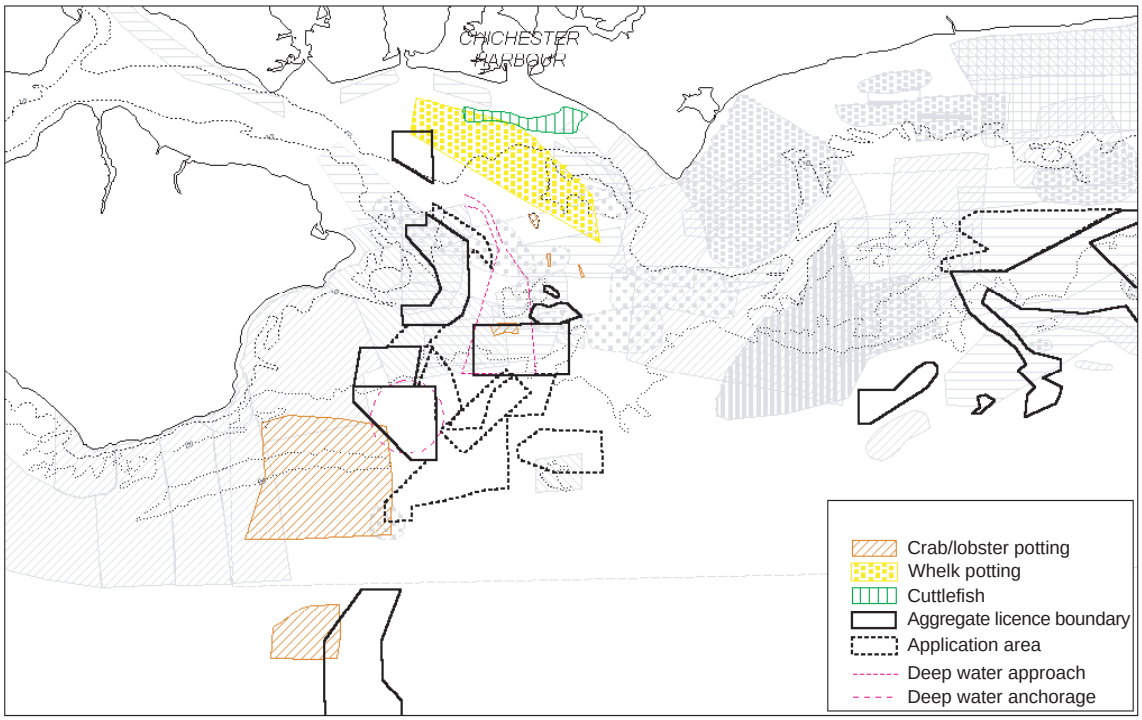

Figure 5. Location of effort for a vessel fishing from Chichester Harbour in 2001 in relation to the boundaries of current and proposed dredging licences. The map also shows the location of fishing effort from other ports (shaded grey)

anticipating losing further area as a result of dredging operations in Area 351. He has also noticed an increase in the number of vessels working in the area to the south of the Isle of Wight. He believes that there is additional pressure on this area, as a result of the loss of grounds within the extraction areas. Provided by way of an example, this skipper estimated that around seven or eight boats have ceased working within the extraction areas in the last 10 years, and that some of these boats have left fishing altogether. He also expressed concern that dredging operations may be removing juvenile lobsters and that suspended sediment may be adversely affecting young lobster populations.

3.1.5 East Wittering

Fleet

There are two full-time beach boats at East Wittering. These vessels will deploy both pots and nets, but are thought to fish relatively close inshore due to their size. No fishermen from East Wittering were interviewed.

3.1.6 Selsey

Fleet

The fleet of 33 registered vessels at Selsey are composed of thirty-one <10 m boats and two >10 m vessels. The majority of these vessels are engaged in potting for crab and lobster, although there is some trawling, netting and lining. Most vessels are moored off Selsey Bill from April to September. During the winter, these moorings are too exposed and most boats will transfer to Chichester Harbour, adding approximately four hours onto a days fishing. Local fishermen indicate that the fleet has halved in size in the last 10-15 years. This decline is attributed both to a lack of fish and poor 'first sale' fish prices. For example, individuals interviewed report that first sale prices for some species have remained largely unchanged for ten years, whilst expenses have increased.

Potters

There are around 20 full-time potting vessels based at Selsey. The main species taken by potters here include brown crab, lobster, spider crab (*Maja squinado*) and whelks. There are around ten <10 m potters working in Area A and up to three >10 m vessels working in Area B (Figure 6). Within these broad areas, individuals tend to remain in separate zones. Boats use short strings of around 20-40 pots. Brown crabs are caught all year, mainly on shingle, whilst lobsters are generally caught in the rocky areas (Area A, Figure 6). For the inshore boats, there is no overlap of the grounds with aggregate extraction sites as fishing effort is confined to inshore waters. Similarly, there is also no overlap with the potting grounds of the larger offshore vessels, although the annual loss of hundreds of pot markers is attributed, by fishermen, to the dredgers moving to and from the Owers Bank extraction licences. One interviewee also remarked that he has had a number of 'close calls' with certain dredgers.

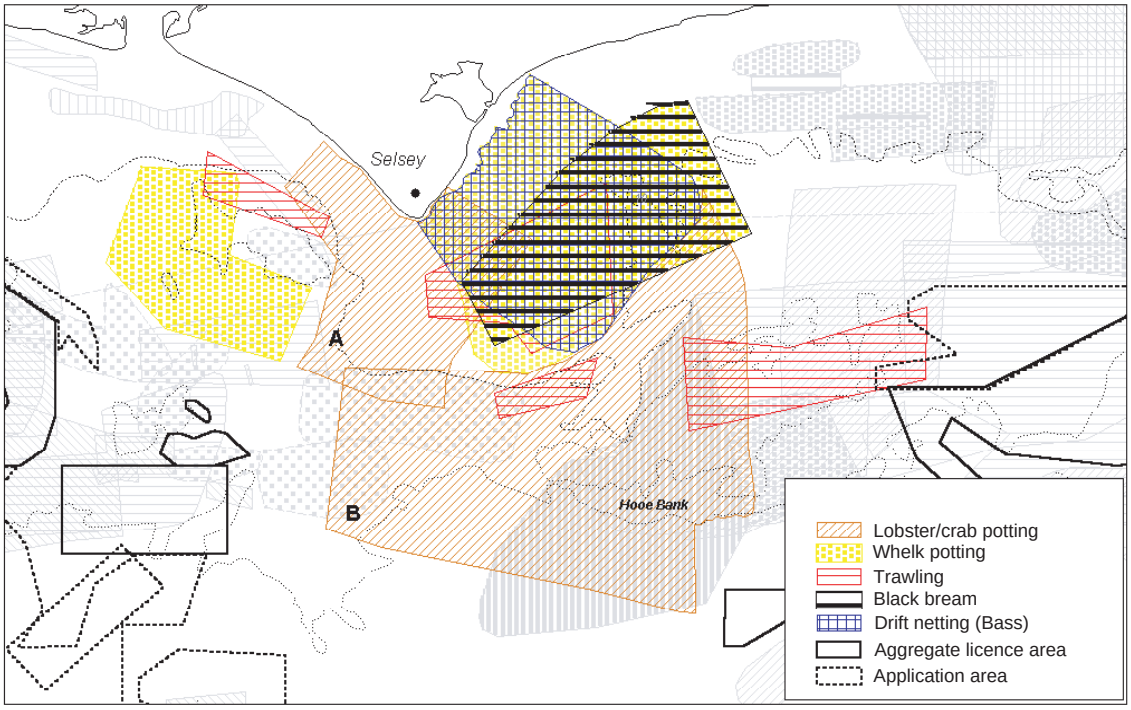

Figure 6. Location of effort for a vessel fishing from Selsey in 2001 in relation to the boundaries of current and proposed dredging licences. The map also shows the location of fishing effort from other ports (shaded grey)

Fishermen from Selsey have also noticed a decline in the catches of brown crab. During the winter, pots are not laid on the 'hard ground' of the Hooe Bank to avoid the risk of damage. Instead, they are laid on the shingle, just off the bank. Fishing to the west of the Nab Tower was considered a productive lobster ground in contrast to experience in recent years. In addition to brown crab, seasonal onshore migrations of spider crab are also targeted, particularly from September to December.

Whelk Potting
Around 5 boats target whelk from January to July in the area shown in Figure 6.

Netting/Trawling
One individual fishes from a small open beachboat to the east of Selsey and also in Bracklesham Bay. There are 4-5 boats netting from Selsey with effort being largely confined to within three miles of the shore. Beyond this, the tidal currents are viewed as being too strong for working. Black bream are targeted from the end of April to the end of May by local netters. The whelk ground to the east of Selsey Bill overlaps with black bream ground, but whelk potters either remove their pots from this area for the 6-8 weeks of the black bream season or make the position of their gear known. Drift nets and long lines are also deployed on whelk ground for bass from January to March.

An increase in the amount of fixed gear placed in the area was reported to have reduced the available grounds for trawling. A number of boats also target prawns in the potting grounds.

3.1.7 Bognor Regis

Fleet summary
There are 10 full-time small beach-launched open boats, all of which are primarily concerned with lobster potting. Boats will also target crab and set a variety of nets. No individuals from this port were interviewed.

3.1.8 Littlehampton

Fleet Summary
There are a total of six full-time boats working from Littlehampton. Of these vessels, there are two <10 m trawlers whilst the others set pots and nets. Interviews were conducted with the skippers of two potting/netting vessels. Species targeted include crab, lobster, spider crabs, whelks, bass, black bream, sole and cod.

Potting
The main potting area used by Littlehampton vessels is shown in Figure 7, region A. This is an area of rough ground, which relatively few trawlers will exploit. In contrast, potters view this area as very important to the success of their operations. Some concern was

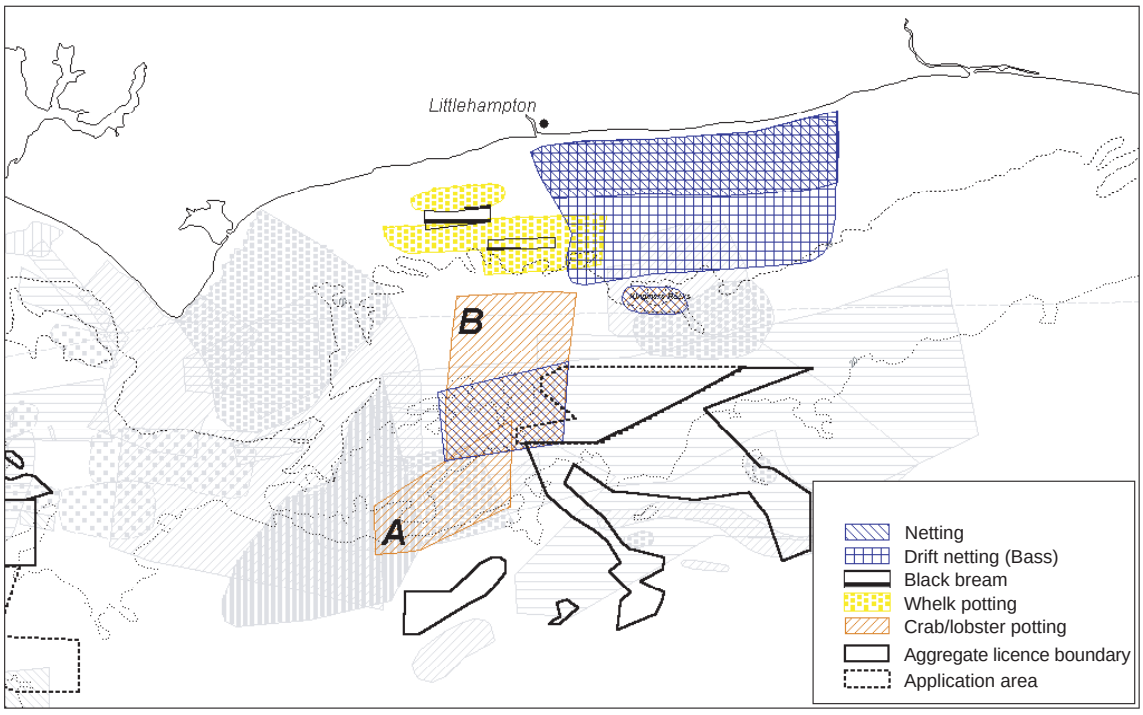

Figure 7. Location of effort for a vessel fishing from Littlehampton in 2001 in relation to the boundaries of current and proposed dredging licences. The map also shows the location of fishing effort from other ports (shaded grey)

expressed about the proposed extraction activities in Area 396 (see Figure 1) as it was considered that muddy sediments within the extraction site, north-east of the potting area, would be suspended by dredging operations and impact the ground on south-westerly flowing ebb tides. Potting also takes place on the Kingmere rocks during the summer months.

Fishermen complained about the loss of pot markers or 'buffs', the majority of which they attribute to the movement of dredger traffic. It was estimated that individuals can lose up to 80-100 pot markers per annum. Apart from the financial implications associated with such loss, it also results in time having to be invested in replacing/repairing the gear.

Potters will also target the seasonal movement of spider crabs as they move inshore in box B Figure 7. In addition vessels will also pot for whelks in the areas south of Littlehampton shown in Figure 7.

Currently, no potting gear is placed within the extraction areas as the one-hour notice provided before the commencement of dredging operations does not allow sufficient time to retrieve the deployed pots.

Expansion of the Owers Bank extraction licences was a concern to the individuals interviewed as the area is already heavily fished, with very few alternative grounds, particularly for smaller fishing vessels.

Netting
Fishermen have recently commenced the occasional netting for rays in the south of box B, but only on neap tides. There is also some drift netting for bass, usually after bad weather when static gear has been removed, but this activity is largely conducted on an opportunistic basis. Between the end of October and mid January, fishermen will net for cod around the 6 metre contour line. Some netting also occurs around the Kingmere Rocks during the winter months. Furthermore Black bream are targeted using both nets and rod and line in the areas shown in Figure 7.

3.1.9 Worthing

Fleet Summary
There are around 4 or 5 full-time beach boats operating from Worthing. The main focus is drift netting for bass after storms, and trammel netting for sole and plaice. Boats will also gill net for cod (*Gadus morhua*) when they are locally abundant. No fishermen were interviewed from this port.

3.1.10 Shoreham

Fleet Summary
There are 8 full-time vessels moored in the river at Shoreham. Whelks are the main target for around half these vessels. In addition to whelks, the other vessels will use nets and crab and lobster pots. There are also a number of trawlers based at Shoreham (three <14 metres, five 24 metre beam trawlers and others >18 metres in length).

Trawler (14 m)
The main area used by this 'non-sector' vessel is shown in Figure 8. The term 'non-sector' refers to a vessel that has monthly restrictions placed on the quantity of quota species it is allowed to catch. Fish quotas were assigned to vessels on the basis of catches during a reference period between 1994 and 1996. Vessels which were unable to demonstrate a track record of catching certain species during this period were therefore likely to receive little or no quota allocation. In common with many other 'non-sector' vessels, the allocation of quota species for this vessel is very limited. The skipper remarked that he can easily catch his very limited quotas within a very short space of time. As a result, he is dependent on non-quota species for a large part of his income. The main grounds that are targeted for these non-quota species are also coincident with marine aggregate extraction licences. In his view a proportion of the area that is fished has already been lost due to an alteration in the topography of the seabed as a consequence of dredging which has made the ground unsuitable for trawling. Although, at present, there are sufficient remaining areas of seabed for trawling there is concern regarding the recent introduction of larger trailer suction hopper dredgers working the area. Previously, the dredgers working in the vicinity of an area known locally as the Banana Bank (see Figure 8) were more predictable in terms of their movements.

Beam Trawler
Within the Owers Bank extraction licences, areas of seabed where sediments have changed from gravel to fine silty muds were identified by the interviewee. The skipper of this vessel indicated that it is not possible to tow across these areas, as the gear sinks into the fine sediment. As a result, these changes have led to a loss of fishing ground. Figure 8 shows the location of these lost tows. This change in the composition of sediments is attributed, by this skipper, to the exposure of underlying finer sediments as a result of extraction.

Whelk Potters
Strings of around 40 pots are laid across the tide by these vessels. Interviewees identified important whelk grounds inside the dredging areas which are rarely fished due to the presence of dredgers. Concern was expressed that there might be important spawning areas inside of the dredging areas and that gravel is being removed before its role is fully understood.

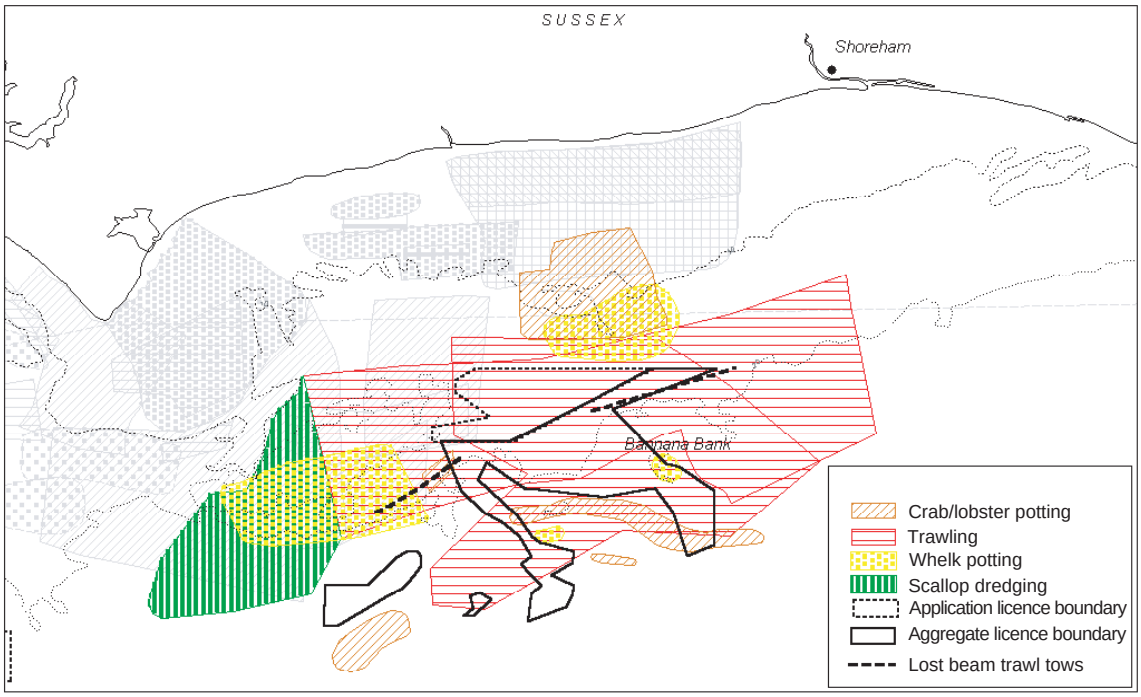

Figure 8. Location of effort for a vessel fishing from Shoreham in 2001 in relation to the boundaries of current and proposed dredging licences. The map also shows the location of fishing effort from other ports (shaded grey)

3.2 Extent of dredging activity

Figure 9 shows the cumulative extent of dredging operations on the seabed from 1993-2001, derived from block analysis of EMS records. The area dredged in any individual year has remained relatively constant, varying between about 26 - 50 km^2 (Figure 10). Figure 10 also shows the area of new seabed dredged in each year. These maps represent the maximum area of direct impact of dredging on the seabed for the period of analysis. However, the data used in this analysis can potentially over-represent the extent of the seabed actually dredged. In practice, within any 100 m by 100 m block dredging will be targeted at particular deposits, therefore some areas of the seabed may have been dredged on a regular basis, whilst others may not have been dredged at all. Furthermore, this analysis is likely to over-estimate the scale of disturbance, as it does not give consideration to the potential for recovery of the seabed. Despite these limitations, the approach was considered useful in order to document the location of dredging effort combined over time. It also provides a more accurate representation of the dredging effort than portrayed by the boundaries of the extraction licences, which invariably over-represent the true extent of activity.

The analysis indicates that the cumulative area of seabed dredged has increased from approximately 26 km^2 to around 94 km^2 over the period 1993 to 2001. No records exist on the location of dredging activity prior to the introduction of the EMS in 1993 and therefore this method does not provide an earlier historical perspective on the distribution of dredging effort in the region.

3.3 Evaluation of fishery concerns in relation to EMS data

In this section, the EMS records are employed in order to document the location of dredging operations over time within important fishery resource areas, in order to assess the potential for conflict between the distribution of these two activities. The analysis shows the area of seabed affected in individual years and also the cumulative extent of dredged areas over the period 1993-2001.

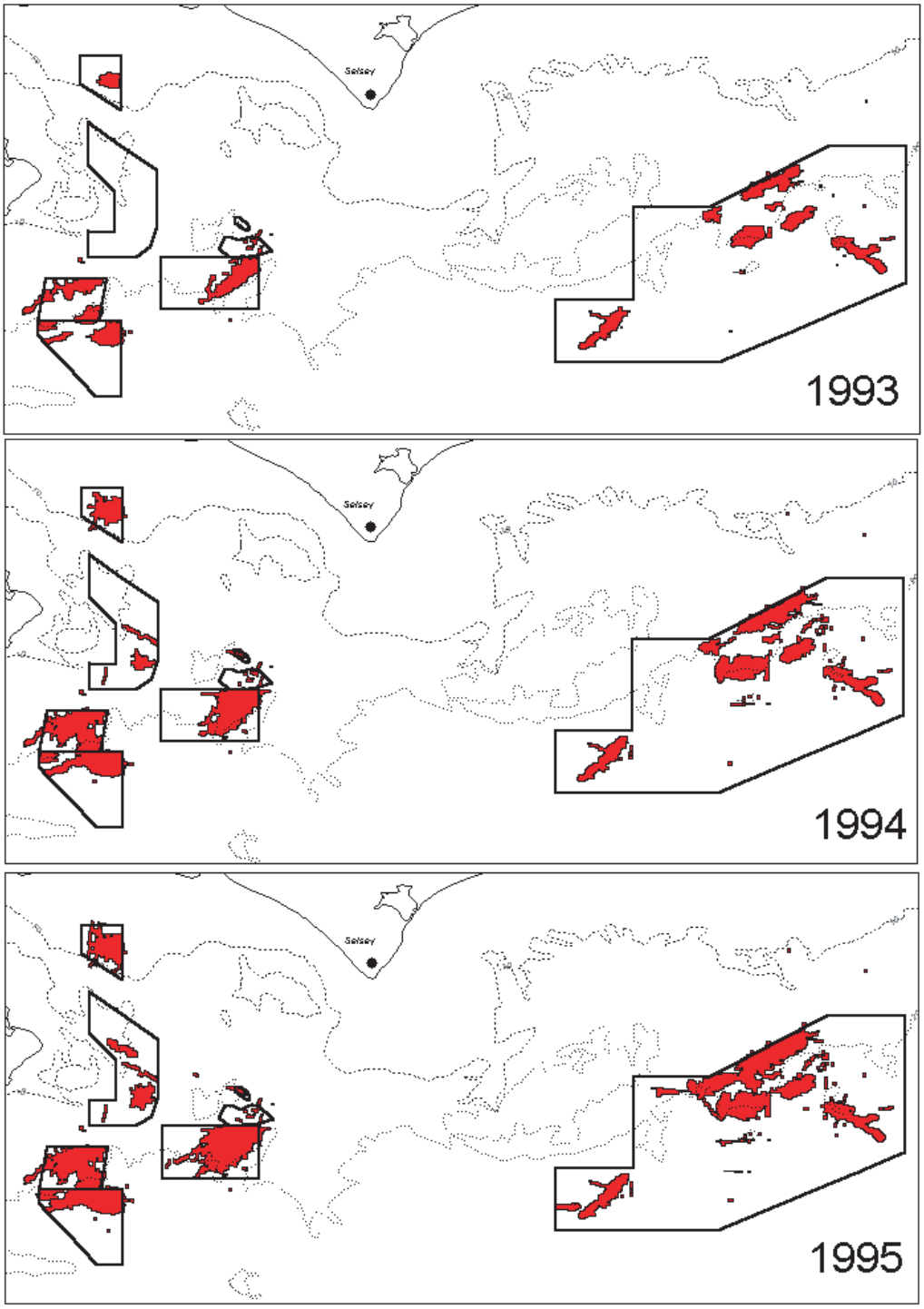

Figure 9. Cumulative extent of dredging over the period 1993-2001 derived from block analysis of EMS data

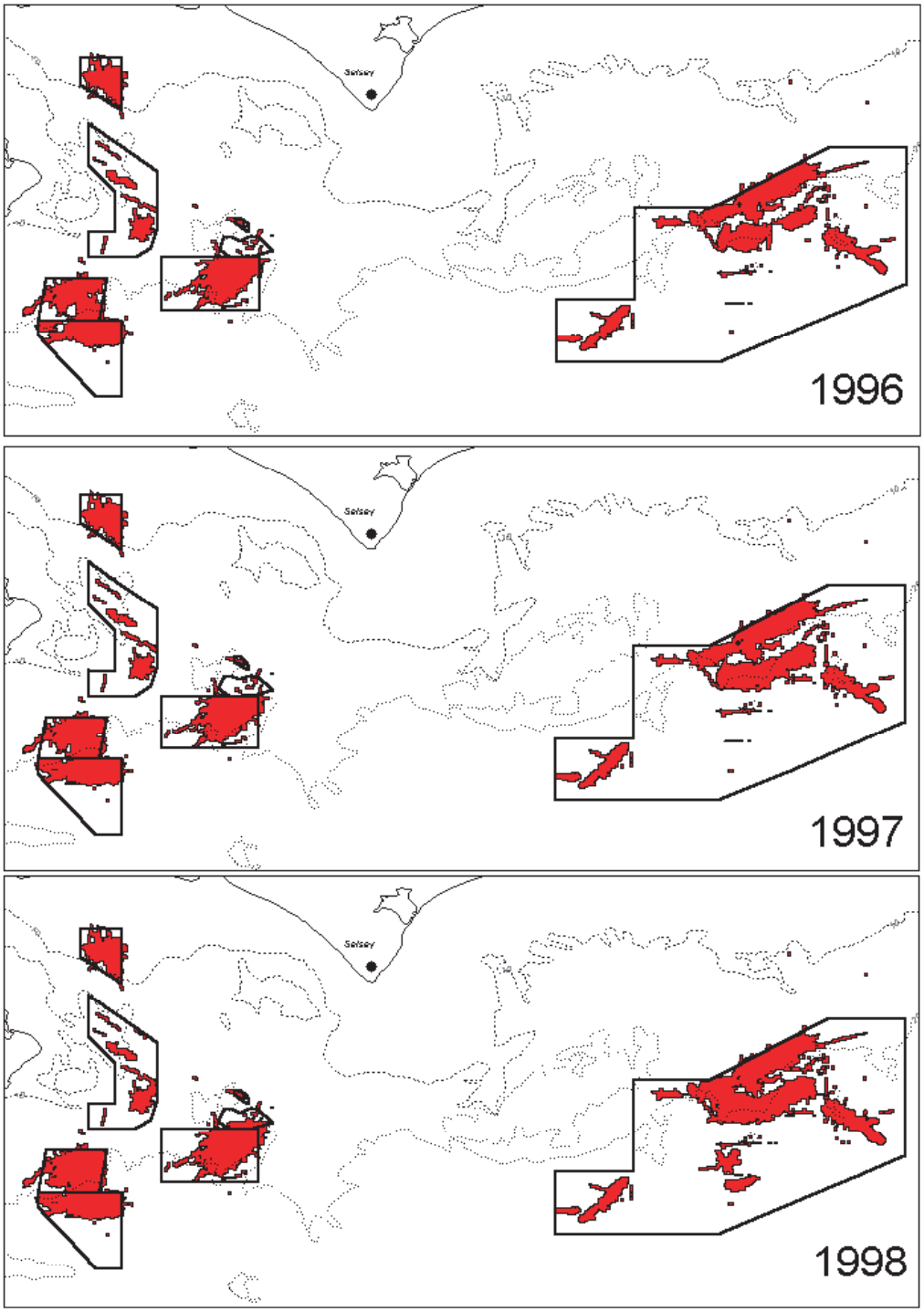

Figure 9. Continued

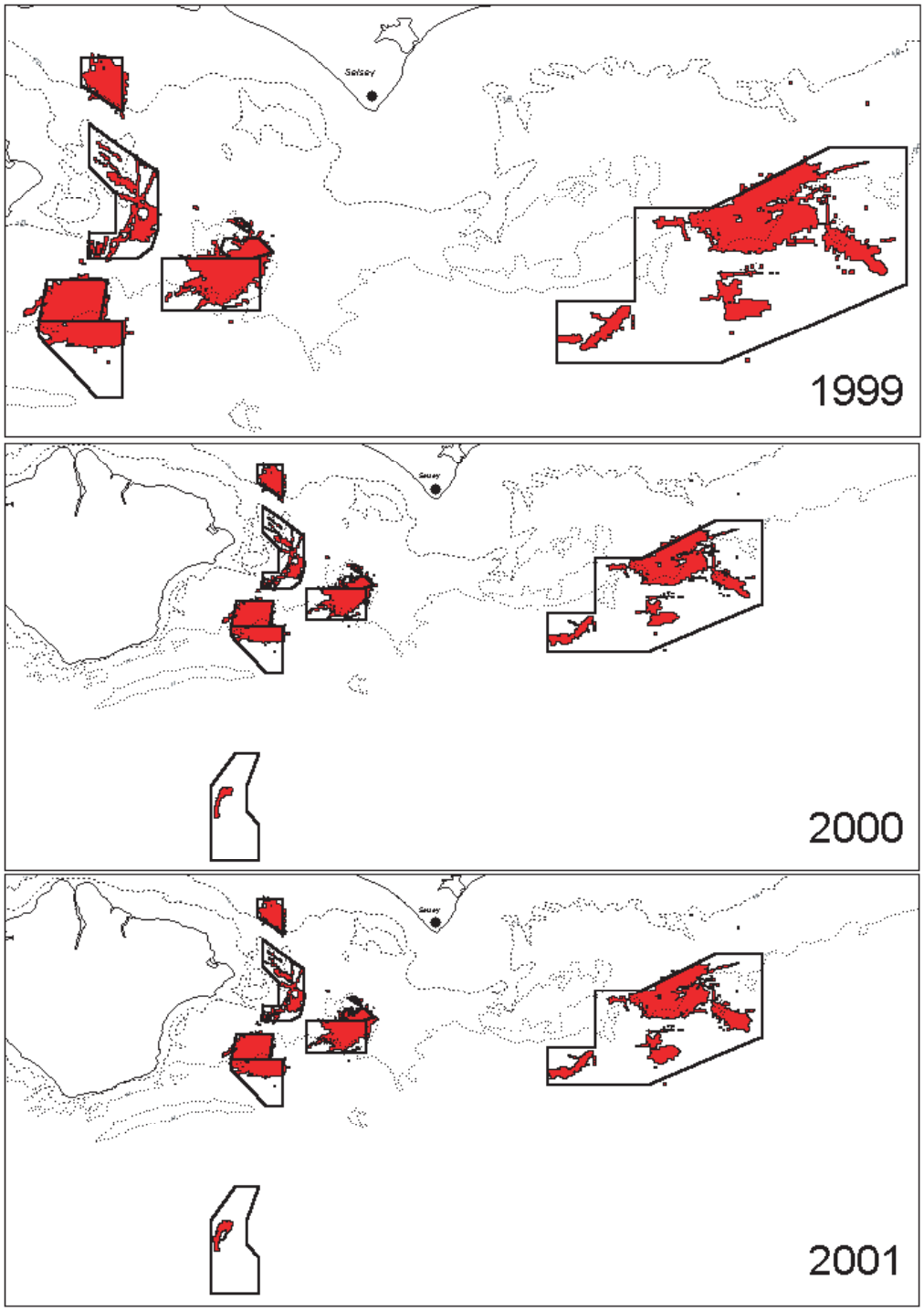

Figure 9. Continued

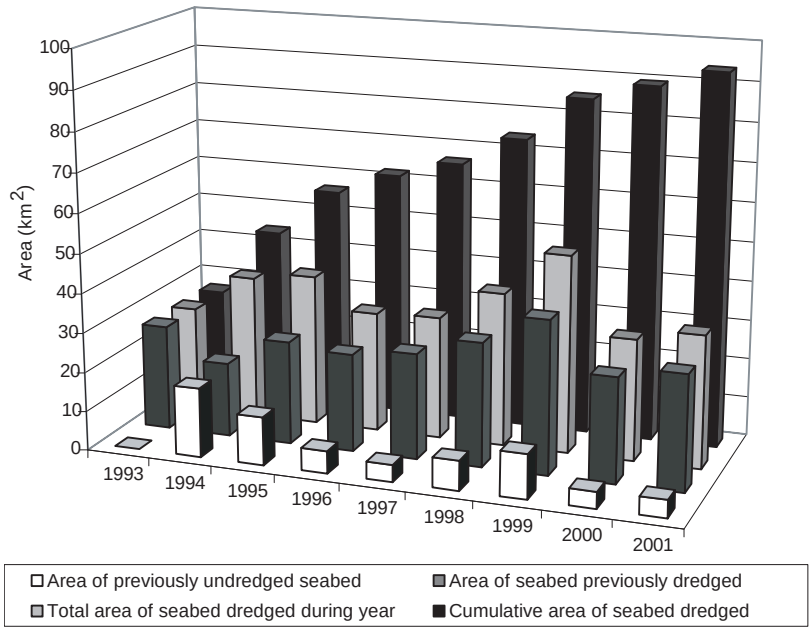

Figure 10. Contribution of previously dredged and undredged areas to the total annual area dredged in the study area. The graph also shows the annual cumulative area dredged

3.3.1 Assessment of the influence of dredging on brown crab populations

An apparent decline in the brown crab fishery was reported by fishermen from Bembridge, Chichester and Selsey. The potential for dredging to affect areas of the seabed thought to fulfil critical functions for maintaining brown crab populations were investigated by utilising map overlaps. Figure 11 shows the location and extent of a suspected spawning ground and migration route for female crabs utilised from July to December in relation to cumulative dredging effort. The location of these habitats was derived from

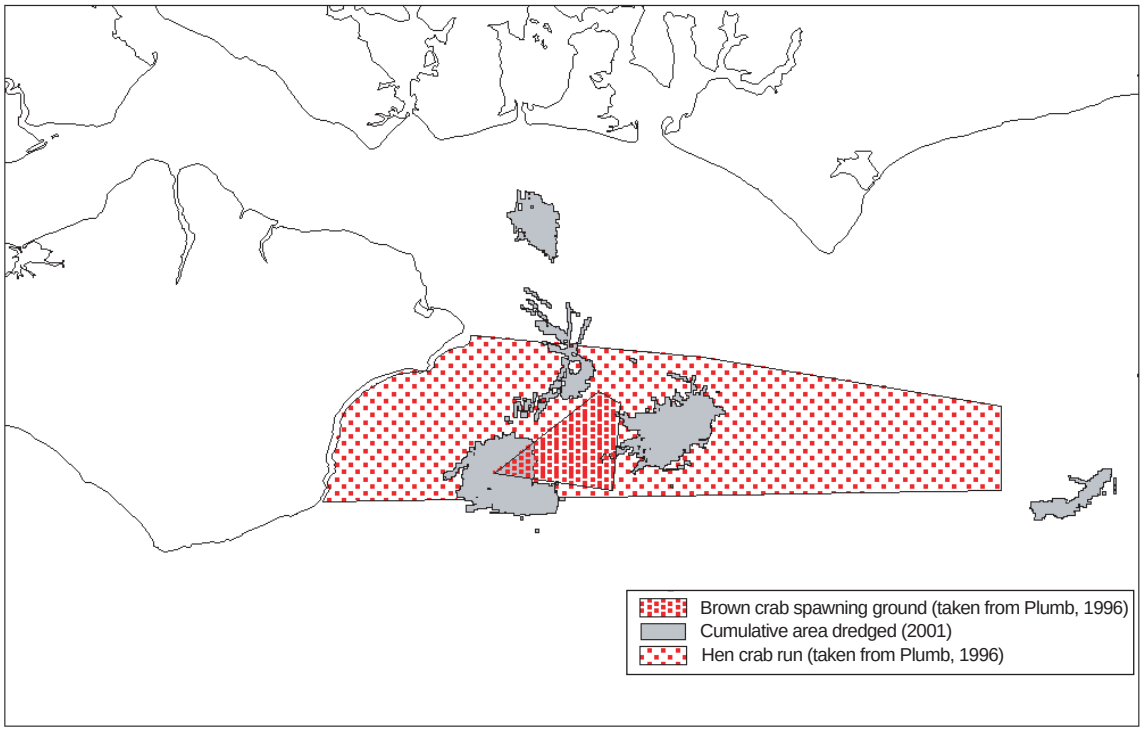

Figure 11. Cumulative extent of dredging on the seabed in 2001 and the crab habitats identified by Plumb (1996)

maps prepared by Plumb (1996). However, there is no scientific evidence to support their hypothesised functions. The analysis indicates an overlap in the distribution of sensitive habitats and dredging activity over the period between 1993 and 2001. In terms of the cumulative area dredged, the overlap has increased marginally over time. However the potential for recovery of the seabed will determine whether the 'impact' has increased in line with this.

3.3.2 Assessment of the influence of dredging on trawling grounds

A similar approach was adopted for examining any relationship between the distribution of dredging efforts and identified trawling grounds (see Figure 12). Again, the location of trawling grounds were provided by Plumb (1996) and the same reservations apply as above. Figure 12 indicates an overlap of dredged areas and trawling grounds. The cumulative extent of dredging within these trawl grounds is of interest as it represents the maximum total area within which there is at least the potential for the effects of dredging operations to interfere with trawling operations. However this should be weighed against an assessment of potential for recovery of the seabed environment following dredging. It is also likely that obstructions to trawling operations will be very localised. Thus the area of seabed which will pose a threat to normal trawling activities is likely to be significantly smaller than the dredged area indicated by Figure 9.

Three trawler fishermen identified in this study have reported operational conflicts with dredging vessels. The location of their grounds is shown in Figure 13. Area 1 shows the grounds fished by an individual from Shoreham who reports that concentrations of various non-quota species, upon which he is heavily dependent, are found in this area. This, and the reported unsuitability of the ground for trawling outside this immediate area, provided no alternative but to work around the dredging operations. The percentage area of the ground in Area 1 dredged in 2001 was approximately 9%. Areas 2 and 3 are the grounds fished by two individuals from Portsmouth. Approximately 9% of Area 2 was dredged in 2001. The individual fishing in area 3 purposely avoids aggregate extraction areas and none of these grounds overlap with dredging licences in 2001.

3.3.3 Assessment of the potential for loss of smooth hound angling ground

Charter anglers have expressed concern that dredging was responsible for the decline in catch of smooth hound in Area 1 (Figure 4). Figure 14 shows the location of this previously fished area in relation to the cumulative extent of dredging on the seabed in 2001. It also shows the locality of a mussel bed identified in Plumb (1996): mussels are identified as one of the food items that may be responsible for attracting smooth hound into this area. Figure 15 shows the percentage area of seabed within this angling area that has been dredged in each year from 1993-2001. The percentage area of this ground dredged on an annual basis varies between 28.0% (0.9 km^2) and 78.3% (2.7 km^2), whereas the cumulative area dredged within these grounds has increased from 28.0% (0.9 km^2) in 1993 to 87.4% (3.12 km^2) in 2001.

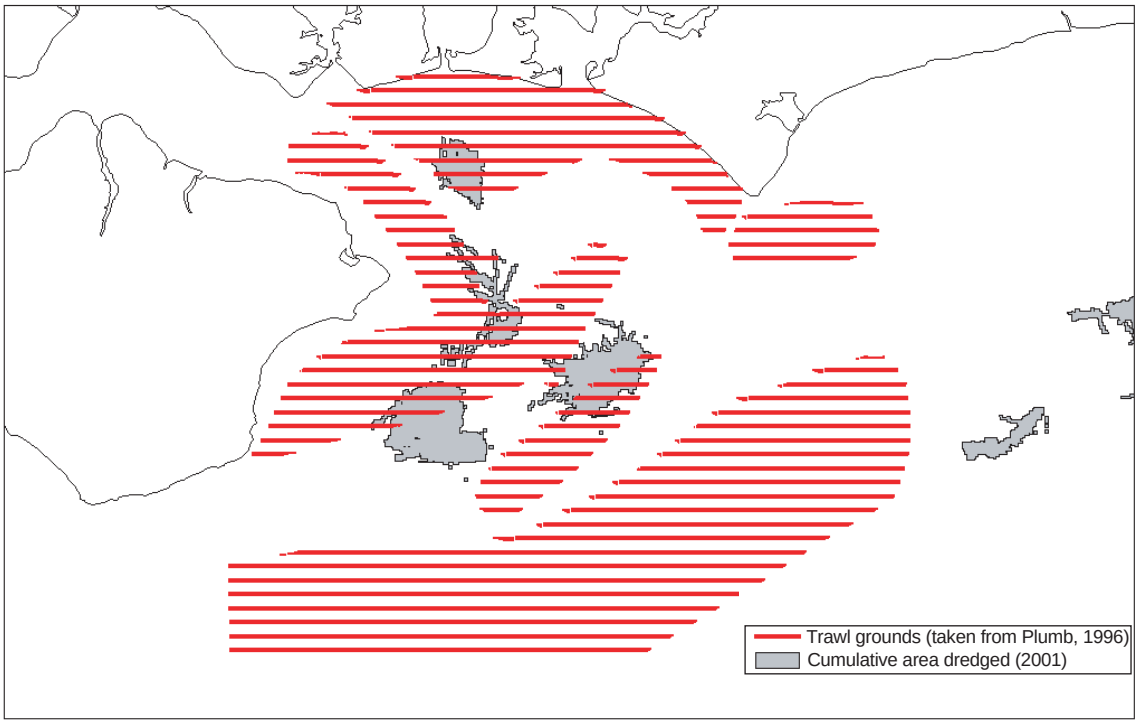

Figure 12. Cumulative extent of dredging on the seabed in 2001 and the trawl grounds identified by Plumb (1996)

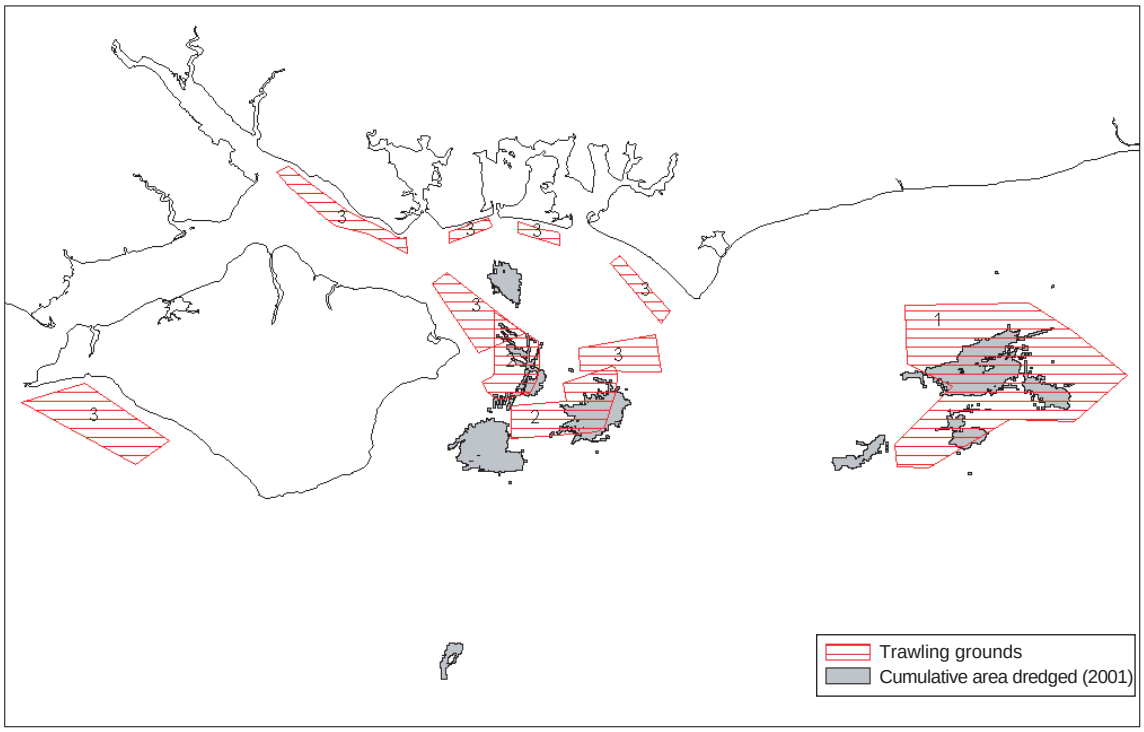

Figure 13. Cumulative extent of dredging in 2001 and the trawl grounds of three individuals from this study who reported interference from dredging operations. The location of each individual's grounds is labelled 1,2 and 3 respectively

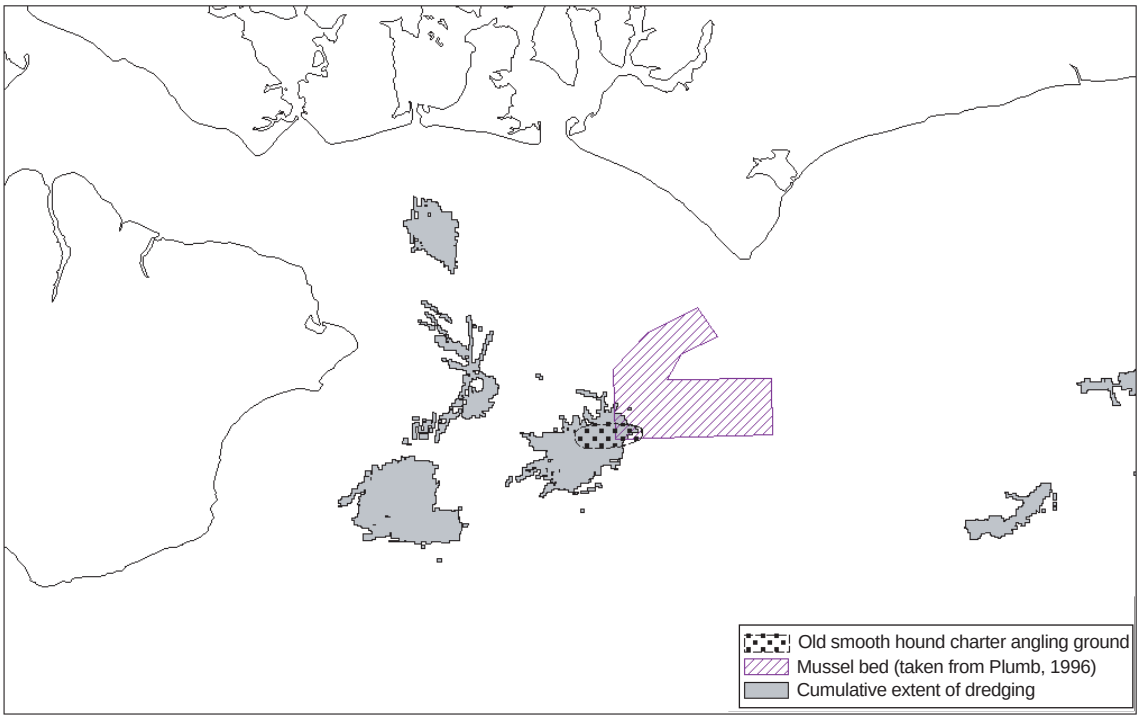

Figure 14. Cumulative extent of dredging on the seabed in 2001 and the location of ground previously used by charter anglers for catching smooth hound. The map also shows the location of a mussel bed identified in Plumb (1996)

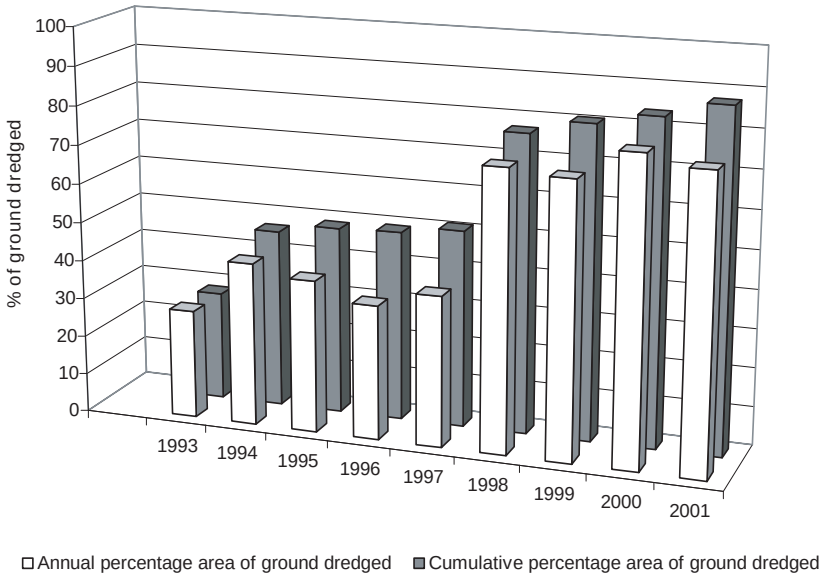

Figure 15. Percentage area of the smooth hound angling area (detailed in figure 15) dredged in each year from 1993-2001. The graph also shows the cumulative percentage of this area dredged

3.3.4 Assessment of the potential interference with netting grounds

Figure 16 shows the location of netting grounds used by two individuals interviewed in this study. The grounds in 'Area 1' are currently used by an individual from Bembridge, whilst the grounds in 'Area 2' were used by an individual from Portsmouth who has recently abandoned this method of fishing as a consequence of interference from dredging and trawling activities. In 2001 approximately 3% (2 km^2) of Area 1 and 13% (2.6 km^2) of Area 2 was dredged.

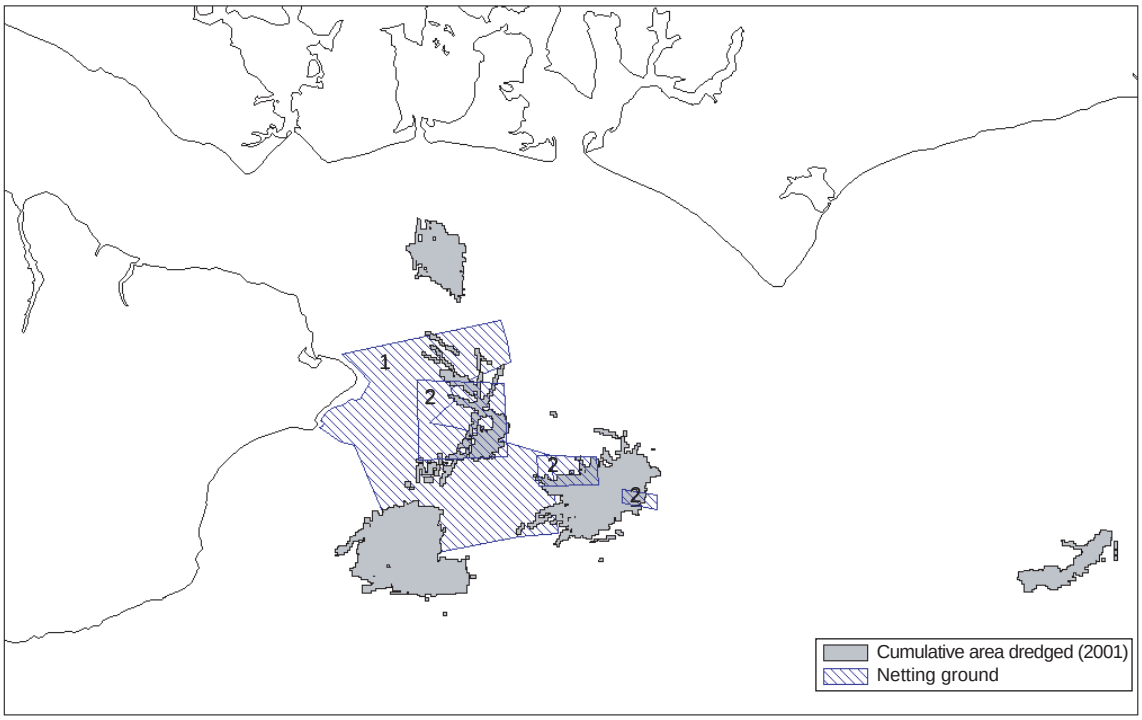

Figure 16. Cumulative extent of dredging on the seabed in 2001 and the netting grounds of two individuals from this study who reported interference from dredging operations. The location of each individual's grounds are labelled 1 and 2 respectively

4. DISCUSSION

This study has documented a number of concerns expressed by fishermen regarding the potential impacts of marine aggregate extraction activities on local fisheries in the region to the east of the Isle of Wight. These concerns can be divided into two broad areas. Firstly, that dredging operations affect access to traditional fishing grounds and, secondly, that dredging operations affect the abundance and distribution of commercially targeted species. The assessment of the latter concern is made difficult by the absence of quantitative data on localised spatial and temporal scales. Even were such data to be available, cause-effect attributions are often challenging due to the interaction of anthropogenic and natural influences. However, the observations of fishermen and existing scientific understanding can be combined for the purpose of generating hypotheses for observed change, which are presented below.

- **Relationship between dredging activity and brown crab abundance**

At Selsey, Bembridge and Chichester, potters have reported a steady decline in the number of potting vessels. This trend is confirmed, at Bembridge, by southern Sea Fisheries Committee data on the number of registered vessels (see Figure 17). Fishermen from these areas attribute this decline to a fall in the abundance of brown crab. Confirmation of this by independent methods, for example, using Defra landing statistics, is difficult as these data are not of sufficient resolution or quality. However, personal log book records submitted to CEFAS by a crab fisherman from Selsey show a decline in catch and 'catch per unit effort' (CPUE) over the period 1989-97. In contrast, logbook records from another crab fisherman operating in the Solent show a slight increase in catch over the period 1988-98 (S. Lovewell, CEFAS, *pers. comm.*). Unfortunately, there are no log-book records of sufficient length for crab fishermen operating to the south of the Isle of Wight. Available data suggest a localised change in the abundance of brown crab in the region. However, there are a number of factors which might explain this observation, including the potential for overfishing, changes associated with natural variability as well as the effects of aggregate extraction. Figure 18 shows the recorded landings of crab at ports across the region between 1994 and 1998.

Plumb (1996) indicated the presence of a brown crab spawning ground within an accumulation of dredging licences to the east of the Isle of Wight. Further weight is given to the existence of crab spawning grounds in the region from the results of a preliminary crab (*Cancer pagurus*) larval study designed to look at the spatial distribution of spawning crabs. This study, carried out in June 1981, found a relatively dense patch of larvae south of Selsey and due east of St Catherines Point (Thompson and Ayers, 1987). Furthermore, tagging studies demonstrated a west to south-west migration of brown crab in the eastern English Channel (Bennet and Brown, 1983). This migration is thought to be important for two reasons. Firstly, it ensures that egg-bearing female crabs are able to find suitable substrata in which to bury during a dormant overwintering phase. A laboratory study

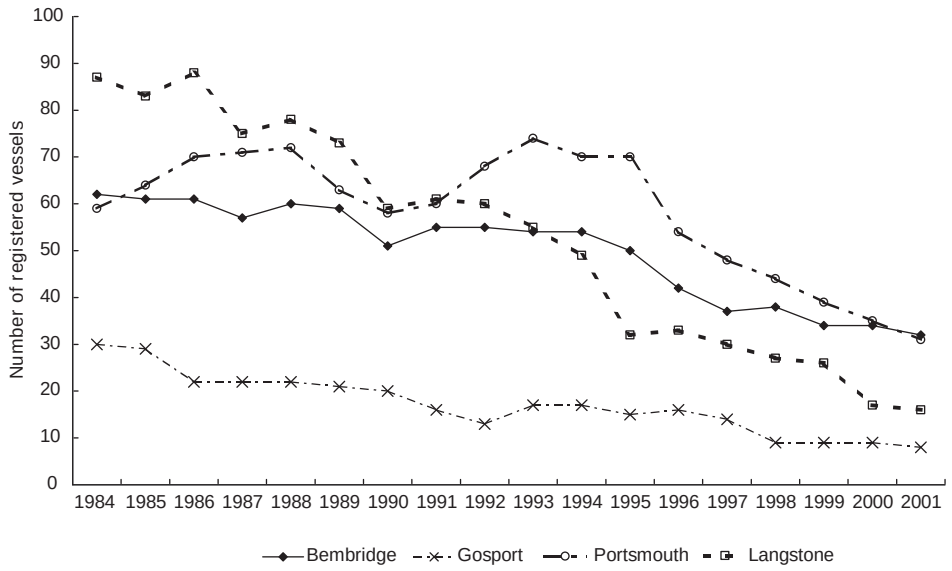

Figure 17. Number of registered vessels at various ports within the southern Sea Fisheries district

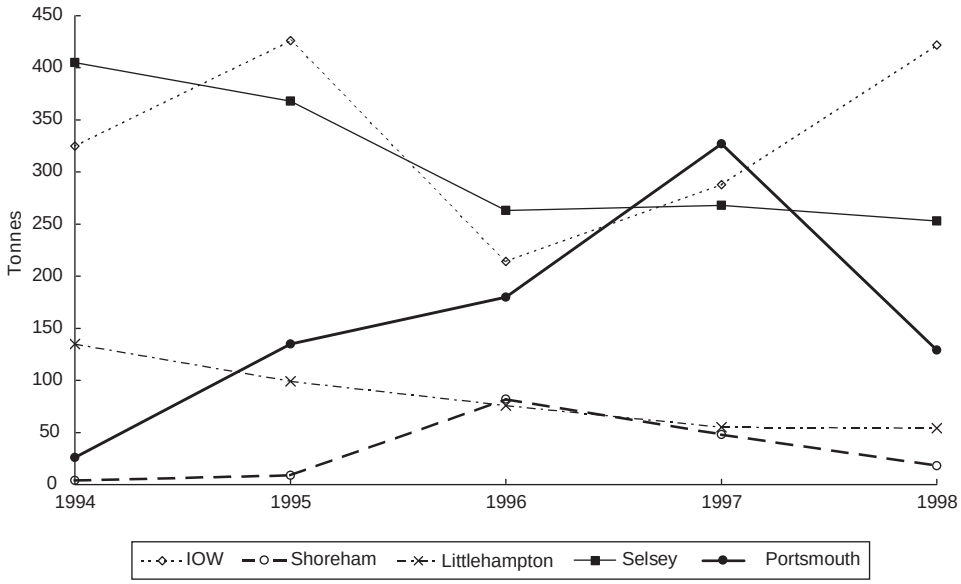

Figure 18. Annual landings (live weight) of 'crabs' at important crab fishing ports across the region. Note that data for the Isle of Wight (IOW) represents the combined landings from Southampton, Bursledon, Christchurch, Cowes, Barton-On-Sea and Lymington in addition to other Isle of Wight ports. Data from Defra landings statistics

by Edwards (1979) has also shown that female crabs will preferentially select gravel beds for spawning. In addition, it is thought that the westerly migration ensures that crab larvae drift back towards their nursery grounds on the residual easterly currents (Bennet and Brown, 1983).

Plumb (1996) has, through discussion with fishermen, identified an area known locally as the 'hen crab run' where soft-shelled females can be found from the end of July to December. The overlap of this area with a number of aggregate extraction licences (areas 122/3, 395/2, 351, 213 and 340) suggests the potential for the uptake of individual crabs with the aggregate resource, within these areas, as a result of dredging. During their overwintering phase, female crab may be particularly vulnerable to uptake by the drag-head. Crabs may also be affected by suspended sediment arising from turbidity plumes (Collinson and Rees, 1978; Poiner and Kennedy, 1984; Van de Veer *et al*., 1985) which may interfere with their respiratory function (Howard, 1982). Research conducted as part of the wider aims of the present study has also indicated that the effects of dredging can be detected on the macrobenthos beyond the margins of the extraction sites (Boyd and Rees, 2003). However, there is a lack of information on the precise location of crab migration routes and their overwintering grounds, which precludes quantification of the effects of turbidity plumes.

Evidence from the present study suggests the exclusion of static gear fishermen from potting grounds within the extraction sites and this has served to increase effort in grounds nearby. This effect was noted by potters from Bembridge and Chichester. The addition of displaced vessels from outside the local area has also increased the risk of gear entanglement, in circumstances where they are not party to the understanding on the distribution of fishing effort agreed between local fishermen. Furthermore, the available catch from these grounds is being shared between an increased number of individuals. To compensate for this reduced share of the catch, individuals have increased their effort in an attempt to maintain their level of income. This increase in fishing pressure on local resources may also explain the observed declines in the abundance of brown crab reported by fishermen in the region, on the assumption that current effort exceeds its carrying capacity. In this context, any relationship between dredging and fishing success would be an indirect one.

- **Relationship between dredging activity and the distribution of angling grounds**

Charter anglers have reported that catches of smooth hound within an area traditionally fished by anglers for this species have declined to a point where this area is no longer fished. However, anglers have been able to catch this species in an area to the east. This would appear to indicate that a very localised change in the distribution of the species has occurred.

Plumb (1996) indicates that localised concentrations of smooth hound may be attributed to the presence of various prey items, including mussels, soft-shelled crabs and bass. There is some evidence to support this assertion as a mussel bed, identified in Plumb (1996), coincides with the angling area identified in this study. Analysis of the EMS records shows that a large proportion of this area has been dredged between 1993 and 2001. This may have resulted in damage to the mussel bed. Active dredging is also likely to have removed many of the benthic prey items (Boyd and Rees, 2002), which may have attracted bass to the area.

- **Potential for the exclusion of static gear fishermen from areas where dredgers operate**

Fishermen have reported that exclusion from fishing grounds in this region occurs as a result of a number of factors. These include dredging operations, vessel traffic, yachting and commercial anchorages, maritime constructions, disposal sites and other fishing methods. Some of these activities result in permanent exclusion of fishermen, whilst others are only temporary. The contribution of dredging operations must therefore be considered in addition to these other factors. The method of fishing has an important bearing on the degree to which vessels are excluded.

In common with set net fishermen, potters are very cautious when it comes to placing gear in the vicinity of dredging operations as they require a suitable period of notice in order to move their pots. For this reason, most potters appear to avoid dredged areas altogether, unless they are confident of the locality of current dredging operations within the extraction licences. Well-publicised zoning arrangements will undoubtedly help in this connection. In addition the aggregates industry have, in recent years, surrendered areas of extraction licences which are no longer required. Since 1999, although a further 65.16 km^2 of seabed was licensed on the south coast, an area of 158.62 km^2 was surrendered, resulted in an overall reduction 93.46 km^2 (Tony Murray *pers. comm.*)

Set netters from Portsmouth and Bembridge have also indicated that dredging operations have precluded access to some of their grounds. One fisherman reportedly abandoned this method of fishing, citing a combination of interference from trawlers and dredgers in explanation. However, the analysis of the overlap between the netting grounds of two interviewees and dredging shows the areas involved in 2001 were relatively small. This illustrates that a 'perceived risk' of gear damage may lead to fishermen actually avoiding much larger areas than may be necessary. Improved liaison between dredging companies and fishermen may help in this respect.

- **Relationship between dredging activity and trawling**

Exclusion from traditional trawling grounds was also a concern of trawler fishermen from across the region. Reasons for exclusion included the presence of dredging vessels on trawling grounds and changes to the topography and sediment composition of the seabed. The resulting uneven seabed affects fishing activity as it can cause snagging of long-lines and bottom trawls (Cruckshank and Hess, 1975).

Changes in the topography of the seabed attributed to dredging operations were reported, by fishermen, in areas 122/1 123 and 122/2. The length of time that trailer dredged furrows or depressions created by static dredging will remain as distinctive features on the seabed depends on the ability of tidal currents or wave action to transport or re-distribute sediments (Van der Veer *et al*., 1985; Dickson and Lee, 1972; Millner *et al*., 1977; McGarty and Reading, 1984). Erosion of dredge tracks in areas of moderate wave action and tidal currents have been observed to take between 3 and >7 years (Millner *et al*., 1977; Kenny and Rees, 1996; Boyd *et al*., 2002). In contrast, dredged depressions have been reported to remain as recognizable seabed features for a considerable time at Hastings (Shelton and Rolfe, 1973). Indeed Dickson and Lee (1973) concluded many years, perhaps amounting to decades, would be required for the seabed to revert to its pre-dredged condition. These differences in the persistence of dredge scarring are likely to influence the recovery potential of extraction sites and may have significant implications for interference with other activities such as trawling.

Another factor that was reported to affect trawling activity was a change in sediment composition as a consequence of dredging operations. Changes in sediment composition as a result of dredging are well documented in the literature (Dickson and Lee, 1972; Jones and Candy, 1981; Kenny *et al*., 1998; Jewett *et al*., 1999). Indeed, a study undertaken as part of the present research programme indicated that sediments collected within areas of intensive dredging within the Isle of Wight region contained reduced quantities of gravel in comparison with undredged areas (Boyd and Rees, 2002). Reported changes from this study included the fining of sediments in area 122/2 and the exposure of boulders east of the Isle of Wight. As infilling of dredged depressions or tracks is typically dependent on the mobilisation of fine material by tidal currents, this can result in a change of sediment composition from an admixture of sand and gravel to

finer deposits (Dickson and Lee, 1972, 1973; Shelton and Rolfe, 1972; Van der Veer *et al*., 1985; Desprez, 2000). The coarsening of sediments as a result of the exposure of underlying deposits by dredging has also previously been documented in other areas (Kenny *et al*., 1998; Jewett, *et al*., 1999).

The physical presence of dredgers within extraction licences was also highlighted as an issue affecting the displacement of fishing vessels. A number of fishermen reported that trailer suction hopper dredgers were particularly difficult to work around, as their movements were difficult to predict in comparison to static suction hopper dredgers which tend to have restricted movements whilst dredging.

The displacement of fishing activity, either as a result of changes in the distribution and abundance of targeted fish species, the nature of the seabed, or as a direct result of the presence of a dredger, can have consequences that affect many other fishermen. The location of fishing effort is determined not solely by the location of resource species but also by the availability of suitable fishing grounds. The latter is determined by the nature of the seabed and tides, weather conditions and the use of the area by other types of gear. For example, the use of towed and fixed gears in the same area is unlikely to occur. Fishermen are also limited in their range depending on the size of their vessels, primarily for reasons of safety. In the region of study, many of the vessels are limited to <14 m in length (Sussex Sea fisheries district) and <12 m (Southern Sea Fisheries district) as a result of local by-laws. Therefore, when fishermen are excluded from areas it can prove difficult to find alternative grounds. A further option is to switch fishing methods or diversify to other target species, assuming grounds are available.

5. CONCLUSIONS

- This study has documented the distribution of some fishing activity in the eastern Isle of Wight area. It has also provided an evaluation of the impact on this activity of marine aggregate extraction, both at individual licensed areas and cumulatively across all areas in the region.

- The study has revealed a general avoidance of aggregate licensed areas by static gear fishermen (set nets and pots) due to the potential for gear damage.

- The avoidance of certain areas has the effect of increasing fishing pressure on alternative grounds remote from dredging, which are accessible to small vessels. This has led to increasing concerns amongst fishermen over the sustainability of already heavily-exploited stocks in these areas.

- This study has highlighted concerns for vessel safety in relation to the increased distances offshore that some relatively small vessels (<14 m) are working and this was attributed by fishermen to be a direct consequence of displacement from extraction areas.

- Within certain extraction licences, local fishermen identified areas that had been fished prior to dredging operations and that are now avoided by trawlers as a result of changes in the nature of the seabed. The persistence of dredging-related changes (e.g. dredged tracks and depressions) will depend on local hydrographic conditions. Reduced accessibility for trawl fishing may also result in the displacement of local vessels into other areas leading to conflicts with other gear types.

- Declines in brown crab (*Cancer pagurus*) stocks were reported by fishermen from Selsey, Bembridge and Chichester. Factors which may explain this observation include (*inter alia*) over-fishing and the potential interference of the movement of crabs onto fishing grounds as a result of dredging operations. However, there is no supporting scientific evidence for this.

- Charter anglers have reported significant declines in catches of smooth hound (*Mustelus mustelus*). A large proportion (75%) of the fished area was dredged in 2001 and therefore dredging cannot be ruled out as a causative factor.

- The outcome of the present study provides a useful regional context for evaluating the future impacts of additional dredging permits on the performance and distribution of local fishing fleets, although it will be important to update this review as new information becomes available.

- Geographic Information Systems (GIS) can be used to map fishery and fishery resource areas, allowing for a more quantitative assessment of the potential impacts from future dredging licences. On a wider scale, Stocks *et al*. (2001) employed a similar approach to investigate the regional distribution of fisheries resources in relation to proposals for the extraction of marine aggregate in the eastern English Channel. The techniques described by Stocks *et al.* (2001) and those employed in the present study can also be applied to other spatially referenced datasets including the distribution of resource species and habitats and this is the subject of follow-up research funded by Defra. This will allow greater accuracy in predicting the consequences of any future expansion of dredging effort in the region.

6. ACKNOWLEDGEMENTS

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