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Study Title: Integrated Report On The Impact Of Marine Aggregate Dredging On Physical And Biological Resources Of The Seabed

Report Title: Integrated Report On The Impact Of Marine Aggregate Dredging On Physical And Biological Resources Of The Seabed – Final Report

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Project Manager: David R. Hitchcock, Ph.D.

Affiliation (Project Manager): Coastline Surveys Ltd

Address: Bridgend Farmhouse, Downton Road, Bridgend, Gloucestershire GL10 2AX, United Kingdom

Principal Investigators: David R. Hitchcock, Ph.D., Richard C. Newell, Ph.D., D.Sc., Lindsay Seiderer, Ph.D.

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Background: The project encompasses several key elements of interest to INTERMAR and the MMS's Marine Minerals Programme. Principally, the requirements for integrated information regarding the impact of benthic and surface sediment plumes, on physical and biological resources of the seabed, previously identified as a key requirement in several INTERMAR and State/Federal Task Force documents, are addressed by this project

Objectives: Overspill and, more importantly, screened and rejected material will disperse downstream and cause an impact. It is important that this is quantified. There have been many predictions of dispersion by modelling techniques and many of these have had to be modified substantially in the light of our fieldwork programmes. Assessment of the actual impact on the seabed (physical and biological) will enable correlation with the predicted dispersion of material, actual dispersion of material (footprint) and impact of settled material (footprint of significant impact, rather than any impact no matter how small).

- Does the use of ADCP techniques supported by traditional water sample characterisation still provide a best value approach to defining the gross morphology of the dispersing plume and any sub-divisions attributable to different sources and processes?

- Is there a detectable impact on the sedimentary provinces that may be caused by marine aggregate mining?

- Can high-resolution sidescan sonar mosaic imagery provide broad scale mapping at sufficient resolution to identify any impacts due to mining operations either due to changing sedimentary or biological community?

- Is there a detectable impact of marine aggregate mining on key features of benthic biological community structure including species diversity (S), population density (N), biomass (B) or body size (B/N)?

- Is there a detectable impact on community structure as assessed by non-parametric multivariate techniques?

- How far beyond the immediate limits of the dredged area do such impacts extend?

- Can any impact on community structure beyond the boundaries of the dredged area be related to 'far-field' deposition of material in the outwash?

- Are there differences in impact of anchor dredging where material is essentially exploited at one site, and trailer-dredging over a wider area?

- What is the nature and rate of the recolonisation and recovery processes in a commercially dredged area?

- Can any recommendations be made on the scale, frequency and number of samples required for cost-effective monitoring of the impact of sand and gravel mining on sea bed resources?

Description: An integrated study of the impacts of dredging on the physical and biological resources of a non-screened dredge area on the South Coast of Britain has been completed. This site has been dredged since 1991 by anchored suction dredgers and occasionally (since late 1998) by trailing suction dredgers, removing a total of nearly 2 million tonnes over that period. The gravelly resource has been extracted from a very small target area of roughly 400m x 400m, within a larger licence.

Over 350km of high-resolution sidescan sonar mapping has confirmed the areas that have been dredged by observing the extent of small pits formed on the seabed. 171 seabed samples have been obtained and the majority analysed for sedimentary and faunal analysis. The study area extended up to 10km either side of the dredge zone (one tidal excursion) in order to identify far-field effects.

Study Results: The results clearly show that the physical impact of dredging on the seabed (without screening) is limited to a zone within approximately 300m down tide of the dredge area. There is no visible evidence of suspended sediments falling to the seabed beyond this zone, which may be manifested as infilling of small pits by fine sediments, siltation within crevices or development of migratory sand ripples. However there is some statistical evidence that the surface sediment samples have a greater sand fraction within the excursion track of the plume than those samples either side.

The biological "footprint" of impact has been established. Species diversity, population density and biomass of benthic macrofauna of the study site is typical of that recorded in UK waters. Average benthic macrofauna biomass as a whole is equivalent to 4.06 grams Carbon per m2.

The studies show that dredging at anchor using a modern 2300 tonne suction dredger is associated with a reduction of species diversity of 66%, population density (87%) and biomass (80-90%) of benthic invertebrates. The deposits are loaded as an 'all-in' cargo with no discharge of screened material at this site. In this case the suppression of invertebrate species variety, population density and biomass appears confined to the dredge sites themselves, with no evidence of impact outside the boundaries of the dredge pit.

Some distance outside the dredge site, there is evidence of an enhancement of benthic diversity and biomass in an elongated 'halo', which extends for a distance of up to 3 km from the dredge site. Average benthic macrofauna biomass is equivalent to 17 grams Carbon per m2, some 4 times greater than the surrounding deposits.

Our monitoring aboard the dredge vessel determined some 17.36 tonnes ash-free dry weight of organic matter may be released per year in the outwash of dredgers operating within the restricted worked site of the much larger North Nab licence. This material is likely to be carried beyond the boundaries of the Licence Area along the axis of the tidal excursion: whether this is sufficient to account for the enhanced values of biomass 1-3km from the dredge site is unknown.

In contrast with the intensively anchor dredged site, the trailer dredged site has been exploited less intensively. Communities within this site are largely similar to those in the surrounding deposits. This suggests that the processes of recolonisation and recovery are sufficient to keep pace with the rate of removal of biomass when dredging. It must be noted that the key factor here may be intensity rather than method of dredging used.

Sites which have been left undredged for known times suggests that initial recolonisation by mobile components of the benthos can occur within weeks with some 70-80% of the species variety returning. This process is often accompanied by a similarly rapid increase in population density, although not as frequently, but with both of these stages in the recolonisation sequence being substantially completed within 3-6 months after cessation of dredging. Restoration of biomass is achieved by growth of the small individuals that recolonise the deposits. This stage is incomplete even after 18 months compared with areas some distance away from the dredge site, and this finding is in keeping with anecdotal information available from the literature.

The results for trailer-dredged studies elsewhere indicate that species diversity may initially recover much quicker, as mentioned above. Population density is not dissimilar to anchor dredge sites, with biomass recovering to within 80% of the undredged sites within 3 months.

We conclude with the following general hypothesis based on this study and another partial study carried out in the Southern North Sea on a trailer dredge study site:-

(1) The degree of suppression of the fauna in the dredge site itself is clearly dependent on the intensity of dredging. In high intensity dredging (North Nab) the suppression of population density, species variety and biomass can be as high as 60-80%. In areas that are dredged less intensively by trailer techniques, the suppression is either less than at anchor dredge areas (North Nab), or undetectable (North Sea).

(2) There is no evidence of an impact outside the immediate dredge sites.

(3) Both sites show some evidence of an enhanced biomass and population density at some distance from the dredge site, possibly reflecting the deposition of organic components from fragmented invertebrates discharged in the outwash.

(4) Recovery of population density and species variety can be very rapid indeed. This depends on the degree of disturbance to which the area is subjected under natural conditions. In shallow water wave disturbed areas such as the North Sea, colonising species are mobile and well adapted to rapid recolonisation. In more stable (equilibrium) communities such as occur on coarse rocks and cobbles, recolonisation is slower.

(5) Recovery of biomass is achieved by growth of the recolonising individuals. In this case restoration of biomass generally requires at least several years. In some of the deeper water communities that we have recently analysed, individual species may be at least 20 years old. This implies that deep-water stable equilibrium communities may require a time of at least 20 years for recovery, compared with 2-3 years in shallow water coastal sands.

(6) Anchor dredging has a significant impact on the species variety, population density and biomass of benthic macrofauna, although without screening is largely limited to within a hundred metres of the active dredged zone. Trailer dredging, on the other hand, appears to have a much lesser impact on species variety, population density and biomass, although this may be limited to the lower intensity of trailer dredging activities in the study areas. However, species recovery data suggests that recovery is quicker for trailer dredge areas, due to the reduced distance of 'inwalk' for colonising species (only the widths of trailer tracks), compared with the more substantial impact of an anchor dredged area.

(7) On the available evidence collected herein, we would suggest that trailer dredging over a wide area at an intensity carefully matched to the potential times for species recovery (indicated by the response times to natural disturbances e.g. turbulent shallow water or less disturbed deeper waters) will be more sustainable than intensively dredging small areas of seabed.

Importantly, the detailed analyses of these and other data for this project have revealed the susceptibility of analysis methods to 'noise' within the datasets. This is caused by inter-sample variability due to significant under sampling of the diverse benthic macrofauna of sands and gravels by conventional methods. We have shown that single samples of macrofauna obtained from a 'Hamon' type grab contain sufficient taxa to use non-parametric multivariate analytical techniques to define community composition. Values for individual variables, such as species variety are, however, heavily dependent on the number of replicate samples taken. At least 3 replicate samples are required to obtain a satisfactory assessment of the species composition of the macrobenthos of sands and muds, but that 13 or more replicates are required for gravels. The repercussions of this in terms of scale, frequency, density of sampling sites and number of replicate samples and subsequent cost implications must be carefully considered when designing suitable monitoring protocols.

Study Products:

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