Seabed habitats around the Isle of Man

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Executive Summary

In the first systematic survey of benthic habitats in Manx waters, substantial areas of habitats of high conservation importance have been identified. Still photographs of the seabed were analysed from most of the 154 sites visited around the Isle of Man. Preliminary cluster analysis of the seabed sediment and communities at each site revealed 7 main communities:

A. High current areas dominated by the bryozoan *Alcyonidium diaphanum* and the common star fish *Asterias rubens.*

B. Deeper water muddy substrates dominated by the burrows of Norway lobster *Nephrops norvegicus*, polychaetes with emergent tubes, and *Sagartia* spp. anemones.

C. Brittle star *Ophiothrix fragilis* beds with hydroids, polychaete tubes, hermit crabs and queen scallops.

D. Coarse substrates dominated by top shells of the genus *Gibbula* with hydroids (e.g. *Nemertesia antennina),* dog cockles (*Glycymeris glycymeris)* and hermit crabs (second most common community identified in this survey).

E. Sand and gravel substrates dominated by the brittle star *Ophiura albida*, polychaete tubes, queen scallops, hydroids and hermit crabs (the most common community identified in this survey).

F. Algal and hydroid turfs.

G. Coastal areas dominated by *Laminaria* spp. and other algal cover with hydroid turf, emergent polychaete tubes and the anemone *Anthopleura ballii*.

Three main habitats of international conservation interest were identified during the survey: horse mussel reefs, maerl beds and *Sabellaria spinulosa*, which are all OSPAR priority habitats. Individuals of the UK BAP priority species, the sea anemone, *Edwardsia timida* were also identified but formal confirmation of identification of this rare species is

awaited. Current zones proposed by DAFF to be closed to queen scallop dredging would be effective in reducing the risk of impact of queen scallop dredging on most areas of horse mussel reef and maerl beds identified. However, the current proposed zones may leave the *Sabellaria spinulosa* vulnerable to queen scallop dredge damage. Statutory protection of some of these habitats is recommended and could enhance the role of habitats such as maerl as a nursery area for queen scallops.

This preliminary analysis of the benthic survey data demonstrates the potential for this dataset to further improve the understanding and management of Manx fisheries.

Introduction

The king or great scallop *Pecten maximus* and the smaller queen scallop *Aequipecten opercularis* are highly valuable commercial species. Both species are caught using dredges, while otter trawls are also used to fish for queen scallops. Experimental and large-scale comparative studies that have quantified the effects of towed bottom-fishing gears have clearly identified that these fishing gears cause direct mortality to benthic biota leading to a reduction in diversity, abundance, biomass and production (Collie et al. 1997; Kaiser et al. 2006; Hiddink et al. 2006, Hinz et al. 2009). The magnitude of these effects will vary among different types of habitat according to the species assemblage associated with that habitat. Thus habitats composed of sensitive or long-lived organisms will be affected most severely by fishing disturbance. The recovery time of, for example, reef forming organisms and their associated fauna will be measured in periods of between 5 – 20 years or may not occur at all. At the other extreme, habitats that are subjected to frequent seasonal disturbance and periods of intense natural disturbance are associated with species that are tolerant of these environmental conditions. Examples of large-scale disturbances would include wave erosion at the seabed from winter storms (greater exposure is associated with a higher magnitude of disturbance) that would lead to the resuspension of seabed sediment and its associated fauna, resuspension of sediment by tidal currents leading to scouring of the seabed fauna and movement of sediments by currents leading to periodic smothering and death of fauna. The species that live in these habitats tend to be opportunistic species that have high growth rates, high reproductive output and frequently recruit following disturbance events. These habitats typically have low species diversity and are dominated by small-bodied fauna and ephemeral epifauna that tend to be highly mobile and are scavengers (e.g. crabs, whelks, starfish). Therefore, while scallop dredging will have a negative impact on such species, the recovery rate of these habitats and their fauna is measured in periods of less than one year (Kaiser 1998; Kaiser et al. 2002; Kaiser et al. 2006).

Accounting for the effects of fishing on critical habitats is a fundamental facet of the ecosystem approach to fisheries management (FAO 2006). TACs alone may be insufficient to mitigate the impacts of fisheries on non-target species (Reiss et al. 2010) and target species may depend, at least partially, on sensitive habitats. For instance, maerl provides a nursery ground for cod, saithe and pollack (Kamenos et al. 2004a) and queen scallops (Kamenos et al. 2004b). In particular, structurally complex habitats can increase species richness and abundance relative to spatially simpler environments (Kohn & Leviten 1976; Hunter & Sayer, 2009), provide a settlement substrate for juveniles (Kamenos et al. 2004c) and refuge from predators (Kamenos et al. 2004d; Ochwada et al. 2009; Stoner 2009).

Until recently, relatively little information existed about the distribution of benthic habitats and sensitive species around the Isle of Man, hampering progress towards a spatial management approach. In summer 2008 the School of Ocean Sciences (Bangor University) conducted a habitat survey using an underwater video and stills camera system to assess the distribution of benthic habitats.

The current report presents only preliminary results because the analysis of images and data processing is ongoing. Despite some individual stations being missing from the present dataset, most of the area surveyed has been covered by the preliminary analysis within this report. These data allow description of the main benthic communities and the location of sensitive habitats around the Isle of Man.

Method

Survey design

154 survey stations were sampled during the survey. Most stations were positioned on a sampling grid of approximately 5 km spacing between individual stations, covering the entire area from the coast of the Island up to the 12 nautical mile limit (Fig 1). Spatially more intense sampling was conducted at the Point of Ayre to determine the current extent of a known *Modiolus modiolus* reef (see Hinz et al. 2008).

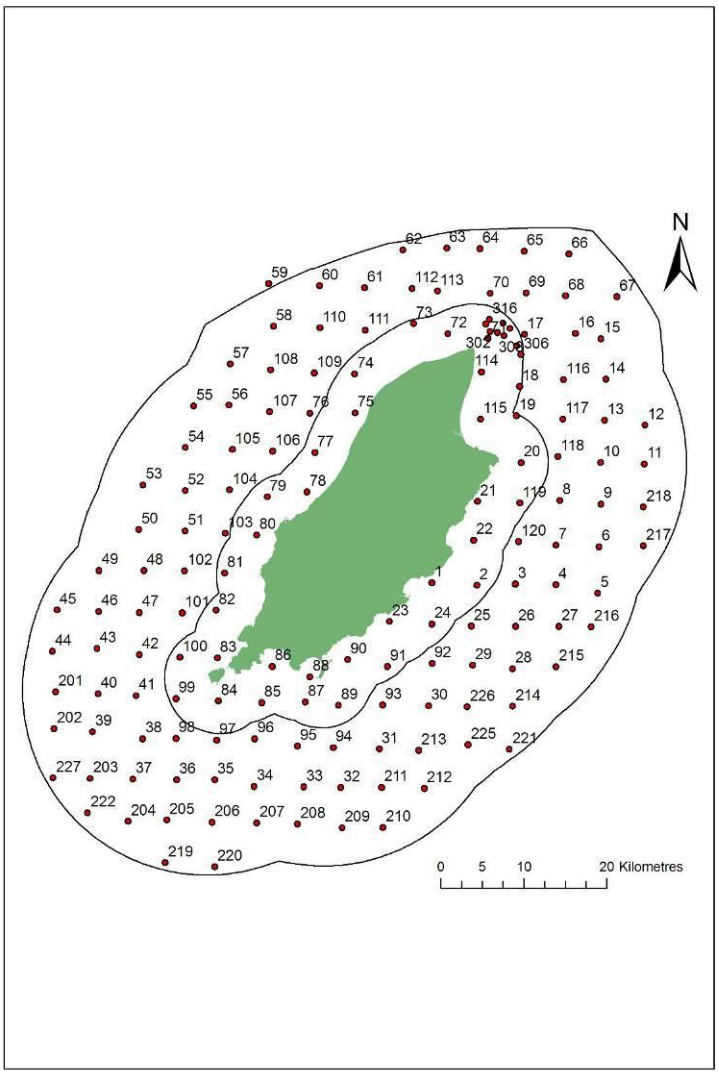

Fig 1. Location of sites sampled during the 2008 habitat survey

Video and stills camera tows

A sledge mounted video and stills camera system was deployed at each station and towed at a speed of approximately 0.5 knots for a period of 15 minutes. Start and end positions of each tow were recorded from the point the sledge had visibly reached the sea floor to the point when the sledge lifted off the seabed during hauling. While the video system delivered continuous live pictures that were recorded on DVD the digital stills camera took a high resolution (10 MP) image every 10 seconds. The field of view of the video camera covered an area of approximately $0.12m^2$ (width 0.41m x depth 0.30m). Each still image covered an area $0.194m^2$ (0.54m x 0.36m). Each 15 minute tow resulted in approximately 90 images.

Abundance of benthic organisms as well as numbers of species were determined from video recordings and still images. The results presented in this report are based on the still image analysis only. While from the video footage only larger benthic fauna could be identified and counted the still images allow a more detailed description of benthic fauna. Organisms in the still images were identified to the lowest taxonomic level possible, while organisms in the video could be identified only to family or higher ranks due to its poorer image quality.

In addition to abundance of organisms, substratum types were assessed visually as the frequency of occurrence of a certain habitat type within the still images. For this preliminary analysis, data were categorized into six main substrate categories: a) very coarse substrate (this included boulders, cobbles and pebbles) b) gravel c) sand d) fine sand to muddy sediments, maerl and e) areas dominated by shell deposits.

Currently only the video data and the first 15 images of 127 stations have been processed (1905 images). For future analysis a total of 50 images from each station will be used. At 6 stations no still images were available due to malfunctioning equipment. 20 stations still need to be analysed.

Community analysis

Benthic community composition as identified from the still photographic images was analysed using multivariate statistics PRIMER v6 (Clarke & Gorley 2006). Prior to analysis the data were standardised to 15 still images per tow. A square root transformation was applied to the data to down-weight the influence of extreme abundance records that occurred at a relatively small number of stations. A similarity matrix of the standardised community data was calculated using the Bray-Curtis index of similarity for each pair-wise combination of sampled sites. A cluster analysis was then performed to generate a dendrogram to indicate potentially significantly different groups of sites based on their community composition. Significantly different clusters were ascertained using the SIMPROF randomisation permutation procedure. A multidimensional scaling ordination plot was then generated to visualise the relationship among sites and groups identified by the SIMPROF procedure. To identify characteristic species that most contributed to the similarity of station groups SIMPER analysis was used. The distributions of both sensitive and target species were plotted within a GIS to determine any overlap.

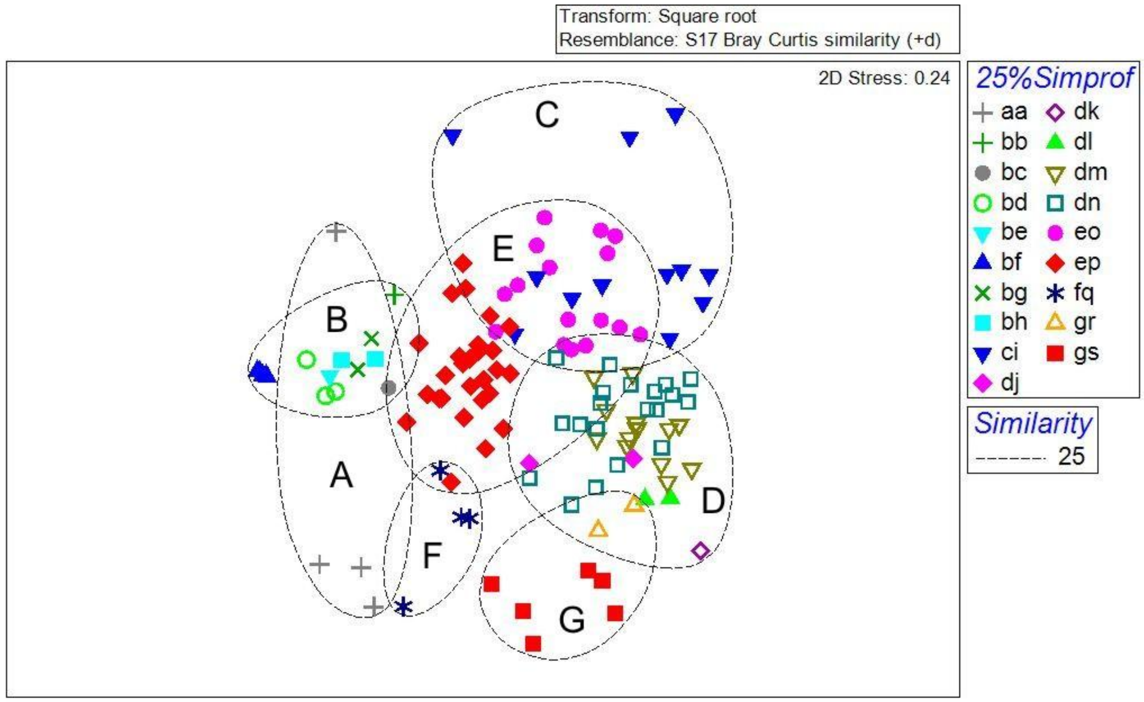

Fig 2. Station groups as indentified by the SIMPROF and represented by different symbols and at a 25% similarity level.

Results

Community analysis

The cluster analysis with the SIMPROF routine identified 18 significant groupings of station groups at different similarity levels (Fig 2). However, to make the data accessible and to describe the more general pattern of community distribution around the Isle of Man a similarity level of 25% was chosen to delineate station groups. The seven identified station groups (A-G) were subsequently analyzed with the SIMPER routine to identify characteristic species that contributed most to the similarity of these groups (Table 1). The identified clusters were visualized within a GIS to describe the distribution of identified communities around the Isle of Man (Fig 3). Future work will aim to classify the communities and substratum types into biotope categories which are used by internationally recognized conservation agencies (i.e. EUNIS/JNCC).

Stations of group (A) were located mainly to the north of the Island (Fig. 3) where tidal current velocities are high. This station group consisted of 4 stations that were dominated by two species; the gelatinous bryozoan *Alcyonidium diaphanum* and the common star fish *Asterias rubens* (Table 1).

Station group (B) was composed of 16 stations located in the main to the south west of the Island in deeper waters over muddy substrate (Fig. 3). Four stations of this grouping were also found to the north east of the Island. This community was dominated by burrows most likely belonging to the Norway lobster *Nephrops norvegicus* and polychaetes. Additionally, emergent polychaete tubes were visible and an anemone species of the genus *Sagartia* was present (Table 1).

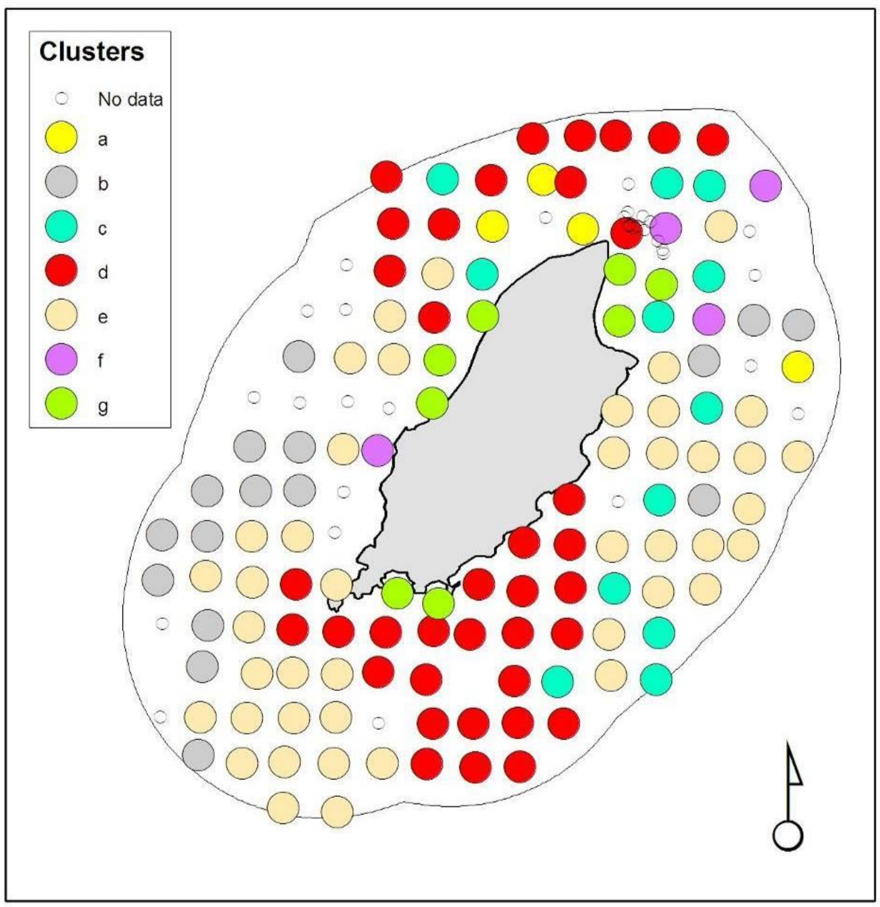

Fig 3. Map showing the distribution of benthic communities at a similarity level of 25% identified by cluster analysis.

14 stations were identified for station grouping (C). Most stations were found among other station groups in the north east, north west and south east of the Isle of Man (Fig. 3). The stations were dominated by the brittle star *Ophiothrix fragilis* forming dense beds. In addition, hydroids and polychaete tubes and hermit crabs (*Pagurus* spp.) were abundant. The queen scallop *Aequipecten opercularis* was also found to be an important species characterizing this habitat (Table 1).

Station group (D) formed the second largest cluster with 37 stations. Stations of this cluster were found in more discrete areas to the north west and south east of the Island over coarse substrates (Fig. 3 and 4). Top shells of the genus *Gibbula* dominated these areas together with hydroids including the species *Nemertesia antennina*. Furthermore, the dog cockle *Glycymeris glycymeris* and hermit crabs *Pagurus* spp. were characteristic for this station group (Table 1).

Stations of group (E), the largest cluster consisting of 43 stations, were located over sandy and gravelly substrates to the east and south west of the Island (Fig. 3 and 4). These stations were dominated by the brittle star *Ophiura albida*, tubes of polychaetes, and *Aequipecten opercularis*. Hydroids and hermit crabs were also found to be characteristic species of this station group (Table 1).

Station group (F) consisted of only 4 stations located among other station groups to the west and north east of the Island (Fig. 3). This community was dominated by algal and hydroid turfs (Table 1).

Group (G), with 8 stations, was found in the near coastal areas around the Island (Fig. 3) and dominated by *Laminaria* spp. and algal cover. Moreover, hydroid turf, emergent tubes and the anemone *Anthopleura ballii* were characteristic for this station group.
(Table 1).

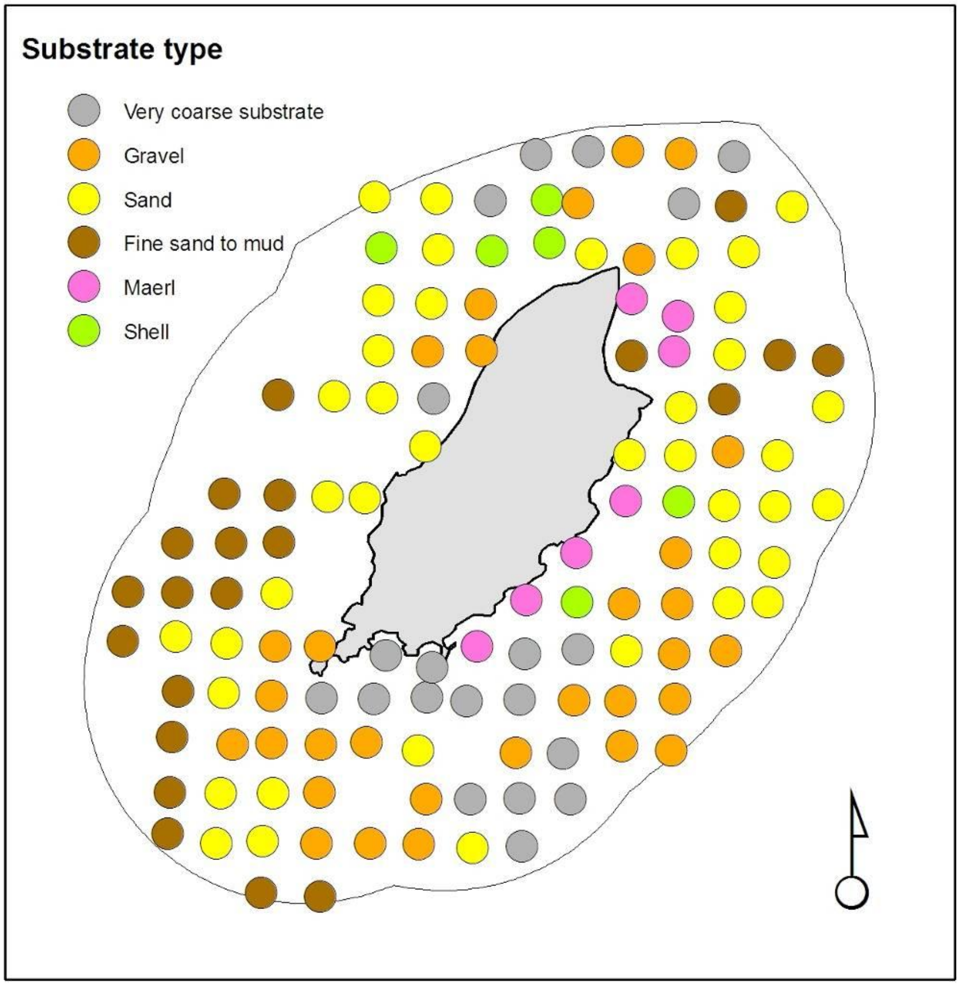

Fig 4. Distribution of dominant substrate types identified from still images.

Table 1. SIMPER analysis showing the characteristic species of individual clusters indentified at a similarity level of 25%. Number of stations in each group in brackets. Continued on next page.

Group A (4)
Average similarity: 7.80

Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Alcyonidium diaphanum	1.47	4.22	0.41	54.11	54.11
Asterias rubens	0.5	3.58	0.41	45.89	100

Group B (16)
Average similarity: 51.21

Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Burrow	8.52	42.19	1.93	82.38	82.38
Emergent tube	1.85	3.53	0.7	6.89	89.27
Sagartia sp.	2.91	2.92	0.34	5.7	94.98

Group C (12)
Average similarity: 40.54

Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Ophiothrix fragilis	23.47	30.69	2.13	75.68	75.68
Hydroida unid.	1.91	2.07	0.9	5.11	80.8
Pagurus sp.	1.76	1.15	0.79	2.85	83.64
Emergent tube	1.27	0.88	0.58	2.18	85.82
Aequipecten opercularis	0.78	0.79	0.52	1.96	87.78

Group D (37)
Average similarity: 32.13

Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Gibbula sp.	2.93	6.9	1.61	21.47	21.47
Hydroida unid.	2.97	5.49	1.52	17.09	38.56
Glycymeris glycymeris	2.53	3.04	0.52	9.45	48
Pagurus sp.	1.11	1.76	0.91	5.47	53.47
Nemertesia antennina	1.24	1.59	0.68	4.96	58.43

Table 1 continued.

Group E (43)					
Average similarity: 30.21					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Ophiura albida	2.72	4.98	0.91	16.47	16.47
Emergent tube	2.07	4.94	0.96	16.35	32.82
Aequipecten opercularis	2.06	3.92	0.95	12.97	45.79
Hydroida unid.	1.71	3.84	1.04	12.7	58.48
Pagurus sp.	1.1	2.69	0.69	8.9	67.38
Burrow	1.4	2.59	0.59	8.58	75.96

Group F (4)					
Average similarity: 35.43					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Algae unid.	2.95	27.44	2.8	77.44	77.44
Hydroida unid.	1.16	5.98	0.83	16.86	94.3

Group G (8)					
Average similarity: 38.37					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Algae unid.	14.26	19.84	2.02	51.71	51.71
Laminaria sp.	7.12	6.22	0.87	16.22	67.94
Hydroida unid.	2.06	1.88	0.96	4.91	72.85
Emergent tube	1.25	1.38	1.02	3.6	76.45
Anthopleura ballii	1.46	1.07	0.49	2.79	79.24

Distribution of sensitive habitats and species

In this preliminary survey, three main habitats of conservation interest have been identified within the 12 nautical mile limit of the Isle of Man: a) Horse mussel beds b) Maerl beds and c) *Sabellaria spinulosa* (see Figure 1). These habitats have been identified by both UK national and international conservation plans, BAP and OSPAR respectively. Reefs including horse mussel reefs and *Sabellaria* reefs are also EU Habitats Directive features of interest. All three habitats represent biogenic habitat that are known to be vulnerable to fishing impacts (Kaiser et al. 2006). Additional habitats of national and international conservation interest are known to occur, for example eelgrass beds (*Zostera marina*), but they cover relatively small areas and were not detected in this survey.

Furthermore, the burrowing anemone *Edwardsia timida,* a UK BAP priority species, was identified at stations within this survey. The correct identification of this species has yet to be confirmed and the data presented for this species should therefore be viewed with respect to this uncertainty.

Horse mussel beds (**Modiolus modiolus*****)***

The horse mussel *Modiolus modiolus* can form dense beds from the shallow sublittoral to more than 100 m depth, often in moderately tide-swept areas (Rees 2009). Although this species is widespread in UK waters, dense beds or reef are less common. Predation from crabs and starfish on small *M. modiolus* individuals may be intense but refuge from predators is obtained once animals reach a larger size (Seed & Brown 1978). *M. modiolus* individuals over 25 years old are not untypical (Seed & Brown 1978; Anwar et al. 1990). Spawning success of *M. modiolus* is strongly temperature-dependent (Brown 1984) and thus may be irregular. *M. modiolus* beds harbour a diverse epifauna (Rees et al. 2008; Sanderson et al. 2008) and may be an important feeding and nursery area for demersal fish. Due to the longevity of this species, its reef building capacity and its sporadic recruitment it is vulnerable to dredging and trawling impacts.

M. modiolus has been located at several sites around the Isle of Man in addition to the known *M. modiolus* reef at the Point of Ayre (Hinz et al. 2008). While at most stations only low abundances were recorded, a fully developed reef with a highly diverse associated fauna was identified south of Douglas (Station 23, see Fig 5). Fishing intensities thus far have been relatively low within areas in which *M. modiolus* are present (Fig 8, 9 and 10), which is probably related to the low abundance of scallops within these areas. The *M. modiolus* reef south of Douglas appeared to be in good condition suggesting that it had not yet been impacted by fishing. However, due to the relatively high level of fishing activity close to the area (Fig 10) this reef may be vulnerable to accidental damage.

Maerl beds

Maerl is a general term used to describe several species of free-living coralline red algae including *Lithothamnion corallioides*, *L. glaciale* and *Phymatolithon calcareum*. Maerl forms beds that are high in biodiversity (Kamenos et al. 2003). Due to the fragility of maerl the beds are easily damaged, which can affect the associated fauna. Bivalve dredging has been identified as the major threat to these habitats and their associated fauna (Hall-Spencer & Moore, 2000; Hall-Spencer et al. 2003). However, it is important to note that limited dredging on maerl beds does not necessarily lead to the elimination of this habitat (Hall-Spencer et al. 2003).

Maerl has been identified as an important settlement substrate for juvenile queen scallops (Kamenos et al. 2004c). There are extensive maerl beds in the eastern coastal area of the Isle of Man in depths of approximately 20-30 m (Fig 6). The status of these maerl beds has not yet been formally assessed with respect to live maerl and associated fauna. Some high quality patches of maerl have been detected in surveys of Ramsey Bay in 2008 (Murray et al. 2009). However, in general the maerl appears not to be in a pristine state as the area is an active fishing ground for great and queen scallops and has been for many years. Ramsey Bay is currently closed to dredging for the great scallop and will fall within the queen scallop conservation zone. Any mitigating measures within this area should enable some improvement in environmental status of the maerl in future and may also improve the capacity for Manx maerl beds to act as settlement grounds and nursery areas for commercially important species, including queen scallops.

Sabellaria spinulosa

The tube-building polychaete worm *Sabellaria spinulosa* commonly occurs individually but may also form colonies and reefs (Wilson 1974; Holt et al. 1998; Hendrick & Foster-Smith 2006). *S. spinulosa* reefs may rise over 30 cm above the surrounding seabed (Holt et al. 1998) and harbour a diverse faunal assemblage (Barrio Froján et al. 2008). *Sabellaria* reefs are highly sensitive to trawling and dredging impacts. In the German Wadden Sea this species formed an important habitat for a wide range of associated species, which due to the intensive beam trawling in the area since the beginning of the 20th century have been completely lost (Riesen & Reise 1982). While this species has been reported from various areas around the UK, established reefs are relatively rare (Holt et al. 1998).

Sabellaria spinulosa has been recorded at three sites around the Isle of Man located in the south close to the 12 nautical mile limit (Fig 7, Stations 205, 219 and 221). At Stations 205 and 219 this species occurred over fine sand in high abundances and with associated epibenthic fauna such as dead man's fingers (*Alcyonium digitatum*). Due to the presence of well established emergent epifauna these *Sabellaria* aggregations seem not to be ephemeral structures as reported from other areas. The location of *S. spinulosa* coincides with high abundances of *Aequipecten opercularis* (Fig 11). Past fishing effort of the dredged queen scallop fishery shows that this area is currently being used as a fishing ground. As the proposed no-dredge zone to date does not include this area (see Fig 7) the *S*. *spinulosa* may be degraded by dredging and trawling if no protective measures are put into place.

The burrowing anemone *Edwardsia timida*

Edwardsia timida, a small burrowing anemone, has been listed as a priority species for conservation within the BAP. This species appears to be relatively rare within UK waters (UK BAP, 2009) and has been reported only from the north west of the UK. Areas with previous sightings of this species include the south of the Isle of Man (Calf of Man). Little is known about the vulnerability of this species to dredging and trawling activities but it can be expected to have similar vulnerability to other burrowing anemones. *Edwardsia timida* has been recorded at various locations around the Island with one hot spot to the south of the Island (Fig 11). However, due to the size of the animal the identification of this species is difficult from still images and some uncertainty exists about the correct identification. It can easily be confused with other similar species of anemones and the sightings around the Isle of Man therefore need to be verified by an expert.

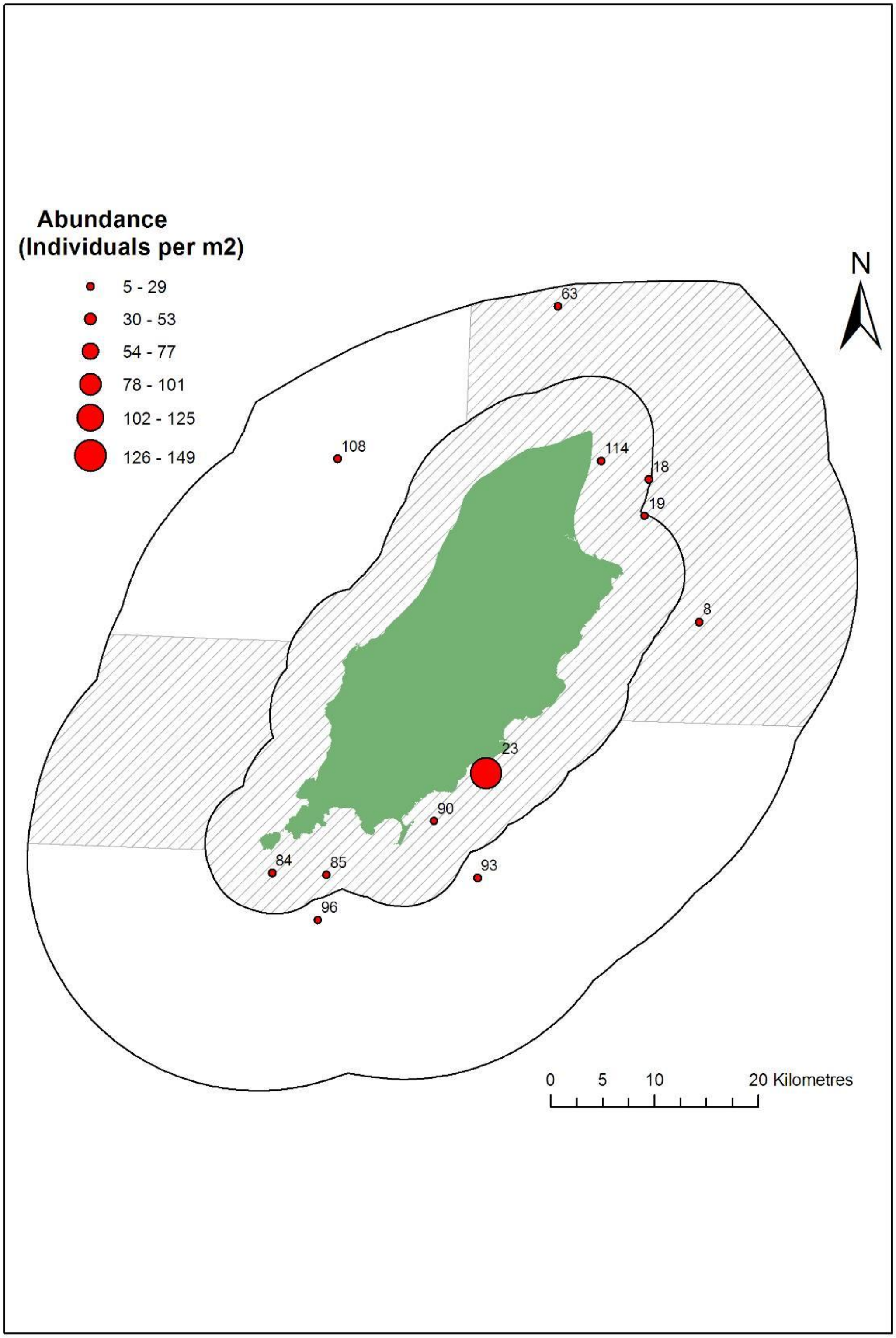

Fig 5. Distribution and abundance of *Modiolus modiolus* within still images analyzed. Shaded area represents the no dredge zone proposed by DAFF.

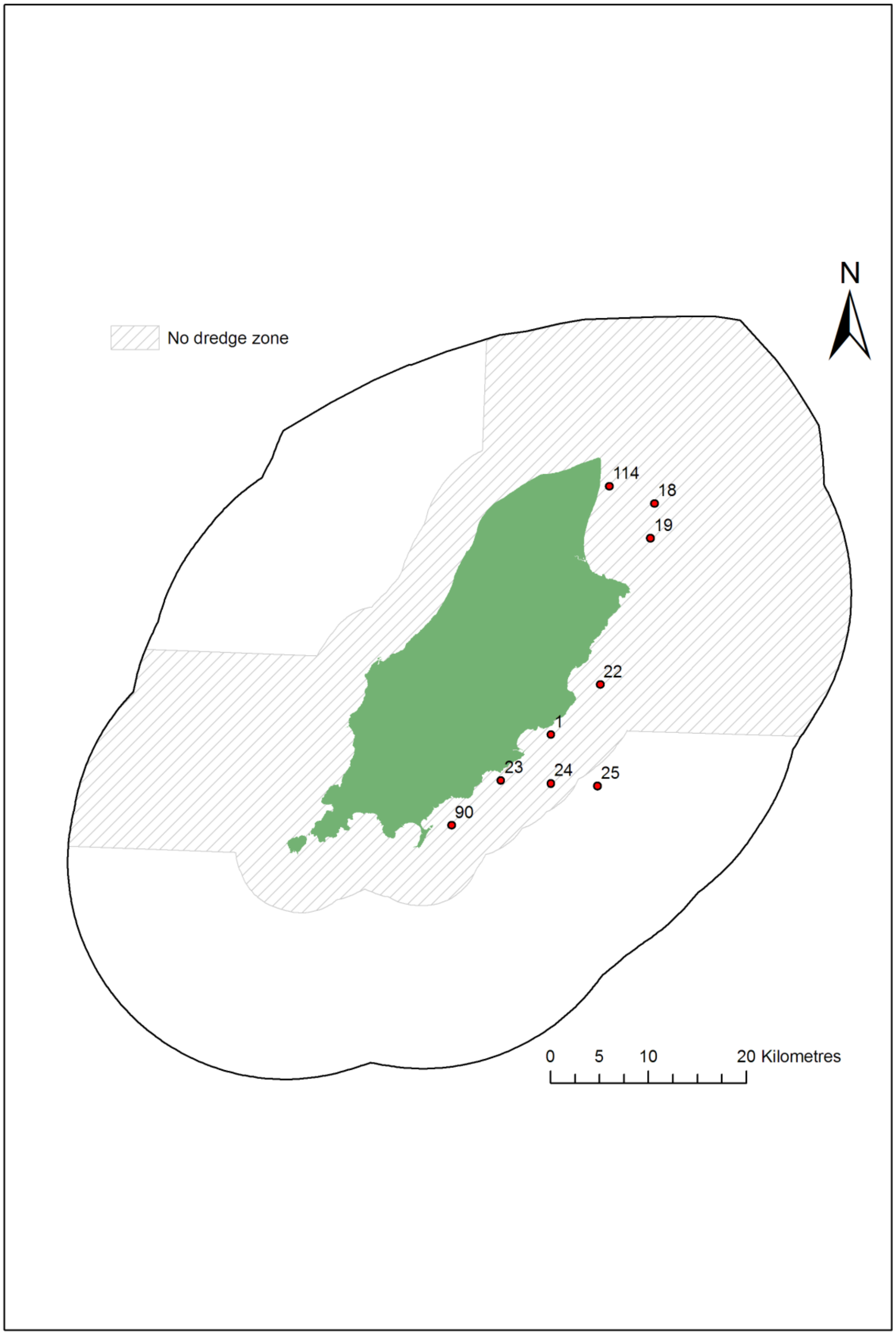

Fig 6. Presence of live maerl within still images analyzed. Shaded area represents the no dredge zone proposed by DAFF.

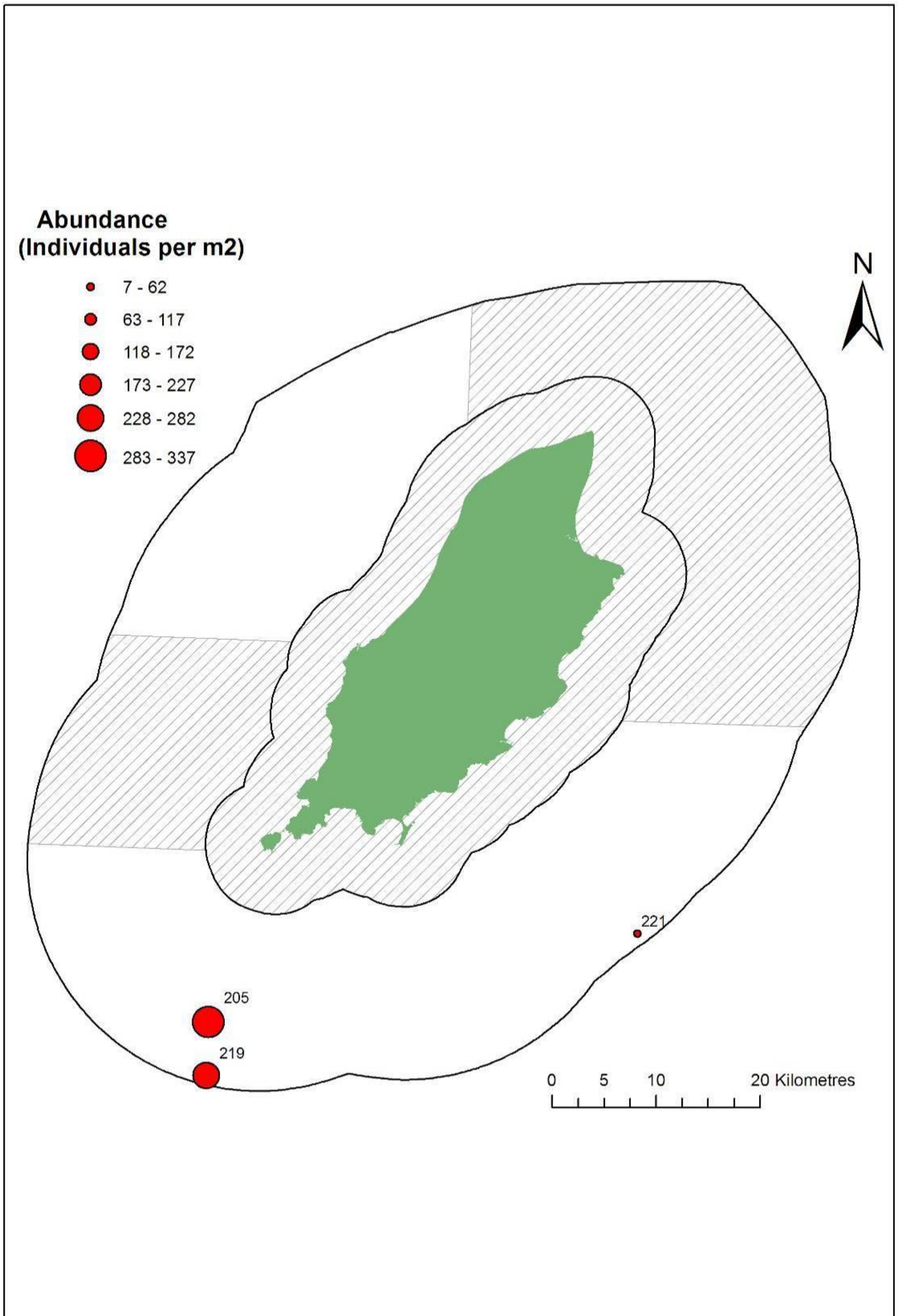

Fig 7. Distribution and abundance of *Sabellaria spinulosa* within still images analyzed. Shaded area represents the no dredge zone proposed by DAFF.

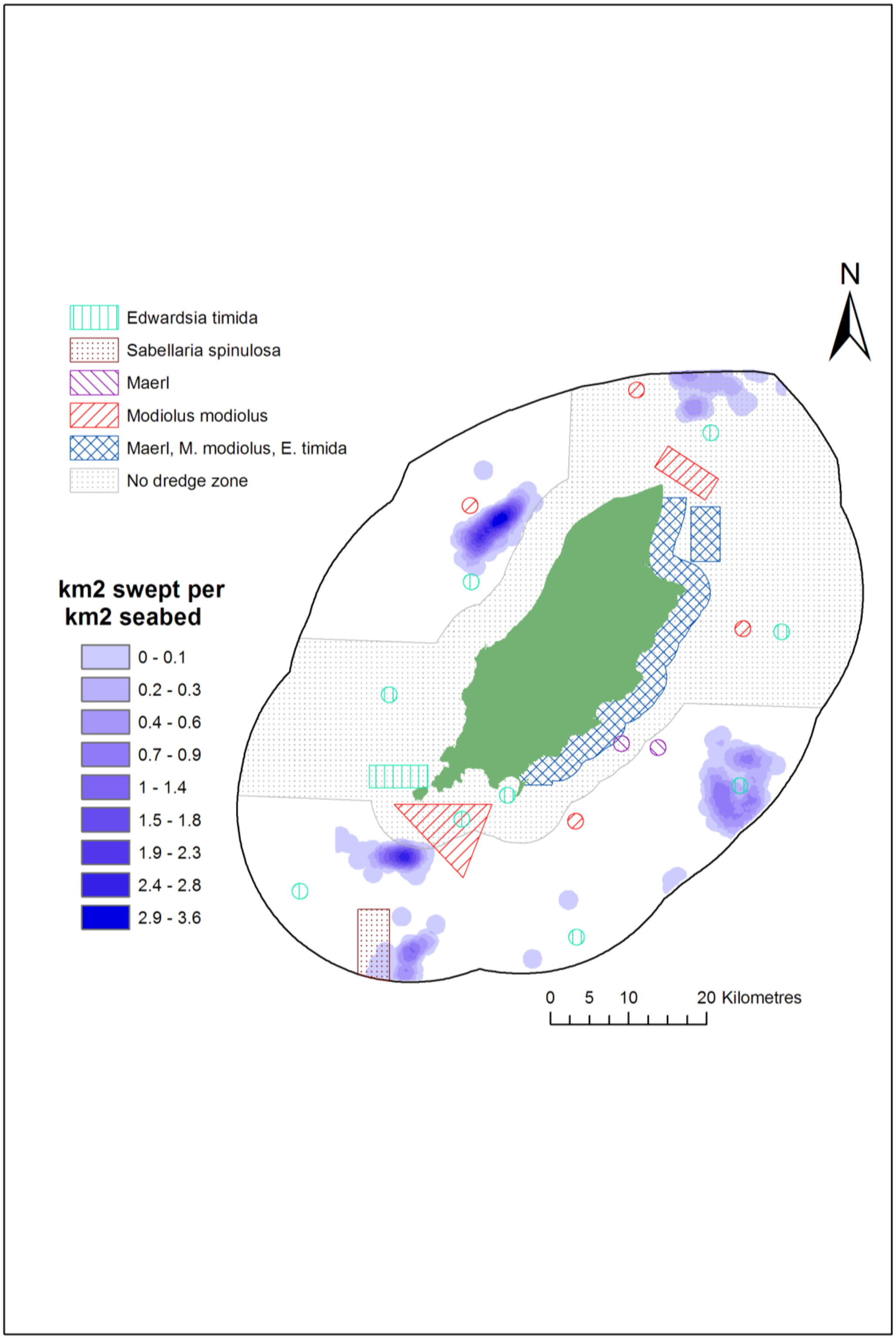

Fig 8. Estimate of areas dredged for queen scallops between November 2007 and October 2008. General areas containing species of conservation importance are shown. Shaded area represents the no dredge zone proposed by DAFF.

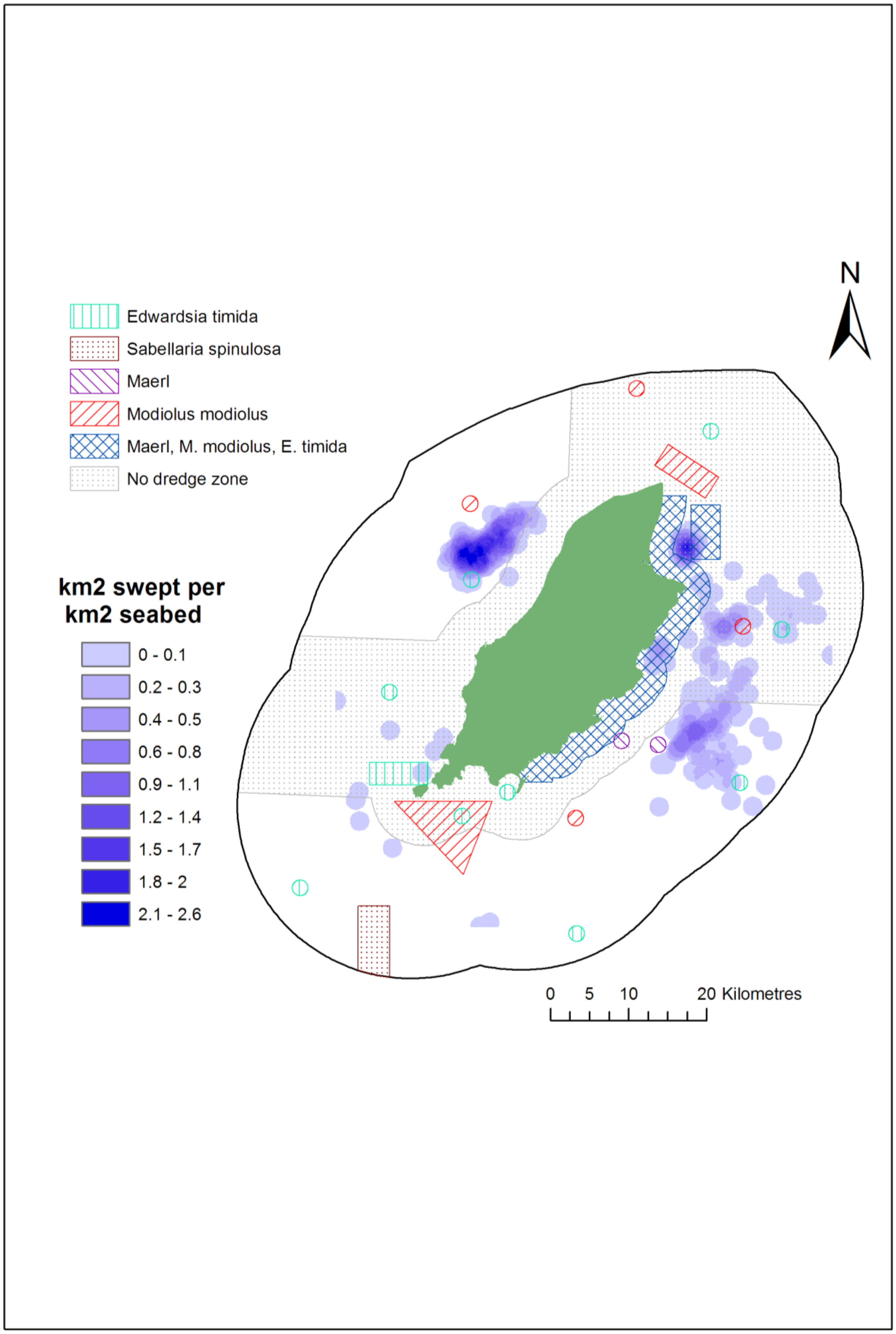

Fig 9. Estimate of areas trawled for queen scallops between November 2007 and October 2008. General areas containing species of conservation importance are shown. Shaded area represents the no dredge zone proposed by DAFF.

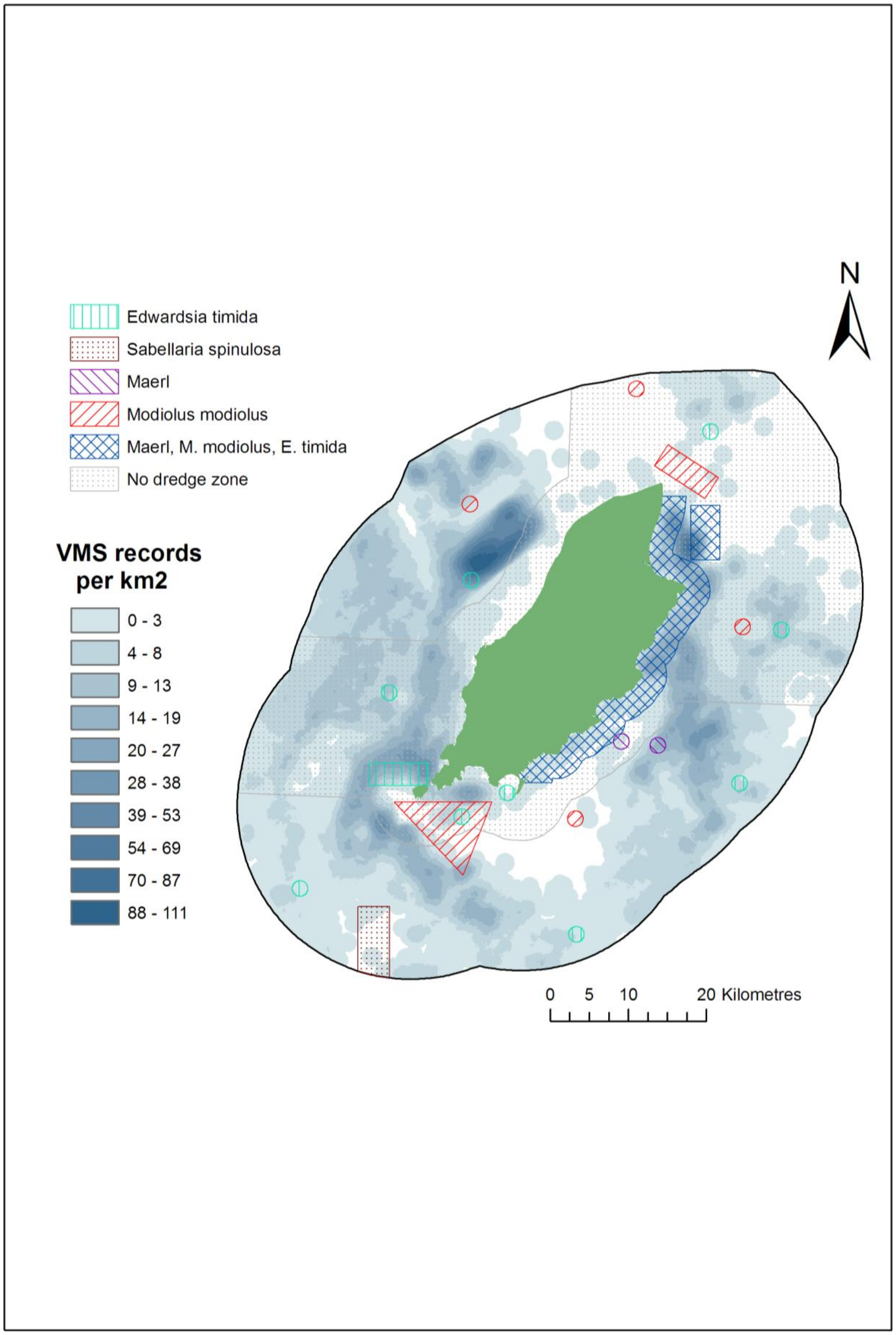

Fig 10. All fishing activity between August 2007 and July 2008. General areas containing species of conservation importance are shown. Shaded area represents the no dredge zone proposed by DAFF

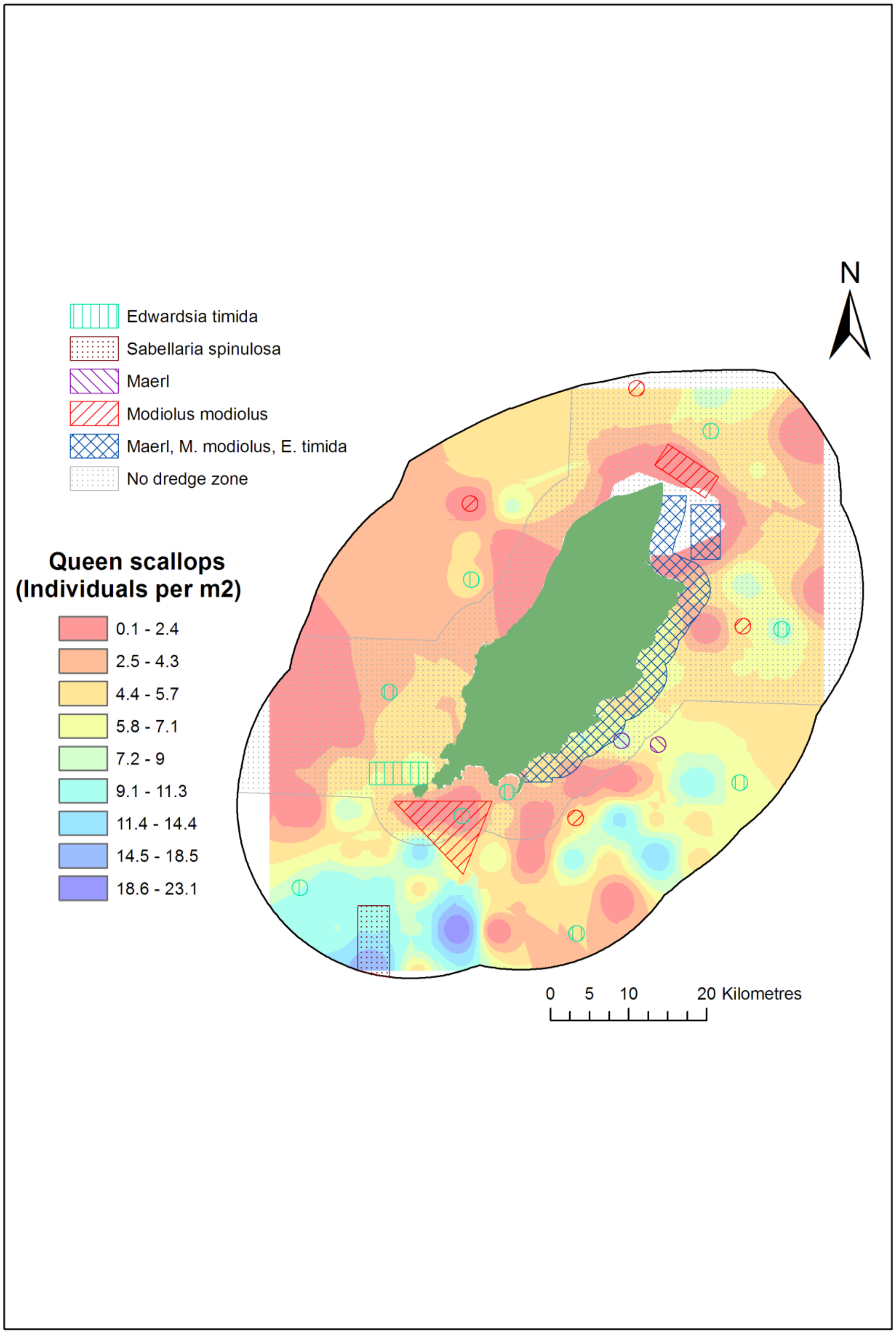

Fig 11. IDW interpolated density of queen scallops. General areas containing species of conservation importance are shown. Shaded area represents the no dredge zone proposed by DAFF.

Conclusions

The analysis of the survey data collected and processed thus far indicates that the Isle of Man has a variety of distinct benthic habitats and associated communities. Some of the habitats identified have special conservation status in the UK and internationally. Horse mussel beds, *Sabellaria spinulosa* reefs and maerl beds are biogenic habitats that have special conservation status within the UK's Biodiversity Action Plan (BAP) and the OSPAR convention, which the Isle of Man is party to via the UK. The Isle of Man possesses several areas that harbour these habitats, none of which are protected under conservation designations. All three habitats are vulnerable to dredging and trawling activities. From the distribution of previous fishing effort and populations of *Aequipecten opercularis* it is apparent that fishing activity may impact on these biogenic habitats.

Of scallop dredging, beam trawling and otter trawling, scallop dredging tends to have the greatest negative impact on habitats, and otter trawling the least (Kaiser et al. 2006). Therefore, the proposed dredging ban for queen scallops would mitigate some pressure on these habitats. While the horse mussel beds to the north of the Isle of Man are not located within traditional fishing grounds, areas to the south are directly exposed to fishing activities, which historically has led to the degradation of these habitats (Veale et al. 2000). A pristine horse mussel reef with a rich associated fauna of soft corals and sponges has been located close inshore south of Douglas. Densities of live horse mussels at this site were an order of magnitude higher than those found at most other sites on the survey. Presently, the site is still vulnerable to accidental damage from trawling and scallop dredging. Therefore, to ensure the conservation of this habitat the prohibition of dredging and trawling, in addition to a number of other activities, in this area would be necessary.

The *Sabellaria spinulosa* identified by this survey is located within an area of high queen scallop densities. Thus there is the potential for this habitat to be damaged or destroyed by dredging. *S. spinulosa* can occur ephemerally, therefore it is recommended that monitoring of this site is maintained, in addition to further analysis of the existing images. Past fishing effort has been located within this area, which may have already degraded the status of the site. The area currently lies outside the proposed dredging ban and the habitat is at risk from dredging impacts. While trawling is a less damaging fishing activity than dredging it could still lead to degradation of the site. There is no statutory protection for *S. spinulosa* reefs in the UK, although the feature may be represented in other Annex I habitats. Similar to the horse mussel bed, full protection of would be desirable to help ensure the survival of this habitat. It is important to note that the inclusion of *S. spinulosa* in the EC habitats directive (Council Directive 92/43/EEC) refers explicitly to reefs. A detailed reef quality classification system was presented by Hendrick and Foster-Smith (2006) including factors such as longevity, tube density, tube height, extent and species richness and diversity indices. Based on the study by Hendrick and Foster-Smith (2006), Gubbay (2007) presented possible values to allow the classification of *S. spinulosa* reef quality based on elevation, extent and patchiness. Although the *S. spinulosa* observed in the present study would appear to meet these criteria of reef status, the criteria and values are not well established. Further analysis will be necessary to confirm the reef quality status of *S. spinulosa*.

The maerl beds around the Isle of Man have been a traditional trawling ground for decades and appear not to be in a pristine state. Live maerl was visible at all sites; however, a rich associated fauna was not apparent. This may be the result of the sampling methodology used as many organisms are cryptic, living interstitially between the maerl, or a result of fishing impacts. The maerl beds lie within the proposed dredging ban area and any reduction in damaging activity may have a positive effect on this habitat. To improve the environmental status of this habitat further mitigation measures would be desirable. Full protection of a significant area of maerl habitat from trawling and dredging may allow the habitat to begin recovery, increasing live maerl cover and therefore the habitat's important role in the life histories of commercial species.

In addition to the described biogenic habitats, a species of anemone *Edwardsia timida,* which has been listed as a priority species for conservation within BAP, has been identified around the Isle of Man. However, due to uncertainties related to the correct identification from still images a formal assessment for this species can yet not be made.

Overall, it is recommended that to ensure the survival of these vulnerable habitats, further mitigation measures need to be put in place. Spatial management should allow the coexistence of both viable fisheries and the long-term survival of vulnerable biogenic habitats. Based on the information presented in this report, statutory protection of some of the best examples of biogenic reefs identified in this survey would have limited impact on queen scallop and great scallop fisheries and could bring significant benefits to habitat quality and ecosystem services and support the Isle of Man's compliance with international conventions such as OSPAR.

References

Anwar, N.A., Richardson, C.A., Seed, R. (1990) Age determination, growth rate and population structure of the horse mussel *Modiolus modiolus.* Journal of the Marine Biological Association of the United Kingdom 70:441– 457

Barrio Froján, C.R.S., Boyd, S.E., Cooper, K.M., Eggleton, J.D. & Ware, S. (2008) Long-term benthic responses to sustained disturbance by aggregate extraction in an area off the east coast of the United Kingdom. Estuarine, Coastal and Shelf Science 79: 204 – 212

Brown, R.A. (1984) Geographical variations in the reproduction of the horse mussel, *Modiolus modiolus* (Mollusca, Bivalvia). . Journal of the Marine Biological Association of the United Kingdom 70:441– 457

Clarke, K.R. & Gorley, R.N. (2006) User manual/tutorial Primer V.6. Plymouth

Collie, J. S., Hall, S.J., Kaiser, M.J. and Poiner, I.R. (2000). A quantitative analysis of fishing impacts on shelf-sea benthos. *Journal of Animal Ecology* **69**: 785-798.

FAO (2006) Putting into practice the ecosystem approach to fisheries. Rome, Food and Agriculture Organization of the United Nations.

Gubbay, S. 2007. Defining and managing *Sabellaria spinulosa* reefs: report of an inter-agency workshop 1-2 May, 2007. Joint Nature Conservation Committee Report No. 405 22pp. JNCC, Peterborough. ISSN 0963-8091

Hall-Spencer, J.M. & Moore, P.G. (2000) Scallop dredging has profound, long-term impacts on maerl habitats. ICES Journal of Marine Science 57: 1407 - 1415

Hall-Spencer, J.M., Grall, J., Moore, P.G. and Atkinson, R.J.A. (2003) Bivalve fishing and maerl-bed conservation in France and the UK – retrospect and prospect. Aquatic Conservation: Marine and Freshwater Ecosystems 13: S33 – S41

Hendrick, V.J. & Foster-Smith, R.L. (2006) *Sabellaria spinulosa* reef: a scoring system for evaluating 'reefiness' in the context of the Habitats Directive. Journal of the Marine Biological Association of the United Kingdom 86: 665-677

Hiddink, J.G., Jennings, S., Kaiser, M.J., Queiros, A.M., Duplisea, D.E. and Piet, G.J. (2006) Cumulative impacts of seabed trawl disturbance on benthic biomass, production, and species richness in different habitats. Canadian Journal of Fisheries and Aquatic Sciences, 63: 721-736

Hinz, H., Murray, L. & Kaiser, M.J. (2008) Side-scan-sonar survey of the Horse mussel (*Modiolus modiolus*) beds off the Point of Ayre (August 2008). Fisheries & Conservation report No. 4, Bangor University. pp. 19

Hinz, H., Prieto V. and Kaiser, M.J. (2009) Trawl disturbance on benthic communities: chronic effects and experimental predictions. Ecological Applications 19 (issue 3) pp 761-73

Holt, T.J., Rees, E.I., Hawkins, S.J. & Seed, R. (1998). Biogenic reefs: An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science (SAMS). UK Marine SACs Project. 169 pp.

Hunter, W.R. & Sayer, M.D.J. (2009) The comparative effects of habitat complexity on faunal assemblages of northern temperate and natural reefs. ICES Journal of Marine Science 66: 691 – 698

Kaiser, M.J. 1998. Significance of bottom-fishing disturbance. Conservation Biology, 12: 1230-1235

Kaiser, M.J. and Spencer, B.E. 1996. The effects of beam-trawl disturbance on infaunal communities in different habitats. Journal of Animal Ecology 65: 348–358.

Kaiser, M.J., Clarke, K.R., Hinz H., Austen, M.C.V., Somerfield, P.J., & Karakassis, I. (2006) Global analysis and prediction of the response of benthic biota and habitats to fishing. Marine Ecology Progress Series 311: 1-14

Kaiser, M.J., Collie, J.S., Hall, S.J., Jennings, S. & Poiner, I.R. (2002) Modification of marine habitats by trawling activities: prognosis and solutions. Fish and Fisheries 3: 114-136.

Kamenos, N.A., Moore, P.G. & Hall-Spencer, J.M. (2003). Substratum heterogeneity of dredged vs un-dredged maerl grounds. Journal of the Marine Biological Association of the United Kingdom 83: 411 – 413

Kamenos, N.A., Moore, P.G. & Hall-Spencer, J.M. (2004a) Small-scale distribution of juvenile gadoids in shallow inshore waters; what role does maerl play? ICES Journal of Marine Science 61: 422 – 429

Kamenos, N. A., Moore, P.G. & Hall-Spencer J.M. (2004b). Nursery-area function of maerl grounds for juvenile queen scallops *Aequipecten opercularis* and other invertebrates. Marine Ecology Progress Series 274: 183–189

Kamenos, N.A., Moore, P.G., Hall-Spencer, J.M. (2004c). Attachment of the juvenile queen scallop (*Aequipecten opercularis* (L.)) to maerl in mesocosm conditions; juvenile habitat selection. Journal of Experimental Marine Biology and Ecology 306:139 – 155

Kamenos, N. A., Moore, P.G. and Hall-Spencer, J.M. (2004d) Maerl grounds provide both refuge and high growth potential for juvenile queen scallops (*Aequipecten opercularis* L.) Journal of Experimental Marine Biology and Ecology 313: 241-254.

Kohn, A.J. & Leviten, P.J. (1976) Effect of habitat complexity on population density and species richness in tropical intertidal predatory gastropod assemblages. Oecologia 25: 199 – 210

Murray, L.G., Hinz, H. & Kaiser, M.J. (2009) The Isle of Man *Aequipecten opercularis* Fishery: Science and Management. Fisheries & Conservation report No. 10, Bangor University. pp.33.

Ochwada, F., Loneragan, N.R., Gray, C.A., Suthers, I.M. and Taylor, M.D. (2009) Complexity affects habitat preference and predation mortality in postlarval *Penaeus plebejus*: implications for stock enhancement. Marine Ecology Progress Series 380: 161 – 171

Rees, I. (2009) Assessment of *Modiolus modiolus* beds in the OSPAR area JNCC/OSPAR Commission. 22 pp.

Rees, E.I.S., Sanderson, W.G., Mackie, A.S.Y. & Holt, R.H.F. (2008) Small-scale variation within a *Modiolus modiolus* (Mollusca: Bivalvia) reef in the Irish Sea. III. Crevice, sediment infauna and epifauna from targeted cores. Journal of the Marine Biological Association of the United Kingdom 88:151 – 156

Reiss, H., Greenstreet, S.P.R., Robinson, L., Ehrich, S., Jørgensen, L.L., Piet, G.J. & Wolff, W.J. (2010) Unsuitability of TAC within an ecosystem approach to fisheries: An ecological perspective. Journal of Sea Research 63: 85 – 92

Riesen, W. & Reise, K. (1982) Macrobenthos of the subtidal Wadden Sea: revisted after 55 years. Helgolander Meeresuntersuchungen 35: 409 - 423

Sanderson, W.G., Holt, R.H.F., Kay, L., Ramsay, K., Perrins, J., McMath, A.J. & Rees, E.I.S. (2008) Small-scale variation within a *Modiolus modiolus* (Mollusca: Bivalvia) reef in the Irish Sea. II. Epifauna recorded by divers and cameras. Journal of the Marine Biological Association of the United Kingdom 88:143 – 149

Seed, R. & Brown, R.A. (1978) Growth as a strategy for survival in two marine bivalves, *Cerastoderma edule* and *Modiolus modiolus.* Journal of Animal Ecology 47:283 - 292

Stoner, A.W. (2009) Habitat-mediated survival of newly settled red king crab in the presence of a predatory fish: Role of habitat complexity and heterogeneity. Journal of Experimental Marine Biology and Ecology 382: 54 – 60

UK BAP (2009) UK Priority Species data collation. URL: http://www.jncc.gov.uk/_speciespages/2237.pdf. Accessed: 31st March 2010.

Veale, L.O., Hill, A.S., Hawkins, S.J. & Brand, A.R. (2000) Effects of long-term physical disturbance by commercial scallop fishing on subtidal epifaunal assemblages and habitats. Marine Biology 137: 325-337.

Wilson, D.P. (1974) *Sabellaria* colonies at Duckpool, North Cornwall, 1971 – 1972, with a note for May 1973. Journal of the Marine Biological Association of the United Kingdom 54: 393 – 436