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Marine Strategy Framework Directive Shallow Sublittoral Rock Indicators for Fragile Sponges and Anthozoan Assemblages
Part 1: Developing Proposals for Potential Indicators

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This project report has been reviewed by a Project Steering Group consisting of experts from the Statutory Nature Conservation Bodies.

Summary

This report presents outcomes and conclusions resulting from work undertaken on behalf of the Joint Nature Conservation Committee (JNCC) to examine options and assess approaches to the development of Marine Strategy Framework Directive (MSFD) indicators for the determination of shallow sublittoral rock habitat status in respect of achievement of Good Environmental Status (GES). In particular, this project was tasked with addressing Commission Indicator 1.6.1 - *Condition of the typical species and communities*. Indicator feasibility and ease of application in the field was investigated in the context of relevant existing data. In addition, the development process for the proposed indicators, termed 'supporting indicators', took into account one of the key MSFD requirements for responsiveness to anthropogenic pressures, thereby providing an evidence-base for a management response in the event of a detection of undesirable status.

Indicator proposals were focused on sponge and anthozoan communities with two supporting indicator types. These were:

- Indicator 1: Morphological richness and diversity of sponge assemblages; and
- Indicator 2: Species composition and abundance of fragile sublittoral sponge and anthozoan assemblages.

A literature review was undertaken in support of the indicator development process, together with a data collation exercise with a view to identifying datasets that could be used to test the validity of the proposed supporting indicators. The literature review concluded that there were few studies where anthropogenic pressures could be directly linked to either change in sponge morphological diversity or the modification of composition and abundance of fragile sponge and anthozoan assemblages. A current lack of understanding of the range and effects of natural variation in sponge and anthozoan assemblages remains a clear confounding issue in the identification of adverse anthropogenic impacts and presents a significant obstacle for the immediate deployment of the two proposed supporting indicators.

A single dataset was identified as suitable for supporting indicator testing, but the associated anthropogenic activity/pressure data proved to be insufficient for undertaking a statistically valid assessment of indicator response parameters.

After expert consideration, it was concluded that further data collection and testing should be expended on establishing the range within which natural variation of sponge and anthozoan community attributes is constrained before attempting to directly apply the supporting indicators to the ecosystem-based management of human activities. Proposals for four supporting indicators are, however, presented, with assessments of practicality and viability based on: (1) data precision; (2) time and resource requirements; and (3) financial cost of implementation. A consideration of sampling strategies and the steps required to make the supporting indicators operational are also provided.

Glossary

EurOBIS	European Ocean Biogeographic Information System
DASSH	The Archive for Marine Species and Habitats Data
Defra	Department for Environment, Food and Rural Affairs
GES	Good Environmental Status- for reporting for MSFD
HBDSEG	Healthy and Biologically Diverse Seas Evidence Group
ICES	International Council for Exploration of the Sea
JNCC	Joint Nature Conservation Committee
MarLIN	Marine Life Information Network for Britain & Ireland
MPA	Marine Protected Area
MNR	Marine Nature Reserve
MSFD	Marine Strategy Framework Directive
NaGISA	Natural Geography in Shore Area database
NE	Natural England
NRW	Natural Resources Wales
OBIS	Ocean Biogeographic Information System
OSPAR	Oslo Paris convention for the protection of the marine nnvironment of the north-east Atlantic
RMNC	Review of Marine Nature Conservation
SAC	Special Area of Conservation
SNCB	Statutory Nature Conservation Bodies
SNH	Scottish Natural Heritage
UKMMAS	UK Marine Monitoring and Assessment Strategy
WFD	Water Framework Directive

Contents

1 Introduction

In order to ensure the marine environment is healthy, productive and safeguarded for the use of future generations, marine nature conservation is a requirement of a number of national, European and international legislative instruments, including the Marine and Coastal Access Act (2009); the Marine (Scotland) Act (2010); the Habitats Directive (92/43/EEC); the Birds Directive (2009/147/EC); the Water Framework Directive (2000/60/EC) (WFD); the Marine Strategy Framework Directive (2008/56/EC) (MSFD); and the Convention on Biological Diversity (1992).

A number of threats face Europe's marine resources, and therefore cooperation and collective action is required across European Union Member States to respond to these threats. The Integrated European Maritime Policy aims to provide a coherent framework for integrated governance of the marine environment, and this is being implemented through the Marine Strategy Framework Directive (MSFD). The MSFD is developed around the 'ecosystem approach[1]' to the management of anthropogenic activities that have an impact on the marine environment and aims to integrate the concepts of environmental protection with those relating to sustainable use. In order to achieve this objective, Member States are required to develop marine strategies (e.g. Marine Strategy Part One: Defra, 2012). The marine strategies include an initial assessment of the current environmental status of the Members States water bodies and also include definitions, targets and actions to achieve or maintain 'Good Environmental Status' (GES).

The overarching aim of the MSFD is to achieve or maintain GES for the marine environment by 2020. Evaluating the achievement of GES requires taking account of the structure, functions and processes of marine ecosystems, together with confirmation that the associated physiographic, geographic, geological and climatic processes are functioning fully and maintaining their resilience to anthropogenic-induced environmental change. GES also requires that marine species and habitats are protected; anthropogenic-induced decline of biodiversity is prevented; and diverse biological components function in balance (European Commission 2008).

1.1 Policy background

Much work has already been undertaken by the Department for Environment, Food and Rural Affairs (Defra), the Joint Nature Conservation Committee (JNCC), OSPAR[2] and a range of other stakeholders on preparing measures to achieve GES by 2020. The MSFD implementation process timeline is shown in Figure 1.1.

GES will be determined at the level of the marine region or sub-region on the basis of a set of qualitative 'descriptors' that are provided in Annex I of the Directive (see Table 1.1). The qualitative descriptors are thematic objective statements that guide Member States through the assessment of GES for their marine waters. It is important to note the overlap between the descriptors, for example, Descriptor D1 focuses on the assessment of biological diversity; however, biological diversity assessment is also strongly linked to Descriptor D2 (Non-indigenous species), Descriptor D4 (Elements of marine food webs), Descriptor D6 (Sea floor integrity) and to some extent D3 (Populations of commercially exploited fish and shellfish).

[1] For more information on the 'ecosystem approach', see http://www.cbd.int/ecosystem.
[2] The Oslo Paris Convention (OSPAR) is the current legal instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic.

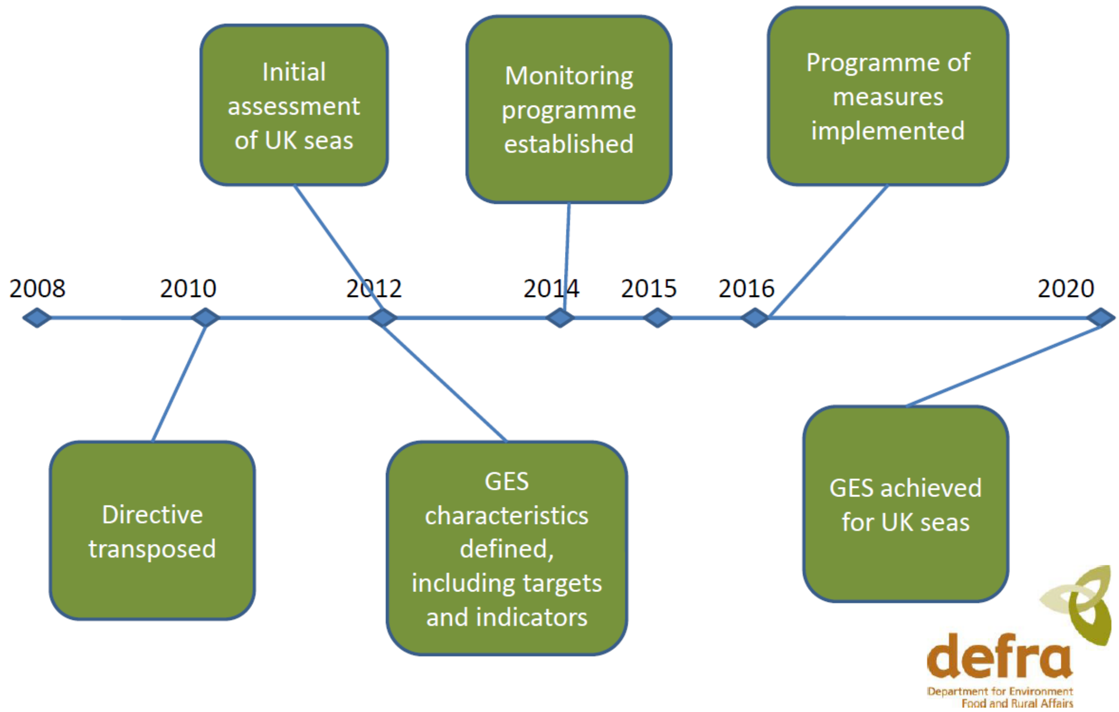

Figure 1.1. Defra summary of MSFD requirements timeline.

Table 1.1. List of the qualitative descriptors described in Annex I of the MSFD.

Descriptor	Theme
D1	Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.
D2	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.
D3	Populations of commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
D4	All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
D5	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.
D6	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
D7	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
D8	Concentrations of contaminants are at levels not giving rise to pollution effects.
D9	Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
D10	Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
D11	Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

The Commission Decision (2010/477/EU) provided further guidance on the criteria contributing to the assessment of GES under each qualitative descriptor and the methodological standards for assessment (European Commission 2010). For most criteria, the assessment and methodological standards are based on procedures already in place for existing community legislation, in particular the WFD, the Habitats Directive and the Birds Directive. Each criterion includes a set of Commission Indicators[3], which are attributes of each criterion that can be quantitatively or qualitatively assessed to determine the criterion's correlation with GES (Hinchen 2014; see Table 1.2). Some of the Commission Indicators are specific and measurable (e.g. Commission Indicator 1.5.1 - *Habitat area*), while others operate at a broader level and can be considered as a 'class' of Commission indicator (e.g. Commission Indicator 1.6.1 - *Condition of the typical species and communities*).

Table 1.2. GES Criteria and indicators for Descriptor 1 (Biological Diversity) as described in the Commission Decision 2010/477/EU.

Level	Number	Criterion	Number	Indicator
Species	1.1	Species distribution	1.1.1	Distributional range
			1.1.2	Distributional pattern within 1.1.1 (where appropriate)
			1.1.3	Area covered by the species (for sessile/benthic species)
	1.2	Population size	1.2.1	Population abundance and/or biomass, (where appropriate)
	1.3	Population condition	1.3.1	Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/ mortality rates)
			1.3.2	Population genetic structure (where appropriate)
Habitat	1.4	Habitat distribution	1.4.1	Distributional range
			1.4.2	Distributional pattern
	1.5	Habitat extent	1.5.1	Habitat area
			1.5.2	Habitat volume (where relevant)
	1.6	Habitat condition	1.6.1	Condition of the typical species and communities
			1.6.2	Relative abundance and/or biomass (where appropriate)
			1.6.3	Physical, hydrological and chemical conditions
Ecosystem	1.7	Ecosystem structure	1.7.1	Composition and relative proportions of ecosystem components (habitats and species)

To ensure that Commission Indicators can be utilised effectively, it is desirable to be able to define a target state or trend direction for GES. Although the Commission Indicators are identified for each criterion, no specific indicator targets are provided within the MSFD or the related Commission Decision. It is the responsibility of the UK to identify their own indicator targets that will contribute to the achievement of GES.

The MSFD required the UK to undertake an initial assessment of its marine waters, determine the characteristics of GES in such waters, and identify targets and indicators that will contribute to the assessment of GES by 2012. This was submitted to the European Commission (EC) in 2012 as Part One of the UK Marine Strategy (Defra 2012).

[3] The term 'Commission Indicator' relates specifically to those indicators defined in Commission Decision (2010/477/EU).

Advice on these indicators and targets was developed by the Centre of Fisheries and Aquaculture Science (Cefas), JNCC and the UK Marine Monitoring and Assessment Strategy (UKMMAS). Cefas led the development of advice for the 'pressure' descriptors (D3, 5, 7-11) and also for non-indigenous species (D2). A specialist evidence group within UKMMAS, the Healthy and Biologically Diverse Seas Evidence Group (HBDSEG), produced advice on GES targets and indicators for the ecologically-orientated descriptors (D1, D4 and D6) and this process was facilitated by JNCC.

Table 1.3. Targets for biodiversity descriptor (D1 & D6) marine habitats taken from Part One of the UK Marine Strategy (Defra 2012).

Habitat types	Commission Indicator	Target
Rock & Biogenic Reef habitat	Habitat distribution	At the scale of the MSFD sub-regions rock and biogenic reef habitats are stable or increasing: For all listed (special) and predominant habitat types, range and distribution are stable or increasing and not smaller than the baseline value (Favourable Reference Range for Habitats Directive habitats).
	Habitat extent	At the scale of the MSFD sub-regions rock and biogenic reef habitats are stable or increasing: For all listed (special) and predominant habitat types area is stable or increasing and not smaller than the baseline value (Favourable Reference Area for Habitats Directive habitats).
	Habitat condition; Physical damage; Condition of the benthic community	At the scale of the MSFD sub-regions of rock and biogenic reef habitats are not significantly affected by anthropogenic activities: For all listed (special) and predominant habitat types the area of habitat in poor condition (as defined by condition indicators) must not exceed 5% of the baseline value (Favourable Reference Area for Habitats Directive habitats).
Sediment habitat	Habitat distribution	Predominant habitat types: No target proposed – see target below for Criterion 1.6. Listed (special) habitat types: At the scale of the MSFD sub-regions the range and distribution of listed (special) sediment habitat types is stable or increasing and not smaller than the baseline value (Favourable Reference Range for Habitats Directive habitats).
	Habitat extent	Predominant habitat types: No target proposed – see target below for Criterion 1.6. Listed (special) habitat types: At the scale of the MSFD sub-regions the area of listed (special) sediment habitat types is stable or increasing and not smaller than the baseline value (Favourable Reference Area for Habitats Directive habitats). WFD extent targets for saltmarsh and seagrass should be used within WFD boundaries as appropriate.
	Habitat condition; Physical damage; Condition of the benthic community	Predominant habitat types: At the scale of the MSFD sub-regions damaging anthropogenic impacts on predominant sediment habitats are reduced: The area of habitat which is unsustainably impacted by anthropogenic activities (as defined by vulnerability criteria) is reduced and the precautionary principle is applied to the most sensitive habitat types and/or those which are most important for ecosystem functioning. Listed (special) habitat types: At the scale of the MSFD sub-regions, the area of special (listed) sediment habitat types below GES (i.e. unacceptable impact / unsustainable use) as defined by condition indicators must not exceed 5% of baseline value (favourable reference area for Habitats Directive habitats). WFD targets (km2 thresholds) for area of unacceptable impact for benthic invertebrates, macroalgae, saltmarsh and seagrass should be used within WFD boundaries as appropriate.

Part One of the UK Marine Strategy included targets and indicators for all ecosystem components. Targets for descriptors D1, D4 and D6 were presented in a combined section, reflecting their close association and simultaneous applicability to two or more descriptors. Table 1.3 presents the marine habitat targets for the descriptors discussed above.

Commission Indicators with a broad scope require a range of 'supporting indicators' to be developed so that each one can be measured and assessed. Supporting indicators are proposed at the UK implementation level and collectively address the Commission Indicator. One Commission Indicator that requires a range of supporting indicators is '1.6.1 – *Condition of the typical species and communities*', which is identified under Descriptor 1: Biodiversity (see Figure 1.2).

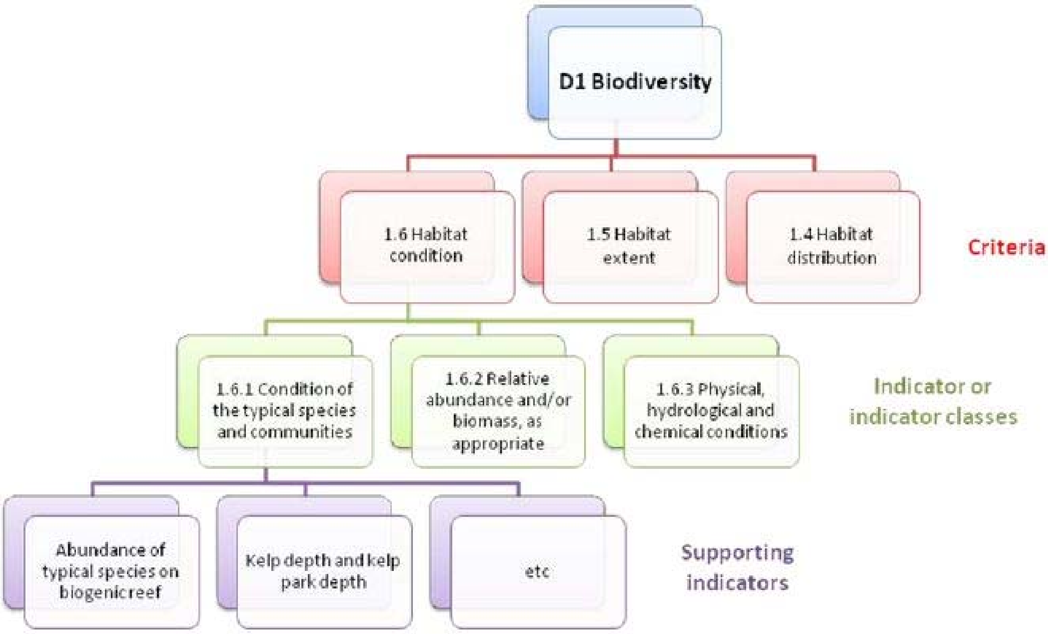

Figure 1.2. Flow chart showing the breakdown of descriptor D1 into criteria, indicators / indicator classes and supporting indicators (Moffat *et al* 2011).

The Commission Indicators identified for rock and biogenic reef habitats as part of the UK implementation of the MSFD were proposed by an expert group under HBDSEG (Rock & Biogenic Reef Subgroup). The supporting indicators identified through this process were further refined and prioritised as part of the remit of HBDSEG, and it was agreed that the proposed shallow sublittoral rock supporting indicators required further research and development.

1.2 Development of shallow sublittoral rock supporting indicators

Many of the supporting indicators proposed by HBDSEG for benthic habitats require further development and testing to ensure they are suitable and practically achievable as a determinant of achievement of GES. A research and development work programme was developed by HBDSEG to make the proposed supporting indicators operational[4].

[4] An indicator becomes 'operational' when appropriate monitoring, quality standards and a process for disseminating the results has been put in place (Moffat *et al* 2011).

It was recommended by HBDSEG that the development of three supporting indicators for shallow sublittoral rock habitats should be taken forward. These supporting indicators were identified based on existing UK Special Areas of Conservation (SACs) monitoring schemes required under the Habitats Directive and are listed below:

- Kelp depth and kelp park depth.
- Morphological richness and diversity of sponge assemblages.
- Species composition and abundance of fragile sublittoral sponge and anthozoan assemblages.

This report is for the development of the last two supporting indicators only: the sponge morphology indicator; and the fragile sponge and anthozoan composition and abundance indicator.

1.3 Project aims and outputs

This project aims to evaluate and validate supporting indicators under Commission Indicator 1.6.1 - *Condition of the typical species and communities*, for rocky habitats in shallow waters, and in addition, establish their practical feasibility through the identification and use of directly applicable existing data. The proposed supporting indicators were required to be responsive to the main anthropogenic pressures acting on shallow sublittoral rock habitats. They were also required to span the full extent of the UK's MSFD assessment area and the range of biogeographic conditions present, whilst also maintaining compatibility with the UK's regional seas approach[5] (U.K. Marine Monitoring Assessment Strategy Community 2010).

For the purposes of this project, only sponge and anthozoan communities in circalittoral waters were considered. Shelf sublittoral (deep circalittoral) habitats were not included. MSFD assessments should only be undertaken for marine waters, as transitional waters are assessed through the WFD.

The objective of this project was to use the two supporting indicators proposed for further research and development by HBDSEG (see Table **1.4**) to achieve the following aims:

1) To evaluate and validate, where possible, two supporting indicators for shallow sublittoral rock habitat that are responsive to the main anthropogenic pressures acting on this habitat; and

2) To identify and detail the future research and development requirements to make the supporting indicators for shallow sublittoral rock habitat operational in the UK.

Table 1.4. Supporting indicators proposed by HBDSEG requiring further investigation within this project.

Indicator	ID	Description
Supporting Indicator 1	MorphSponge	Morphological richness and diversity of sponge assemblages
Supporting Indicator 2	SpongeAntho	Species composition and abundance of fragile sublittoral sponge and anthozoan assemblages

[5] The UK's regional seas were based on the 11 bio-geographic regions identified as part of the Review of Marine Nature Conservation (RMNC) 2004. Utilising the regional sea map allows harmonisation of reporting on the WFD and MSFD.

2 Supporting indicator development

This section details the methods and findings of a feasibility study for the two supporting indicators proposed by HBDSEG in
Table **1.4**.

The methodological approach undertaken by this project focused on a review of relevant literature and an appraisal of existing survey and monitoring datasets for their ability to provide a practical basis on which to build the development of supporting indicators. Experts in sponge and anthozoan ecology and taxonomy were also consulted on the viability of the proposed supporting indicators, including the possibility of linking them to anthropogenic pressures.

2.1 Review of relevant literature

2.1.1 Methodology

The project team with assistance from experts at a workshop (see Section 2.2) compiled relevant scientific literature relating to the key elements of the two supporting indicators proposed by HBDSEG. Primary literature included examples of studies where either species-abundance or morphological approaches were applied to the assessment of sponge diversity. In addition, other documented community assessment techniques employed in the study of sponge and anthozoan assemblages were also evaluated, while all associated datasets were examined to identify possible candidates that would constitute a test environment for the two proposed supporting indicators.

Supporting Indicator 2 (SpongeAntho) is focused on the abundance and composition of fragile sponge and anthozoan assemblages, but aspects other than abundance and species composition may be applicable to the assessment of GES. Therefore other biological/ecological traits[6] and associated metrics relating to sponges and anthozoans were identified from the literature and through expert consultation at the workshop.

Finally, species with the potential to be indicators of anthropogenic change, or those that are considered to be characteristic of fragile sponge and anthozoan assemblages were also identified. These traits, metrics and potential indicator species were collated and discussed during the expert consultation. A full list of the literature reviewed is provided in Appendix 1.

2.1.2 Results

i. Supporting Indicator 1: Morphological richness and diversity of sponge assemblages

A considerable amount of previous research has been undertaken to test the suitability of a morphological-based assessment of sponge richness, diversity and assemblage composition. Multiple studies across a range of habitat types have demonstrated a strong positive correlation between species diversity (e.g. evenness and richness) and sponge morphological diversity (Bell & Barnes 2001, 2002; Bell 2007). Similarly, strong correlations have been found between multivariate patterns of spatial variation in sponges using both morphological and species-level information (Bell & Barnes 2001, 2002; Bell *et al* 2006;

[6] Biological and ecological traits are defined as a measurable property, phenotype, or characteristic of an organism that may influence its survival.

Berman *et al* 2013). While this relationship is upheld in shallow rocky environments throughout the world, it has not been observed for sponge assemblages present in cave and boulder habitats (Bell & Barnes 2002) and therefore this approach cannot be considered appropriate for such habitats.

Most studies that have utilised a morphological approach in the context of causes of change have assessed the morphological diversity in relation to sediment deposition (Bell *et al* 2002; Bell 2004; Bell & Barnes 2000a); bathymetry (Bell *et al* 2002; Bell & Barnes 2000a); flow rate (Bell *et al* 2002; Bell & Barnes 2000a, 2000b, 2000c; Bell 2001); habitat type (Bell & Barnes 2002; Barnes & Bell 2002b; Berman 2012); and substrate type (Barnes & Bell 2002a; Bell & Barnes 2002; Barnes & Bell 2002b). However, none of the studies have attempted to specifically associate the diversity and richness of sponge morphologies to anthropogenic pressures in temperate sponge assemblages, although most of the studies have identified sedimentation as a key driver of both species and morphological diversity.

There have been few studies in the UK examining the spatial variation in entire sponge assemblages, and even fewer studies examining temporal variation. Research at Skomer Island Marine Nature Reserve (MNR) has examined both spatial and temporal variation using both species and morphological approaches (Berman *et al,* 2013). This study showed significant variation in the composition of sponge assemblages across small spatial scales; substrates; habitats and seasons of the year based on both morphological and species-level information. This provides strong evidence that morphological data can be a surrogate for monitoring changes in sponges. However, as for many shallow sublittoral marine species, high levels of variation create challenges for predicting the response of sponge assemblages to specific anthropogenic pressures. Although an assessment of morphological variation allows a baseline for the natural variation of sponge assemblages to be established, it does have lower resolution compared to species-level data (Bell *et al* 2006). This might be a problem if one or a small number of species are showing a response to an anthropogenic pressure.

The major strength of the sponge morphological approach lies with the relative ease with which data can be acquired. Morphological features are easily-recognised visual attributes, which lend themselves to rapid assessment techniques, such as diver observation or remote video deployment, each of which can be undertaken by non-specialist surveyors (Bell 2007).

The use of a sponge morphological indicator, therefore has the obvious potential to be a cheaper and less resource intensive alternative to species-level studies of diversity. There are, however, significant issues with its application as a sole indicator that must be considered, in particular the loss of species-level information (Bell *et al* 2006).

ii. Supporting Indicator 2: Species composition and abundance of fragile sublittoral sponge and anthozoan assemblages

A number of previous studies have detailed the abundance and richness of sponge assemblages in UK waters (Picton & Goodwin 2007; Bell *et al* 2006; Bell & Barnes 2002, 2001, 2000a; Barnes & Bell 2002b). However, most studies related to anthozoans have focussed on assemblages found deeper than 50m, particularly deep sea corals. Unfortunately, there are few studies that have investigated the response of sponge and anthozoan abundance and composition to anthropogenic pressures in temperate sublittoral waters. However, there are studies that can be drawn on from elsewhere. The most studied sponge and anthozoan assemblage response has been in respect of sedimentation, and to a lesser degree physical disturbance (particularly from fishing activities). Ocean Acidification and climate change are also likely to be important and are currently expanding areas of study.

Settling sediment and turbidity are known to have a number of negative impacts on suspension feeding organisms, including smothering and blocking of filtering apparatus (Hiscock 1983), and reducing light penetration for symbiont-containing species (e.g. hermatypic corals). However, the impacts of sedimentation on sponges and anthozoans tend to be species-specific. For example, Bell and Barnes (2000a) found the highest diversity and abundance of sponges in highly sedimented areas compared to areas free of sediment in a temperate sea lough (Lough Hyne), with many of the sponges living beneath a layer of sediment. This is an observation common to other locations and suggests that many sponge species are adapted to tolerate high levels of sediment (e.g. Bell 2004). However, despite many species appearing to have a preference for sites with high sediment loadings (or being restricted by interactions with other organisms such as algae), a number of studies have shown physiological stress in sponges when exposed to sediment (e.g. Tjensvoll *et al* 2013). Typically, anthozoans are less tolerant to sediment than sponges, although some species have developed physiological, behavioural and morphological adaptations (e.g. Bell & Turner 2000). Sediment may also play an important role in mediating the recruitment success of sponges and anthozoans (see Maldonado *et al* 2008), with sediment generally being considered detrimental to larval settlement.

Physical disturbance is known to have a major impact on the abundance and distribution patterns of benthic organisms, and in the context of rocky reef environments this is most likely to come from fishing activities, particularly from potting/creeling. While the impacts of trawling on sponge and anthozoan assemblages have received considerable attention, this is mainly associated with deeper water communities (such as deep sea coral reefs), and they have not been studied in detail for the fragile sponge and anthozoan assemblages being considered here.

Most ocean acidification and climate change studies focus on the negative impacts associated with a reducing pH and the effect on calcifying reef-forming anthozoans (Anthony *et al* 2008; Edmunds *et al* 2012). In contrast, positive effects are predicted for some non-calcifying anthozoans, for example, an increased abundance and size of the symbiont-containing *Anemonia viridis* is predicted (Suggett *et al* 2012). While, ocean acidification is generally considered to have negative effects for calcifying organisms, there are contrasting responses in the literature for sponges, although sponge groups with calcareous skeletons may be susceptible. While no studies have specifically examined the effects of changes in pH on temperate sponges, consideration has been given to tropical and subtropical species. In a recent study by Goodwin *et al* (2013) in the Mediterranean, the number of species and proportion (%) of sponges decreased with increasing pH at a natural carbon dioxide seep. In contrast, experimental studies of tropical sponges have shown no measureable impact of both pH and temperature changes on a number of sponge species (Duckworth *et al* 2012).

iii. Other supporting indicators for assessing sponges and anthozoans found on sublittoral rock

To support the determination of ecological status within the WFD, the Marine Biological Association undertook a scoping study for the development of a Hard Substratum Benthic Invertebrate Classification Tool, (Hiscock *et al* 2005b). The report revealed that there are very few anthropogenic effects identified for hard substratum species, although some biotic and abiotic factors (including turbidity and salinity gradients) have been studied. The report identified species within biotope complexes that are intolerant or favoured by particular adverse conditions. Species of sponges and anthozoans identified in the report are presented in Table 2.1. The use of indicator species as supporting indicators is discussed further in Section 2.2.2.

Little information was found that directly links the two proposed supporting indicators with specific anthropogenic pressures and further work will be required in the future to establish the nature and magnitude of the sponge and anthozoan response to specific anthropogenic pressures as distinct from responses to natural influences (see Section 5.6).

Table 2.1. Sponges and anthozoans of hard substratum that are intolerant or tolerant of adverse conditions (from Hiscock *et al* 2005b).

Taxon	Indicator Species	Intolerant	Tolerant	Comments
Anthozoa	*Actinothoe sphyrodeta* (Sandalled anemone)		X	• Tolerant of sedimentation.
Anthozoa	*Alcyonium digitatum* (Dead man's fingers)	X		• Highly intolerant of substratum loss, displacement, changes in oxygen, and synthetic compound contamination; • Intolerant of abrasion & physical disturbance, smothering, and acidified-halogenated effluent.
Anthozoa	*Eunicella verrucosa* (Pink sea fan)	X		• Highly intolerant of substratum loss, displacement and changes in oxygen; • Intolerant of abrasion and physical disturbance, smothering, and increases in wave exposure.
Anthozoa	*Leptopsammia pruvoti* (Sunset cup coral)	X		• Highly intolerant of substratum loss, abrasion & physical disturbance, smothering, and displacement.
Anthozoa	*Metridium senile* (Plumose anemone)	X		• Highly intolerant of substratum loss; • Tolerant of changes in temperature and oxygenation; increases in turbidity, and acidified-halogenated effluent; • Intolerant of abrasion and physical disturbance.
Anthozoa	*Protanthea simplex* (Sealoch anemone)	X		• Highly intolerant of substratum loss, abrasion and physical disturbance, smothering, increases in wave exposure and temperature change.
Anthozoa	*Urticina felina* (Dahlia anemone)	X		• Highly intolerant to substratum loss; • Intolerant of abrasion and physical disturbance, changes in oxygenation and synthetic compound contamination; • Tolerant of acidified-halogenated effluent.
Sponge	*Axinella dissimilis* Yellow staghorn sponge	X		• Highly intolerant to substratum loss and displacement.
Sponge	*Halichondria panicea* (Breadcrumb sponge)	X		• Highly intolerant of substratum loss, smothering, synthetic compound contamination, changes in nutrient levels and displacement; • Intolerant of abrasion and physical disturbance, and changes in oxygen.
Sponge	*Hymeniacidon perleve* Encrusting sponge	X		• Highly intolerant to substratum loss, synthetic compound contamination and changes in nutrient levels.

Observations of damage to individual anthozoans and sponges could be measured as an indicator of trawling damage. This assessment of direct damage to sponges and anthozoans could be combined with signs of damage to the substrate e.g. overturned rocks and boulders (JNCC 2013). For example, it may be possible to identify stones and boulders with upturned sponges and anthozoans or where these species are no-longer growing in their natural positions.

Diseases of both sponges and anthozoans have been reported and are of considerable research interest (Hall-Spencer *et al* 2007; Webster 2007), although very little is known in terms of the pathology of such diseases in UK species (but see Hall-Spencer *et al* 2007 for discussion about diseases of *Eunicella verrucosa*). The timely identification of infection and spread of disease through these species groups presents many difficulties. Unless monitored very frequently, disease outbreaks will be missed as neither skeleton nor structure remains after most sponges and anthozoans die.

Three anthozoans are included on a list of 'climate change winners (*Anemonia viridis* and *Actinia fragacea*) and losers (*Bolocera tuediae*)', which was developed for a Marine Life Information Network for Britain & Ireland (MarLIN) topic note (Hiscock *et al* 2005b). It is possible that these anthozoans could be included as indicator species for the effects of climate change, although they do not typically occur in the biotopes we are considering in the context of this report.

iv. Other traits, variables and species relating to sponges and anthozoans potentially suitable for determining GES

Biological/ecological traits relating to sponges and anthozoans and suitable associated metrics that might be applied to an assessment of GES were identified and collated from previous studies for appraisal by experts who were consulted as part of this project. The tables produced during this process are discussed further in the following section.

2.2 Expert consultation

2.2.1 Methodology

The supporting indicators were assessed and developed further through expert consultation with experienced researchers and surveyors of sponges and anthozoans within the UK and Ireland. The expert consultation was undertaken in the form of a workshop.

A skills profile for workshop attendees was developed to ensure that attendees provided the required expert input into the development of the supporting indicators. The major criteria for the skills profile were:

- Field surveyors with experience of surveying for sponge and anthozoan assemblages;
- Researchers of sponge and anthozoan assemblages;
- Surveyors and researchers of shallow sub-littoral rock habitats;
- Researchers and policy development officers involved in developing and using condition indicators for marine habitat assessment including the determination of GES;
- Researchers investigating the pressures acting on shallow sublittoral rock habitats; and
- Researchers investigating the impacts of water quality or abrasion on marine habitats.

Invitees to the workshop were sourced from key literature, marine research establishments, Non-Governmental Organisations (NGOs), Statutory Nature Conservation Bodies (SNCBs), universities, natural history museums and consultant marine ecology companies. In total, 45 people were invited and 19 participants were confirmed for the workshop (including the members of the project team). The workshop was held on the 24th October 2013 at the

University of Birmingham Conference Park. Details of attendees and workshop materials are presented in Appendix 2.

The objectives of the workshop were to:

1) Appraise the two supporting indicators proposed by HBDSEG;
2) Consider additional supporting indicators focussed on sponges and anthozoans by investigating ecological and biological traits that could be measured, and suitable metrics and indicator species;
3) Investigate what is known about sponge and anthozoan assemblages' responses to anthropogenic pressures and whether they can be measured; and
4) Consider the practical application of a UK-wide assessment of sublittoral rock habitat that would deliver a contribution towards the evaluation of GES.

The findings of point 4 will be discussed in Section 5.2.

2.2.2 Results

This section presents the findings of the expert consultation and includes the contributions and advice of the experts that attended the workshop.

The experts at the workshop were requested to identify important ecological traits of sponges and anthozoans, together with metrics to measure those traits that could then be used to initiate targets for fragile sponge and anthozoan assemblages that could support the determination of GES. The experts were provided with an initial series of collated traits and metrics from the literature review referred to in Section 2.1.2.

i. Identification of important ecological traits and suitable metrics

Table 2.2 and

Table **2.3** present the ecological traits and metrics identified in the literature review and discussed at the workshop. The tables also provide an account of the advantages and disadvantages of using each trait and metric in any assessment of GES.

ii. Appraisal of the proposed supporting indicator for 'Morphological richness and diversity of sponge assemblages (MorphSponge)'

A morphological approach to sponge surveys would be an affordable, relatively fast and reasonably simple set of surveys to conduct because of the reduced requirement for specialist knowledge. However, the replacement of species-level with morphology-level surveys would provide less detailed information about the assemblages under investigation and it was generally agreed that morphological information on its own was insufficient for monitoring sponges. Data regarding thin encrusting sponges might also be lost through morphology-only assessments as they are highly diverse compared with other morphological groups.

The MorphSponge indicator will identify overall change but not the drivers of change. It was recommended that the MorphSponge indicator should be utilised to identify if changes are occurring, which would then initiate a switch to species-level surveys if deemed appropriate.

Table 2.2. Appraisal of ecological traits for sponges and anthozoans.

	Expert comment on using the trait as an indicator		
Trait Description	**Advantages**	**Disadvantages**	**Literature References**
1) Abundance	• Provides important demographic information about a population and is likely to provide the best evidence for population increase or decline.	• If collected alone (e.g. overall sponge or anthozoan abundance) this trait will not identify if specific species are declining.	Bell *et al* 2006; Berman *et al* 2012
2) Recruitment	• An important component of resilience of any population and essential for long-term population maintenance.	• Reproduction is generally seasonal so observing recent recruitment events may depend on when sampling is undertaken • Also, recruitment might only occur very rarely for longer-lived species.	Bell *et al* 2006
3) Mortality	• Important for understanding demographic processes.	• For all sponges and most anthozoans there is no physical structure left very quickly after an organisms dies so this would need to rely on abundance information.	Bell 2004
4) Growth	• Positive growth might indicate suitable growing conditions.	• Information would be required to determine ‘normal’ growth rates, which is not currently available for most species; • Also, many sponge species show a reduction in size during winter months.	Bell & Barnes 2001; Bell 2008
5) Disease occurrence	• Not always easy to detect, but this can be recorded if it is something visual (i.e. damage, obvious fungal growth, *etc*.); • Suited to both sponges and anthozoans.	• Sponges die quickly when diseased, so observing disease can be difficult. Sponges also change shape based on other conditions and can appear ‘diseased’ to non-experts.	Hall-Spencer *et al* 2007; Webster 2007
6) Deformity	• Presence of damaged individuals.	• The natural processes of regeneration and decay need to be considered when setting limits of acceptable change; • Damage indicators must also take into account the effects of natural negative indicators (such as damage) that are very difficult to attribute to specific activity.	Wulff 2006
7) Larval dispersal	• None given.	• Difficult to measure; • Little known about larval development for most species.	No available literature
8) Microbial community composition	• The presence of microbes tends to be consistently different between species, but they are known to change in response to anthropogenic pressures.	• Difficult to survey; • Specialist knowledge required.	Webster & Taylor 2012

	Expert comment on using the trait as an indicator		
Trait Description	**Advantages**	**Disadvantages**	**Literature References**
9) Regeneration	• The natural processes of regeneration and decay need to be considered when setting limits of acceptable change.	• Species-dependent (for example, if you tried to assess regeneration on a branching sponge, the species might not grow back).	Bell *et al* 2002
10) Physiological adaptation and tolerance	• An understanding of the specific adaptations and tolerances of specific species of sponges and anthozoans can provide additional information about the conditions influencing the environment and have the potential to identify further indicator species.	• Extensive laboratory and field research to identify these tolerances is required.	No available literature, discussed at workshop only
11) Spicule variation	• Possible indicator of changes in water flow and also changes in pH.	• Fairly large amount of environmental variation in spicule size; • Requires microscopic examination	e.g. Bell *et al* 2002
12) Life history traits	• Different species traits (e.g. fast or slowing growing, ephemeral or long-lived) are likely to reflect prevailing environmental conditions.	• Species specific information is required which is currently available for only a small number of species.	Discussed at workshop

Table 2.3. Appraisal of metrics for sponges, anthozoans and sublittoral habitat, and the traits measured (see Table 2.2) with each metric.

	Expert comment on using the metric as an indicator			
Metric Description	**For**	**Against**	**Trait measured** *	**Literature References**
Species composition	• Able to detect range expansions, influences of climate change; • Reduction in the abundance of larger species could be a possible indicator of abrasion.	• Gives no indication of relative dominance of species, or shifts in assemblage composition; • Requires high level of taxonomic expertise.	1	Various references - see literature review list (Appendix 1)
Species composition and abundance (diversity)	• The same as for species composition metric, but provides an opportunity to assess changes in assemblage composition and examine population and assemblage level dynamics; • Easy to collect for anthozoans; • Ability to identify recruitment and mortality events.	• Need to identify all species; • Spicule analysis and sectioning required for many sponge species, especially encrusting species; • Expensive to collect data; • Need to decide on whether to measure numbers, area occupied, or volume, which will have different costs.	1-4, possibly 5 and 6	Various references - see literature review list (Appendix 1)

	Expert comment on using the metric as an indicator			
Metric Description	**For**	**Against**	**Trait measured ***	**Literature References**
Size distribution of species	• Possible indicator of physical disturbance for upright species, with larger individuals expected to reduce in abundance with increasing disturbance.	• Data collection is very time-consuming.	4-6	Various references - see literature review list (Appendix 1).
Growth rate	• Possible indicator of changes in water quality.	• Data collection is very time-consuming as it requires marking and returning to specific individuals.	4	Various references - see literature review list (Appendix 1).
Regeneration rate	• Possible indicator of changes in water quality.	• Data collection is very time-consuming as it requires marking and returning to specific individuals and also requires repeat sampling over short temporal scale (weeks to months) as regeneration can occur quickly.	9	Various references - see literature review list (Appendix 1).
Respiration rate	• Would give a good indication of stress.	• Difficult and time consuming to measure *in situ* and hard to resource for laboratory studies.	10	Tjensvoll *et al* 2013
Morphological abundance and composition (morphological diversity)	• Surrogate for species diversity; • Cheap to collect data compared to species level information; • Suited to volunteers; • Faster than collecting species data and can be more easily collected from photographs and video.	• Only suitable for sponges; • This would need to be suitably tested at each sample site first; • Reduced precision of the information collected.	1	Various references - see literature review list (Appendix 1).
Abundance of specific morphological types	• Some specific morphologies may be lost in responses to physical disturbance; • Cheap surveys to undertake; • Reduced emphasis on specialist skills; • Faster surveys than species-level.	• Less data obtained than from species-level surveys; • Less data obtained for encrusting sponges; • Research is focussed on sponges (but anthozoans are easier to identify).	1	Various references - see literature review list (Appendix 1).
Rates of population connectivity	• This is important to determine as it provides information sources of new recruits following a disturbance; • The larval duration of sponges and anthozoans is typically short so connectivity between populations is likely to be at the scale of 100 m.	• This is difficult to measure, typically genetic tools have been used to determine connectivity for marine species and it depends on local as well as regional barriers (including current and potential barriers) and would need to be estimated at a species level.	7,12	Duran *et al* 2002

	Expert comment on using the metric as an indicator			
Metric Description	**For**	**Against**	**Trait measured ***	**Literature References**
Abundance of indicator species	• Indicator species known to be indicative of specific disturbance could be a viable method of assessing condition; • Indicator species that are ubiquitous and distinctive would reduce the taxonomic skills required for any assessment; • Volunteers are likely to be able to undertake surveys; • Particularly important for anthozoans (many are more distinctive than sponges).	• Few species will be present in all UK regional seas; • Indicator species will only be useful if research into understanding the ecology of each species and their response to natural and anthropogenic pressures is undertaken.	1	Hiscock *et al* 2005b
Abundance of ephemeral species	• An indicator of disturbance.	• Requires the initial identification of such species.	12	Wulff 2006
Abundance of fast-growing species	• Fast growing species are a possible indicator of negative pressures, but they also influence measures of assemblage diversity; • Can be an indicator of disturbance.	• Requires the initial identification of such species.	12	Wulff 2006
Abundance of slow-growing species	• An indicator of disturbance (disturbance reduces the abundance of slow-growing species).	• Requires the initial identification of such species.	12	Wulff 2006
Disease prevalence	• Possible indicator of temperature stress.	• Very little is known about sponge disease in UK waters; • Requires extensive surveys and time series observations over short temporal scales.	5	Webster 2007; Hall-Spencer *et al* 2007
Spicule size	• Has the potential to be an indicator of pH changes, Dr Bell's research group has found changes in spicule size across natural Carbon Dioxide gradients.	• Requires microscopic examination and heavily influenced by local environment including water flow rates.	11	Bell *et al* 2002

* = The trait measured column links the traits numbered in Table 2.2 with the metrics presented above.

iii. Appraisal of the proposed supporting indicator for 'Sublittoral species composition and abundance of fragile sponge and anthozoan assemblages (SpongeAntho)'

It is important for both the sponge and anthozoan components within the fragile sponge and anthozoan biotopes to be considered for any indicator contributing to GES appraisal. Gathering species-level data for the sponge component of any indicator will be more expensive than gathering data at a morphological level (as proposed in the MorphSponge indicator). Anthozoans are generally more easily identified than sponges making an analogous morphological approach to monitoring anthozoans unnecessary. The traits and the associated metrics described in Table 2.2 and

Table **2.3** *could be used in the determination of GES for these biotopes. Given the overall lack of data regarding most of the ecological traits, temporal data will be required for any preliminary assessment against GES for these biotopes.*

iv. Linking supporting indicators to anthropogenic pressures

The experts were asked to identify likely and detectable anthropogenic pressures on sublittoral rock habitat and comment and their relevance to sponge and anthozoan assemblages. Table 2.4 presents the pressures, based on the MSFD Initial Assessment reporting definitions (European Commission 2012).

There are insufficient data and knowledge at the present time to directly associate most of the traits and metrics identified in Table 2.2 and

Table **2.3** with anthropogenic pressures. However, a suite of indicator species are suggested, some of which could be used to assess specific pressures (see Table 2.5 and Table 2.6).

Table 2.4. Anthropogenic pressures and their relevance to sponges and anthozoans

Pressure*	Is the pressure relevant (Yes/No/Unknown)? **	Comment
Physical loss (all)	Yes	• None given.
Physical loss (smothering)	Yes	• Some sponge species do prefer to live under a layer of sediment.
Physical loss (sealing)	Yes	• None given.
Physical damage (all)	Yes	• None given.
Physical damage (changes in siltation)	Yes	• Physical damage does affect sponge and anthozoans, but the coincidental nature of siltation should be considered. Furthermore, siltation occurs around some sponge species and they often appear to favour areas protected from wave action where siltation naturally occurs. • Identifying what is a natural change in siltation and anthropogenic change is necessary.
Physical damage (abrasion)	Yes	• Abrasion has a significant negative impact.
Non-selective extraction e.g. dredging	Yes	• Fine sediment from dredging spoil is likely to be detrimental to sponges and anthozoans.
Physical damage (selective extraction)	Yes	• Sponges have been targeted in the past by the pharmaceutical industry. Sponges and anthozoans are also collected as 'curios' and whilst this is not a

Pressure*	Is the pressure relevant (Yes/No/Unknown)? **	Comment
		regular activity it should be considered.
Physical disturbance (other)	Yes	• None given.
Underwater noise	No	• Not an issue for sponges/anthozoans as far as we know.
Marine litter	Yes	• Litter is an important issue, as it occurs in all areas. Litter originates from a variety of industries and impacts on all natural features in some way. However, there are issues with understanding how sponges and anthozoans are affected by this. Sponges ingest micro-particles but it is unclear if this should be classed as litter or chemical contamination. Larger litter can also affect communities by smothering. • Legislation relating to litter already exists. • Presence of marine litter might be worth while pursuing as an indicator.
Interference with hydrological processes (all)	Yes	• None given.
Changes in thermal regime	No	• Unlikely to be an issue for the assemblages we are considering (given their depth).
Changes in salinity regime	No	• Unlikely to be an issue for the assemblages we are considering (given their depth).
Contamination by hazardous substances (all)	Yes	• None given.
Introduction of synthetic compounds	Unknown	• Not clear what these impacts might be. There is little research on small particles of pollution on sponges and anthozoans.
Introduction of non-synthetic substances and compounds	Unknown	• Not clear what these impacts might be. There is little research in this area.
Introduction of radio-nuclides	Unknown	• Unknown response.
Acute pollution events	Yes	• These would have an affect but would be highly localised. Indicators may be difficult to apply to these as they do not occur regularly.
Systematic/intentional release of substances	Yes	• Substance dependent.
Nutrient and organic matter enrichment (all)	Yes	• This is an issue, but the source is normally from transitional waters. Therefore management actions are more difficult to apply. Has the potential for indirect effects on sponges through increased food supply.
Inputs of fertilisers and other N- and P-rich substances	Yes	• Change in assemblage/species, and abundance of some species.
Inputs of organic matter	Yes	• Can cause changes in assemblages and species abundance.
Biological disturbance (all)	Yes	• None given.
Introduction of microbial pathogens	Yes	• Difficult to determine. Needs to be studied but not suitable for indicators as data to assess this pressure is not available.
Introduction of non-indigenous species and translocations	Yes	• No examples of sponges or anthozoans being impacted as yet in UK, but many examples overseas.

Pressure*	Is the pressure relevant (Yes/No/Unknown)? **	Comment
Selective extraction of species, including non-target catches (all)	Unknown	• Does removing these species have a knock-on rather than direct effect? Currently no evidence of this.
Extraction of species: fish & shellfish	Yes	• It is not known whether or how the targeted removal of fish and shellfish influence sponge and anthozoan assemblages.
Extraction of species: maerl extraction	No	• Unlikely given the biotopes we are considering.
Extraction of species: seaweed harvesting	No	• Unlikely to have a major impact.
Extraction of species: other	Yes	• None given.
Marine acidification	Yes	• A range of research is available that shows the effects of acidification, but nothing so far on temperate marine sponges and few studies on temperate anthozoans

*= Pressure definitions taken from European Commission 2012.
**=The relevance of the pressures is base on expert knowledge and judgement.

v. Proposed indicator species

Indicator species are widely used in condition assessment monitoring and the consulted experts were requested to develop a list of species that could be utilised as indicators based on the following criteria: responsiveness to anthropogenic pressures; distinctiveness within the fragile sponge and anthozoan biotopes; and biogeographical representation. The list of species provided by each expert also included information about their applicability as indicator species.

The indicator species are primarily applicable to the SpongeAntho indicator proposed by HBDSEG. A number of the proposed species are those that are considered indicative of the fragile sponge and anthozoan biotopes rather than being an indicator of a specific pressure.

Table 2.5 and Table 2.6 presents the list of indicator species proposed by the experts that were subsequently reviewed by the project team. Pressures that are thought to significantly affect each species are also provided, together with an indication of sensitivities and tolerances. However, the primary justification for the selection of most of the species was their characterising occurrence in the fragile sponge and anthozoan biotopes as, for most sponge and anthozoan species, tolerance and responses to specific pressures are unknown. Information regarding distribution and the specific biotopes in which each species is present is also included.

Table 2.5. Sponge indicator species proposed by the consulted experts and the justifications for their selection.

Indicator Species Name	Morpho-type(s)	Relevant traits*	Distribution	Detectable pressures**	Sensitivities and tolerances	Reasons for choice as an indicator	Biotope(s)***	Bio-geographic region of assessment ****
Amphilectus fucorum	Fistulate/ Encrusting/ Massive	Fast-growing and early coloniser	Common throughout the UK and has been recorded from the Shetland Isles, Orkney, Fraserburgh, the Firth of Forth, Northumberland and east Yorkshire, the south-east, south and south-west coasts of England and the west coasts of England and Scotland.	Unknown	Sensitive to sediment	Easy to ID (although some morphological variability), and early coloniser	CR.HCR.FaT.Ctub.CuSp; CR.HCR.Xfa.ByErSp.DysAct; CR.HCR.Xfa.FluHocu; CR.MCR.CFaVS.CuSpH.As	1,2,3,4,5,6,7
Axinella dissimilis	Arborescent/ Branch	Long-lived; slow-growing; large (3D structure); fragile	Common on the south coast of the UK to as far north as Mull in Scotland.	Physical disturbance	Tolerates silt. Very sensitive to physical disturbance	Easy to ID (distinct form) and likely to be sensitive to physical disturbance	CR.HCR.DpSp.PhaAxi	6,5,4
Axinella infundibuliformis	Cup	Long-lived; slow-growing; large (3D structure); fragile	West coast of Scotland down to the southwest coast of England.	Physical disturbance	Tolerates silt. Very sensitive to physical disturbance	Easy to ID (distinct form) and likely to be sensitive to physical disturbance	CR.HCR.DpSp.PhaAxi	4,5,6,7
Cliona celata	Massive	Long-lived; slow-growing, but fast regeneration	UK-wide.	Unknown	Sensitive to sediment	Easy to ID (very distinct form) and long-lived	CR.HCR.DpSp.PhaAxi; CR.HCR.Xfa.ByErSp.DysAct; CR.HCR.Xfa.ByErSp.Sag CR.HCR.Xfa.SubCriTf; CR.MCR.EcCr.CarSp.PenPcom; CR.MCR.CFaVS.CuSpH; CR.MCR.CFaVS.CuSpH.As	All
Halichondria panicea	Cushion/ Massive	Fast-growing	UK-wide.	Nutrient enrichment	Very tolerant of high levels of organic nutrients	Easy to ID and appears to respond to changes in nutrient input	CR.HCR.Xfa.SubCriTf; CR.MCR.CFaVS.CuSpH; CR.MCR.CFaVS.CuSpH.As; CR.MCR.CFaVS.CuSpH.VS	1,2,3,4,5,6,7
Haliclona oculata	Arborescent/ Branch	Fast-growing	Recorded from the Shetland Isles, Cromarty Firth, Firth of Forth, Northumberland, southern coasts of England, Isles of Scilly, north Devon, Wales, Cumbria, western Scotland, Hebrides, and northern Ireland.	Physical disturbance	Tolerates silt; Sensitive to physical disturbance	Delicate branching species	CR.HCR.Xfa.FluHocu; CR.MCR.CFaVS.CuSpH.VS	1,2,3,4,5,6,7

Indicator Species Name	Morpho-type(s)	Relevant traits*	Distribution	Detectable pressures**	Sensitivities and tolerances	Reasons for choice as an indicator	Biotope(s)***	Bio-geographic region of assessment ****
Hemimycale columella	Encrusting	Unknown	This species has a widespread distribution from south-east England to northwest Scotland, it has not been recorded from the North Sea coast except at Blyth.	Unknown	Intolerant of sedimentation	One of the few encrusting species that is easy to ID	CR.HCR.FaT.Ctub.CuSp; CR.HCR.DpSp.PhaAxi; CR.HCR.Xfa.ByErSp.DysAct; CR.HCR.Xfa.ByErSp.Sag; CR.HCR.Xfa.SpAnVt;	2,3,4,5,6,7
Pachymatisma johnstonia	Massive	Long-lived; large and likely to be slow growing	Wide distribution having been found on the south and west coasts of Great Britain and as far north as Orkney.	Unknown	Some tolerance to sedimentation	Easy to ID and through to be long-lived	CR.HCR.FaT.Ctub.CuSp; CR.HCR.DpSp.PhaAxi; CR.HCR.Xfa.ByErSp.DysActCR. HCR.Xfa.ByErSp.Sag; CR.HCR.Xfa.SpAnVt; CR.MCR.EcCr.CarSp.PenPcom	2,3,4,5,6,7
Phakellia ventilabrum	Cup	Long-lived; fragile; slow growing	West coast of Scotland and the Hebrides, and from the very south western tip of Wales.	Physical disturbance	Tolerates silt; Very sensitive to physical disturbance	Easy to ID (distinct form) (although possible to confuse with *A. infundibuliformis*)	CR.HCR.DpSp.PhaAxi	4,5,6
Polymastia penicillus	Papillate	Long-lived	Widely distributed.	Unknown	Tolerates sediment	Usually on upward-facing rocks; tolerant of turbid water	CR.HCR.Xfa.ByErSp.Sag; CR.HCR.Xfa.SubCriTf;	1,2,3,4,5,6,7
Raspailia ramosa	Arborescent/ Branch	Rapid and regular recruitment	Broad distribution around the UK, from the southwest coast of the UK to Scotland, but is absent from the North Sea.	Physical disturbance	Tolerates silt; Very sensitive to physical disturbance	Delicate species, sensitive to disturbance	CR.HCR.Xfa.ByErSp.DysAct; CR.HCR.Xfa.SubCriTf; CR.MCR.CFaVS.CuSpH.As	3,4,5,6,7
Stelligera stuposa	Arborescent/ Branch	Rapid and regular recruitment	Widely distributed around the UK, but is typically more common on the west coast as far north as Scotland.	Physical disturbance	Tolerates silt. Sensitive to physical disturbance	Hard to differentiate from *Raspailia hispida* when small; slimey when stressed. Possible to group recent recruits - would need microscopic identification. Although would be quick as spicule compliment very different.	CR.HCR.DpSp.PhaAxi; CR.HCR.Xfa.ByErSp.DysAct; CR.HCR.Xfa.ByErSp.Sag;	3,4,5,6,7
Tethya aurantium	Globulose	High levels recruitment; reliant on asexual reproduction	South-west England, the west coast of Wales, and western Scotland down to 130m.	Physical disturbance		Easy to ID; size can alter by contracting.	CR.HCR.DpSp.PhaAxi; CR.HCR.Xfa.ByErSp.DysAct	3,4,5,6,7

*= 'Relevant traits' are those features of the species biology/ecology that could be used as a component of a supporting indicator (e.g. the presence of long-lived species).
**= 'Detectable pressures' provides professional judgement from the consulted experts on the pressures that the species may be able to detect.
***= The biotope column provides a list of the biotopes in which this species occurs as a characterising element.
****= 'Biogeographic regions of assessment' are the regions where the species could be utilised as an indicator (based on: Regional Sea Boundaries (UKMMAS 2010))

Table 2.6. Anthozoa indicator species proposed by the consulted experts and justifications for their selection.

Indicator Species Name	Morpho-type(s)	Relevant traits*	Distribution	Detectable pressures **	Sensitivities and tolerances	Reasons for choice as an indicator	Biotope(s)***	Bio-geographic region of assessment ****
Alcyonium digitatum	Massive	Opportunistic; fast-growing; long-lived	Widely distributed.	Physical disturbance	They have high sensitivity to substratum loss, and some susceptibility to smothering.	Easy to ID (though some possible confusion of orange form with pale *A. glomeratum*); long-distance larval dispersal; occurs from pristine to 'challenging' environmental conditions; high abundance in environmentally compromised areas. Low abundance where a wider variety of species can colonise; Long-lived brooder; relatively easy to see physical damage; indicative of lack of disturbance in some habitats.	CR.HCR.FaT.Ctub.Adig CR.HCR.Xfa.ByErSp.Eun CR.HCR.Xfa.CvirCri CR.HCR.Xfa.ByErSp.Sag CR.HCR.Xfa.ByErSp.DysAct CR.HCR.Xfa.SwiLgAs CR.HCR.Xfa.SpAnVt CR.MCR.EcCr.CarSwi.LgAs CR.MCR.EcCr.CarSp.PenPcom CR.MCR.EcCr.FaAlCr.Car CR.MCR.EcCr.AdigVt CR.LCR.BrAs.NeoPro CR.FCR.FouFa.AdigMsen	1,2,3,4,5,6,7
Alcyonium glomeratum	Massive	Common/ frequent species	South and west coasts of Britain, but has been reported as far north as western Scotland.	Physical disturbance	They have high sensitivity to substratum loss, and some susceptibility to smothering.	Easy to ID (though some possible confusion with orange form of *A. digitatum*); fast growing, long-lived, probably long-distance larval dispersal and colonised new surfaces quickly. High abundance in environmental conditions that are favourable to a high diversity and often rare or scarce species. May be susceptible to eutrophic conditions and disease; indicative of lack of disturbance in some habitats; common but needs research to see if it is a reliable indicator; disappearing from SMNR monitoring sites, but the cause is unknown.	CR.FCR.Cv.SpCup	4,5,6
Caryophyllia smithii	Cup coral	Ubiquitous; relatively common; slow-growing; long-lived; associated with other species	Wide distribution from Shetland, north eastern England, the south west, Wales, and north western Scotland.	Physical disturbance	Tolerant to sedimentation	Easy to ID; can reach high abundance so might be able to use univariate statistics. Often associated with *Axinella* sp.; Change in morphology of calyx due to high sediment loads.	CR.HCR.Xfa.ByErSp.Eun CR.HCR.Xfa.CvirCri CR.HCR.Xfa.ByErSp.Sag CR.HCR.Xfa.ByErSp.DysAct CR.HCR.Xfa.SwiLgAs CR.HCR.Xfa.SpAnVt CR.MCR.EcCr.CarSwi.LgAs CR.MCR.EcCr.CarSp.PenPcom 1CR.MCR.EcCr.FaAlCr.Car CR.MCR.EcCr.AdigVt CR.FCR.Cv.SpCup CR.FCR.FouFa.AdigMsen	3,4,5,6,7,

Indicator Species Name	Morpho-type(s)	Relevant traits*	Distribution	Detectable pressures **	Sensitivities and tolerances	Reasons for choice as an indicator	Biotope(s)***	Bio-geographic region of assessment ****
Corynactis viridis	Anemone-shaped	Locally common	Reaches its northern limit in Shetland. It is commonly found along the south and west coasts of Britain.	Unknown	Unknown	Easy to ID; common to some locations, lend themselves to quantification via photoquadrats.	CR.HCR.FaT.Ctub.Adig CR.HCR.Xfa.CvirCri CR.HCR.Xfa.ByErSp.Sag CR.HCR.Xfa.ByErSp.DysAct CR.HCR.Xfa.SpAnVt CR.MCR.EcCr.CarSp.PenPcom CR.MCR.EcCr.AdigVt CR.FCR.Cv.SpCup CR.FCR.FouFa.AdigMsen	3,4,5,6,7,
Eunicella verrucosa	Arborescent/ fan	Long-lived; slow-growing; fragile; supports other spp.; local	Skomer south and west to Isles of Scilly and east to Dorset. Also in S & W Ireland.	Physical disturbance	Intolerant of scour; vibrio disease/necrosis Intolerant smothering and changes in water flow and exposure regime. It has some tolerance to physical disturbance and abrasion.	Easy to ID; "flagship" spp; existing data (from several sites throughout SW); intolerant of scour - doesn't occur in any significant abundance where sand is in suspension). Probably limited (<1km) larval dispersal. Grows fairly slowly (~1cm/yr). Very sensitive to physical disturbance (physical disturbance = towed fishing gear). May be sensitive to eutrophication & vibrio bacterial infections. Has a specific fauna of associated (bryozoan) species. Often part of a rich community.	CR.HCR.Xfa.ByErSp.Eun	4,5
Leptopsammia pruvoti	Cup coral	Found in caves & overhanging walls; very rare and very local	Occurs at Portland Bill, Lyme Bay, off Plymouth Sound, the Isles of Scilly and Lundy only.	Physical disturbance	Highly intolerant to substratum loss, smothering, desiccation and abrasion/physical damage	Easy to ID; existing data (from Lundy); associated with high spp. richness; only found in caves and overhangs but the species is an important feature in these habitats; distribution shift/abundance.	CR.FCR.Cv.SpCup	4
Parazoanthus anguicomus	Colonial anemone	Associated with high spp. richness	Restricted distribution to western and northern Scotland, but has also been reported from south-west Wales & SW England.	Unknown	Indicative of good water quality	Useful edge of range species (north/south).	CR.FCR.Cv.SpCup	4,5,6,
Parazoanthus axinellae	Colonial anemone	Associated with high spp richness; Uncommon	South west and west coasts of the British Isles.	Unknown	Indicative of good water quality	Useful edge of range species (south/north); easy to ID; NRW methodology in place with photos.	CR.HCR.Xfa.ByErSp.Eun CR.FCR.Cv.SpCup	5,6,7

Indicator Species Name	Morpho-type(s)	Relevant traits*	Distribution	Detectable pressures **	Sensitivities and tolerances	Reasons for choice as an indicator	Biotope(s)***	Bio-geographic region of assessment ****
Swiftia pallida	Arborescent/ fan	Long-lived; slow-growing; fragile; local; relatively common on west coast of Scotland	North-west (Scotland)	Physical disturbance; entanglement	Sensitive to smothering, but not to changes in suspended sediments or turbidity. They are likely to be sensitive to physical disturbance and substratum loss	Easy to ID; existing data; associated with Axinella spp. and *Caryophyllia smithii.*	CR.HCR.Xfa.SwiLgAs	6,7
Urticina felina	Anemone-shaped	Common	Widely distributed	Physical disturbance	Low sensitivity to smothering and increased suspended sediment, but some sensitivity to changes in flow rate, temperature and abrasion.	Could be good abrasion indicator; impact feeder – subject to dredging / infill; conspicuous. Possible confusion with *U. eques*	CR.HCR.FaT.Ctub.Adig CR.HCR.Xfa.ByErSp.Sag CR.MCR.EcCr.CarSp.PenPcom CR.MCR.EcCr.UrtScr CR.MCR.EcCr.AdigVt	1,2,3,4,5,6,7

*= 'Relevant traits' are those features of the species biology/ecology that could be used as a component of a supporting indicator (e.g. the presence of long-lived species).
**= 'Detectable pressures' provides professional judgement from the consulted experts on the pressures that the species may be able to detect.
***= The biotope column provides a list of the biotopes in which this species occurs as a characterising element.
****= 'Biogeographic regions

2.3 Data review

2.3.1 Methodology

To assess the potential of the suggested indicator species, datasets that contained relevant biotic and abiotic records were appraised. This action was undertaken in conjunction with the literature collation exercise. Datasets meeting the following criteria were investigated:

- acceptable level of morphological diversity in sponge assemblages;
- suitable species composition and abundance of fragile sponge and anthozoan assemblages; and
- the presence of identified pressures with the potential to confer impacts on sublittoral habitats, sponges and anthozoans.

Datasets were requested from:

- SNCBs.
- NGOs.
- Researchers (including the authors of the papers from the literature review).
- Universities.
- Commercial ecological consultants.
- Research bodies.

Deadlines were set to respond to data requests and only those datasets retrieved in the collation period were included in our assessment.

In addition, online data portals were also explored to retrieve data matching the criteria above. Data portals investigated included: JNCC's 'Marine Recorder[7]'; the Ocean Biogeographic Information System (OBIS); the International Council for the Exploration of the Sea (ICES); the European Ocean Biogeographic Information System (EurOBIS); the Archive for Marine Species and Habitats Data (DASSH); and the Natural Geography in Shore Area database (NaGISA).

The collated datasets were then reviewed to assess their relevance to the project specification and whether sponge and anthozoan datasets could be utilised to perform validation tests for the supporting indicators. In addition, the following questions were asked of the environmental and pressure data:

1) What is the geographic and temporal applicability of the dataset?
   a) Does it coincide with existing records for sponges, anthozoans and sublittoral rock habitats?
   b) Are the data continuous or discrete?
2) What environmental parameters have been measured?
   a) Can any of the parameters be used as a proxy for a specified pressure?
3) How relevant are the parameters to sponge and anthozoan indicators?
4) How accurate are the data (e.g. detailed or generalized temporal/spatial information given)?

The list of collated datasets is included in Appendix 3.

[7] http://jncc.defra.gov.uk/page-1599

2.3.2 Results

The initial data search revealed eight data sources that could be considered to be potential candidates for indicator assessment (see Appendix 3). The datasets that were subsequently found to be available were subjected to a high level assessment, to establish suitability for further analysis. The data were scored on ‘Detail/Accuracy’ and ‘Geographical coverage’. They were then assigned an ‘Overall suitability’ score (see Table 2.7). The results show that out of the eight datasets/studies assessed, only two demonstrated any suitability for indicator assessment. The selected datasets were from: 1) Skomer Marine Nature Reserve (MNR), from Natural Resources Wales (NRW), and 2) Bell et al, 2006 (see Table 2.7). Although the latter dataset was subsequently not used in this report, its findings guided proposals for the morphological aspect of the supporting indicators. After further consultation with the project steering group, it was agreed that distribution data held in the Marine Recorder database could assist in the determination of the temporal and biogeographical constraints that might apply to the species and biotopes under investigation.

Table 2.7. Datasets considered for the overall suitability for testing pressure data

Data source	Comments: positive	Comments: negative	Detail / Accuracy	Spatial coverage	Overall suitability
Skomer MNR, Natural Resources Wales	• Count/abundance data available for many individual species. In some cases the data are available in two formats: individual species abundance, along with the same data grouped by morphological type. In other cases either species or morphological data are available. • Time series data available up to present day (some studies dating back to 1995). • Environmental (abiotic, climatic) and recreational/fishing data available. • Data are reliable and current. • Positional information available for each survey site.	• Requires combination of data from different surveys that are designed for different purposes. Can lead to difficulties e.g. different time recording periods, differences in equipment or method used. • Data cover a very small geographic area, and within a protected area- may not be representative of sublittoral habitats throughout the region (or beyond). • Environmental data not available for every sponge/anthozoan survey site.	High	Low	Moderate
Menai Strait and Conwy Bay SAC, Natural Resources Wales	• Abundance data available for morphological types. • Time series 2005-2011. • Data are reliable and current.	• No supporting environmental data. • Very limited geographic coverage. • No information on individual species.	Moderate	Low	Low
Pembrokeshire Marine SAC, Natural Resources Wales	• Abundance data available for individual species. • Sample points represent different habitats (e.g. depth) and levels of disturbance (e.g. within shipping channel) - could make some inferences on disturbance level. • Could analyse individual species or group into morphological type. • Time series 2005-2012. • Some survey locations very close to Skomer MNR - may be possible to pool data. • Data are reliable and current.	• No supporting environmental data. • Limited geographic coverage. • No positional data.	Moderate	Low	Low
James Bell sponge survey data: Bell *et al* 2006	• Abundance data available for morphological types. • Some supporting environmental data. • Time series 1993-2003. • Sampling carried out at Skomer MNR monitoring sites - could analyse with Skomer environmental data. • Data are reliable and current.	• Very limited geographic coverage. • No information on individual species.	High	Low	Moderate
UKSeaMap JNCC: http://jncc.defra.gov.uk/page-2117	• Continuous (national coverage) substrate and habitat context data for UK waters. • Shows extent of sublittoral habitat.	• Data are modelled. • Not a suitable dataset with respect to indicator pressures.	Low	High	Low

Data source	Comments: positive	Comments: negative	Detail / Accuracy	Spatial coverage	Overall suitability
EUSeaMap JNCC: http://jncc.defra.gov.uk/page-5020	• Continuous (national coverage) coverage of UK waters. • Data available for wave energy, tidal current energy, and light penetration. • Light penetration data, which could possibly been used as a proxy for turbidity, is only sufficient for infralittoral zone only. • Sediment type and general habitat context data (e.g. salinity class, biozone). • Data are free and accessible to all users via web download. • Could be used to investigate relationships between species distribution and pressure intensity. Species existing at extreme of their tolerance to an environmental parameter may be more vulnerable to other stresses.	• Data are modelled. • Resolution and date of input data varies or are unknown. • Not a suitable dataset with respect to indicator pressures.	Moderate	High	Low
EMODnet: http://www.emodnet-hydrography.eu/	• Continuous (national coverage) bathymetry for UK waters. • Data are free and accessible to all users via web download.	• Data are modelled. • Data comprises mosaic from different sources, using different methods. • Accuracy and date unknown. • Not a suitable dataset with respect to indicator pressures.	Low	High	Low
Marine Recorder JNCC: http://jncc.defra.gov.uk/page-1599	• Very large data set in terms of number of records and geographic range. • Records presence of individual species. • Could use to analyse species geographic range. • Contains habitat description and some environmental data e.g. temperature, salinity, exposure. • Could possibly gather more information about community composition by analysing detailed habitat descriptions.	• No information on species abundance. • Some of the records are very old. • No time series data. • Very little supporting quantitative environmental data. • Accuracy unknown. • Compiled by many recorders – different survey methods and descriptive terminology. • For further information, see Appendix 6	Low	High	Low

2.4 Analysis of proposed indicator responses to pressures

2.4.1 Skomer pressure data

The response of sponge and anthozoan species composition and abundance to a range of environmental conditions was tested by applying analytical tests to field data that was obtained during the data capture phase of this project (see Section 2.3). This step was needed to evaluate if and how existing datasets could be used for the design of the approaches underpinning the indicator, and the testing and validation of the proposed metrics. Although the data available was very useful in informing the development of a set of metrics and the conceptual methodologies for these indicators, analysis of the data for testing and validation proved inconclusive. The surveys were not designed to test changes driven by a wide range of anthropogenic pressures and as a consequence the power to detect those changes was not a consideration of the original sampling design. This meant the existing datasets were not well suited for validation.

To test the proposed indicators properly, a bespoke sampling strategy with clear statistical objectives is recommended. Despite data limitations, morphological diversity showed the greatest potential for future indicator specification.

2.4.2 Data analysis tests

The indicator species and anthropogenic pressure information gained from the expert consultation (see Section 2.2.2) was applied to analysis of the Skomer species datasets (see Appendix 4 for statistical details and Appendix 5 - Further details on the analysis of proposed indicator responses to pressures for further analyses). The Skomer species dataset incorporated analyses of sponge species data collected at Skomer MNR as part of a PhD research project at Victoria University of Wellington (Berman 2012) (see Figure 2.1).

The Skomer dataset consisted of species abundance recorded at three sites between 2006 and 2009. The temporal distribution of these surveys is shown in Table 2.8. For several years multi-temporal species data were recorded; through spring, summer and autumn. For other years, only spring and summer surveys were carried out, and some of the sites were not visited. The dataset provides records for a total of 46 sponge species of which eleven were identified as potential indicators during the consultation; these species are listed in Table 2.9.

Abiotic data for Skomer were available for the same period, although the recording stations were not always in the same location as the sponge survey sites (Figure 2.1). Temperature was not identified as a significant environmental driver during the consultation, but relationships between this parameter and species abundance were also investigated.

Abrasion was identified as the most significant known pressure affecting sponge and anthozoan assemblages, predominantly by means of direct physical damage and entanglement. No specific data were available regarding abrasion. However, Skomer MNR researchers record annual summaries of fishing pot locations within the MNR. These data were therefore used as a proxy for abrasion by calculating pot density within a 50m radius (Figure 2.2). The precise positions of the three sponge survey sites were unknown, as no locational data were available for the sites. Therefore an estimate was made for the purpose of this spatial data analysis, using a map illustration and descriptions from Berman (2012) as a guide.

Table 2.8. Seasonal timing and location of sponge species surveys at Skomer MNR.

Year	Season	Site
2006	Summer	Spongey Hillocks
	Autumn	Broad Gulley Dog Leg Spongey Hillocks
2007	Spring	Broad Gulley Dog Leg Spongey Hillocks
	Summer	Broad Gulley Dog Leg Spongey Hillocks
2008	Spring	Broad Gulley Dog Leg Spongey Hillocks
	Summer	Broad Gulley Dog Leg Spongey Hillocks
	Autumn	Broad Gulley Dog Leg Spongey Hillocks
2009	Spring	Spongey Hillocks
	Summer	Dog Leg
	Autumn	Broad Gulley

Table 2.9 Matrix of indicator species to pressure susceptibility, during workshop consultation.

Species	Life strategy	Sensitive to abiotic pressure		
		Abrasion	Siltation	Salinity
Axinella dissimilis	Long-lived	Yes	Yes	Yes
Axinella infundibuliformis	Long-lived	Yes	Yes	Yes
Haliclona oculata	Fast-growing	Yes	No	No
Stelligera stuposa	Fast-growing	Yes	No	Yes
Raspailia ramosa	Unknown	Yes	No	Yes
Hemimycale columella	Unknown	No	Yes	Yes
Halichondria panicea	Fast-growing	No	Yes	Yes
Amphilectus fucorum	Fast-growing	No	Yes	Yes
Pachymatisma johnstonia	Long-lived	No	No	Yes
Cliona celata	Long-lived	No	Yes	Yes

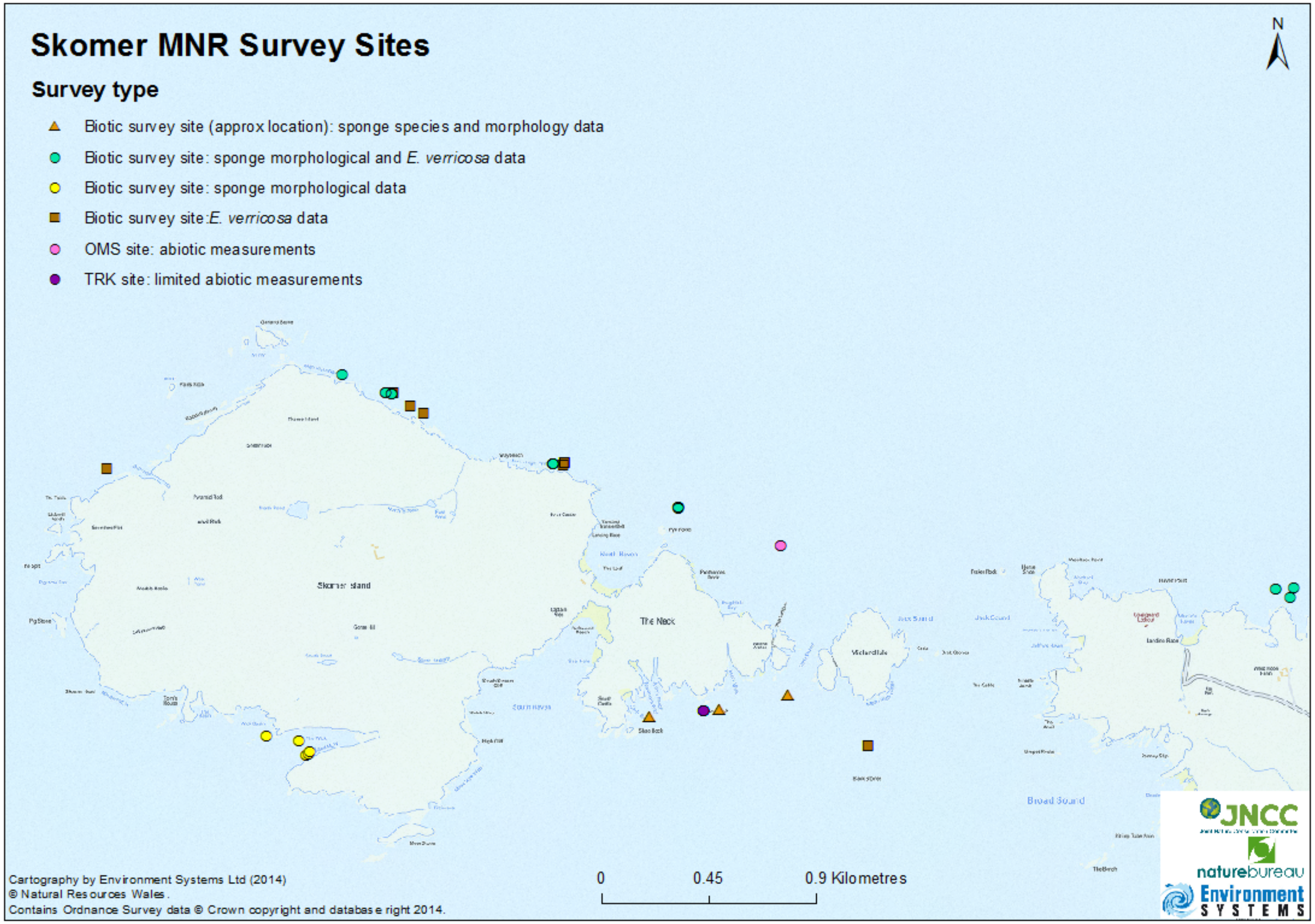

Figure 2.1. Skomer MNR survey sites used for analysis.

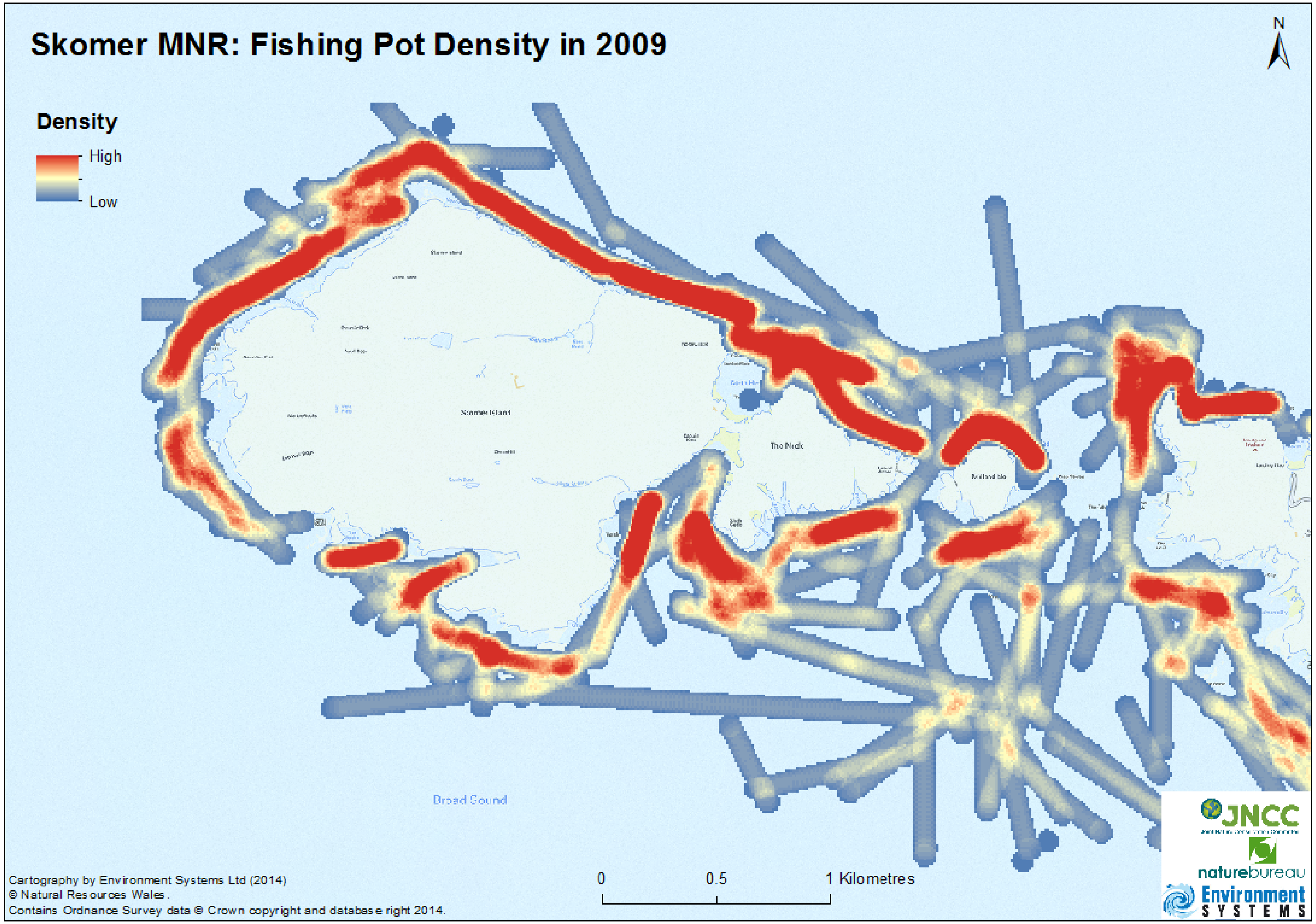

Figure 2.2. Estimated fishing pot density at Skomer MNR (2009)

The fishing pot location data were supplied in MAPINFO[8] point format, as estimated locations of individual pots along fishing lines together with the year of deployment. From these data an annual summary of potting activity throughout the summer months were derived (Figure 2.2). The specific dates of potting activity at each location were not provided, so the pot data were only evaluated with reference to autumn species records. The autumn dataset consisted of species records for three sample sites in 2006, two in 2008 and one in 2009.

As discussed in Section 2.4.1, no significant results were found from the data tests, however the results were considered inconclusive due to the limited availability of suitable (fit-for-purpose) environmental and pressure data. Surveys focussed on the collection of key environmental and pressure data require further development in order to inform an assessment of GES (see Section 5.6).

[8] MapInfo Professional is a desktop geographic information system (GIS) software product used for mapping and location analytics.

3 Evaluation of the supporting indicators proposed by HBDSEG

The review of relevant literature relating to the two supporting indicators proposed by HBDSEG (MorphSponge and SpongeAntho; see Table ***1.4***) concluded that there were few studies where anthropogenic pressures have been directly linked to the diversity of sponge morphological types or the composition and abundance of fragile sponge and anthozoan assemblages. It is clear from the literature that a greater understanding of natural variation in sponge and anthozoan assemblages is required before the two supporting indicator proposals can be expanded to detect specific anthropogenic pressures.

In addition, a range of traits and metrics (see Table 2.2 and

Table ***2.3***) were identified through the literature review and expert consultation, and although some were identified by experts as possible indicators of anthropogenic pressures, there is little published evidence for these associations. Moreover, most of the identified traits are known to be influenced by natural processes, the mechanisms of which are poorly understood. Considerable further work is therefore required to test specific traits and metrics to determine that they can act as indicators.

A list of indicator species was identified within the expert consultation (see Table 2.5 and Table 2.6) that represents a subset of species found in fragile sponge and anthozoan assemblages. These species were primarily chosen because they are easy to identify and a range of traits have been identified for them (Table 2.2). Some indicator species were identified as possible indicators of anthropogenic pressures, but the results of testing the association between these species and the pressures to which they are thought to be vulnerable (using existing data) showed no association (see Appendix 5). It should be noted that this data testing was based on data collected from different sources and from studies that were not specifically designed to test the association of sponge and anthozoan assemblages with anthropogenic pressures.

The authors conclude that in the first instance monitoring effort should be focussed on establishing the range within which natural variation of sponge and anthozoan community attributes is constrained before attempting to directly apply the supporting indicators to status assessments. If such monitoring is undertaken across the UK this will allow a baseline to be established and the drivers of change can then be subsequently identified and further investigated.

3.1 Revisions to the proposed supporting indicator for ‘Morphological richness and diversity of sponge assemblages’ (MorphSponge)

The morphological approach to assessing sponge diversity is a proven monitoring methodology for detecting change in sponge assemblages with existing datasets available for Welsh and Irish waters (see Appendix 3). If the morphological approach is developed into an operational indicator, it is important that anthozoans are included or that a separate indicator is established to take account of the anthozoan community component.

3.2 Revisions to the proposed supporting indicator for sublittoral species composition and abundance of fragile sponge and anthozoan assemblages (SpongeAntho)

The literature review was unable to locate documented studies that had set out to establish a strong relationship between sponge and anthozoan assemblages and anthropogenic pressures. There are some species-specific studies however, that have attempted to establish anthropogenic pressure-mediated effects, but no studies have looked at the components of the indicator as a whole (such as the MorphSponge indicator).

The SpongeAntho indicator was discussed at the expert consultation with most experts agreeing that a fragile sponge and anthozoan community status metric for the purposes of GES evaluation should be assessed through the collection of species-level data (e.g. species richness and abundance). In general terms, anthozoans are easier to identify with certainty than sponges, so species-level assessments of the anthozoan assemblage component can be undertaken without the need for morphology-level assessments. However, appreciation was expressed over the likely effort and financial resources that would be required to undertake such surveys at the national level and the probable limitations on these resources. There was therefore recognition of the need to propose practical alternatives, such as the use of collecting data only on specific indicator species, if these could be identified and demonstrated to be ‘fit for purpose’.

3.3 Other considerations

It is recommended that all monitoring events should include an assessment of sponge morphology and anthozoan species presence as a minimum.

It is also important to consider the precision of data retrieved using either the morphological approach or the indicator species approach. A full species-level assessment of each sample area will provide more precise information than either the morphological approach or the indicator species approach. There are, however, likely to be considerable financial constraints on monitoring programmes that are repeated over short periods (e.g. annually or every other year).

The following Section outlines the recommendations for deploying supporting indicators that will faciliate determination of the range of natural variation. A range of options are provided based on a common indicator framework to ensure a favourable compromise is reached between (1) achieving adequate data precision; (2) achieving a practical balance for the required time and resources; and (3) establishing the optimum financial cost of implementing the final supporting indicator.

Based on the current limitations in availability of ecological information on sponges and anthozoans in UK waters, particularly with respect to the impacts of anthropogenic pressures, determining if GES has been achieved will be difficult. An assessment of temporal and spatial variability in the assemblages found in shallow sublittoral biotope types is a critical step in assessing any future influence of anthropogenic pressures, and in understanding what environmental state constitutes an acceptable target for GES.

While we are confident that the proposed indicators will detect change within sponge and anthozoan assemblages, the lack of understanding of what constitutes natural variation, both within assemblages and across regions, presents considerable challenges to the ultimate goal of detecting and responding to anthropogenic pressures. A longer-term set of community/biotope data will provide clarity on natural variability and will allow definitive parameters to be set for what is considered “unnatural” and therefore in all likelihood, an indicator of anthropogenic influence and an unfavourable GES determinant. With this in mind, Section 5 details some approaches to dealing with this problem in the meantime.

4 Final supporting indicator recommendations for detecting natural variation

This section describes proposals for the final supporting indicators. Each of these proposals includes both sponge and anthozoan assemblages.

Table 4.1 shows the final list of proposed supporting indicators. They are in descending order based on the quality of data that each indicator will provide. The following sub-sections describe the supporting indicator proposals in detail.

Table 4.1. Final supporting indicator proposals

Indicator	ID	Supporting Indicator Name	Sensitivity of Indicator* (5 = High, 1=Low)
Indicator 1	SpongeAntho	Sublittoral species composition and abundance of fragile sponge and anthozoan assemblages	5
Indicator 2	SpongeMorphAntho	Morphological diversity of sponge assemblages plus anthozoan species composition and abundance	4
Indicator 3	SpongeMorphAnthoSpongePresAb	Morphological diversity of sponge assemblages plus presence/absence of anthozoan indicator species	3
Indicator 4	SpongeAnthoPresAb	Presence/absence of sponge and anthozoan indicator species	2

* = these values are based on the expert knowledge of the project team.

4.1 Indicator 1: Sublittoral species composition and abundance of fragile sponge and anthozoan assemblages (SpongeAntho)

4.1.1 Introduction

Sponge and anthozoan species composition and abundance data provide the highest level of ecological information for monitoring changes in sponge and anthozoan assemblages. However, it is important to note that (as described earlier in this report) little is known about temporal and spatial variation within fragile sponge and anthozoan assemblages, and any assessment against GES will require these data to provide a baseline.

Sponge abundance can be estimated in three different ways, using: 1) area occupied (area of rock substratum covered); 2) number of sponge patches/individual sponges; or 3) volume. While some researchers working on coral reef sponges have argued that volume is the most appropriate abundance measure for sponges (Wulff 2006) since this provides an indicator of abundance relative to the most important sponge functional role (water pumping), this is mostly impractical for UK species given their small size and irregular shapes. Although photographic methods (see Abdo *et al* 2006) may make this possible in the future for upright species, it is unlikely to be suitable for encrusting, massive or cryptic forms and therefore the authors recommend using the number of sponge patches/individual sponges and area occupied methods to characterise the abundance of each species.

There are few data available for the overall abundance of anthozoans in specific marine communities as most studies have tended to be species specific (e.g. Bell *et al* 2006; Bell & Turner 2000). The authors propose two measures of anthozoan abundance: 1) total number of each anthozoan species and 2) area occupied by anthozoans, the latter being more important for colonial/encrusting species, while the former would be most appropriate for sea fans.

4.1.2 Methods

This approach focuses on counting the number of each species present and the area they occupy. Previous work at Skomer (see Appendix 3 – Dataset Review for more information) used $1m^2$ quadrats to characterise sponge assemblages, with five quadrats being examined at each of three sites. A site is defined as an area less than $50m^2$. The Skomer study used fixed, permanent quadrats, which are revisited. The size of the quadrat was based on the time taken to survey one quadrat, as typically one quadrat could be surveyed on each dive. The number of quadrats was based on species area curves for the location, whereby 95% of the species found were captured within five quadrats (Berman *et al* 2013). Therefore, the authors propose that the same quadrat size and the same number of quadrats used for the Skomer study are used for other survey locations, although an initial assessment will be needed to determine the appropriate number of quadrats and size of quadrat at each locality in the first instance. Each quadrat can be further subdivided into smaller 'sub-quadrats' using string or similar if the sponge/anthozoan abundance is high and to aid in taking high resolution photographs. Although $1m^2$ quadrats are proposed based on the analysis by Berman *et al* (2013), this may not be practical in some areas due to the nature of the substrate. In such circumstances, smaller-sized quadrats may be appropriate ($0.25m^2$), although further statistical analysis should be conducted to determine the appropriate number of quadrats.

The abundance of each species (sponges and anthozoans) within each quadrat would be estimated including both the number of patches and the area occupied. The best way of collecting data on the number of patches of each species is to collect the data *in situ* (using a combination of direct diver observations and photographs). It is proposed to record the number of patches for each species of sponge and anthozoan, and where there is any doubt in the identity of a species, a sample should be taken for laboratory microscopic examination. For determining the area occupied, rough maps of sponge locations should be made of each quadrat so that individual sponge patches can be matched up with samples in the post-dive analysis. Photographs should be taken of the quadrats and the area occupied estimated using image analysis. Sponges typically show high rates of regeneration (1-$3mm^3$), therefore small samples should be taken from the actual individual sampled. However, in cases where the sponge patch is very small or a larger sample is needed, it should be collected from outside the quadrat. It is less likely that samples will need to be taken for anthozoans as most species (but not all) can be distinguished by eye.

There is some debate regarding the need to remove any sediment layer on rocky surfaces (which is common for these biotope types) prior to sampling rocky habitats (Bell *et al* 2006; Berman *et al* 2013). Any sediment layer present is likely to reduce the number of encrusting species observed. Therefore the authors recommend that sediment should be gently 'wafted' away by hand prior to sampling.

A range of analytical methods are available to analyse these data including a suite of univariate and multivariate indices and analyses. These would be appropriate for assessing changes in these assemblages over time.

4.1.3 Advantages

This indicator is based on a tested methodology that is capable of detecting changes in sponge and anthozoan assemblages and enables temporal patterns to be evaluated at the species level. Furthermore, this indicator has the potential to detect range expansions and the arrival of non-indigenous species (e.g. as a result of climate change). Importantly, the implementation of this indicator could provide data on a number of the traits identified in Table 2.2 (Abundance, Recruitment, Mortality, Growth, Disease Occurrence; Deformity), which could also be assessed from the data and photographs.

4.1.4 Disadvantages

The collection of the data for this indicator will be very expensive (compared to all other proposed indicators) as it requires a high level of taxonomic expertise and a considerable amount of dive time. It would likely take two divers a single dive to complete a single quadrat each, or a sponge/anthozoan expert one dive to complete two quadrats, which then needs to be followed up with extensive taxonomic work and computer analysis to determine the area occupied. Many species are unable to be reliably identified from pictures alone. Furthermore, it can be difficult to distinguish small patches (<1cm^2) and also young arborescent sponges from the genera *Stelligera* and *Raspailia*, which have similar colours and similar surface and gross morphology. There are also a number of encrusting species that require microscopic examination for confirmation of identity. It is important to note that after the first sampling event, the effort required to collect these data would be reduced as a database of species would have already been created to compare future samples with.

4.1.5 Temporal frequency

A long-term on-going sponge monitoring programme is being undertaken at Skomer Island, where sponge species composition is assessed every five years. However, more detailed work at Skomer (see Berman *et al* 2013) has shown inter-annual and seasonal variability in sponge assemblage composition (amongst other variables). Adequate temporal sampling will be challenging to collect in the context of a national assessment of GES. This proposed frequency is very much based on what is likely to be practical, since changes in sponge assemblages or species abundances could change very rapidly. For example, trawling might cause a very rapid decline in species with three-dimensional morphologies. However, how sponge and anthozoan assemblages respond to subtle declines in environmental quality (e.g. changes in nutrient levels) is poorly understood.

4.1.6 Spatial spread

Given the comparatively high cost of this approach it would be unlikely that this indicator would be suitable for a large number of sites, and the number of sites will be dependent on the funding available.

4.1.7 Sensitivitity

Numerous studies around the world (mostly based on spatial variation) have shown that both sponge and anthozoan composition vary in response to a range of environmental factors including sedimentation, water flow, habitat type and light (see 2.1.2) However, there are less data to support how these assemblages respond to temporal changes in environmental conditions, but it is likely that assemblage composition will change if the local environmental conditions change. As the levels of natural variability in UK sponge assemblages have only been quantified in a few cases, we would suggest a future power analysis of temporal data to determine the limits to the detection of change. Sponge assemblage monitoring at the species level (as per this indicator) has only been conducted for three years, during which time seasonal changes have been observed, with little inter-annual variation (see Berman *et al* 2013).

4.2 Indicator 2: Morphological diversity of sponge assemblages plus anthozoan species composition and abundance (SpongeMorphAntho)

4.2.1 Introduction

Morphological monitoring has been proposed and developed as a surrogate for identifying patterns of sponge assemblage composition and diversity. An important consideration for the sponge morphological approach is that it provides no information on the anthozoan assemblages. Anthozoans are typically less taxonomically challenging than sponges. They can be identified (in most cases) from photographs and therefore a morphological surrogate is not appropriate or required.

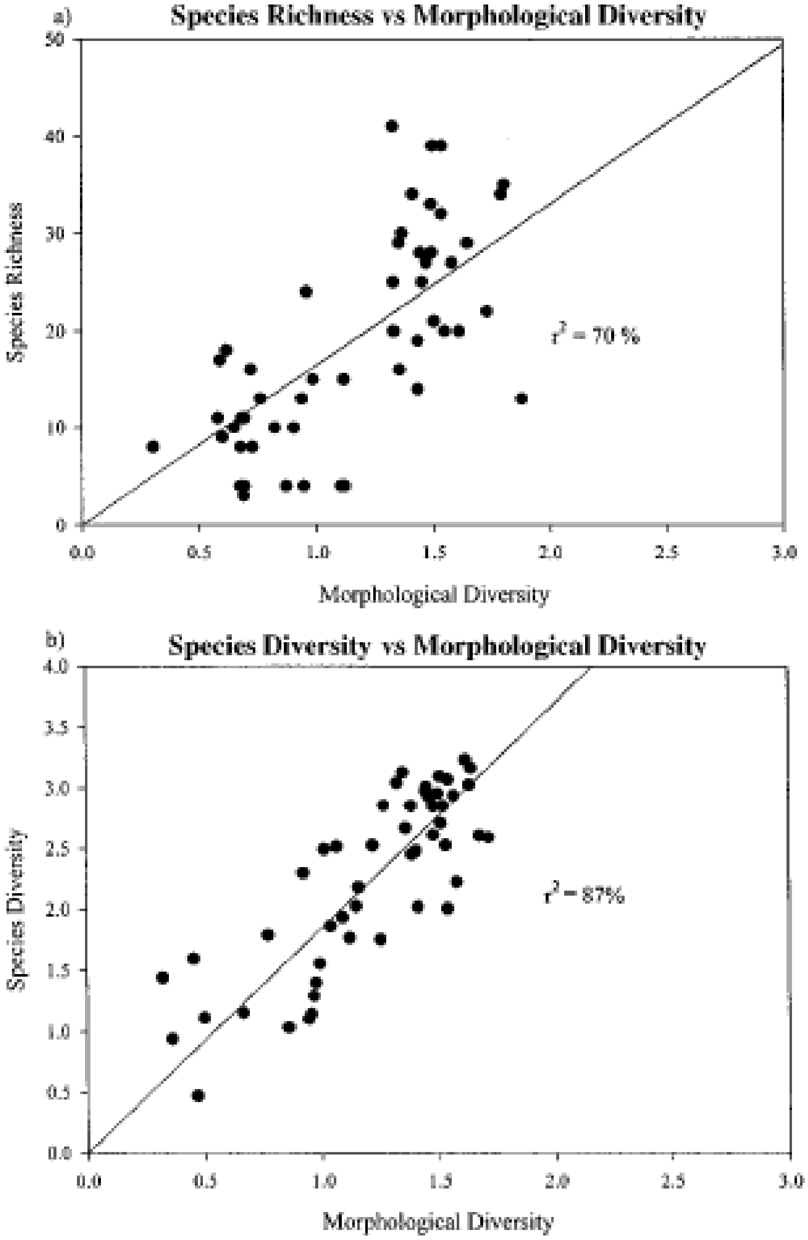

Figure 4.1. The relationship between sponge diversity and richness and morphological diversity at Lough Hyne Marine Nature Reserve in Ireland (Bell & Barnes 2001)

4.2.2 Method

A sponge morphological approach focuses on counting the number of different morphologies present, rather than a species abundance or species diversity-based metric. These data would be collected from the same 1m^2 quadrat areas used to characterise sponge and anthozoan assemblages for the SpongeAntho indicator, with five quadrats being examined at each site, with a site being defined as an area less than 50m^2 (based on the previous work at Skomer). The number of each morphology would be counted in each quadrat, along with the abundance of each anthozoan species present. The morphologies would be divided into appropriate pre-defined categories, for example: Arborescent, Encrusting, Flabellate, Globular, Massive, Papillate, Pedunculate, Repent, and Tubular, following Bell and Barnes (2001); see Figure 4.2. An initial assessment of each site should be conducted to ensure all of the morphological variability within the site is captured within these groups or if further groups are required. As for the SpongeAntho indicator, surfaces should have the sediment removed before sampling to ensure the encrusting species are not underestimated.

Alternatively, this information could also be collected from photographs or video data within the sample quadrats, reducing the time in the field, but increasing the post-dive time. It could also be applied to much larger areas, or sites deeper than can be accessed by divers through drop camera or video transects, as long as the abundance of the morphologies can be estimated for a unit area.

Each larger quadrat can be further subdivided into smaller ‘sub-quadrats’ using string or similar if the sponge/anthozoan abundance is high and to aid in taking high resolution photographs. Although the authors are proposing 1m^2 quadrats based on the analysis by Berman *et al* (2013), this may not be practical in some areas due to the nature of the substrate. In such circumstances smaller-sized quadrats may be appropriate (0.25m^2), although further statistical analysis should be conducted to determine the appropriate number of quadrats.

There are many ways in which the data can be analysed (see Berman *et al* 2013) and it can be used to generate univariate statistics (e.g. morphological diversity) and for identifying multivariate patterns in morphological assemblage composition. This data could be treated in the same way as species data.

4.2.3 Advantages

This morphological surrogate method is a time and cost effective method to estimate the patterns of sponge diversity within an area instead of collecting species level data. Bell *et al* (2006) estimated that this method was 40 times cheaper than collecting species level information. This method requires limited taxonomic information to be collected and just the ability to distinguish between different shapes, although this can also be viewed as a disadvantage (see below). This method requires much less time in the field than collecting species level information and if photographs are taken the pictures can also be used to collect some species level information if required for conspicuous species. The addition of information on the anthozoan composition and abundance is important to ensure this group is also included in any assessment of GES. As for the SpongeAntho indicator, this indicator could also provide data on a number of the traits identified in Table 2.2 (Abundance, Recruitment, Mortality, Growth, Disease Occurrence, Deformity), although this would not be at the level of individual species. This could also be assessed from the data (in some cases) and from photographs.

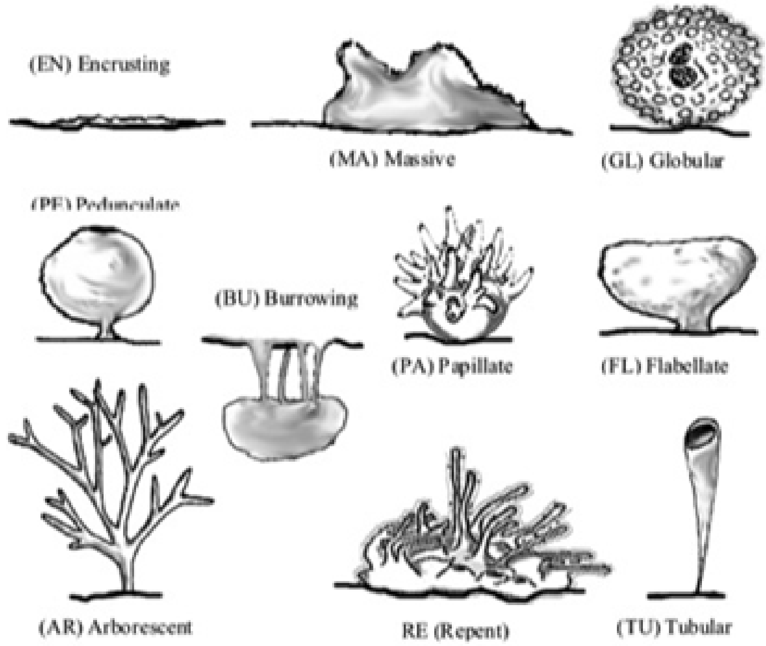

Figure 4.2. Morphological categories used to classify sponges (Bell & Barnes 2001)

4.2.4 Disadvantages

The collection of morphological data rather than sponge species data has received criticism from sponge ecologists (see Bell & Barnes 2001, 2002; Bell *et al* 2006) because of the loss of ecological and species level information. The experts at the workshop were clear that this method should not be viewed as a replacement for collecting species level information at the UK scale. However, it has been shown to be a suitable method to monitor sponges rapidly. It is also important to note that although changes in sponge species and morpholgical data are correlated in most cases, the consequences of a change in morphologies is unknown. However, Bell (2008) demonstrated that morphological diversity is related to functional diversity in tropical sponge assemablages.

Morphological data is of a lower resolution than species-level data and is likely to be less sensitive to change than species-level information. However, it is particularly suitable for areas where sponges predominate and taxonomic expertise or financial resources are not readily available. The relationship between morphological and species diversity should be tested at each location before being used, so it would require a large initial investment of resources since the relationship can vary between locations (see Bell & Barnes 2002).

There may be limits to the type of habitat where a morphological assessment may be applied. Bell and Barnes (2002) found the method to be unsuitable in tropical cave habitats, but data for temperate caves are limited. For some specialist habitats such as caves or areas of very high current flow, morphological diversity may be very low so it could be more appropriate to monitor specific species. For example, in the Menai Strait (North Wales, UK) current flow is very fast due to local hydrodynamic conditions and the massive form of *Halichondria panicea* dominates (Peattie & Hoare 1981).

The relationship between species diversity and morphological diversity was originally described from Lough Hyne MNR (Ireland) where the kelp zone is reduced and from the Skomer MNR where all monitoring has been conducted within the circalittoral zone, where sponges dominate. It will be much more difficult to use the method described in this report in areas of dense kelp forest or dense algal coverage using photographic methods as the fronds are likely to interfere with the pictures. However, for the biotopes being considered as part of this contract we believe this is unlikely to be a problem as they are generally found within the circalittoral zone.

4.2.5 Temporal frequency

Temporal morphological data taken from Skomer Island has demonstrated that the morphological method can detect statistically significant changes in sponge assemblages between seasons and between years. Seasonal sampling is unlikely to be practical and while annual sampling would be preferred this is also unlikely to be acceptable. Although annual changes have been reported in morphological data, the patterns of variation observed to date indicate the changes are the result of patterns of natural variability (Bell *et al* 2006; Berman *et al* 2013).

4.2.6 Spatial spread

The comparatively lower expense compared to the SpongeAntho indicator means this indicator is suitable for a larger number of sites, but the number of sites will be dependent on the funding available.

4.2.7 Sensitivity

An important aspect of the development of the morphological diversity indicator (SpongeMorphAntho) is to understand the reasons for variation in morphological patterns. Although the relationship between species and morphological data (univariate and multivariate patterns) is well established, whether or not the patterns are the result of the same natural processes remains to be demonstrated. Furthermore, some specific sensitivity analysis is required to compare the limits of change detection (as for the SpongeAntho indicator). There is no evidence to support the fact that the patterns are not the result of the same processes and that morphological patterns are sensitive to the same changes found for species level patterns. The method could potentially be made more sensitive to change by creating more morphological groups, which could be possible with some baseline surveys from monitoring sites. Overall, this indicator will be able to identify if there is a change in these assemblages, but without longer-term data it will not be possible to separate natural variation from changes due to anthropogenic pressures. However, morphological groups can be indicative of different environmental conditions. For example, changes in the abundance of encrusting (decrease) and branching sponges (increase) may indicate changes in sedimentation and flow regimes, given the abundance of these morphologies are known to vary spatially with these environmental variables (see Bell & Barnes 2001).

4.3 Indicator 3: Morphological diversity of sponge assemblages plus presence/absence of anthozoan indicator species (SpongeMorphAnthoPresAb)

4.3.1 Introduction

This indicator is similar to the SpongeMorphAntho described in Section 4.2, except that the abundance of anthozoans is no longer collected. Instead the presence or absence of the anthozoan indicator species is recorded. These anthozoan indicator species are those that are characteristic of these biotopes and therefore loss of these species might be expected to indicate some pressure impact.

4.3.2 Methods

The same methods would be employed as for the SpongeMorphAntho indicator, except there would be no need to collect anthozoan species abundance data, and only a requirement to look for the indicator species.

The same sponge morphological approach described for the SpongeMorphAntho indicator would be used. Data would be collected from the same 1m^2 quadrat areas used to characterise sponge and anthozoan assemblages for the SpongeAntho indicator, with five quadrats being examined at each site, with a site being defined as an area less than 50m^2 (based on the previous work at Skomer). However, in this case the quadrats would be examined for the presence of the anthozoan indicator species and no abundance data collected.

Alternatively, both the morphological data and anthozoan indicator species data could be collected from photographs or video data within the sample quadrats, reducing the time in the field, but increasing the post-dive time. It could also be applied to much larger areas, or sites deeper than can be accessed by divers through drop camera or video transects, as long as the abundance of the morphologies can be estimated for a unit area. However, care must be taken in the interpretation if it is not possible to remove sediment from surfaces before taking pictures, as encrusting morphologies are likely to be underestimated.

The analysis of the sponge morphological data is described above. The presence/absence data could also be analysed in the same way, although the resolution of the data will be lower.

4.3.3 Advantages

The advantages are the same as for the SpongeMorphAntho indicator, with the added advantage that the time to collect the data would be reduced as there would be no need to count the number of anthozoans. While there might be some cost reduction, this is likely to be small as these assemblages don't contain that many anthozoan species (unlike sponges).

4.3.4 Disadvantages

The disadvantages are primarily the same as for the SpongeMorphAntho indicator. However, the loss of anthozoan abundance data and the entire anthozoan assemblage data would limit the extent and resolution of the possible analyses. Furtermore, it would not be possible to determine the status of populations (e.g. declining or increasing), which ultimately is likely to be important for determining GES.

4.3.5 Temporal frequency

Same as for the SpongeMorphAntho indicator.

4.3.6 Spatial spread

Same as for the SpongeMorphAntho indicator.

4.3.7 Sensitivity

Same as for the SpongeMorphAntho indicator, with the exception that there will be no ability to statistically compare any changes in the anthozoan assemblages.

4.4 Indicator 4: Presence/absence of sponge and anthozoan indicator species (SpongeAnthoPresAb)

4.4.1 Introduction

The proposal of a presence/absence indicator for sponge and anthozoan indicator species represents the quickest assessment of the fragile sponge and anthozoan biotopes, although the ability to determine any population trends is not possible. This indicator is based on the indicator species that have been chosen in Table 2.4 and Table 2.5 being representive of the different fragile sponge and anthozoan biotopes.

4.4.2 Methods

The SpongeAnthoPresAb indicator is more suited to remote sampling techniques such as ROV, drop camera or large-scale photoquadrat approaches, as the proposed indicator species are easily identified from photographs (see below). However, using fixed quadrats would provide confidence that the same site is being consistently sampled.

If using quadrats the data could be collected from the same 1m^2 quadrat areas used to characterise sponge and anthozoan assemblages for the SpongeAntho indicator, with five quadrats being examined at each site, with a site being defined as an area less than 50m^2 (based on the previous work at Skomer). In this case the quadrats would only be examined for the presence of the sponge and anthozoan indicator species.

4.4.3 Advantages

The information required would be cheaper, faster and easier to collect compared to the other indicators as the majority of the species are easily distingushed. The method also requires no specific taxonomic expertise and can be applied to photographic data sets. This method has the advantage that it could be applied rapidly to large areas of the seabed.

4.4.4 Disadvantages

There is an obvious reduction in the resolution of information obtained in applying this indicator approach as no quantitative information about species is collected. This will limit the extent to which GES can be determined in the future, since it will not be possible to look at possible trends or changes in overall biodiversity. However, if further research can link specific indicator species to the most important anthropogenic pressures, this indicator could be very cost-effective. It is also possible that without *in situ* examination it might be difficult to confirm the presence or absence of some species, particularly the sponges that have encrusting morphologies (see Table 2.5). Furthermore, some of the proposed indicator sponge species, particularly *Raspalia ramosa* and *Stelligera stuposa*, can be difficult to tell apart from each other and may need to be aggregated. Finally, some of the proposed indicator species are not widely distributed across the UK, so an initial assessment of suitable species and biotopes would need to be made (see Section 5.2). It is possible that the loss of information could be minimised if the SACFOR scale was used for the indicator species.

4.4.5 Temporal frequency

Same as for the SpongeMorphAntho indicator.

4.4.6 Spatial spread

Same as for the SpongeMorphAntho indicator.

4.4.7 Sensitivity

This indicator has the sensitivity to detect some changes in the fragile sponge and anthozoan biotopes, and the loss of these species is likely to be indicative of a sub-GES condition. However, an initial baseline assessment of the locations and sampling sites would need to be made to assess which of the indicators were initially present.

5 Research and development required for the final recommended supporting indicators

This section considers the practical elements that are required in order to make the supporting indicators of natural variation (discussed in Section 4) operational.

5.1 Biogeographical scale of assessment

It is proposed that the most appropriate biogeographical scale for the supporting indicators to use are the Regional Seas, as set out in Charting Progress 2 (UKMMAS 2010) illustrated in
Figure ***5.1***. Within these Regional Seas, there are sites that are already being monitored which have accumulated some datasets (many are monitored as part of marine Special Areas of Conservation (SAC) under the Habitats Directive). However, our knowledge of shallow sublittoral habitats outside of these monitored sites is poor or lacking. The consulted experts identified that Regions 1, 2 and 3 are poorly represented and although there are baseline data for Region 5, there is no regular monitoring programme presently in place.

Datasets showing the location of shallow circalittoral and infralittoral rock habitats are available from Natural England (NE), Natural Resources Wales (NRW) and Scottish Natural Heritage. These habitats are highly likely to support sponges and anthozoans, but these groups may not necessarily be the dominating component within a community.

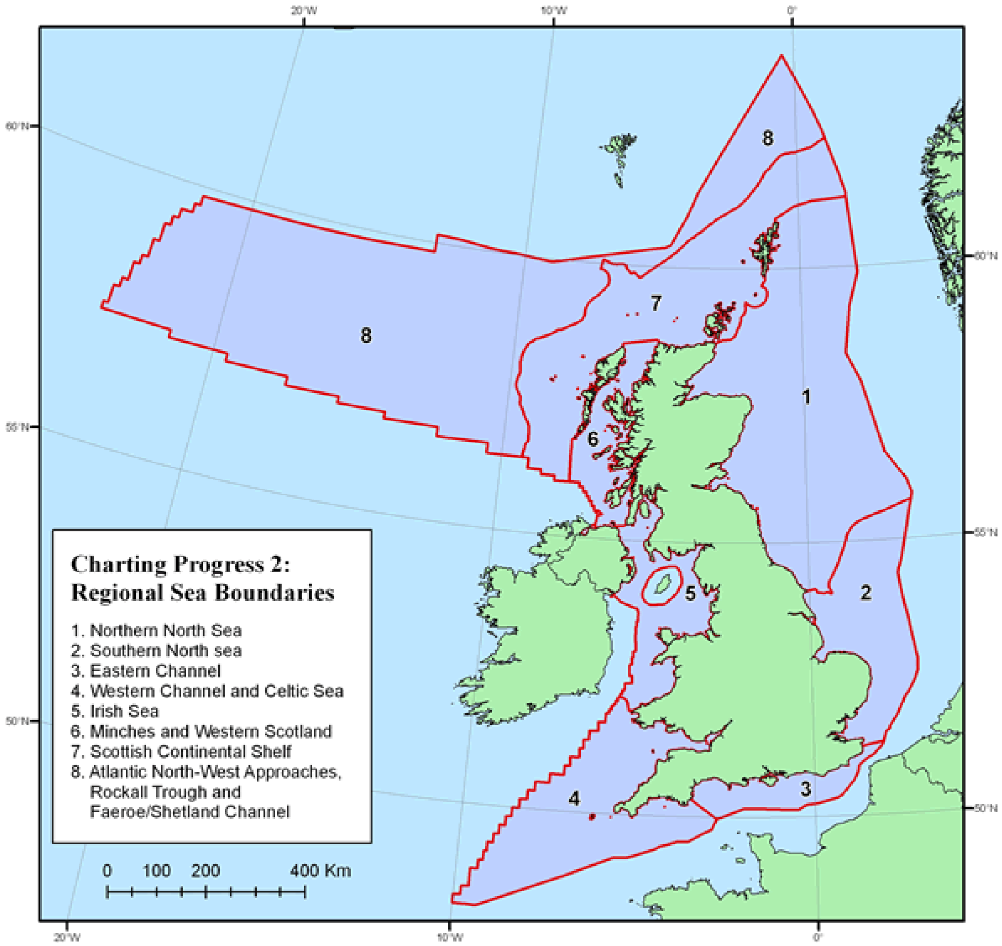

Figure 5.1. Charting Progress 2 Regional Sea Boundaries (UKMMAS 2010)

It is also important to note that the spatial range of many of the indicator species identified in Table 2.5 and Table 2.6 is limited and often region-specific within UK waters. This presents difficulties when nominating a set of indicator species to be monitored across all UK waters. Figure 5.2 and
Figure **5.4** display the locations, obtained from the Marine Recorder database, where biotopes characterised by the presence of sponges and anthozoans have been recorded. The species composition of biotopes is a major defining parameter and will vary in response to a range of physical influences.

Figure 5.2 suggests that there may be a strong north-south difference in the suite of sponge- and anthozoan-characterising biotopes identified. This is not unexpected, since component species ranges will be influenced by the progressive seawater cooling associated with increasing latitude. A secondary factor may simply be attributable to differences in coastal morphology (e.g. the characteristic fjordic coastline of western Scotland) and/or regional limitations or differences in sampling opportunities and methodologies. Regardless of the cause, the distribution map strongly supports the case for a regional approach in the identification of targeted indicator species and assemblages.

Figure 5.3 and
Figure ***5.5*** show the frequency of the selected recorded biotopes in relation to the latitudinal location of each record for sponge and anthozoan biotopes respectively. While the results show that there are some biotopes/assemblages for each taxonomic group that broadly span the full UK latitudinal range, there is usually a tendency towards a northern or southern preference, broadly segregating southern England and Northern Ireland from northern England and Scotland. Obvious distinctions are evident in the case of, for example the anthozoan characterised biotopes *CR.HCR.XFa.ByErSp.Eun* and *CR.MCR.EcCr.CarSwi*, the former being characterised by the southern seafan species *Eunicella verrucosa*, while the latter supports the presence of the northern seafan species *Swiftia pallida*. Changes to the distributon of these species, particualy a northward spread of *E. verrucosa* may potentially by indicative of climate change.

It should be emphasised again that the latitudinal factor is not likely to be the sole parameter influencing species or biotope distribution, but this approach, based on current knowledge, does allow the region-specific selection of target biotopes/assemblages for indicator assessment on the grounds of local commonness and representivity, while also reducing the undesirable potential effort expended on locating and surveying locally rare or unusual biotopes. It is therefore recommended that further work be undertaken to refine a list of region-specific representative target biotopes within which the proposed indicators would operate. This should take into account current monitoring and surveillance programmes, such as that for the Habitats Directive, so that, wherever possible, the proposed indicators can be incorporated as an adaptation of, or addition to, current monitoring efforts.

In general, the lack of appropriate biotopes on the east coasts of England and Scotland corroborates the data deficiencies in Regions 1, 2 and (to a lesser extent) 3 highlighted in the expert consultation.

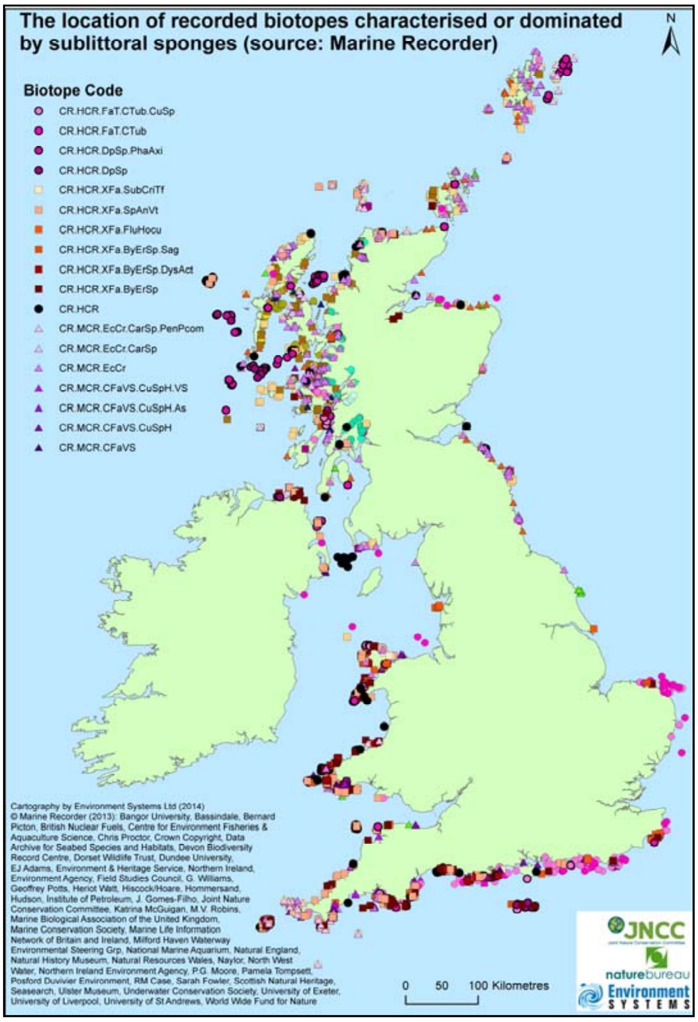

Figure 5.2. Sponge biotope distribution map (points obtained from the Marine Recorder database).

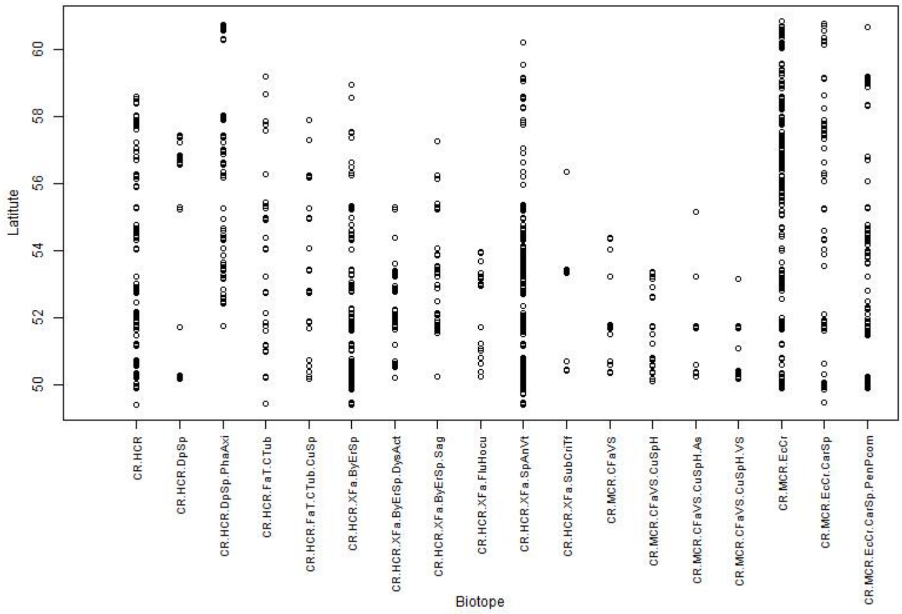

Figure 5.3. Sponge biotope latitudinal distribution plots.

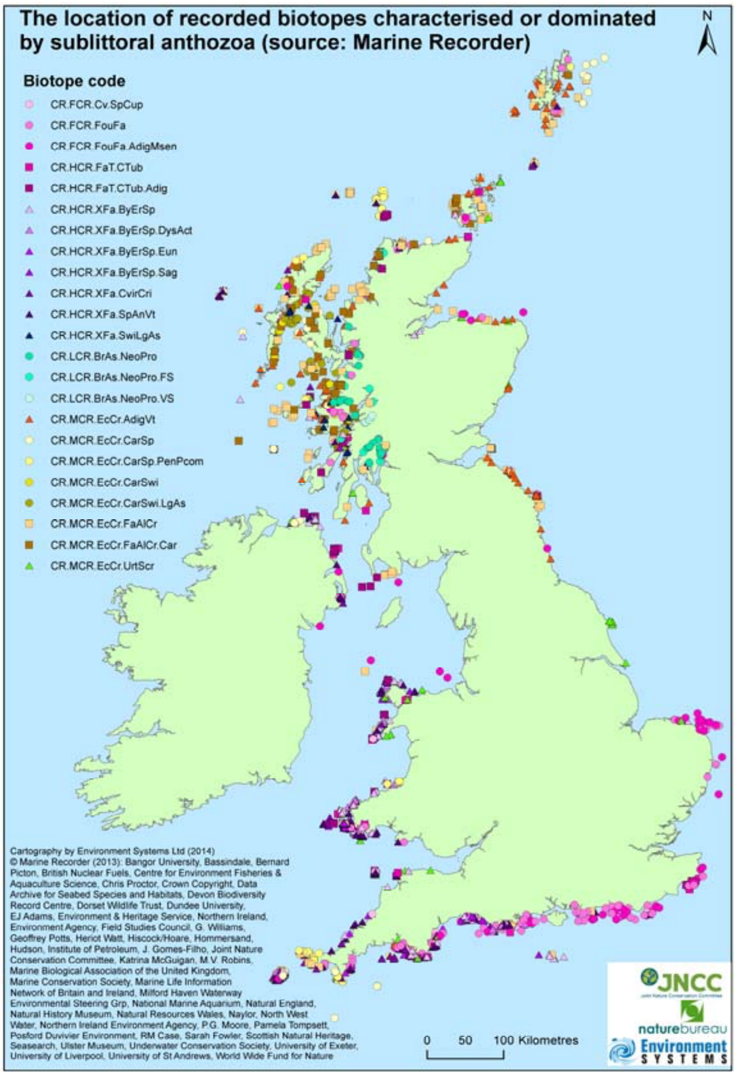

Figure 5.4. Anthozoan biotope distribution map (points obtained from the Marine Recorder database).

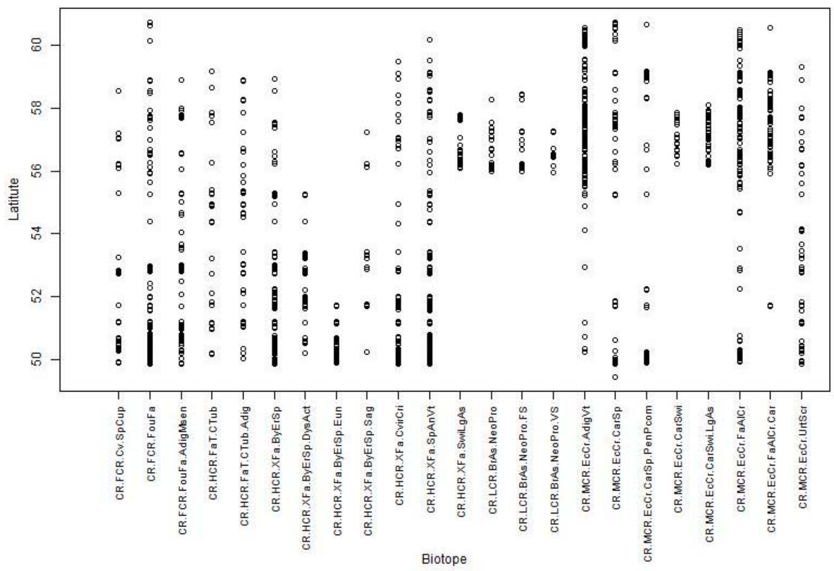

Figure 5.5. Anthozoan biotope latitudinal distribution plots.

5.2 Sampling strategy

The following sampling strategy recommendations are applicable to all of the final supporting indicator proposals in Section 4.

Discussion during the expert consultation concluded that survey sites[9] should include:

- Sites where there are known anthropogenic pressures, or where specified anthropogenic pressures will exist in the future (e.g. in the vicinity of a proposed long sea outfall);
- Sites adjacent to known sites of anthropogenic pressures to measure indirect effects;
- Sites believed to be relatively free from anthropogenic disturbance (to act as reference sites[10]);
- Sites identified as damaged, and undergoing recovery;
- Existing survey sites (e.g. within marine SACs) and previously un-surveyed sites;
- Representative sites that in combination encompass the full range of biotopes in
- Figure ***5.2*** and Figure 5.4.

It would be preferable if reference sites have a long history of study so that their current condition might be understood in a historical context. Examples might include selected Marine Protected Areas (MPA) (such as Skomer or Lundy) where certain shallow sublittoral monitoring studies began in the early 1980s.

Sites could also be assigned on the basis of representivity of the region and relevance to current (and future) local pressures, while attempting to assign adequate coverage of the UK's MSFD assessment region.

5.3 Expected skills required

This section investigates the skills and resources required to undertake each of the supporting indicator proposals identified in Section 4 if they are made operational across UK marine waters. The final indicator proposals require different types and levels of skill. Table 5.1 shows the skills that will be required to plan, survey, analyse and report on each supporting indicator.

The level of skill required in the planning and reporting phases are considered to be the same for each supporting indicator (it should be noted that this relates to both JNCC and to the body undertaking the work).

The skills required in the survey phase vary in both the level and type of skills required. These differences also influence the cost implications of each indicator (see Section 5.4).

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[9] A 'site' in this context refers to an area believed to include shallow sublittoral rock habitat with sponge and anthozoan assemblages found in UK marine waters.
[10] A 'reference site' in this context is a site including relevant sponge/anthozoan assemblages that are considered to be intact, with negligible influence of anthropogenic pressures, representing natural ecological functions and processes.

Table 5.1. Skills required to make each final supporting indicator operational. The skills are scored 1-5 (1=basic skills and 5=advanced skills).

Skills required	Sponge Antho	SpongeMorph Antho	SpongeMorph AnthoSponge PresAb	SpongeAn thoPresAb
Planning phase				
Project management	5	5	5	5
Budget management	5	5	5	5
Understanding of marine survey duration and timings	5	5	5	5
Knowledge of sublittoral rock biotopes	5	5	5	5
Survey phase				
Project management	5	5	5	5
Level of supporting indicator survey training	5	3	2	1
Knowledge of sponge and anthozoan ecology	3-5	3-5	3-5	3-5
Knowledge of sublittoral rock biotopes	1-5	1-5	1-5	1-5
Level of Sponge identification skills required	5	2	1	1
Level of anthozoan identification skills required	5	5	2	2
Diving experience required	2-4	2-4	2-4	2-4
Sublittoral rock surveying experience	2-4	2-4	2-4	2-4
Data analysis phase				
Data entry and standardisation	1-3	1	3	1
Analysis of photographic/video data	3-5	3-5	3-5	3-5
Level of Sponge identification skills	5	5	5	5
Level of anthozoan identification skills	5	5	5	5
Statistical analysis	3-5	3-5	3-5	3-5
GIS	3-5	3-5	3-5	3-5
Reporting phase				
Report writing	3-5	3-5	3-5	3-5
GIS	3-5	3-5	3-5	3-5
Knowledge of sponge and anthozoan ecology	3-5	3-5	3-5	3-5
Knowledge of MSFD reporting requirements	3-5	3-5	3-5	3-5

5.4 Cost implications

Table 5.2 to 5.5 provide the estimated days and team members required for each final proposed supporting indicator and
Table ***5.6*** includes an estimate of equipment and resource costs. All of these estimates are based on the project team's knowledge of survey and assessment of similar biotopes and scales of study. Table 5.2 to 5.5 assume that two sites will be assessed and that a survey period lasts ten days in the field (no time has been allowed for travelling to/from site or for travel costs); and that a diving team consists of four divers (Project Officer + three surveyors) and one diving supervisor. Note that if volunteers are used for diving tasks then costs would be considerably reduced.

Table 5.2. Estimated time inputs (days) for Indicator 1 (SpongeAntho) for one survey period (covering 2 sites).

		Days required				
Project teams	**Team Member**	**Planning phase**	**Survey phase**	**Data analysis phase**	**Reporting phase**	**Total days per team**
JNCC	Project Manager	10	2	2	5	19
Surveyor team	Project Manager	8	5	10	10	33
	Project Officer	8	10	5	10	33
	Data Officer	2	0	5	10	17
	Data Analyst	0	0	15	5	20
	Regional Survey Manager	4	1	0	0	5
	Surveyors	0	10 (x4)	0	0	40
	Assistant	4	10	2	2	18
	Total days per phase	36	68	39	42	
					Total days	**185**

Table 5.3. Estimated time inputs (days) for Indicator 2 (SpongeMorphAntho) for one survey period (covering 2 sites).

		Days required				
Project teams	**Team Member**	**Planning phase**	**Survey phase**	**Data analysis phase**	**Reporting phase**	**Total days per team member**
JNCC	Project Manager	10	2	2	5	19
Surveyor team	Project Manager	8	4	10	10	32
	Project Officer	8	9	5	10	32
	Data Officer	2	0	5	10	17
	Data Analysts	0	0	15	5	20
	Regional Survey Manager	4	1	0	0	5
	Surveyors	0	10 (x4)	0	0	40
	Assistants	4	9	2	2	17
	Total days per phase	36	65	39	42	
					Total days	**182**

Table 5.4. Estimated time inputs (days) for Indicator 3 (SpongeMorphAnthoSpongePresAb) for one survey period (covering 2 sites).

		Days required				
Project teams	**Team Member**	**Planning phase**	**Survey phase**	**Data analysis phase**	**Reporting phase**	**Total days per team member**
JNCC	Project Manager	10	2	2	5	19
Surveyor team	Project Manager	8	4	10	10	32
	Project Officer	8	9	5	10	32
	Data Officer	2	0	5	10	17
	Data Analysts	0	0	13	5	18
	Regional Survey Manager	4	1	0	0	5
	Surveyors	0	9 (x4)	0	0	36
	Assistants	4	9	2	2	17
	Total days per phase	36	61	37	42	
					Total days	**176**

Table 5.5. Estimated time inputs (days) for Indicator 4 (SpongeAnthoPresAb) for one survey period (covering 2 sites).

		Days required				
Project teams	**Team Member**	**Planning phase**	**Survey phase**	**Data analysis phase**	**Reporting phase**	**Total days per team member**
JNCC	Project Manager	10	2	2	5	19
Surveyor team	Project Manager	8	1	9	10	28
	Project Officer	8	9	5	10	32
	Data Officer	2	0	5	10	17
	Data Analysts	0	0	12	5	17
	Regional Survey Manager	4	1	0	0	5
	Surveyors	0	9 (x4)	0	0	36
	Assistants	0	9	2	2	13
	Total days per phase	32	58	35	42	
					Total days	**167**

Table 5.6. Estimate of equipment and resource costs (excluding team costs) for all supporting indicators.

Equipment and resource costs	**Price estimate**
Planning phase	
Office overheads	£300/survey
Laminating/w'proof paper	£100/survey
Survey phase*	
Hire of u/w camera gear	£350/survey
Hire of u/w video gear	£600/survey
Refilling of gas cylinders	£500/survey
Purchase of u/w site transponders	£1800/site
Purchase of u/w re-locating guns	£2000 (one-off)
Re-charging equip. for cameras	£200
Microscopes	£3000 (one-off)
Field laptops	£3000 (one-off)
Other computer equipment	£500 (one-off)
Data analysis phase	
GIS + statistical/analysis software	£1000

* = Divers would be expected to provide all their own equipment.

5.5 Steps required to make the indicators operational

This section details the steps required to make the final supporting indicators operational. These steps are summarised in Table 5.7 and are described below.

Table 5.7. Summary of the steps required to make the supporting indicator operational.

Steps	Description
1	Decide on final supporting indicator
2	Undertake supporting indicator survey trial
3	Review methods
4	Finalise sampling strategy and survey effort (based on available budgets)
5	Survey site selection
6	Develop reporting and final statistical analysis
7	Create survey schedule
8	Develop supporting indicator survey handbook
9	Recruit surveyors (paid or voluntary)
10	Surveyor training
11	Implementation of supporting indicator surveys
12	Commission and promote preferred research topics
13	Review supporting indicator as appropriate

Step 1: Decide on final supporting indicator
The first step will be to decide on the final supporting indicator and how it is to be made operational. The proposals provided in Section 4 are developed to allow a compromise between funding and data accuracy.

Step 2: Undertake supporting indicator survey trial
It is recommended that the final supporting indicator is trialled in the field at a limited number of locations. This trial will allow any problems associated with the surveys to be considered and will also allow cost estimates to be refined.

Step 3: Review methods
Modifications to the supporting indicator may be required subsequent to field testing and evaluation.

Step 4: Finalise sampling strategy and survey effort (based on available budgets)
Once the supporting indicator is reviewed the final sampling strategy should be determined and budgets allocated to support the work on a six year cycle.

Step 5: Survey site selection
The final survey sites for assessment will be chosen based on the Regional Sea biogeographical units and considerations provided in Section 5.2.

Step 6: Develop reporting and final statistical analysis
It is important that the final reported outputs and statistical analysis are outlined before the work commences, to ensure that compatible outputs are retrieved from each Regional Sea.

Step 7: Create survey schedule
A survey schedule should be set up that accounts for 2-3 reporting cycles of surveys (12-18 years).

Step 8: Develop supporting indicator survey handbook
It is important that the methods of undertaking the surveys, conducting analyses and reporting results are detailed in a form that can be used by field surveyors and data analysts. The documentation should be prepared and distributed to surveyors before work commences. Another possibility is for the handbook to be available as an online resource, which would support editing and revision of the methods.

Step 9: Recruit surveyors (paid or voluntary)
Surveyor recruitment should be conducted in a manner appropriate to the final indicator chosen. This could include regional contracts, national contracts or volunteer-led assessments.

Step 10: Surveyor training
It would be valuable if a training workshop is held for surveyors to ensure that the methods are fully understood. This could be led by the group responsible for undertaking the field trials in Step 2.

Step 11: Implementation of supporting indicator surveys
At this stage the supporting indicator surveys can begin.

Step 12: Commission and promote preferred research topics
It is important that the supporting indicator proposals in Section 4 are not considered in isolation to the research required to refine the indicators. This research programme should be budgeted and promoted to relevant research institutes and experts (see Section 5.6).

Step 13: Review supporting indicator as appropriate
It is important that the supporting indicator is reviewed on a regular basis (possibly every 1-2 reporting cycles). This review should consider relevant studies, data and changes to the implementation of the MSFD. The results of projects promoted as part of the research requirement in Section 5.6 should also be considered as part of the review process.

5.6 Future research requirements

A range of contributing subject areas requiring further research were identified in Section 2. Further work within these research areas will allow the supporting indicators to be further refined to improve our understanding of sponge/anthozoan responses to anthropogenic pressures. These research areas are presented in Table 5.8 including their priority.

Table 5.8. Subjects requiring further research

Subject Area	Priority*
Indicator species ecology	5
Sample size	5
Anthropogenic pressure survey methodology development	5
Standardisation of morphological types for UK waters	5
Sample station-based anthropogenic pressure assessment	4
Biotope research	4
Sponge morphology and its association with anthropogenic pressures	3
Research into sponge/anthozoan species and assemblage-level responses to anthropogenic pressures	3
Species inventories for Regional Seas	3
Slow vs. fast growing species of anthozoans and sponges	3
Tall fragile soft corals and sponges	3

* 5 = urgent, 1 = long term goal

It is recommended that a research budget is considered along with the cost estimations in Section 5.4. It is also important that universities, research establishments, benthic ecologists and sponge and anthozoan experts or specialists are made aware of the following areas requiring further research:

Indicator species ecology
If the SpongeMorphAnthoSpongePresAb or SpongeAnthoPresAb supporting indicators are to be made operational, then it is important that the ecology of the indicator species identified in Table 2.5 and Table 2.6 are further investigated. Most of the traits and responses to anthropogenic pressures highlighted in Table 2.5 and Table 2.6 are derived from anecdotal and empirical data and are required to ascertain response information.

Sample size
It is important to note that our recommendations on the sample (quadrat) size are based on previous work at Skomer and were chosen based on logistical constraints and species-accumulation curves. We suggest a more formal statistical approach is undertaken (e.g. power analysis) to further confirm the suitability of this sampling unit. A further analysis will be required for locations where $1m^2$ quadrats can't be used.

Anthropogenic pressure survey methodology development
It is very important that detailed data begin to be collected for the anthropogenic pressures highlighted in Table 2.4, particulary abrasion. These data need to be collected so they are compatible with the sampling strategy for the final supporting indicator. Ideally, these data will be collected at the same time. A standardised method for assessing these pressures needs to be developed and could be designed so that it is cross compatible with other indicators under the MSFD.

Standardisation of morphological types for UK waters
It would be beneficial that a standard list of sponge morphological types be developed if the SpongeMorphAntho or SpongeMorphAnthoSpongePresAb supporting indicators are to be made operational. This would allow a common approach to all UK assessments to be undertaken.

Sample station-based anthropogenic pressure assessment
An important element of the supporting indicators is the ability to relate change to either natural variability or an anthropogenic driver. This can only be achieved if information on activities that impart identified pressures is collected proximal to the survey site as an integral part of the indicator programme. This may be undertaken in a variety of ways and might simply constitute Local Officer observations or could, more usefully, utilise additional metrics or data collection techniques, such as the use of fishing vessel satellite tracking to determine fishing activity. Changes in local physical and chemical conditions will influence community structure and the use of inexpensive automatic temperature and salinity loggers may be an option worth considering over the longer term. Periodic or sudden turbidity changes, or acute pollution events should be monitored and recorded, perhaps as a joint or cooperative undertaking between Agencies.

Biotope research
A greater understanding of the contributing community structure, stability, range, distribution and physical tolerances of relevant biotopes will be valuable and can form the basis for an operational indicator and allow the supporting indicators to be refined.

Sponge morphology and its association with anthropogenic pressures
Studies that focus on the morphological responses of sponges to the anthropogenic pressures identified in Table 2.4 are important. Abrasion through fishing activities is a pressure that should be considered as a priority as it is considered to be one of the most

relevant to the fragile sponge and anthozoan assemblages. Further research is also required to understand whether spatial and temporal change in sponge morphological diversity is driven by the same factors as those driving changes in sponge species diversity. It is important to note that this continues to be an active area of on-going research within Dr Bell's research group at Victoria University of Wellington (New Zealand). Recent research projects by Dr Bell's research group include: 1) examination of patterns of spatial and temporal variation in sponges and the identification of drivers of these patterns of change, 2) determination of the ecological, physiological and symbiont responses of sponges to sedimentation, microplastics, nutrients, climate change and ocean acidification; 3) development of appropriate monitoring programmes for temperate and tropical sponge assemblages based on traits, functional roles and assemblage composition; and 4) determination of sponge functional roles in temperate systems, specifically focusing on the interactions between sponges and the watercolumn.

Research into sponge and anthozoan species and assemblage-level responses to anthropogenic pressures
It is important that research into the responses of sponges and anthozoans to the anthropogenic pressures identified in Table 2.4 are undertaken. We consider abrasion from fishing activities (particularly potting/creeling); variation in nutrient concentrations; and sedimentation to be the most important pressures to be given priority. While there are currently no research groups, to our knowledge, working on temperate sponges in relation to anthropogenic factors in the UK, there are numerous groups working in Australia, New Zealand, USA and Netherlands engaged in research in these areas, which will be highly relevant to sponges in UK waters. There is less information for anthozoans, which in most cases (with the exception of global coral research) appear more poorly studied compared to sponges and should be given priority.

Species inventories for Regional Seas
Any surveys undertaken that allow a greater understanding of the species of sponges and anthozoans present within the Regional Seas will improve the sampling strategy for site selection. Site selection methods should be periodically reviewed in light of Marine Recorder database updates (and any other significant sources of data).

Slow- vs. fast-growing species of anthozoans and sponges
A possible link between disturbance and the presence of slow-growing and fast-growing species of anthozoans and sponges was discussed during the expert consultation. It is assumed that larger, slow-growing species are more likely to be adversely affected by disturbance events, such as abrasion. It is also assumed that the presence of faster-growing species could be an indication of previous disturbance. This, however needs to be confirmed in the field.

Tall fragile soft corals and sponges
The presence of tall, fragile soft corals and sponges could be utilised as an indicator of abrasion (in a similar way to the slow- vs. fast-growing research discussed above). Further research into the response of tall, fragile soft corals and sponges to abrasion is required.

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Appendix 2 - Workshop Details

Table A2.1. Workshop Programme

<table>
<tr><th>Time</th><th>Title/Description</th></tr>
<tr><td>09:30</td><td>Attendee arrival and registration</td></tr>
<tr><td>09:45</td><td>Workshop and project introduction and aims:
To identify the pressures that will have the most significant impacts on sponge and anthozoan assemblages that can be assessed and to identify where monitoring will be required.
To identify the most practical and effective measures than can be utilised to gather information on the condition of sponge and anthozoan assemblages.
To develop practical and realistic methods of assessing the condition of the typical species and communities of sponge assemblages and sponge/anthozoan assemblages.
To investigate the effectiveness of indicators based on:
Sponge diversity (using a morphological approach).
Sublittoral species composition and abundance (sponge/anthozoan community).
To discuss any further research and development required to make these indicators operational.</td></tr>
<tr><td>10:00</td><td>Monitoring sponge assemblages and indicator integration</td></tr>
<tr><td>10:20</td><td>Developing indicators - project progress to date</td></tr>
<tr><td>10:40</td><td>Discussion 1 (Indicator approaches/Important pressures to monitor) – key questions:
What are the most important aspects to monitor that can indicate the condition of sponge assemblages?
What are the most important aspects to monitor that can indicate the condition of anthozoan assemblages?
What are the positive and negative aspects of a morphological approach to assessing sponge diversity? What data will be lost from using this approach? Which pressures can this approach detect?
What methods can be used to assess species composition and abundance of anthozoan assemblages? What are the positive and negative aspects of using species composition and abundance as a measure of habitat condition? What data will be lost from using this approach? Which pressures can this approach detect?</td></tr>
<tr><td>11:00</td><td>Coffee Break</td></tr>
<tr><td>11:10</td><td>Plenary – feedback from Discussion 1</td></tr>
<tr><td>12:25</td><td>Lunch</td></tr>
<tr><td>13:25</td><td>Discussion 2 (Pressure monitoring priorities and scoring) – key questions:
What are the most important pressures that impact on the condition of sponge assemblages?
What are the most important pressures that impact on the condition of anthozoan assemblages?
Which measures (discussed previously) are the best representatives of these pressures? Are there some measures that have strong associations with certain pressures? In absence of firm evidence, what is your expert opinion?</td></tr>
</table>

13:45	Plenary – feedback from Discussion 2
14:25	**Coffee Break**
14:40	Plenary continued – feedback from Discussion 2
15:20	Discussion 3 (Scales of assessment and other considerations) – key questions: • What is the most appropriate scale of assessment for these indicators? What distribution data is available that could provide information on a representative scale for UK waters? • What targets should be set for the measures and pressures discussed? Note: It is important that these targets are broad enough to take account of natural change. • Are there any further practical considerations to take into account regarding the development of these indicators? • What further work is required to make these indicators operational in the UK?
15:40	Plenary – feedback from Discussion 3
17:00	Workshop Close

Table A2.2. List of workshop attendees

Name	Organisation
Thomas Haynes	NatureBureau Ltd
Stephen Beal	NatureBureau Ltd
Gemma Bell	Environment Systems
James Bell	NatureBureau Associate
Graham Saunders	NatureBureau Associate
Rober Irving	NatureBureau Associate
Keith Hiscock	MBA
Francis Bunker	Freelance
Jon Moore	Freelance
Claire Goodwin	National Museums Northern Ireland
John Turner	Bangor University
Bernard Picton	National Museums Northern Ireland
Jen Jones	Freelance
Becky Hitchin	JNCC
Rohan Holt	NRW
Gavin Black	NE
Laura Robson	JNCC
Phil Newman	NRW
Chris Wood	MCS

Appendix 3 – Dataset Review

Table A3.1. Review of all datasets collated for the two proposed supporting indicators. Data are categorised as 'important' (blue) and 'less important' (red).

ID	Data Name	Data details, including scale and region covered	Data format	Dates	Source of data	Comment on the datasets relevance to the project
DS01	Marine Recorder JNCC	Access database of data covering a wide range of marine survey data.	Various: species presence and habitat description	1800-2013	JNCC: http://jncc.defra.gov.uk/page-1599	Wide range of surveys using various methods included.
DS02	James Bell sponge survey data: Bell *et al* 2006	Study: Use of a morphological method to examine photoquadrat data collected at 3 hard substratum sites over a 10 yr period at Skomer Marine Nature Reserve, south-west Wales.	Abundance and mono-photo / digitised	1993-2012	Skomer MNR (Mark Burton)	Useful data relating to morphological approach to assessing sponge diversity.
DS03	Skomer MNR - Sponge 2	Species recording at Thorn Rock, Skomer.	Species list	2002/3, 2007/8, 2011	Skomer MNR (Mark Burton)	Species list; a review of quadrat data showed that it will not be useful for assessing condition.
DS04	Skomer MNR - Sponge x15 fixed quadrats	Seasonal monitoring from 15 fixed quadrats – Dr J Bell.	Species list	2006-ongoing	Skomer MNR (Mark Burton)	Species list; a review of quadrat data showed that it will not be useful for assessing condition
DS05	Skomer MNR, NRW	A range of datasets for Welsh waters including sponge morphological diversity/richness used as a monitoring tool, and species composition of anthozoan communities.	Count and abundance, morph types	2004-2012	NRW (Rohan Holt)	Important dataset with relevant environmental data.
DS06	Menai Strait and Conwy Bay SAC, NRW	A range of datasets for Welsh waters including abundance data for sponge morphological types.	Abundance, morph types and time series	2007-2011	NRW (Rohan Holt)	Important dataset with relevant environmental data.
DS07	Pembrokeshire Marine SAC, NRW	A range of datasets for Welsh waters including data available for individual sponge species. Sample points were representative of both varying habitats (e.g. depth) and levels of disturbance (e.g. within shipping channels).	Abundance and time series	2007-2011	NRW (Rohan Holt)	Important dataset with relevant environmental data.
DS08	ICES Data link - Anthozoa	Data collected: Abundance number (number counted) Biomass - Ash weight - for legacy data Biomass - dry weight Biomass - wet weight Lower length bound Number of prey from that species found in the stomach Upper length bound Weight of the specimen	see left	1903 2012 1986 2001 1980 2003 1979 2012 1981 1991 1980 1991 1981 1991 1980 1991	http://ecosystemdata.ices.dk/inventory/Index.aspx?Species=0&Class=997&Area=Class&LatN=&LatS=&LonE=&LonW=&Sdate=&Edate=	The scale of assessment is too coarse and is the product of trawling/coring
DS09	ICES Data link - Porifera	Data collected: Abundance number (number counted)	see left	1980 2006 1982 1982	http://ecosystemdata.ices.dk/Map/ind	The scale of assessment is too

		Biomass - carbon content Biomass - cell volume (Unit example: um3) Biomass - dry weight Biomass - plasma volume (Unit example: um3) Biomass - wet weight Lower length bound Number of prey from that species found in the stomach Upper length bound Weight of the specimen		1982 1985 1981 1990 1982 1982 1981 2011 1990 1990 1981 1991 1990 1990 1981 1991	ex.aspx?Action=AddLayer&Phylum=883&LatN=&LatS=&LonE=&LonW=&Sdate=&Edate=	coarse and is the product of trawling/coring
DS10	Sponge Biodiversity of the UK (Goodwin & Picton 2011) National Museums Northern Ireland	Presence of sponge species across UK Waters	Presence/ absence	2008-2011	National Museums Northern Ireland	Data are the result of multiple field visits and are not comprehensive. Data are mostly presence/absence.
DS11	Plymouth Marine Applications	Abundance data collected during diver surveys of some subtidal assemblages around Plymouth Sound. Little environmental data were collected for this particular survey, however, considerable data exists to describe the physical parameters associated with the River Tamer which is the major influence at these sites.	Abundance		Plymouth Marine Applications	
DS12	David Barnes and James Bell	Lough Hyne study: Species diversity was measured at 6m intervals on vertical and inclined profiles (to a maximum of 30m) at six sites, spanning a range of flow rate and sedimentation regimes.	Abundance, morph types and diversity	2000	Published in Journal of Nature Conservation or http://www.db.uac.pt/pdf/island/12_sponge.pdf	Data could be of use for validation
DS13	A comparison of benthic biodiversity in the North Sea, English Channel and Celtic Seas - Epifauna	69 stations sampled, 2735 distribution records. Samples were obtained by MAFF research vessels from 69 stations between 1992 and 1996. A standard 2m Lowesoft beam trawl with a 3mm mesh coded liner was deployed for 5-10 min across each station at a speed of approximately 0.5m/s. The "start" (locking of winch following seabed contact) and "end" (commencement of hauling) positions were recorded. Tow length averaged about 400m, but varied substantially (s.d. = 290) depending on tidal current velocity and wind strength at the time of sampling. On retrieval of the trawl, an estimate of sample volume was made, along with a summary of the contents, noting especially the presence of stones, rock, etc. The sample was then sorted on deck over a 5mm mesh sieve. Most specimens were identified and enumerated at sea. Any problematic specimens were preserved in formalin for identification on land.	Abundance	2005	http://bio.emodnet.eu/portal/index.php?dasid=505#	Trawl data
DS14	BIS dataset of the south-western part of Netherlands (1985-2004) (EurOBIS)	136677 distribution records; 522 species; 15564 sampling events. The data included are the available data from 1985 until 2004. All included samples are from the south-western part of the Netherlands (Delta and coastal area) taken with a Reineck Box-core. All samples are taken approximately 30cm deep into the sediment. All actual counted numbers and measured weights are included as well as the calculated density and weights (mg) per m2. Positions are given in the Dutch system and as geographic coordinates (datum: European 1950 and World 1984).	Various	1985-2004	http://www.marbef.org/data/imis.php?module=dataset&dasid=599	Box corer data

DS15	EMODNET: http://www.emodnet-hydrography.eu/	The BioMar project was and remains the largest marine ecological seabed survey of the Republic of Ireland. Standard field survey and data management methods developed by the UK Marine Nature Conservation Review (now part of Joint Nature Conservation Committee) were used. Field surveys of inshore waters (usually < 5km from shore and < 50m deep) collated data on littoral and sublittoral biotopes (i.e. habitat and community together) from Britain and Ireland. BioMar surveyed 1000 sites (half seashore) in Britain and 900 (200 seashore) sites in the Republic of Ireland. Of the approx. 6,000 species known to occur in British and Irish seas, about 3000 have been recorded in Britain and 1500 in Ireland by BioMar. Field surveys were completed in September 1996. Over 34 surveys were conducted in a range of sea areas in Britain and Ireland, using different research vessels and equipment, and involved collaboration with different groups (BioMar partners and various government authorities). The comparability of the maps produced from the surveys demonstrated the wide application of the methods. The database currently stores environmental information on from over 22,000 sampling stations at over 10,000 sites from over 500 surveys around Britain and Ireland.	Abundance	<1996	http://www.eurobis.org/eurobissearch.php?dataprovider=10	Data appears to be based on the relative abundance of species present, therefore no real abundance data to work with.
DS16	Biogeography Scheldt Estuary (EurOBIS)	Taxonomy database of the Western and Sea Scheldt from the of the Netherlands Institute of Ecology; Centre for Estuarine and Marine Ecology; Department of Ecosystem Studies. Estuarine data representing 31747 distribution records of about 250 marine species from Schel Scheldt Estuary. Data were collected between 1962 and 2003.	Distribution	1962 - 2003	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=Eurobis_496	Aggregated data from multiple surveys. Broad scale. Data of limited use.
DS17	Cross Sands broadscale survey 1998 (EUROBIS)	Broadscale benthic survey undertaken by CEFAS off the east coast of the United Kingdom. The purpose of this study was to determine whether there was any evidence of a large-scale cumulative impact on benthic macro-invertebrate communities as a result of the multiple sites of aggregate extraction located off Great Yarmouth in the southern North Sea. Forty 0.1m2 Hamon grab samples were collected from across the region, both within and beyond the extraction area, and analysed for macrofauna and sediment particle size distribution in order to produce a regional description of the status of the seabed environment. In addition, the data were analysed in relation to the area of seabed impacted by dredging over the period 1993-1998. Areas subject to 'direct' impacts were determined through reference to annual electronic records of dredging activity and this information was then used to model the likely extent of areas potentially subject to 'indirect' ecological and geophysical impact. Size reference: 40 localities, 201 species		1998	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=Eurobis_781	Wrong habitats
DS18	DASSH Data Archive Centre Academic surveys	A collection of marine biological survey data collated from literature. Data has been quality controlled. For some surveys only selected species have been entered from the dataset.	Various including presence and abundance		http://www.marbef.org/data/imis.php?module=dataset&dasid=1890	Aggregated data from multiple surveys; broadscale; data of limited use.
DS19	DASSH Data Archive Centre expert sighting records (EurOBIS)	Occasional sighting of marine species recorded by academics, professionals or expert amateur naturalists.	Various including presence and abundance	1855-2007	http://www.marbef.org/data/imis.php?module=dataset&dasid=1885	Aggregated data from multiple surveys; broadscale; data of limited use.
DS20	Historical benthos data (North Sea/ Baltic Sea, 1902-1912 (EurOBIS)	This dataset represents presence data has been reconstructed from museum collections from old ICES routine cruises between 1902 and 1912. Identification of the species was done by specialists at the Christian-Albrechts-University Kiel; Leibniz Institute of Marine Sciences; Marine Ecology Division; Benthos Ecology section.	Various including presence and historical data	1902-1912	http://www.marbef.org/data/imis.php?module=dataset&dasid=1817	Aggregated data from multiple surveys; broadscale; data of limited use.

DS21	Historical hyperbenthos data (North Seaand some adjacent areas, 1987-2001 (EurOBIS)	This ongoing collaboration between Ghent University (UGent), Biology Department, Marine Biology Section and Flanders Marine Institute (VLIZ) aims at integrating historical hyperbenthic data. The data is stored in the IMERS database at VLIZ.	Distribution and abundance	1987-2001	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=Eurobis_754	Aggregated data from multiple surveys; broadscale; data of limited use.
DS22	Macrobenthos from English waters (2000-2002) (EurOBIS)	This dataset contains macrobenthos data from English waters between 2000 and 2002. 2-3 replicates were taken. Identification was done up to species level. Samples were taken by Hamon, Day or van Veen grab.	Distribution and abundance	2000-2002	http://www.marbef.org/data/imis.php?module=dataset&dasid=1681	Aggregated data from multiple surveys; broadscale; data of limited use.
DS23	Macrobenthos from the Norwegian waters (EurOBIS)	Contains information mainly from studies around offshore oil and gas platforms in the Norwegian waters.	Distribution and abundance	2000-2001	http://www.marbef.org/data/imis.php?module=dataset&dasid=1856	Aggregated data from multiple surveys; broadscale; data of limited use.
DS24	Macrobenthos from the eastern English Channel (1999 and 2001) (EurOBIS)	This dataset contains macrobenthos data from the eastern English Channel from 1999 and 2001. It is a compilation of 5 individual surveys/datasets, which together make up the mass of closely-spaced aggregate dredging stations in the middle of the eastern English Channel. These surveys were 'baseline' studies in advance of applications to commercially dredge the eastern Channel area.	Distribution and abundance	1999-2001	http://www.marbef.org/data/imis.php?module=dataset&dasid=1684	Aggregated data from multiple surveys; broadscale; data of limited use.
DS25	Marine Life List of Ireland (EurOBIS)	This dataset contains data on marine species recorded in Ireland during field surveys by EcoServe, Ecological Consultancy Services Ltd.	Distribution and abundance	Various	http://www.marbef.org/data/imis.php?module=dataset&dasid=1947	Aggregated data from multiple surveys; broadscale; data of limited use.
DS26	Marine Life Survey Data (collected by volunteers) collated by MarLIN (EurOBIS)	A collection of marine life surveys collated by the Marine Life Information Network (MarLIN) as part of their data access program. Surveys are either flagged as professional surveys or data collected by volunteer recorders as part of the Sealife Survey. Information about survey methodology can be found on the MarLIN Web site (http://www.marlin.ac.uk/). There are currently 368 surveys containing 250,000 species records.	Distribution and abundance	Various	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=Eurobis_641	Aggregated data from multiple surveys; broadscale; data of limited use.
DS27	Marine Nature Conservation Review (MNCR) and associated benthic marine data held and managed by CCW (EurOBIS)	This dataset includes the survey data that were commissioned and collected by Countryside Council for Wales (now Natural Resources Wales). The data contributed to the MNCR programme which was initiated to provide a comprehensive baseline of information on marine habitats and their associated species around the coast of Britain. Methods of data capture The majority of data were collected using methods described in the MNCR Rational and Methods report (Hiscock 1996). Broadly, this encompassed surveying a range of sites within a geographical area to sample and describe the variety of habitats present (sampling habitats in different substrata, depths, wave exposures, current regimes, salinity regimes and so on). Each habitat was sampled using semi-quantitative recording techniques (SACFOR abundance scales) for recording epibiota on rocky habitats. Geographical Coverage: This dataset relates to Wales. Note however that the dataset "Marine Nature Conservation Review (MNCR) and associated benthic marine data held and managed by JNCC" also includes equivalent and complementary data from Wales. Size reference: Number of records 14,408; Number of recorded sites 563; Number of recorded samples 883; Number of recorded species 1015.	Habitat description	Various	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=Eurobis_657	Aggregated data from multiple surveys; broadscale; data of limited use.

DS28	Marine Nature Conservation Review (MNCR) and associated benthic marine data held and managed by English Nature (EurOBIS)	This dataset includes the survey data that were commissioned and collected by English Nature (now Natural England). The data contributed to the MNCR programme which was initiated to provide a comprehensive baseline of information on marine habitats and their associated species around the coast of Britain. Methods of data capture: The majority of data were collected using methods described in the MNCR Rational and Methods report (Hiscock 1996). Broadly, this encompassed surveying a range of sites within a geographical area to sample and describe the variety of habitats present (sampling habitats in different substrata, depths, wave exposures, current regimes, salinity regimes and so on). Each habitat was sampled using semi-quantitative recording techniques (SACFOR abundance scales) for recording epibiota on rocky habitats Geographical Coverage: This dataset relates to England. Note however that the dataset "Marine Nature Conservation Review (MNCR) and associated benthic marine data held and managed by JNCC" also includes equivalent and complementary data from England. Size reference: 13,769 records; 226 sites; 498 samples; 1,310 species	Habitat description and abundance	Various	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=Eurobis_688	Aggregated data from multiple surveys; broadscale; data of limited use.
DS29	Marine Nature Conservation Review (MNCR) and associated benthic marine data held and managed by Scottish Natural Heritage (EurOBIS)	This dataset includes the survey data that were commissioned and collected by Scottish Natural Heritage. The data contributed to the MNCR programme which was initiated to provide a comprehensive baseline of information on marine habitats and their associated species around the coast of Britain Methods of data capture: The majority of data were collected using methods described in the MNCR Rational and Methods report (Hiscock 1996). Broadly, this encompassed surveying a range of sites within a geographical area to sample and describe the variety of habitats present (sampling habitats in different substrata, depths, wave exposures, current regimes, salinity regimes and so on). Each habitat was sampled using semi-quantitative recording techniques (SACFOR abundance scales) for recording epibiota on rocky habitats Geographical Coverage: This dataset relates to Scotland. Note however that the dataset "Marine Nature Conservation Review (MNCR) and associated benthic marine data held and managed by JNCC" also includes equivalent and complementary data from Scotland. Size reference: 16,531 records; 780 sites; 1,590 samples; 839 species	Habitat description and abundance	Various	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=Eurobis_690	Aggregated data from multiple surveys; broadscale; data of limited use.
DS30	NMNH Invertebrate Zoology Collections (Smithsonian Institute-Invertebrate)	National Museum of Natural History (NMNH) Invertebrate Zoology Collections records: 8,784 Bryozoa, 68,401 Coelenterates, 220,965 Crustacea, 75,012 Echinoderms, 196,851 Mollusks, 28,853 Porifera, 16,466 Tunicates, 171,401 Worms, 93,268 General. Records currently represent approximately 33% of actual specimen holdings, as of 10 May 2007.	Abundance	Various	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=NMNH_Invertebrate_Zoology_Collection	Aggregated data from multiple surveys; broadscale; data of limited use.
DS31	Natural Geography In Shore Areas (NaGISA) Dataset (NaGISA)	This dataset provides data collected during the Natural Geography Inshore Areas (NaGISA) quantitative global nearshore census. The data is coming in (i.e. the dataset is continually being added to and should not be considered complete) from a growing set of globally distributed standard transects from the high inter-tidal zone to the depth of 20m, most of which will be repeated, and many of which are being uploading in stages (i.e. taxonomic detail will improve with time). Target habitats are globally distributed algal/hard bottom and sea-grass/soft bottom communities. For each study site, replicate samples are collected at high, mid and low inter-tidal and 1, 5 and 10m sub-tidal depth (where possible at 15 and 20m). For more details please see the project website http://www.nagisa.coml.org/.	Habitat description and distribution	Various	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=nagisa1	Aggregated data from multiple surveys; broadscale; data of limited use.

DS32	Pembrokeshire Marine Species Atlas (EurOBIS)	This is a collection of historical data from all sources (both published and unpublished) that cover Pembrokeshire. Both intertidal and sublittoral data are included. Data that also are included in the MNCR database have been excluded from this data set (to avoid duplication).The data were collated by Dale Rostron under contract to CCW (1997) - basic validation was undertaken at this point - including the checking of all positional information against appropriate maps/charts.	Historical data	Various	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=Eurobis_692	Aggregated data from multiple surveys; broadscale; data of limited use.
DS33	SeSaM (EurOBIS)	Sesam is the Collection Management System of the Senckenberg Museum. SeSam was developed together with com2 (Bad Homburg). All collections (both zoological and botanical) of the Senckenberg Research Institute are going to use this efficient tool.	Distribution and abundance	Various	http://www.marbef.org/data/imis.php?module=dataset&dasid=961	Aggregated data from multiple surveys; broadscale; data of limited use.
DS34	Seasearch Marine Surveys (EurOBIS)	Purpose of data capture: To provide baseline information on marine habitats and species throughout the UK. Methods of data capture: Data is obtained from visual observations by volunteer divers. Most participating recorders have been through a training process and some are professional marine biologists. Observation Form level provides a single sample containing habitat and species data from each site. The Survey Form level provides multiple habitat and species lists. Records are validated before entry into Marine Recorder. Geographical Coverage: Whole of the UK. Limited records from Eire, Isle of Man and Channel Islands Size reference: 65,982 records; 2,319 sites; 4,026 samples; 1,748 species	Distribution and abundance	Various	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=Eurobis_746	Aggregated data from multiple surveys; broadscale; data of limited use.
DS35	Survey of North Wales and Pembrokeshire Tide Influenced Communities (EurOBIS)	Marine biological surveys of seabed and shore habitats in four areas exposed to strong tidal currents around south-west and north-west Wales, made in summer 2002 and 2003. Survey work focused on rocky reefs and tidal rapids, and recorded the extent, quality and composition of the biotopes and communities. The results forms the basis for CCW Contract Science Report 611. The survey was conducted on the shore or by diving. Survey methods were based on the standard Marine Nature Conservation Review (MNCR) techniques using in-situ identification of conspicuous species and description of habitat and community characteristics. Geographical coverage: Menai Strait (subtidal and intertidal), Daugleddau Estuary & Milford Haven (subtidal and intertidal), North West Anglesey (subtidal only), West Pembrokeshire (subtidal only). Temporal Coverage: Menai Strait (1-5 August 2002 (subtidal) and 7-10 September 2002 (intertidal)), Daugleddau Estuary & Milford Haven (30 August - 4 September 2002 (subtidal) and 7-9 October 2002 (intertidal)), North West Anglesey (24-27 June 2003 (subtidal)), West Pembrokeshire: 23-26 July 2003 (subtidal).	Various including habitat description and community composition	Various	http://www.marbef.org/data/imis.php?module=dataset&dasid=1883	Aggregated data from multiple surveys; broadscale; data of limited use.
DS36	TWorsfold CullercoatsBay 2003 (EurOBIS)	Macrofauna from 2 samples of fine algae from rockpools, collected for reference and quality control test specimens: Cullercoats Bay, Tyne and Wear, UK. Size reference: 52 records; 2 stations		Various	http://gcmd.nasa.gov/KeywordSearch/Metadata.do?Portal=GCMD&MetadataView=Full&EntryId=Eurobis_1048	Aggregated data from multiple surveys; broadscale; data of limited use.

DS37	Volunteer sightings data held by the DASSH Data Archive Centre (EurOBIS)	This dataset consists of casual observations reported by volunteers and members of the public. The dataset aggregates records from the coast and seas around the UK and Ireland with some estuarine sightings. Data is collected by volunteers and members of the public. All records are validated and locations plotted. Some locations are estimated from descriptions and the granularity of the observation is variable. Rare species or species outside their range are verified by experts with photographs or specimens. Species within their range and expected habitat are assumed to be correct.	Observation	Various	http://www.marbef.org/data/imis.php?module=dataset&dasid=1891	Aggregated data from multiple surveys; broadscale; data of limited use.
DS38	UKSeaMap JNCC	Continuous (national coverage) for UK waters. Input data layers: Seabed substrates; depth; proportion of surface light reaching the seabed; energy (disturbance) at the seabed caused by tidal currents and energy (disturbance) at the seabed caused by waves.	Substrate and habitat description/ mapping	2010	http://jncc.defra.gov.uk/page-2117	
DS39	EUSeaMap JNCC	Continuous (national coverage) for EU waters, covering over 2 million square metres, with data also available for marine renewable energies (tidal current and wave).	Substrate/ habitat description/ mapping		http://jncc.defra.gov.uk/page-5020	

Appendix 4 - Statistical analysis of data types collated

All statistical analyses are to be carried out within R 2.15.3. R is a language and environment for statistical computing and graphics. R is open source software and is free to use under the General Public Licence. It is available for Windows, Mac and Unix operating systems and offers a scripting environment, where statistical analysis methodologies are transparent and easily replicated for further research. The scripts created for this project will be included within the report for just such a purpose.

The statistical approach proposed is regression analysis. Simple and multiple regression are parametric tests, therefore it is recommended that the data are normally distributed. An example of such a transformation is a square root (x^2) transformation. A x^2 transformation is suitable for population data, such as quadrat records, where data are Poisson distributed. Counts of <20 are normally highly skewed, therefore should be transformed using a x^2 transformation. A x^2 transformation can be calculated using R, using the `sqrt(x)` function in the base package.

Initially a simple linear regression is used to assess the strength of the relationship between the dependent variable (y), eg. sponge abundance, and each of the explanatory variables x_p (eg. turbidity) individually, using the following equation:

$$y_i = \beta_0 + \beta_1 \times x_i + e_i$$

where: y = dependent variable, β_0 = intercept, β_1 = slope, x = explanatory variable and e = error.

This equation is calculated with the `lm()` function in R. The resulting output from the `lm()` function would be a summary and analysis of variance table of the results. The outputs from this are then be used to assess the goodness of fit of the data to the model, using the r^2 values and significance level.

Principal Component Analysis (PCA) is used to examine whether there were any distinct similarities in the correlations between the dependent variable (y) and all the explanatory variables (x_p). PCA analysis is available in R using the `princomp()` function. The results are plotted using a biplot, which plots the PCA loading (as arrows). The length of the arrow represent the variability in a component. The angles between arrows represent the correlation between those variables. If the arrows are in the same direction, the variables are positively correlated, if they are in opposite directions, they are negatively correlated. The biplot is plotted using the `biplot()` function. Any collinear variables identified with the biplot should then be removed from the potential model. Different combinations of variables are to be examined to ensure the most influential collinear variables are retained in the model, and the less influential ones are discarded.

Multiple regression is used to predict the values of y, given a set (p) of explanatory variable (x_1, x_2, …, x_p). For sponges p could consist of data such as current (x_1), average sea temperature (x_2), turbidity (x_3) and so on. Multiple regression analysis is calculated with the following equation:

$$y_i = \beta_0 + \beta_1 \times x_{1i} + \beta_2 \times x_{2i} + \ldots + \beta_p \times x_{pi} + e_i$$

where y = dependent variable, β_0 = the intercept, β_1 to β_p = coefficients , x = explanatory variable and e = error.

This equation is calculated with the `lm()` function in R. The resulting output from the `lm()` function would be a summary and analysis of variance table of the results. As before, the outputs can then be used to assess the goodness of fit of the data to the model, using the r^2 values and significance level.

The final model will then be available as a R script, for future research and development purposes.

Appendix 5 - Further details on the analysis of proposed indicator responses to pressures

A5.1 Potting

Within the Skomer dataset, five sponge species were present that had been identified during the expert consultation as susceptible to abrasion. These were *Axinella dissimilis, Axinella infundibuliformis, Haliclona oculata, Stelligera stuposa* and *Raspailia ramosa.* Total species abundance and potting data were tested (a proxy for abrasion; see Section 2.4.1 in the main report). Species data were available for the period 2006-2009, from which data from three years were analysed; 2006, 2008 and 2009. Only autumn species records were analysed, providing a total of seven records. Spring and summer species records were not analysed as it was considered that the species surveys could have been undertaken prior to fishing activity. Autumn species data were therefore used as a yearly summary of species composition, in the same way that the available fishing pot data are annual summaries of fishing activity. Species data for 2007 were not analysed due to a lack of autumn species data for that year. Regression analysis indicated that there was no significant relationship between potting density and species abundance ($p \geq 0.05$) (Table A5.1. *Regression analysis results for total species abundance with potting density (n=7).*).

Table A5.1. Regression analysis results for total species abundance with potting density (n=7).

Species	Pressure	*p value*
Axinella dissimilis	Potting density	0.751
Axinella infundibuliformis	Potting density	0.294
Haliclona oculata	Potting density	0.469
Raspailia ramosa	Potting density	0.949
Stelligera stuposa	Potting density	0.410

A5.2 Siltation

Five sponge species were identified during the expert workshop as potentially sensitive to siltation levels. These were *Axinella dissimilis, Axinella infundibuliformis*, *Hemimycale columella*, *Halichondria panicea* and *Amphilectus fucorum,* of which *Axinella dissimilis, Axinella infundibuliformis* and *Amphilectus fucorum* data were present in the Skomer dataset and therefore available for analysis. Mean seasonal siltation values were calculated based on the month of the sponge survey: spring siltation was based on April and May siltation readings, summer siltation was based on June and July readings, while Autumn siltation was calculated using August and September values (except for 2006, where October siltation values were also used due to the sponge survey being carried out in October that year). Regression analysis (Table A5.2) found no significant relationship between siltation levels as measured by sediment trap at the TRK station (Figure 2.1 in the main report) and sponge species abundance ($p \geq 0.05$).

Table A5.2. Regression analysis results for total species abundance, with siltation (n=10).

Species	Pressure	*p value*
Amphilectus fucorum	Siltation (g/day)	0.333
Axinella dissimilis	Siltation (g/day)	0.160
Axinella infundibuliformis	Siltation (g/day)	0.820

A5.3 Salinity

Seven sponge species were identified as potentially sensitive to salinity. These were *Axinella dissimilis, Axinella infundibuliformis, Stelligera stuposa, Raspailia ramosa*, *Hemimycale columella, Halichondria panacea* and *Amphilectus fucorum,* of which *Axinella dissimilis, Axinella infundibuliformis, Stelligera stuposa,* Raspailia ramosa and Amphilectus fucorum data were present in the Skomer dataset and therefore were available for analysis. Total species abundance from the Skomer data, and salinity data from site OMS (Figure 2.1 in the main report) were tested, using seasonal salinity means derived from the same temporal classes as described in Section 0. Regression analysis (Table A5.3) found no significant relationship between salinity and sponge species abundance $p \geq 0.05$).

Table A5.3. Regression analysis results for total species abundance, with salinity (n=10).

Species	Pressure (ppt)	*p value*
Amphilectus fucorum	Salinity	0.468
Axinella dissimilis	Salinity	0.623
Axinella infundibuliformis	Salinity	0.749
Stelligera stuposa	Salinity	0.358
Raspailia ramosa	Salinity	0.200

A5.4 Temperature

Temperature change was suggested by JNCC as a potential modifier of sponge assemblages. For this analysis total species abundance was used. The monthly average near-bed sea temperature was measured at site OMS with a second measurement taken at an approximate depth of 15m at station TRK (Figure 2.1 in the main report).These data were only available up to May 2008. Seasonal temperature means were derived from the same temporal classes as described in Section 0. Regression analysis (Table A5.4 and Table A5.5) found no significant relationship between temperature and sponge species abundance ($p \geq 0.05$).

Table A5.4. Regression analysis results for total species abundance, with mean near-bed temperature (n=10).

Species	Pressure	*p value*
Amphilectus fucorum	Mean near-bed temperature	0.554
Axinella dissimilis	Mean near-bed temperature	0.549
Axinella infundibuliformis	Mean near-bed temperature	0.528
Haliclona oculata	Mean near-bed temperature	0.323
Stelligera stuposa	Mean near-bed temperature	0.641
Raspailia ramosa	Mean near-bed temperature	0.916

Table A5.5. Regression analysis results for total species abundance, with near-bed temperature range (n=10).

Species	Pressure	*p value*
Amphilectus fucorum	Near-bed temperature range	0.635
Axinella dissimilis	Near-bed temperature range	0.936
Axinella infundibuliformis	Near-bed temperature range	0.657
Haliclona oculata	Near-bed temperature range	0.579
Stelligera stuposa	Near-bed temperature range	0.574
Raspailia ramosa	Near-bed temperature range	0.420

A5.5 Morphology

In order to examine the sponge morphological diversity response to selected pressures species were assigned to a morphological type following the protocol of Berman (2012). Since, as previously discussed, abrasion is considered to be a significant pressure on rocky habitats, a regression analysis was performed which examined the potting variable against both sponge life strategy (long-lived versus fast-growing) and morphotype diversity, incorporating pooled data from all Skomer sites, collected between 2006 and 2012. This morphological analysis utilised the species data collected at three locations within the Skomer MNR, along with sponge morphological data collected at a wider range of Skomer survey sites (Figure 2.1 in the main report). The analysis of life strategy utilised species total abundance data from 2006, 2008 and 2009 (seven samples). The results of the regression analysis (Table A5.6) indicate that there is no significant relationship between Skomer sponge life strategy or morphological diversity and potting intensity ($p \geq 0.05$).

Table A5.6. Regression analysis results for morphology ratio with potting density.

Ratio parameters	**Pressure**	***p* value**
Arborescent and tubular to other morphologies *(n=17)*	Potting density	0.714
Encrusting, massive and burrowing to other morphologies *(n=17)*	Potting density	0.919
Long lived to fast growing species (*n*=7)	Potting density	0.243

The relationship between morphological diversity (Shannon-Weiner Index), from the total count of sponges for each morphology and 'pressure' was analysed. Results show there were no significant relationships present (Table A5.7). However, this analysis did result in *p* values closer to the significance threshold of $p \geq 0.05$. It should be noted, as previously described, that the number of data points available and used in these analyses are insufficient for significance to be attributed to the result of any statistical test. It is possible that the insignificant *p* values derived from these analyses mask a genuine relationship between morphological type and pressure levels, constituting a Type II statistical error. This means that further data collection and analysis are required; ideally such data would come from surveys specifically designed to investigate these relationships, to allow greater isolation of environmental pressures from other potential contributing factors.

Table A5.7. Regression analysis results for morphological diversity

Pressure	***p* value**
Siltation	0.062
Salinity	0.108
Near-bed temperature	0.118
Potting density	0.688

A5.6 Anthozoa species

From the 10 anthozoan indicator species identified by the experts, only data for *Eunicella verrucosa* were available and suitable for assessment. *E. verrucosa* was identified as a potential indicator for siltation and abrasion. Total species counts (*n*=13) and potting data were tested (a proxy for abrasion; see Section 2.4.1 in the main report). As previously discussed, siltation data from a single sediment trap station (TRK) (Figure 2.1) was used as the pressure variable. Results from the regression analysis showed that there was no significant relationship between *E. verrucosa* count and potting (p=0.435) or species count and siltation (p=0.610).

Appendix 6 - Marine Recorder Data

Marine Recorder contains a substantial number of data records. The majority of these data cover the waters surrounding the whole of the British Isles, with a limited number of records beyond. Marine Recorder contains species presence data (Figure A6.1, Figure **A6.2** and Figure **A6.3**).

Marine Recorder contains a limited amount of abiotic data within the Survey and Location tables. Examples of environmental parameters recorded in the Survey table are:

- DepthLower (Quantitative);
- DepthUpper (Quantitative);
- TidalCurrent (Quantitative);
- TempSurface (Quantitative);
- TempBottom (Quantitative) ;
- Salinity (Quantitative).

The Location table contains quantitative information relating to salinity, tidal streams and wave exposure. Table A6.1. Number of Marine Recorder records containing qualitative information. and Table **A6.2** show that a higher proportion of Marine recorder records contain qualitative information than quantitative information, and that overall very little quantitative data have been collected. The dates of data collection range from 1764 to 2012.

Table A6.1. Number of Marine Recorder records containing qualitative information.

Location table (number of UK points: 29,506)			
Field name	**Type of collection**	**Classes (if qualitative)**	**Number of No Data values**
Salinity	Qualitative	Full (30-35ppt) Low (<18ppt) Reduced (18-30ppt) Reduced/low (0.5-30ppt) Variable (18-35ppt)	15,771 (53.5%)
Tidal Stream	Qualitative	Moderately strong (1-3kn) Strong (3-6kn) Very strong (>6kn) Very weak (negligible) Weak (>1kn)	19,325 (65.5%)
Wave Exposure	Qualitative	Exposed Extremely exposed Extremely sheltered Moderately exposed Sheltered Very exposed Very sheltered	13,067 (44.3%)

Table A6.2. Number of Marine Recorder records containing quantitative information.

Location table (number of UK points: 43946)			
Field name	**Type of collection**	**Classes (if qualitative)**	**Number of NoData values**
Salinity	Quantitative		43,624 (99.3%)
Temp Bottom	Quantitative		36,124 (82.2%)
Tidal Current	Quantitative		43,938 (>99.9%)

Marine Recorder has a the potential to offer a means for storing information suitable for indicator assessment; currently the quantitative data records are too sparse to satisfy the potential requirements.

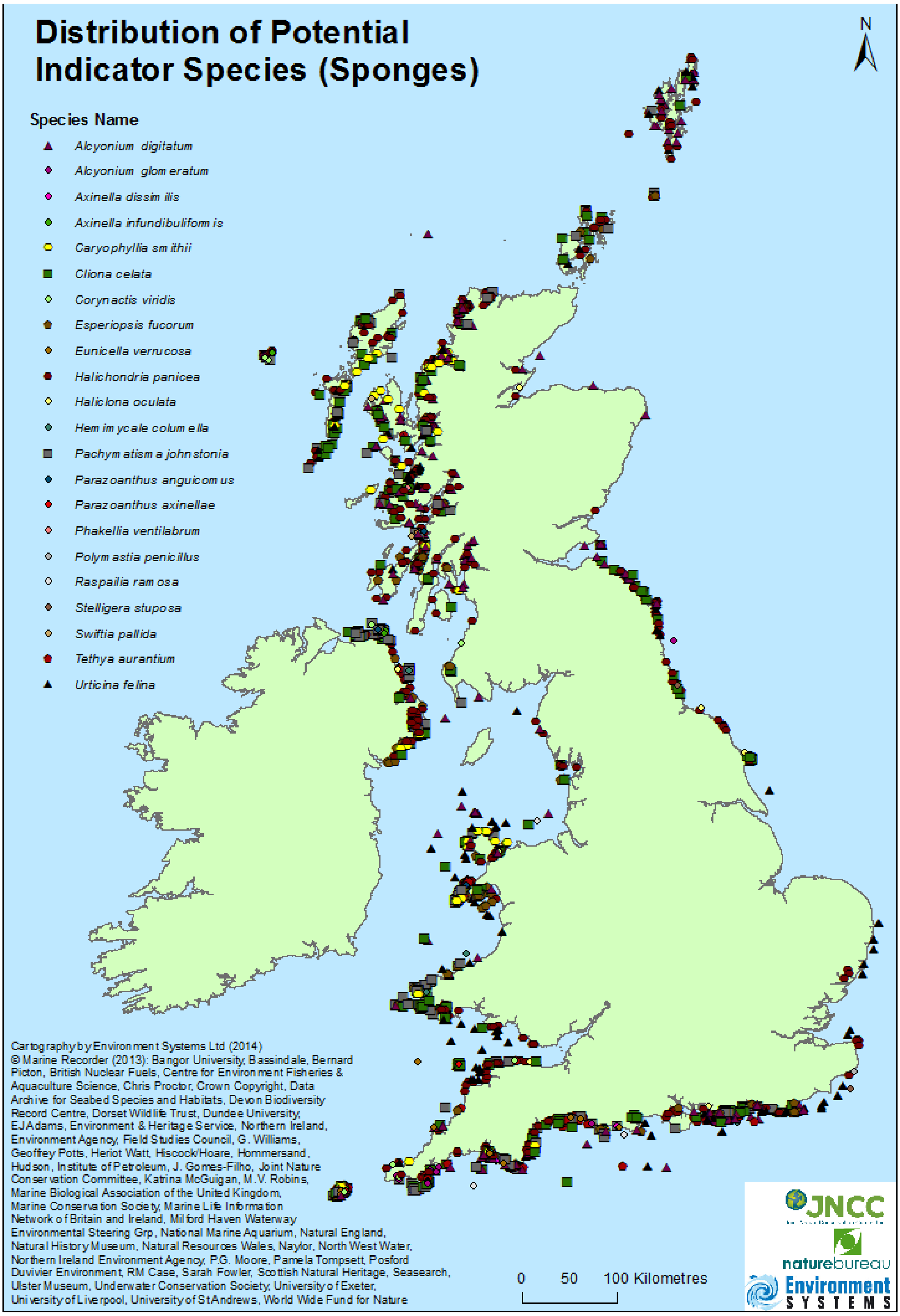

Figure A6.1. Distribution of potential sponge indicator species (see Section 2), from Marine Recorder data.

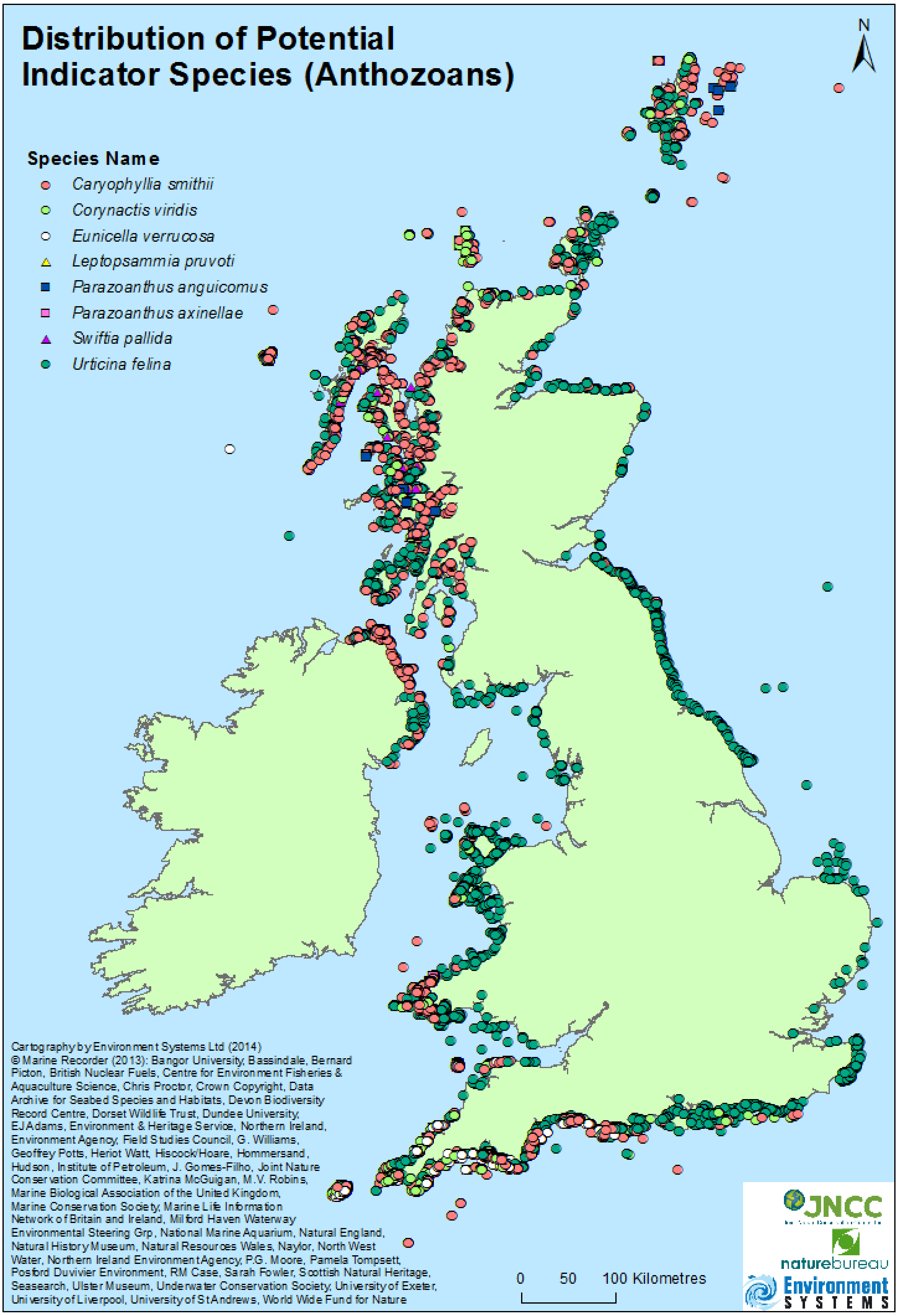

Figure A6.2. Distribution of potential anthozoan indicator species (see Section 2), from Marine Recorder data.

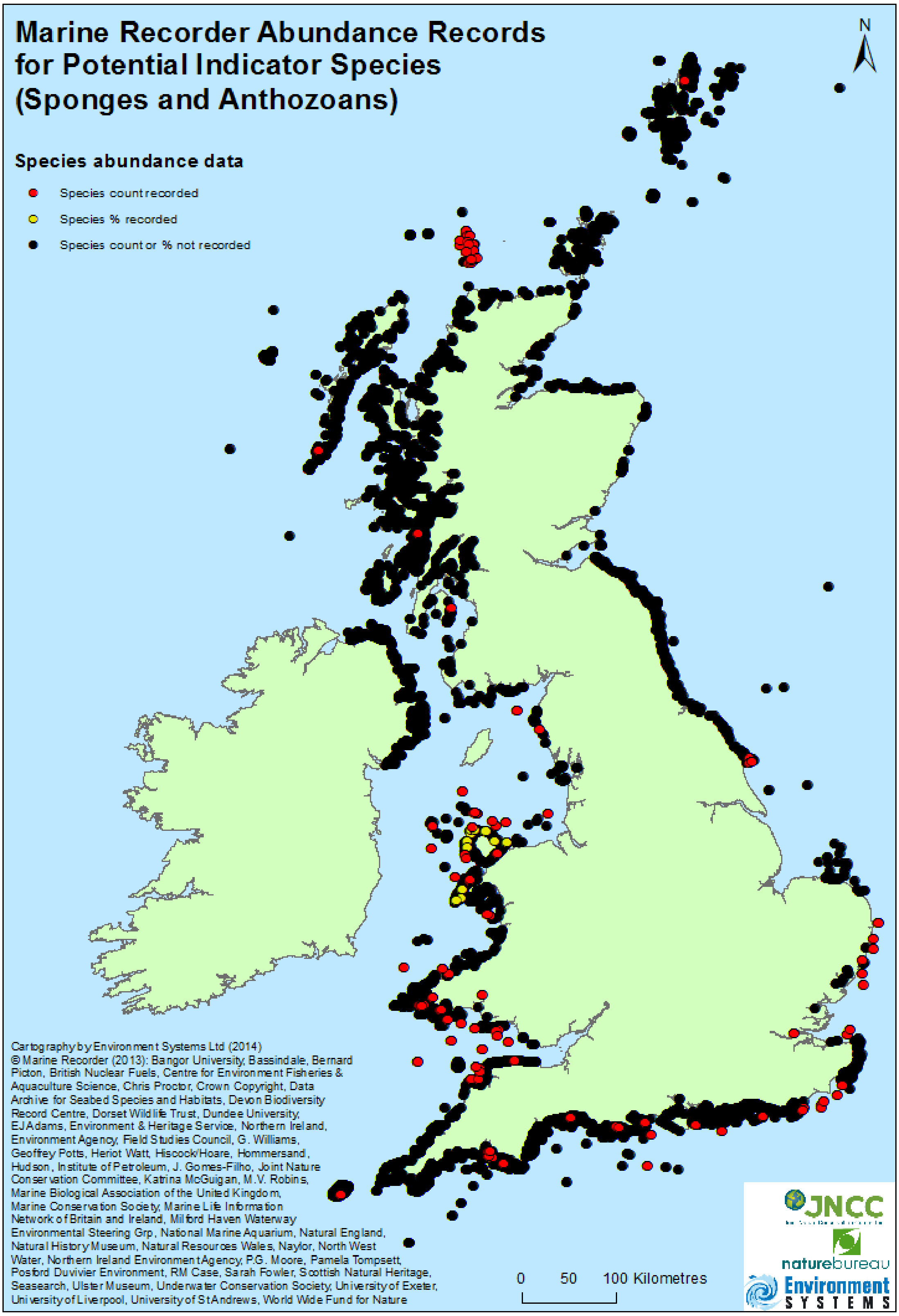

Figure A6.3. Abundance records for potential sponge and anthozoan indicator species (see Section 2), from Marine Recorder data.