



Design of Monitoring Programme for Lundy

Natural England

17 March 2010

Final Report

9V5712

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1 INTRODUCTION

1.1 Background

Lundy Island is England's first Marine Conservation Zone (MCZ) which has been designated in 2010 under the Marine and Coastal Access Act 2009 and supercedes the Marine Nature Reserve (MNR) designation for which Lundy was nominated in 1986. The MCZ boundary shares that of the Lundy Special Area of Conservation (SAC) (nominated in 1996, moderated in 2000 and formally designated in 2004). Under the SAC designation Lundy Island is notified for its reef habitats, subtidal sandbanks, sea caves and Grey Seals. Lundy Island is also designated as a Site of Special Scientific Interest (since 1987) which is primarily a terrestrial designation, but the boundary extends to the mean low water mark and therefore includes intertidal areas, many of which are used by Grey Seals (*Halichoerus grypus*) as pupping and haul-out sites. Natural England must assess the condition of the features of Lundy Island's designations, and ensure their management results in their protection and enhancement.

Natural England is responsible for management of the Lundy Marine Conservation Zone (MCZ), of which the Lundy No Take Zone (NTZ) is a critical part. The No Take Zone protects key species and habitats on the east side of the island which are particularly sensitive and allows the area to fully recover to a natural state.

A summary of the conservation and marine management designations for Lundy and its surrounding waters is provided in Table 1.1 below. Where appropriate the JNCC reference codes for identification of the qualifying features are also provided. The boundaries of the Lundy SAC and NTZ are illustrated in figure 1.1 below.

Table 1.1 Designations at Lundy

Designation	Qualifying Features	Additional Information
Special Area of Conservation (SAC)	Reefs (H1170)[1]	Secondary features – sandbanks (H1110) , Sea Caves (H8330) and Grey Seal (S1364)[1]
Site of Special Scientific Interest (SSSI)	Designated plants and seabirds	
Marine Conservation Zone (MCZ)	N/A	Designated in 2010 as the first MCZ in England it supercedes the Marine Nature Reserve (MNR) designation
No Take Zone	N/A – however the following species of interest have been monitored: • Lobster (*Homarus gammarus*); • Brown crab (*Cancer pagurus*), • Velvet crab (*Necora puber*); • Spider crab (*Maja squinado*) • Scallop, *Pecten maximus*; and • Assemblages of sessile epifauna in circalittoral rocky habitats	A voluntary marine nature reserve was established in 1971. It was designated as England's first statutory NTZ in 2003

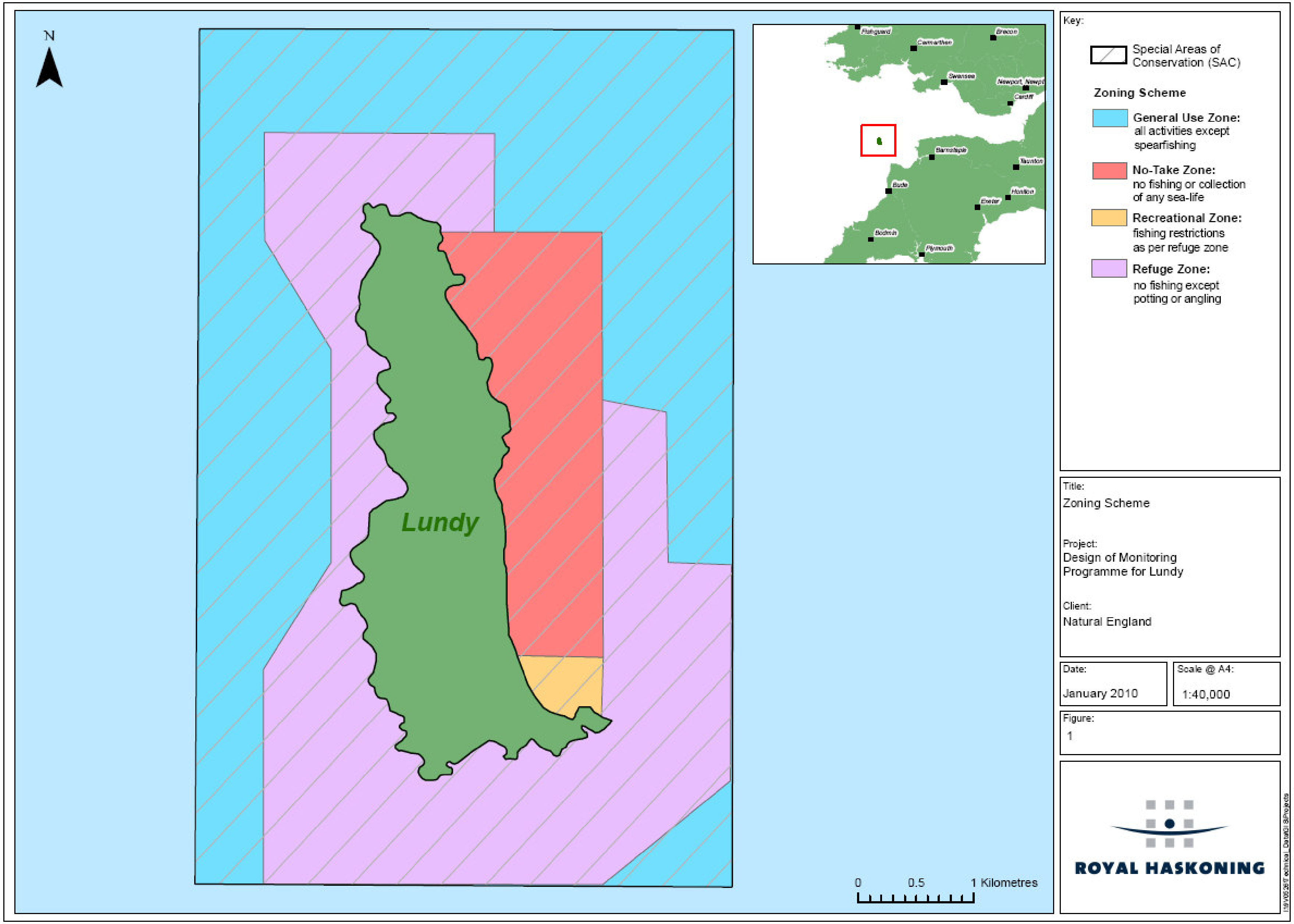
[1] See http://www.jncc.gov.uk/ProtectedSites/SACselection/sac.asp?EUCode=UK0013114

Within Lundy's SAC, Natural England are responsible for undertaking a Condition Assessment monitoring programme to inform Competent Authorities on the condition of the SAC interest features. The Condition Assessment is based on the Favourable Condition table given in Natural England's advice under Regulation 33(2) of the Conservation (Natural Habitats & c.) Regulations 1994. Condition Assessments are undertaken on a 6 year cycle and are reported to Defra.

Over the past 40 years a large number of surveys have been undertaken at Lundy, investigating its shores, seabed and the waters surrounding the island. In 2005 a comprehensive review of all known survey data on the notified habitats and species was carried out (Irving, 2005) on behalf of Natural England.

A separate monitoring programme was set up in 2003 when the No Take Zone was designated in order to record the impact the designation was having on the underwater ecosystems, with specific reference to populations of lobster (*Homarus gammarus),* brown crab *(Cancer pagurus),* velvet swimming crab *(Necora puber),* spider crab *(Maja squinado),* scallop *(Pecten maximus),* and an assemblage of sessile epifauna in circalittoral rocky habitats that are of interest for nature conservation including pink sea fan *(Eunicella verrucosa),* dead men's finger *(Alcyonium digitatum),* and ross coral *(Pentapora fascialis)* (Hoskins, 2008). In addition, regular monitoring of the SSSI features has been carried out, including intertidal rocky shore surveys, and a thorough year-long seal survey was completed in 2009 to provide a baseline for this feature.

Monitoring of Lundy's marine interest features has been carried out on a slightly ad hoc basis and this piece of work aims to provide a suggested monitoring framework to form the basis of a comprehensive, rolling marine monitoring programme. This will enable future monitoring at the site to be carried out consistently and efficiently.


N
Lundy
0
0.5
1 Kilometres
Key:
Special Areas of Conservation (SAC)
Zoning Scheme
General Use Zone: all activities except spearfishing
No-Take Zone: no fishing or collection of any sea-life
Recreational Zone: fishing restrictions as per refuge zone
Refuge Zone: no fishing except potting or angling
Title:
Zoning Scheme
Project:
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1.2 Aims & Objectives

The aim of this contract is to develop a robust monitoring programme to inform future marine monitoring of designated features and attributes on Lundy.

The expected deliverables or output objectives, as outlined in the contract specification, are outlined below:

1. Suggest appropriate survey techniques for each of the features and attributes – ensuring consistency with previous surveys and ability to compare accurately with other existing studies from Lundy and other sites;
2. Describe when each feature and attribute of the Lundy marine designations should be monitored;
3. Identification of possible baseline for each attribute, based on current knowledge;
4. Produce recommendations on the regularity and seasonality of each survey;
5. Produce recommendations on the level of detail required in order to accurately establish the condition of the designated features and their attributes, bearing in mind that changes above the level of natural variation will need to be detected;
6. Number of replicates to ensure statistical significance of data where appropriate;
7. Comment on the level of exposure to risk of each feature and attribute, and how that will impact the regularity of the monitoring cycle and /or set priorities for monitoring; and
8. Ideas on potential efficiency saving recommendations (e.g. combining surveys where appropriate to save time and money).

Section 1.3 below describes the report structure and also aims to provide an indication of where within this report those output objectives outlined above have been addressed.

Where there is potential to use the survey and monitoring programme designed to meet one objective or provide information for one designated area, to additionally inform another objective or management of an area, then we have highlighted this possibility. There is a great deal of crossover between the Common Standards Monititoring (CSM) categories for SAC and SSSI features. In fact, the 2007 Favourable Conservation Status Reporting for the Habitats Directive was largely based around condition assessments of SSSI features due to the paucity of data available for the relatively recent SAC designations. Therefore we consider that monitoring of the marine SSSI elements would be simultaneously achieved by the work necessary to monitor the littoral part of the SAC features. It should be noted that neither the SSSI seabird nor the terrestrial plant interests are dealt with in this report.

1.3 Report Structure

Section 1 provides an introduction to the Lundy designations and describes the background and aims and objectives of this project.

Section 2 considers the general monitoring considerations which need to be address and considers the requirement for establishing an appropriate baseline from which to undertake monitoring.

Section 3 discusses the Common Standards Monitoring (CSM) recommendations for the different designated features of the Lundy site. The attributes for each feature are broken down into the following subheadings the justifications for which are provided below:

- **Attributes:** The attributes listed under each feature have been selected, to conform to CSM guidance where possible;
- **Target:** In line with the Reg 33 and CSM, a target has been provided in order to give an indication of what will constitute unfavourable status;
- **Baseline:** The review by Irving (2005) has been used as a starting point for determining whether a suitable baseline is available. Previous studies that provide supporting information have been tabulated and potential baselines highlighted in bold.
- **Suggested Monitoring Interval:** In order to provide consistency, the recommendations for the suggested monitoring intervals have been structured to conform to the European Habitats Directive 6-year reporting cycle. The stated monitoring intervals are sometimes somewhat arbitrary, since the rate of change in biological communities is not often known and difficult to predict. Given the importance of Lundy we have therefore attempted to stay on the cautious side, but have also allowed room for revision. If a shorter period is adopted initially, and no change is recorded over one or two cycles, then a longer interval could be considered. If, however, too long a period is adopted initially, the consequences of delaying an identification of change could hold severe implications for the feature condition and may compromise the ability to initiate a management action to reverse an undesirable status. Where an interval range is suggested in the text the shortest interval is used for the proposed monitoring time-line presented in Appendix 6.
- **Suggested Method:** Where suitable baselines have already been established the suggested monitoring methods have taken consideration of the original survey techniques in order to provide a more statistically viable framework, as appropriate. While it is outside the scope of this work to provide detailed methological descriptions, wherever possible we have referenced existing methodologies.
- **Timing of Survey:** The timing provides an indication of the most appropriate time to undertake sampling, particularly where there are specific biological considerations or a potential overlap with the sampling recommendations for other attributes, with an associated opportunity for pooling of resources by synchronization of survey timing.
- **Assessment of change:** This provides an indication of how change within a particular attribute would be determined and how such change might be differentiated from natural variation.
- **Estimation of Resource Requirements:** The resource estimations relate solely to the fieldwork element and data processing, report production and administrative tasks are not considered. These have been provided to indicate the time and cost requirements to satisfy monitoring requirements for each attribute.
- **Comments and Observations:** Provides further comments relevant to a particular attribute.

Section 4 provides a discussion of the recommendations resulting from this piece of work and also considered the applicability of the NTZ monitoring and species for interest in the context of condition monitoring.

Additional information is provided in the Appendices, a list of which is provided below:

- Appendix 1: Summary of monitoring recommendations.

- Appendix 2: Sedimentary 'proto-biotopes' identified from Lundy grab sampling.
- Appendix 3: MarClim Sampling Protocols 2008 (Supplied by N. Mieszkowska, MBA)
- Appendix 4: Attribute statistical relevance and baseline information table.
- Appendix 5: Attribute monitoring, prioritisation and justification
- Appendix 6: Proposed monitoring time-line

2 GENERAL MONITORING CONSIDERATIONS

2.1 Common Standards Monitoring

In order to provide consistency of approach Common Standards Monitoring (CSM) was used as a framework for structuring the monitoring recommendations for the features and attributes of the SAC and SSSI. The proposed monitoring strategy in this document has been prepared while directly referring to the following documents:

- Common Standards Monitoring Guidance for Inshore Sublittoral Sediments Version August 2004
- Common Standards Monitoring Guidance for Littoral Rock and Inshore Sublittoral Rock Habitats Version August 2004
- Common Standards Monitoring Guidance for Sea Caves Version August 2004
- Common Standards Monitoring Guidance for Marine Mammals Version May 2005

An indication of whether the attributes discussed are listed as mandatory in the CSM guidance or as discretionary is also given for each attribute. Attributes listed as mandatory mean that these should generally be reported on for all relevant features at all sites. If an attribute is listed as discretionary in the CSM guidance it merely means that this is an attribute which may not be applicable at all sites and the monitoring thereof would therefore be site dependant. As such this listing cannot necessarily be used to determine any hierarchy or priority in attribute monitoring.

In certain cases the monitoring of discretionary attributes has been given a higher priority when establishing attribute monitoring prioritisation (see Appendix 5) compared to the mandatory attributes. In many cases mandatory attributes such as reef extent are likely to remain largely unchanged in the medium to long term and are therefore not considered a monitoring priority if a baseline has already been established. For many of the ‘extent’ attributes the monitoring intervals recommended generally reflect the likely level of change to these attributes with monitoring interval recommendations generally in 12 to 24 years.

2.2 Setting the Baseline Condition

A major requirement for assessing site condition (perhaps more correctly *feature* condition) is the establishment of a **baseline** from which change – either deterioration or improvement – can be determined.

In general, pre-designation baseline data for assessing feature or sub-feature condition in most UK marine SACs are either sparse or totally absent. When historical data are available, they are often incomplete, lacking in accurate geographical positioning and tending more towards broad qualitative or descriptive reports. Although this type of information can provide contextual or supporting weight behind feature condition assessments, it is usually not provided with sufficient detail to allow a direct quantification of change, within the boundaries of the area of interest.

Lundy, however, is in many ways rather unique in terms of the UK suite of marine SACs because it has received sustained survey attention, well before is was under consideration for submission as a candidate Natura 2000 site. Consequently, there are a number of studies that provide insights into the past status of selected species and habitats. Some constitute single-study 'snapshots', while others incorporate repeat monitoring over a number of years. These do not necessarily provide an adequate basis from which a determination of feature condition can be made and the baseline condition must be carefully established, since there is an implied commitment to direct management effort into maintaining the 'standard', should future comparisons indicate undesirable change.

Moreover, consideration must be given to the need for a consistent approach across the suite of marine SACs. Many parallel UK monitoring programmes have struggled to establish a baseline for most, or all, of the attributes under examination and have very often set the results of the inaugural monitoring as the baseline condition. In recognition of this situation guidance from the Natura 2000 Marine Monitoring Manual states:

"*As a guide, and in the absence of information on which to base a different conclusion, the 'value' of the characteristics at the time when the feature was selected is assumed to be representative of favourable condition*" (Davies *et al*., 2001)

This implies that the condition of all features at the time of SAC selection should be assumed as favourable, unless there is any evidence to suggest otherwise.

The SAC designation process for Lundy began around 1996, when it was selected for submission to the proposed UK SAC list, although it had previously been designated as the UK's first statutory Marine Nature Reserve in 1986. The site was formally designated as a Special Area of Conservation in 2005.

In 2003 most of east side of the island was confirmed as a statutory No Take Zone, together with an associated marine zoning scheme.

Perhaps one of the principal barriers to using older datasets as a baseline is a lack of confidence in the accurate positioning of transects and sample stations. Prior, to the availability of reliable hand-held differential GPS most of the positioning for field surveys was achieved using a combination of alignment with notable features, compass bearings, or sometimes angular fixes using a sextant. In later years, some of the sublittoral sampling may have been supported by the use of a vessel-based Loran-C navigation system, but the absolute accuracy of this system was between 185 m and 463 m with a repeatable accuracy of between 18 m to 91 m.

The implications of low positional accuracy are particularly acute when a monitoring method is reliant on repeat visits to a specific location or sample station. Low accuracy can also present problems when attempting to compare sample stations that are stratified and randomised, since there is a strong chance that historical data may have been inaccurately reported within a stratified sampling area, when, in fact, they are from locations outside.

For these reasons we suggest that, where appropriate, a cut-off around 1995-1996 should be taken as a limit for when a baseline condition datum can be considered. Accordingly, in this report where we have indicated data available to be considered as a true baseline, it is a reflection of data availability on or after these dates. Highly relevant data from before this period have not, however, been ignored, but are referred to as 'supporting' information to an assessment of the direction trends in condition.

2.3 Pressures and Impacts

Although afforded a relatively high degree of conservation protection at an early stage, Lundy's designated features are vulnerable to a range of anthropogenic pressures and impacts. The process of developing an appropriate rolling monitoring programme requires that current impacts - both localised and of wider relevance - be correctly identified to ensure that change attributable to those impacts can be discerned from natural variation, ultimately resulting in targeted management action to minimise habitat damage and control biodiversity decline. In addition, it is important to incorporate a degree of forward thinking into any monitoring strategy to identify other pressures that, although not necessarily directly relevant at the time of designation, may increase in significance in future years.

A key starting point for the establishment of the pressures and impacts that should be considered is the statutory Regulation 33 advice provided by the relevant authorities in which the conservation objectives for European Marine Sites and Ramsars are stated, together with any identified operations that may cause deterioration of natural habitats or disturbance to species for which the site has been designated.

The 'Regulation 33 package' is issued by Natural England and "…*is designed to help relevant and competent authorities, who have responsibilities to implement the Habitats Directive, to:*

- *understand the international importance of the site, underlying physical processes and the ecological requirements of the habitats and species involved;*

- *develop a management scheme to ensure that the ecological requirements of the site's interest features are met; and*

- *set the standards against which the condition of the site's interest features can be determined and compliance monitoring undertaken to establish whether they are in favourable condition.*" (English Nature, 2000).

Relevant authorities are then able to use this advice to develop and prioritise a management scheme to control and minimise the impacts of activities considered to pose the greatest threat. Any site condition monitoring strategy is therefore obliged to attempt to incorporate methods that can detect change caused by the influence, either directly or indirectly, of these identified impacts.

At this time Regulation 33 advice has only been issued for the Habitats Directive Annex I feature '*Reefs*' (English Nature, 2000), which translates to 'littoral rock and inshore sublittoral rock' under the UK Common Standards protocol. Regulation 33 Packages for the qualifying Annex I habitats '*Sandbanks which are slightly covered by sea water all the time*', '*Submerged or partially submerged sea caves*' and the Annex II species '*Grey seal*' have yet to be completed and published and so are presently unavailable for consideration in this report.

The Regulation 33 advice for the Reefs feature (English Nature, 2000) identifies four key sub-features which are to be maintained in favourable condition:

- rocky shore communities;

- kelp forest communities;
- vertical and overhanging circalittoral rock communities; and
- circalittoral bedrock and stable boulder communities

A 'Favourable Condition Table listing the features and sub-features is provided together with measures and targets for each, stating that:

"*The favourable condition table is the principle source of information that English Nature will use to assess the condition of an interest feature and as such comprises indicators of condition*."

Accordingly, in this report we have maintained the original favourable condition table elements, while attempting to expand or enhance the monitoring programme to include other relevant studies.

The current Lundy Regulation 33 advice identifies five types of impact (selected from a standard list of categories) that are either of high or moderate concern in relation to rock habitat vulnerability. In general, these fall into two broad groups. The first impact group is direct physical damage, either from siltation or abrasion. Dredging and aggregate extraction is reported to occur within the area, although beyond the SAC boundary, providing the potential for sediment suspension and entrainment to locations where sensitive habitats, such as kelp forest or sponge/bryozoan communities may be damaged or growth rates impaired. Similarly, activities such as vessel anchoring, recreational diving or continued fishing outside the No take Zone will carry a risk of damage through collision or abrasion. Kelp habitats and many of the circalittoral macrofaunal assemblages, particularly the slow growing corals and sponges, would be sensitive to loss *via* this route.

Exposure of shore communities to nutrient and organic enrichment events resulting from sporadic effluent discharges is known to occur and the potential for change in community composition through the proliferation of more tolerant species has been identified.

In addition to the five impacts outlined in the original Regulation 33 advice we suggest that two others may need to be considered when assessing the condition of the Lundy reef feature. Although always likely to be restricted in the Lundy setting, a physical loss of part of the feature may occur during small construction developments or maintenance activity. The effect of these may be particularly acute where vulnerable or isolated intertidal populations may be involved, such as *Balanophyllia regia*. Also absent from the Regulation 33 advice is the possible effects of non-native species proliferation. Two non-native seaweed species have been confirmed on Lundy since 1999, *Sargassum muticum* and *Asparagopsis armata*, both, as yet, relatively benign, but their potential to modify community composition, particularly in intertidal rockpools may justify inclusion as at least a surveillance element in a shore monitoring programme. A modification of the "*operations which may cause deterioration or disturbance*" table presented in the original Regulation 33 advice is shown in Table 2.1. The two additional identified impacts are inserted together with a preliminary assessment of the remaining features.

Table 2.1 Operations which may cause deterioration or disturbance to the Lundy European marine site interest features at current levels of use. Modified from English Nature (2000).

Pressure or impact	Littoral & inshore sublittoral rock	Sea caves	Inshore sublittoral sediment	Grey seals
Physical loss:				
Removal (e.g. harvesting, land claim, coastal development)	✓*	✓		
Smothering (e.g. disposal of dredge spoil)			✓	
Physical Damage:				
Siltation (e.g. dredging, outfalls)	✓			
Abrasion (e.g. mobile benthic fishing, anchoring)	✓	✓		
Selective extraction (e.g. aggregate dredging, entanglement)				✓
Non-physical disturbance:				
Noise (e.g. boat activity)				✓
Visual presence (e.g. recreational activity)				✓
Toxic contamination:				
Introduction of synthetic compounds (e.g. TBT, PCBs, endocrine disruptors)			✓	
Introduction of non-synthetic compounds (e.g. heavy metals, hydrocarbons)			✓	
Introduction of radionuclides				
Non-toxic contamination:				
Nutrient enrichment (e.g. agricultural run-off, outfalls)	✓		✓	
Organic enrichment (e.g. mariculture, outfalls)	✓		✓	
Changes in thermal regime (e.g. power stations)				
Changes in turbidity (e.g. dredging)	✓			
Changes in salinity (e.g. water abstraction, outfalls)				
Biological disturbance:				
Introduction of microbial pathogens				
Introduction of non-native species and translocation	✓*			
Selective extraction of species (e.g. commercial & recreational fishing)			✓	

*Indicates additions to the originally identified impacts for the ‘Reef’ feature.

In general, sea caves are relatively impervious to most of the anthropogenic activities known to occur throughout the area. A possible impact due to coastal development is indicated, but this is a highly unlikely event for Lundy’s cave resource. A more likely scenario, although still of low probability, is a loss of cave communities through abrasion caused by the introduction of large debris items during a coincidence of storm conditions and high spring tides, or through an oil spill event.

Impacts on the sedimentary communities of a SAC are broadly similar for most sites. Sublittoral infaunal assemblages are largely structured by sediment granulometry, organic content, depth and water movement. The introduction of different sediments, through, for example, the disposal of dredge spoil may change the sediment character and subsequently cause a modification of the infaunal communities.

Sublittoral sediments also carry a high affinity for both organic and non-organic chemicals and sediment-bound toxic chemicals from anthropogenic sources could persist in an area for a very long time. Jones (1975) analysed both organisms and sediment samples taken from Lundy in September 1972 for metal concentrations, concluding that concentrations were within the range expected for coastal regions without major sources of chemical input. There have been no similar studies since, so there is no means by which biological changes could be presently correlated with local metal contamination events.

Within the sedimentary feature only one species, the king scallop *Pecten maximus*, continues to be harvested. Recent surveys (Hoskin et al., 2009) suggest that the individual abundance is very low despite only recreational diver collection in recent years.

The potential for impacts on the grey seal population are largely restricted to disturbance effects resulting from commercial vessel movements, recreation and tourism. Disturbance at haul-out sites during the pupping season may lead to increased energy expenditure leading to a reduced survival rate of pups. Seals can become entangled in debris such as discarded fishing nets and plastic litter that can restrict swimming activity and eventually cause drowning.

3 COMMON STANDARDS MONITORING: RECOMMENDATIONS

3.1 Feature: Sea Caves

3.1.1 Attribute: Extent of cave(s) (Discretionary)

Target: No change in dimensions of a cave, allowing for natural change that is part of a wider coastal geomorphological management regime.

Baseline: There are presently no data that could constitute a baseline for this target. There have been no documented quantitative topographical studies in any of the Lundy caves (littoral or sublittoral) that would allow an assessment of dimension change.

Historical studies have been confined to 'by eye' estimation of cave dimensions (Table 3.1). Hiscock (1984b) provides sketches of the entrances and internal layout of eight caves on the southern part of the west coast, but these will not be sufficiently quantitative or accurate to provide a basis for measurement of change.

Table 3.1 Summary of supporting information available for determination of the extent of sea caves.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Lundy west coast	Number and lay-out of sea caves	Visual count & sketches of cave entrances	1983	Single study	21 caves	Hiscock (1984b)
Lundy	Length of caves	Visual estimation	1996	Single study	Four caves	Heath (1996)

Suggested Monitoring Interval: 18 – 24 years.

Suggested Method: The use of speleological techniques (for which specific mapping software is available) coupled with laser measuring devices (only useable in littoral caves) has been employed by both CCW (Bunker & Holt, 2003) and SNH, (ERT (Scotland) Ltd., 2003) but the methodology is time-consuming and fraught with difficulties in accurate repositioning on subsequent visits if precise measurement is attempted.

Moreover, there are considerable safety issues associated with entering enclosed spaces, particularly where tidal flooding occurs. For sublittoral caves, the difficulties in maintaining diver communication in fulfilment of the HSE diving regulations make sublittoral surveys beyond a small distance from a cave entrance very hard to justify or manage within the required risk assessment framework.

For these reasons we recommend not addressing this attribute as a separate task unless a particular cave of notable value is considered to be under a known threat from anthropogenic pressures. An adequate indication of cave dimension is derived from the methodology suggested for the cave biotope composition attribute (see below).

***Timing of Survey*:** The measurement of physical dimensions of a cave can be undertaken at any time, although other factors, such as limitations on access due to tides and weather would ultimately dictate the practical and seasonal constraints. If, as is suggested below, this attribute is addressed at the same time as the biotope composition attribute then this metric will be obtained during the summer months and at a suitable low spring tide.

***Assessment of change*:** Direct comparison of the cross-section dimensions derived during the biological survey as measured during the biotope composition survey outlined below.

***Estimation of Resource Requirements*:** The resource requirements for this attribute will wholly depend on the intensity of measurement that is undertaken. If, as is recommended, this attribute is integrated with the biotope composition component, then we would anticipate that a team of four would obtain sufficient data from a single cave in one day.

***Comments and Observations*:** In our opinion there is considerable doubt that the precise measurement of change in the dimensions of Lundy's cave resource is an achievable task, or even that it is an attribute that would normally reflect the condition of the cave feature.

On Lundy the most likely change in any cave dimension is collapse due to the natural action of wind, wave and other weathering action. Given the expected number, likely complexity and difficulties with access it would be a sensible and more efficient strategy to address this attribute by selecting a small sub-set of caves as a proxy for regular measurement. The condition assessment would, however, only strictly apply to *those particular caves*.

In general, we suggest that it would be better to maintain surveillance for potentially damaging human events and then assess the potential for impact on the cave resource. Pollutant discharge or water quality issues are likely to be better measured on other features and extrapolated for cave biota. Unusual incidences, such as the arrival of large marine debris in storm conditions may cause physical damage the cave and its associated biological communities by abrasion and should be recorded where possible.

3.1.2 Attribute: Number of caves in site (Discretionary)

***Target*:** No reduction in the number of caves within a site allowing for natural change.

***Baseline*:** There is no definitive baseline figure for the number of caves around Lundy.

Irving (2005) lists a number of *ad hoc* exploratory surveys in the 1960s and 1970s (Table 3.2) which provides descriptions of a selection of usually relatively prominent caves. (Hiscock, 1982) states that there are 37 known intertidal caves, but Irving (2005) suggests that this is likely to be an underestimate. None of the intertidal caves so far documented extend beyond approximately 1 m below chart datum (Irving, 2005). The number of fully subtidal caves is, unsurprisingly, even less certain and only two have been reported in published literature.

The absolute figure for caves is additionally hampered by uncertainty as to what minimum dimension and depth of penetration constitutes a cave under the CSM definition (see comments below).

Table 3.2 Summary of supporting information for the determination of the number of sea caves around Lundy.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Lundy	No of sea caves	Visual count	1966, 1967, 1968	Annually	Nine intertidal caves of a total of 26 (the remainder fully terrestrial)	Mills (1969)
Lundy north-east coast	No of sea caves	Visual count	1975	Single study	18 intertidal caves	Baillie & Clark (1975)
Lundy west coast	Number and lay-out of sea caves	Visual count & sketches of cave entrances	1983	Single study	21 intertidal caves	Hiscock (1984b)
Knoll Pins	Photography of biota	Diver observation	1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991	Anually	One subtidal cave	Hiscock (1984b, c, 1986a, b, 2003), Howard (1987, 1988), Fowler & Pilley (1992a), Irving (1990, 2004)
Foot of Gannet's Rock Pinnacle	None	Diver observation	2000	Single observation	One subtidal cave	Irving (2005), Irving & Northen (2004)

***Suggested Monitoring Interval*:** 18-24 years

***Suggested Method*:** Field inventory with photography and GPS positioning.

***Timing of Survey*:** There are no seasonal restrictions for the quantification and confirmation of the presence of caves and subsequent visits would not necessarily have to be made at the same time of the year. A cave census, would best be undertaken in the months where calm seas are most likely, since boat access will be necessary, particularly for the west side of Lundy. It should be noted, however, that if photographs are to form part of the cataloguing and intertidal cave recognition documentation then repeat visits should be made at the same state of tide, ideally at a low spring tide.

***Assessment of change*:** A simple confirmation that all the listed caves included in a baseline remain extant.

***Estimation of Resource Requirements*:** Assuming good weather conditions we estimate that a team of 3-4 surveyors with an appropriate vessel could complete a cave catalogue in two days.

***Comments and Observations*:** The difficulty in gaining access, inherent dangers of cave surveys and inconsistencies in defining what constitutes a true sea cave make this attribute difficult to fully address. The CSM guidance JNCC (2004b) states:

"*Caves can vary in size, from only a few metres to more extensive systems, which may extend hundreds of metres into the rock. No definition for caves states what the lower size limit is for a cave, there may be tunnels or caverns with one or more entrances, where vertical and overhanging rock faces provide the principal marine habitat, large overhangs, blowholes that include enclosed fully shaded areas and archways that support 'cave' biotopes. At which point does a large crevice or overhang count as a cave? For the purposes of a survey, a pragmatic approach must be adopted and a cave must be large enough to get a surveyor fully into the cave, turn round and exit without damaging the attached flora and fauna (Bunker & Holt, 2003).*"

For intertidal or partially submerged caves we suggest a definitive inventory be established from a dedicated field survey, in which accurately positioned cave entrances are catalogued and photographed, ideally at a low spring tide. This catalogue would constitute the baseline for this attribute.

Sublittoral caves, again suffer from uncertainty in definition, but an even greater problem is a lack of knowledge of where submerged caves are, or may be, present. Additionally, from a monitoring perspective, the time and effort spent in addressing this attribute (which is only likely to be achieved by diver observation) is not considered a cost effective use of resources. In this context, and where practical, it is suggested that a small sub-set of known sublittoral caves are selected as a proxy for the Lundy submerged cave resource and an assumption that any impacts will be similar across all is made.

In general, it is difficult to envisage any type of non-natural event or impact that could result in a reduction in the number of sea caves around Lundy. The most likely reason for the loss of a cave would be a collapse due to natural weathering or increased exposure to storm events. For this reason we recommend that this attribute be considered of low priority.

3.1.3 Attribute: Biotope composition of a cave (Discretionary)

***Target*:** Maintain the variety of biotopes identified for the cave, allowing for natural succession or known cyclical change.

***Baseline*:** No baseline information is available for the biotope composition of the wider cave resource of Lundy.

There are, however, two documented locations from where littoral biological records have been taken (Table 3.3); a single outline description from 1984 of a cave south-west of the Knoll Pins (Hiscock, 1984a) and a series of repeat surveys, including a succession of photographs taken along a transect established at an accessible cave on the north-west side of Rat Island (Eno, 1992a, b; Hiscock, 1986a, b). The photographic records are available for the years 1984, 1985, 1986 and 1991 (although not all during the same months) and have been analysed by Fowler & Pilley (1992a). These supply good supporting information, with quantification of four anthozoan species, normally found subtidally (Table 3.4). For this reason alone, the Rat Island cave would seem an obvious choice as one of the caves to establish a rolling cave monitoring programme.

Table 3.3 Summary of supporting information for the determination of biotope composition of sea caves.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
SW of Knoll Pins, NW side of Rat Island	Quantification of conspicuous fauna	Visual observation and sequential close-up photographs taken above and below a short removable horizontal transect line	1984, 1985, 1986, 1991	Annual, but not the same month	Two caves, but one (Rat Island) repeatedly surveyed	Hiscock (1986a, b), Eno (1992a, b), Fowler & Pilley (1992a)
NE of Hell's Gates (Rat Island), SW of Knoll Pins, N coast (Kittiwake Gully and west of Lighthouse steps), West coast below Old Light, Seals Hole, East Lametry Beach	Description of marine communities	Visual observation	1980 (brief inspection of Seals Hole in 1982)	Single study	Six caves	Hiscock (1982)

Table 3.4 Abundance of Anthozoa along the Rat Island littoral cave transect (1984-1991). Reproduced from Fowler & Pilley (1992).

	Sagartia elegans	*Metridium senile*	*Actinia equina*
April 1984	205	37	8
August 1985	507	75	4
March 1986	298	48	5
October 1991	123	14	38*

*Mainly small

***Suggested Monitoring Interval*:** Six years.

***Suggested Method*:** A detailed cave biotope mapping methodology, suitable for the assessment of this attribute, and applied to both intertidal and subtidal caves, has been used by both Bunker & Holt (2003) and ERT (Scotland) Ltd (2003), adapting the approach developed by Dixon (2000).

A tape measure is laid out along the cave floor starting from a relocatable position marked by a piton or eye bolt at the cave entrance and run to a another relocatable marker at the rear of the cave. Further relocatable pitons or eye bolts are introduced where the cave passage dictates a significant change in direction. At recorded intervals along the tape the biological communities are surveyed using the MNCR Phase II protocol, effectively documenting a cross-section of the cave at a series of points. The intervals can either be at regular distances or, more usually, are selected for biological value and presence of easily recognisable and relocatable features. An example of the type of output is shown in Figure 3.1.

It is recommended that comprehensive photographic or video documentation is taken of the biological communities at each sample section and a pictorial indication of the position of relocation points is also likely to prove very useful for future visits.

Alongside the biological recording, a series of measurements are taken using a laser measuring device (littoral) or tape measure and depth gauge (sublittoral), providing an indication of the dimensions of the cross-section over which the distribution and extent of the biological communities/biotopes can be shown. These measurements will also simultaneously satisfy the attribute for **extent of cave(s)**.

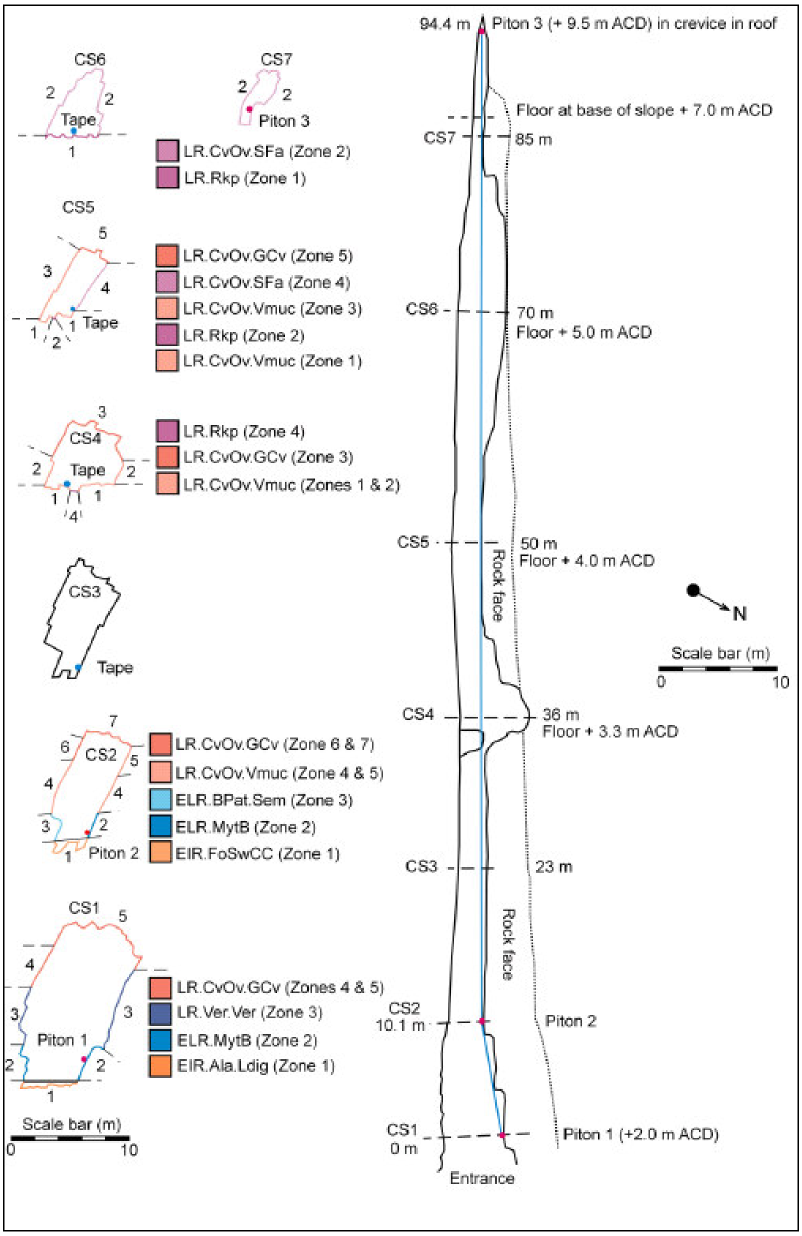


Figure 3.1 Example of (littoral) cave biotope mapping survey results from the Berwickshire and North Northumberland Coast SAC. Reproduced From ERT (Scotland) Ltd (2003).

***Timing of Survey*:** As with any intertidal survey, the timing for this survey method requires periods of good low spring tides and, where cave entrances are close to lower and mid-shore, obvious care needs to be observed in allowing time to safely pack up and exit the cave before inundation. The presence of algal communities will require any survey to take place in the summer months and, since seasonal changes are known to occur in these environments, it is essential that subsequent surveys are carried out at the same time of the year.

***Assessment of change*:** The achievement of the target for this attribute will be assessed by directly comparing the communities/biotopes at each sampling distance along the cave length and examining for direct changes in species presence and abundance.

Estimation of Resource Requirements**:** The number of sample cross-sections for littoral caves will be dictated by the size or penetration depth, number of surveyors, and tidal height at the entrance, but it is likely that with a team of 4-6 surveyors only one cave can be comfortably surveyed in a day, regardless of access restrictions. We suggest that, if possible, a set of five littoral caves are selected as a proxy for the Lundy cave resource.

Sublittoral caves are not normally subject to tidal cycle constraints, but the amount of diver resources required will dependent on depth, effect of swell and current and the level of diver skill. At present there only two sublittoral caves that have been formally reported, one of which will be visited as part of the *Leptopsammia pruvoti* monitoring. The other is at the limits of safe diving depth and would not be suitable for biological survey. Unless new records of sublittoral caves with a suitable depth come to light, we suggest that this attribute is only applied to littoral caves.

Comments and Observations**:** As previously mentioned, difficulties in remaining compliant with HSE diving regulations will probably restrict sublittoral survey activities to cave entrances or within a nominal penetration distance.

3.1.4 Attribute: Presence of representative/notable biotopes (Discretionary)

Target**:** Maintain the presence of the specified biotope, allowing for natural succession/ known cyclical change.

Baseline**:** There are no suitable baseline data for this attribute, although possible target biotopes identified from a single, previously repeatedly surveyed cave (Eno, 1992a, b; Hiscock, 1986a, b) on the north-west side of Rat Island may provide an early tentative indication of change at a single specific location.

Suggested Monitoring Interval**:** Six years.

Suggested Method: As for biotope composition.

Timing of Survey**:** As for biotope composition.

Assessment of change**:** The measure for this attribute is a simple temporal comparison of biological communities to establish whether the nominated biotopes have been maintained at their previously recorded location. Since seasonal changes are known to occur in these environments it is essential that subsequent surveys are carried out at the same time of the year. Any indication of biotope change would have to be assessed alongside records of known anthropogenic events. In the absence of a recorded impact, a judgement of change due to natural succession is invoked unless strong evidence to suggest otherwise is presented.

Estimation of Resource Requirements**:** As for biotope composition.

Comments and Observations**:** Specific biotopes or well-defined communities suitable for this attribute may be identified while addressing the cave biotope composition attributes (see above). If subsequent resource restrictions prevent a survey of the intensity suggested for assessment of biotope composition a reduced monitoring survey may be undertaken where cross-section locations supporting only the identified representative or notable biotopes are re-surveyed.

3.1.5 Attribute: Presence and abundance of *Leptopsammia pruvoti* (Discretionary)

***Target*:** Maintain presence and abundance of *Leptopsammia pruvoti.*

***Baseline*:** A sustained photographic study of a single cave wall at Knoll Pins undertaken between 1981 and 1990 (Table 3.5) and subsequently reported by Fowler and Pilley (1992a) indicated declining populations (in abundance terms) of *Leptopsammia pruvoti* and *Caryophyllia smithii* over that time period (Table 3.6). Hiscock (2003) subsequently reported that *L. pruvoti* showed very low recruitment rates and that the population had declined by 22% between 1984 and 1996. Photographic monitoring has continued (Irving & Northen, 2004; Hiscock, pers. comm.) and could readily be incorporated into CSM reporting.

Table 3.5 Summary of supporting information for the assessment of the presence and abundance of *Leptopsammia pruvoti*.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Knoll Pins	Abundance of *Leptopsammia pruvoti, Caryophyllia smithii* and *C. inornata*	Sequential overlapping close-up photographs	1981, 1983, 1984, 1985, 1986, 1987, 1988, 1990	Annually between 1983 and 1988	One	Hiscock (1984b, c, 1986a, b, 2003), Howard (1987, 1988), Fowler & Pilley (1992a), Irving (1990, 2004)
Knoll Pins, Brazen Ward, Gannets Rock Pinnacle,	Abundance of *Leptopsammia pruvoti*	Diver observation	1999, 2000	Single study	One cave location	Irving & Northen (2004)

Irving (2005), citing Irving & Northen (2004), more recently reported the presence of small numbers of *Leptopsammia pruvoti* close to the entrance of a small cave at the foot of Gannet's Rock in around 28 m depth. Given the numbers and deep location we do not considered this to be a suitable candidate for a repeat monitoring programme.

The issue of when a baseline value should be applied is, however, critical with this attribute, since there is evidence of a continuing and possibly accelerating decline since the mid-1980s. In this instance, and unless the methodology is substantially revised, a baseline population value from around, or after, 1996 should be applied, although this is likely to result in an immediate unfavourable judgement for this attribute.

Table 3.6 Population densities of *Leptopsammia pruvoti* and *Caryophyllia* spp. Reproduced from Fowler & Pilley (1992).

Year	***Leptopsammia pruvoti***		***Caryophyllia smithii & C. inornata***	
	No. in 0.817 m^2	**Density/m^2**	**No. in 0.817 m^2**	**Density/m^2**
1983	215	263.2	-	-
1984	211	258.3	-	-
1985	208	254.6	265	324.4
1986	207	253.4	262	320.7
1987	205	250.9	243	297.4
1988	202	247.3	266	325.6
1990	197	241.4	247	302.3

***Suggested Monitoring Interval*:** The most recent evidence suggests that this species may be declining in abundance. It might therefore be appropriate to maintain an annual monitoring programme until a stable or increasing population, relative to the nominated baseline, is achieved.

***Suggested Method*:** The analysis of Fowler and Pilley (1992a) and the later conclusions of Hiscock (2003) demonstrated the ability of the overlapping photography technique to detect change in a spatially-defined coral population and we suggest that this already well-established element should be incorporated into the CSM programme.

Despite the currently declining trend, *L. pruvoti* is a southern species and may yet benefit from the expected future sea temperature rises associated with predicted climate change, either by increased recruitment or by exploitation of an advantageous change in local community structure. It would therefore be prudent to anticipate a possible enhanced ability to colonise local substrata, by establishing one or more nearby surveillance stations of comparable aspect, habitat type and in a similar depth. These should be periodically visited, perhaps by a timed search, to confirm the presence or absence of *L. pruvoti* individuals.

The quantification methodology relies on comparing wide-angle images combined with the creation of a photo-mosaic from close-up images taken at a set distance and orientation. To improve the constancy of orientation and camera-to-subject distance a framer was subsequently incorporated in 1985 (Figure 3.2).

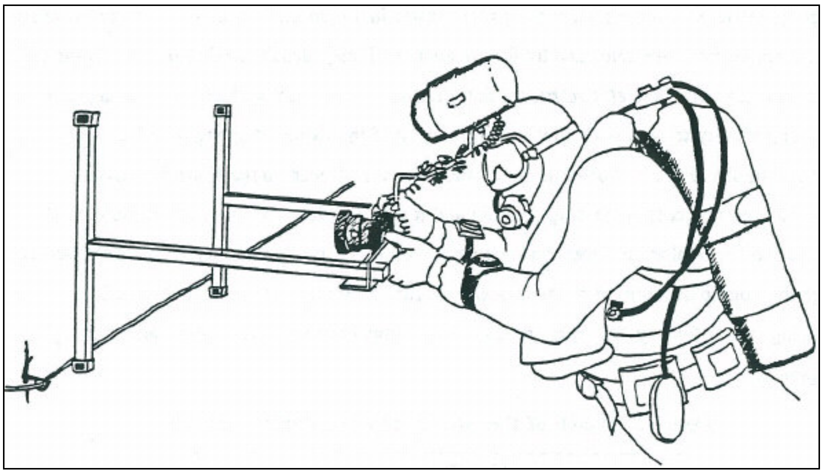


Figure 3.2 Camera and framer configuration used for the photo-mosaic monitoring of *Leptopsammia pruvoti*. Reproduced from Hiscock (1986a).

The Knoll Pins study site is a topographically complex surface and Fowler and Pilley (1992a) experienced considerable difficulties when aligning and interpreting the close-up photographs. The photo-mosaic resulting from the 1985 survey provided the best photographic coverage of the 1983 to 1990 set and was used to create a gridded 'map' of the study site complete with the positions of *L. pruvoti*, *Caryophyllia* spp., *Hoplangia durotrix* and *Parythropodium coralliodes* (Figure 3.3).

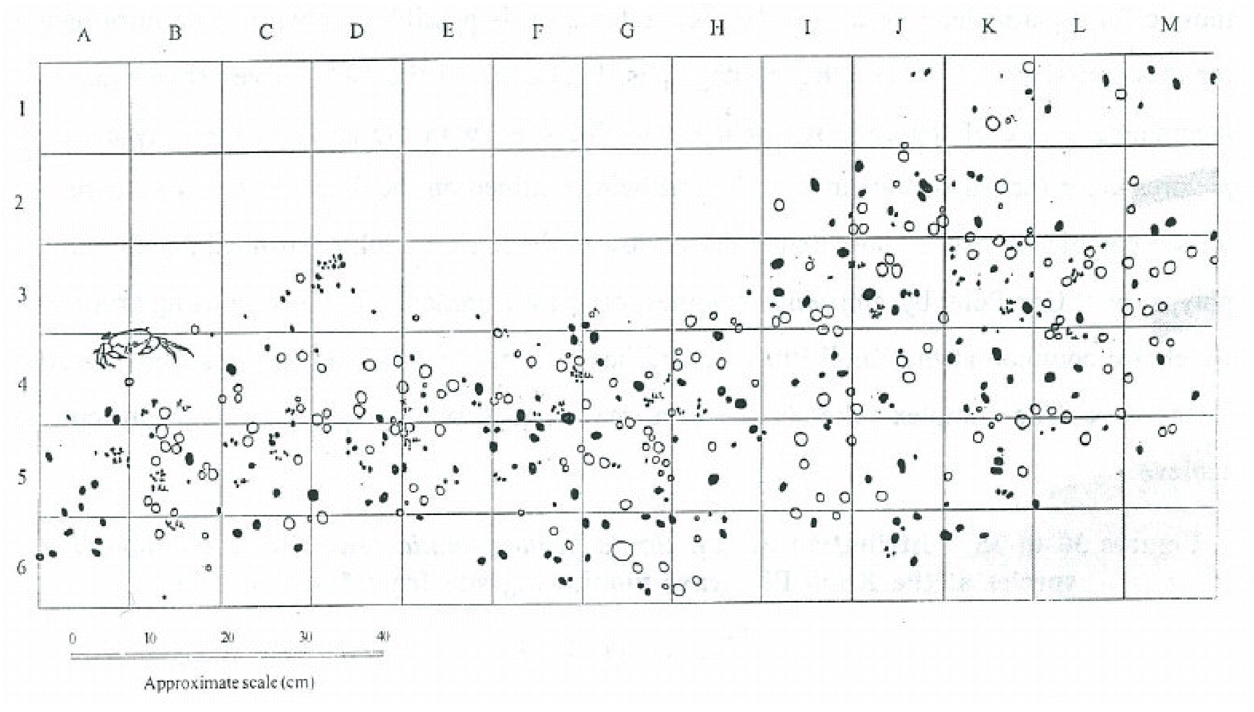


Figure 3.3 Mapped distribution of *Leptopsammia pruvoti* and *Caryophyllia* spp. produced from photographs taken at the Knoll Pins monitoring site in 1985. Reproduced from Fowler and Pilley (1992).

Although this attribute specifically addresses the *L. pruvoti* population at the Knoll Pins site an assessment of the other species previously included may also be possible. *L. pruvoti*, because of its striking colour is, however, particularly prominent and recognisable in the majority of the images and thus provides the best option for accurate quantification. *Caryophyllia smithii* and *C. inornata* were present in comparable numbers between 1985 and 1990, but are less visible and the two species cannot be reliably distinguished in photographic images (Fowler & Pilley, 1992a). *Hoplangia durotrix* and *Parythropodium coralliodes* were present in much lower abundance and are significantly more difficult to see in the original images. Moreover, Hiscock (2003) reports that *H. durotrix* had all but disappeared from the monitoring site by 2001.

The process of creating the map and the associated comparative analysis was rather primitive by today's standards, being achieved by manually tracing the positions of the conspicuous species onto clear acetate marked with a grid. The use of modern computer techniques would greatly improve the accuracy and efficiency of recreating such a map.

Perhaps of most significance to the assessment of this attribute is the advent of affordable high resolution digital photography equipment and the widespread availability of intelligent image manipulation software. The use of photographic film was inevitably restricted by the limited capacity of commercially supplied film, the uncertainty of not knowing whether the photograph had been exposed correctly and the time lag necessary for the film development and printing. Moreover, the manual alignment of the images by eye has proved complex and very time-consuming. Digital photography and associated software offers the opportunity to vastly improve the ability to accurately document the population of *L. pruvoti* (and other species). Some of the more significant improvements include:

- *The ability to instantly review images and discard/retake incorrectly exposed or framed ones*. This obviously greatly increases the chances of obtaining good quality images, while reducing the risk of requiring a second visit.

- *Fast and reliable autofocus ability*. Most modern camera systems incorporate rapid and accurate automatic focusing systems that can operate in low light conditions. There may, however, be some degree of reliance on an auxiliary autofocus assist lighting system which can be obscured or blocked by underwater camera housings. For this reason, when using a system which is set up for a use at a predetermined distance, such as with a framer, consideration should be given to overriding the autofocus operation and setting a suitable fixed-focus distance.

- *Image storage capacity*. Rapidly growing storage capacity for most types of commonly used memory cards has resulted in the ability to capture and store at least hundreds of images at a single monitoring visit even at the highest possible resolution and file size. In practical terms this means that more images with a greater degree of overlap can be considered.

- *The utilisation of the RAW image format*. The use of the proprietary RAW format, available on most quality cameras, for image capture allows a considerable degree of exposure latitude after the photograph has been taken. This is particularly helpful when some corals are indistinct or partially obscured by shading effects resulting in underexposure on some parts of the image. Detail that is not immediately visible can be restored without loss of image quality through increasing the exposure by the equivalent of several f-stops. Similarly, areas of the image over-exposed or 'burnt out' can be darkened and significant detail reinstated if required.

- *Camera mosaic or 'stitch' utility*. Many cameras now incorporate a facility that anticipates that a set of successively taken photographs will be incorporated into a mosaic or 'stitched' together. To assist with this, a section of the last image taken is presented in the viewing display, allowing a subsequent image to be reasonably accurately aligned before pressing the shutter release button. Once the images are transferred to a computer, there is a wide selection of inexpensive software (often supplied with a camera) that will automatically recognise overlapping image areas and will align them to a high degree of accuracy, allowing user intervention and adjustment if considered necessary.

To further improve the chances of obtaining optimal image quality we suggest that a dual lighting system be used to minimise shadow.

The use of a solid framer attachment, while providing a constant camera-to-subject distance and assisting with the correct positioning, does raise considerable concern over the possibility of physical damage when in use. An alternative framing/distancing system that incorporates accurately angled laser beams and therefore requires no contact with the rock surface has been successfully used by CCW (R. Holt, pers. comm).

***Timing of Survey*:** All of the previous sampling at the Knoll Pins cave location has taken place in the months of July or August. To maintain the imaging integrity and to avoid a potential lack of consistency associated with seasonal community change or growth we recommend that the monitoring should continue to be carried out at this time.

***Assessment of change*:** Simple numerical comparison of temporal data.

***Estimation of Resource Requirements*:** A complete photographic record of the study site should be achievable by a single photographer over one dive, assuming rapid relocation. We suggest that two complete sets of coverage are obtained over two dives to maximise success. This would amount to the use of a dive team over a single day.

***Comments and Observations*:** Although this site is well documented, some difficulty has recently been reported in relocating the monitoring station by surveyors unfamiliar with the location. This is a common problem in sublittoral sites and it should be anticipated that future monitoring visits may be undertaken by survey teams that have no previous experience of the site. It may therefore be necessary to place a relocation marker close to the monitoring face. The most obvious option is to secure a marker, such as a stainless steel peg into a nearby rock face using an air drill. The rock forming the cave is, however, thought to be somewhat friable and there is some concern that drilling may damage the sublittoral rock feature and the associated biota (Hiscock pers. comm). We suggest that at an appraisal of possible options for establishing a relocation marker should be undertaken at the earliest opportunity.

It should be noted that although this is represented as an attribute for the Sea Cave feature, since this is how it is described in the literature, there may be some disagreement about whether the physical dimensions of the location could truly be considered a cave. Irving (2005) suggests that the site, being 1 - 1.5m wide and high, penetrating to a depth of 0.5 m, is really nothing more than a 'recess' on a vertical rock wall. Given an element of doubt this attribute could equally form part of the Inshore Sublittoral Rock feature. *L. pruvoti* is now known to be present at a number of locations where the preferred conditions occur (sheltered vertical or overhanging bedrock), with total numbers estimated at around 1,500 (Irving & Northen, 2004). The broader distribution and the identification of other areas that support appreciable numbers of corals has therefore led us to conclude that an addition attribute incorporating *L. pruvoti* for inshore sublittoral rock is justified (see section 3.3.8).

3.2 Feature: Littoral Rock

3.2.1 Attribute: Extent of littoral rock (Mandatory)

Target: No change in extent of littoral rock.

Baseline: There are currently no known recent accurate and reliable baseline data for this attribute.

Irving (2005) incorporating data from Hiscock (1983) provided an approximate estimate of the area covered by all of the main substratum types present, of which just the littoral rock elements are shown in Table 3.7.

Table 3.7 Area (approximate) of littoral rock substratum types within the Lundy Voluntary Marine Reserve. Taken from Irving (2005) (after Hiscock, 1983).

Substratum type	Area (ha)	Length (km)
Granite bedrock	36.8	9.2
Slate bedrock	7.7	1.9
Granite boulder	11.0	2.9
Slate boulder	3.5	0.9
TOTAL	59.0	14.9

An accurate baseline for the total area of littoral rock would be most quickly and accurately derived from remote imaging techniques. Suitable archived aerial photographs or satellite images may be commercially available or may already exist within Natural England as part of a previous project.

In addition, loss of littoral rock areas at a smaller scale should be assessed by maintaining surveillance of local impacts and activities.

Suggested Monitoring Interval: 18 – 24 years

Suggested Method: Digital orthorectified images, of a suitable spatial resolution, should be obtained either by commissioned aerial photography or from a commercial satellite operator such as *Quickbird*. Orthorectified images are adjusted for topographic relief, lens distortion and camera tilt, allowing a measurement of true distances and spatial area. For the most accurate estimation of extent the images must be obtained at low spring tides.

***Timing of Survey*:** The imaging task can technically be undertaken at any time of the year, but should be commissioned such that the best possible low spring tide coincides with full daylight conditions, ideally with strong overhead sunlight and little or no cloud cover. In practical terms the best results are likely to be obtained in the months between mid- to late Spring through to late Summer.

***Assessment of change*:** Assessment of change of extent is achieved by obtaining a total area of intertidal rock habitat calculated by importing the orthorectified aerial or satellite images into a Geographic Information System (GIS) application such as ArcGIS or MapInfo. The area obtained can be directly compared with a previous estimate; although it may be necessary to repeat the analysis of the original baseline data to ensure that both results are achieved using the same criteria, methodology and degree of resolution.

Localised construction development and other human impacts that may result in the loss of intertidal rock habitat should be assessed over an interval and at a scale appropriate to the impact under investigation and, if necessary, a judgement made on whether the loss is of a sufficient magnitude to render the feature unfavourable.

***Estimation of Resource Requirements*:** There are no fieldwork resource requirements for this attribute.

***Comments and Observations*:** Apart from small changes through localised developments, the total extent of the littoral rock feature is unlikely to change over the short to medium term and this is reflected in the suggested monitoring interval. Over the longer term, however, sea level rise, if predictions are correct, may reduce the available area for intertidal species with increasing tidal height in those areas where the slope of the shore increases in gradient towards the existing supralittoral zone.

3.2.2 Attribute: Biotope composition of littoral rock (Mandatory)

***Target*:** Maintain the variety of biotopes identified for the site, allowing for natural succession or known cyclical change.

***Baseline*:** A number of intertidal surveys or studies of varying intensity have been carried out on the rocky shores of Lundy from 1949 to the present (Table 3.8). Unfortunately, only a few are likely to both provide the level of detail sufficient to assign biotopes and are recent enough to fall within the timeframe that would qualify under the baseline criteria set for this report.

In general, most of the published recent (1983 -1996) and sustained intertidal survey effort appears to have been directed towards the monitoring of rockpool habitats located at Devil's Kitchen and Rat Island, largely due to their accessibility and known species richness. A substantial number of the rockpools are present at the mid-tide level, presenting a good monitoring opportunity, less hampered by tidal constraints. Fowler and Pilley (1992a) reported that species abundance estimates were carried out in 1991 using the MNCR abundance scales and Eno (1992a) undertook a detailed comparison of this and previous years' data. The repeat survey at this site was, unfortunately, carried out at different times of the year, ranging between March in 1986 and October in 1991. For this reason Fowler and Pilley (1992a) indicated that the majority of data set could only be used for general comparisons.

Table 3.8 Summary of supporting information for the assessment of the biotope composition of littoral rock. Text in bold indicates a source of possible baseline data.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	References
Lundy	None	Visual observation	1949	Single study	11 sites	Anon. (1949)
Lundy	None	Visual census of shore algae and fauna	1950	Single study	10 sites	Harvey (1951)
Lametry, The Gates (including Devil's Kitchen), north side of Rat Island	None	Visual observation	1951	Single study	3 sites	Harvey (1952)
Jenny's Cove, Quarry Beach, Ladies Beach, Lametry Bay and The Gates (including Devil's Kitchen).	Species abundance	Visual census of shore algae and fauna	1971	Single study	5 sites	Boyden (1971)
North side of Rat Island, Brazen Ward, Lametry and Dead Cow Point	Species abundance	Visual census of shore algae and fauna	1980	Single study	4 sites	Hiscock & Hiscock (1980)
Lametry Beach	None	Visual observation (rockpool communities)	1982	Single study	1 location	Hiscock (1982)
Lametry Beach	Extent of *Bifucaria bifurcata*	Transect quantification	1984	Single study	1 rockpool	Hiscock (1984a), Fowler and Pilley (1992a)
Devil's Kitchen north of Gannets' Rock, south side of South Light, Rat Island	None	Visual observation	1984, 1985, 1986	Annually	4 locations	Hiscock (1984a, 1986a, b)
Landing Beach	None	Viewpoint photography	1982, 1983, 1984, 1985, 1986, 1989, 1990. 1991	Anually	I location	Eno (1992b)
'Divers' Hut' (now re-built as the 'Divers' Building'), at the north-west of Devil's Kitchen (i.e.	None	Visual observation (rockpools)	1996	Single study	Unknown	Munro (1996)

the back of the shore). Selected caves						
Devil's Kitchen, Rat Island	Species abundance	Visual observation and photography along a transect (rockpools)	1984, 1985, 1986, 1991, 1995, 1996	Annual for three years, then erratically	7 rockpools	Hiscock (1984a, 1986a, b), Fowler and Pilley (1992a), **Eno (1992b)**, Irving (1995), Munro (1996)
North of landing beach, South Headland/ Quarry Beach, Quarry Beach boulders, North Headland/ Quarry Beach, Brazen Ward south, Brazen Ward north, Kittiwake Gully, The Pyramid, north side of Jenny's Cove	Unknown	Transect	2000	Single study	Unknown	**Unpublished, but cited by Irving (2005)**

In 2009 there was a successful attempt at relocating the Devil's Kitchen transect by the Lundy Warden (N. Saunders, pers. comm), providing the opportunity for at least some comparative assessment within the current monitoring cycle.

In Irving's (2005) literature review he refers to a survey undertaken by English Nature staff in 2000 which attempted to assess the extent of intertidal habitats and biotopes and established a number of intertidal transects at eight sites around Lundy (Table 3.8). The data collected apparently still remains to be fully analysed and reported, but Irving's description suggests these observations might form an excellent baseline for this attribute if they are able to be located.

***Suggested Monitoring Interval*:** 1-3 years

***Suggested Method*:** A suite of well-documented relocatable transect locations should be established, with an attempt to find and re-establish sites that have been surveyed around 1995 or later, since these are likely to have been assessed using standard MNCR abundance scales.

A standard rocky shore MNCR Phase II survey, either vertically along a shore profile or across an area of easily delineated shore, if considered appropriate, should be undertaken. Points where detailed species records are made should be accompanied by photographic and/or video records, accurate position fixing and the use of a levelling device to record the height above Chart Datum.

Irving (2005) provides a list of key target biotopes that were recorded by English Nature in 2000 (Table 3.9).

Table 3.9 Key rocky shore biotope communities recorded as present on Lundy in 2000 by English Nature. After Irving (2005).

Biotope Code	Biotope Description	Additional Notes
LR.FLR.RKP.Cor	*Corallina officinalis* and coralline crusts in shallow eulittoral rockpools. These 'coralline' pools have a striking appearance as they are dominated predominantly by red algae.	
LR.FLR.RKP.Cor.Bif	*Bifurcaria bifurcata* in shallow eulittoral rockpools	In the south-west the brown alga *Bifurcaria bifurcata* (Cor.Bif) or *Cystoseira* spp. (Cor.Cys) can be dominant.
LR.FLR.RKP.Cor.Cys	*Cystoseira* spp. In eulittoral rockpools	
LR.FLR.RKP.FK	Fucoids and kelps in deep eulittoral rockpools. These deep pools often contain a community characterised by *Fucus serratus* and *Laminaria digitata*, with a wide variety of filamentous and foliose algae occurring beneath this brown algal canopy.	
LR.MLR.BF.Fser.Bo	*Fucus serratus* and underboulder fauna on lower eulittoral boulders. The shaded sides of the boulders are often colonised by a variety of red algae and where space is available beneath the boulders a rich assemblage of animals also occurs.	
LR.MLR.BF.FvesB	*Fucus vesiculosus* and barnacle mosaics on moderately exposed mid eulittoral rock.	
LR.FLR.CvOv.SpByAs	Sponges, bryozoans and ascidians on deeply overhanging lower shore bedrock or caves.	

***Timing of Survey*:** Because of the presence of algal communities all intertidal monitoring should be completed between May and early October when species richness is usually highest. Each survey location should also be monitored on, or close to, the same date every year.

***Assessment of change*:** The full suite of intertidal rock communities/biotopes aggregated from the whole of the SAC is compared against a baseline list to confirm that each biotope is still present on Lundy. If a particular community or biotope is not found, the data for the location where the absence is recorded should be examined against the original baseline to determine:

(a) if the assignment of the replacement biotope classification is correct; and

(b) if the community change can be assigned to a natural change.

If the biotope allocation is correct and there is no obvious indication of natural succession or cyclical change, then the implications of the change on the feature will need to be evaluated.

***Estimation of Resource Requirements*:** In normal circumstances and with favourable tides an intertidal survey team consisting of three or four surveyors could be expected to comfortably complete one transect in a day. Assuming the resumption of the Rat Island rockpool transect and the adoption of transects completed in 2000, we suggest that ten fixed intertidal transects would provide a balance between availability of suitable locations and appropriate coverage of the island.

***Comments and Observations*:** None

3.2.3 Attribute: Distribution and spatial pattern of biotopes at specific locations (Mandatory)

Target: Maintain the distribution and spatial pattern of the biotopes identified at specified locations allowing for natural succession/known cyclical change in biotope distribution.

Note that this attribute is a counterpart to the biotope composition attribute but differs in its reference to specific geographic location and the examination of local zonation or juxtaposition of biotopes at these locations.

Baseline: Because of the close similarity with biotope composition all of the relevant studies given in Table 3.9 and the conclusions of that section equally apply here.

Suggested Monitoring Interval: 3-6 years.

Suggested Method: The method for assessing this attribute is identical to that indicated for the biotope composition and both attributes would be simultaneously addressed by a single survey programme. The ‘distribution’ element would be an inventory of biotope occurrence at a specific relocatable survey site, while ‘spatial pattern’ will almost always be an accurate description of the vertical zonation pattern down the shore. This is achieved with a standard JNCC Phase II survey with accurate position fixing and the use of a levelling device to record the transition limits of each community as a height above Chart Datum. An example of the type of output generated from this method is shown in Figure 3.4.

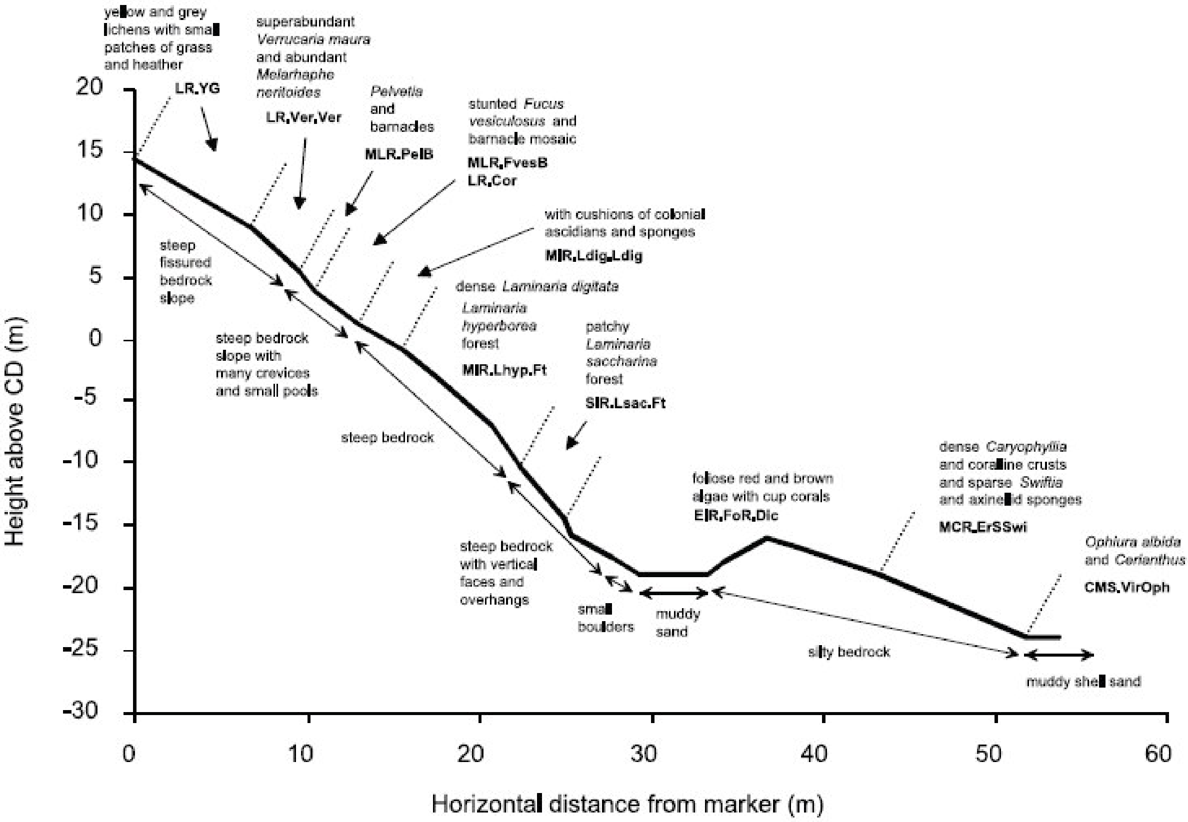


Figure 3.4 An example of a shore profile suitable for the assessment of spatial pattern of biotopes. Note that, in this case, both littoral and sublittoral biotopes are mapped in a single transect. Reproduced from Moore *et al.* (2006).

Timing of Survey: As for 'Biotope composition of littoral rock'.

Assessment of Change: The biotope complement of each relocatable transect is compared to determine if any communities have been lost and/or replaced. In addition the spatial arrangement (height above chart datum, zone extent) of each community/biotope is examined to determine if any substantive spatial rearrangement has taken place.

Estimation of Resource Requirements: As for 'Biotope composition of littoral rock'.

Comments and Observations: None.

3.2.4 Attribute: Presence of rockpool biotopes (Discretionary)

Target: Maintain the presence of the specified rockpool biotopes allowing for natural succession/ known cyclical change.

***Baseline*:** In comparative terms rockpool habitats have received significantly more attention than the wider rocky intertidal zone (Table 3.10). As indicated in section 4.2.2, the accessibility and reported species richness of the rockpools located at Devil's Kitchen and Rat Island have promoted considerable survey effort, not least because of their position higher up the shore and thus availability for study over longer tidal periods.

Table 3.10 Summary of supporting information for the assessment of the presence of rockpool biotopes.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Lametry Beach	Species presence	Visual observation	1982	Single study	One location	Hiscock (1982)
Lametry Beach	Extent of *Bifucaria bifurcata*	Transect quantification	1984	Single study	One rockpool	Hiscock (1984a), Fowler and Pilley (1992a)
Devil's Kitchen, Rat Island	Species abundance	Visual observation and photography along a transect (rockpools)	1984, 1985, 1986, 1991, 1995, 1996	Annual for three years, then erratically	Seven rockpools	Hiscock (1984a, 1986a, b), Fowler and Pilley (1992a), Eno (1992b), Irving (1995), Munro (1996)
North of landing beach, South Headland/ Quarry Beach, Quarry Beach boulders, North Headland/ Quarry Beach, Brazen Ward south, Brazen Ward north, Kittiwake Gully, The Pyramid, north side of Jenny's Cove	Unknown	Transect	2000	Single study	Unknown, but is likely to incorporate rockpool biotopes	Unpublished, but cited by Irving (2005)

Of the seven intertidal biotopes previously reported to be present on Lundy by English Nature (Irving, 2005) four are specifically rockpool biotopes (see Table 3.9 biotope composition).

Overall, the most relevant studies to this attribute, in terms of recent baseline establishment, are the repeat surveys at Devil's Kitchen and Rat Island. Fowler and Pilley (1992a), however, point out that the survey timing was rather erratic, taking place, for example, in March in 1986 and in October in 1991 and was therefore compromised without additional information on seasonal variation. They went on to comment that some of the data were very limited in scope and could only be used for general comparisons of site appearance only. This suggests that only the later surveys may serve as a provisional reference point for condition monitoring, but a new baseline may have to be established for a more reliable ability to report change.

In 2009 there was a successful attempt at relocating the Devil's Kitchen rockpool transect by the Lundy Warden (N. Saunders, pers. comm), providing the opportunity for at least some comparative assessment within the current monitoring cycle.

***Suggested Monitoring Interval*:** 3-6 years.

***Suggested Method*:** Unlike the transect-dependant attributes in previous sections, a more rapid comparative assessment could be carried out using spatially referenced point data gathered from selected rockpools. This would be achieved by establishing a complement of representative rockpools at predetermined GPS positions and undertaking rapid surveys using a check-list based approach to provide the necessary species and semi-quantitative species abundance information required to identify the biotope. Supplementary photographic or video recording should also be considered.

The initial baseline data for each rockpool should, however, be more detailed with a full species inventory, to allow a more precise determination of community change in the event of suspected biotope modification.

Note that the transects undertaken for assessment of biotope composition and spatial pattern of biotopes will also contribute directly to this attribute.

***Timing of Survey*:** Because of the presence of algal communities all intertidal monitoring should be completed between May and early October when species richness is usually highest. Each survey location should also be monitored on, or close to, the same date every year. For many rockpools a low spring tide may be essential, although others may be possible at smaller tidal ranges.

***Assessment of Change*:** A simple temporal comparison confirming that the biotopes identified at the baseline visit remain extant.

Where there are grounds for suspecting that a biotope has deteriorated or changed a second visit may be necessary to repeat the more detailed baseline species inventory.

***Estimation of Resource Requirements*:** The amount of time required for this task is entirely dependent on the number of rockpools selected and how they are scattered around Lundy. As a guide we estimate that 2-4 pools may be surveyed using a rapid assessment method in a single day. We suggest a maximum of two days should be allocated to this attribute.

***Comments and Observations*:** None.

3.2.5 Attribute: Species composition of rockpool biotopes (Discretionary)

Target 1: No decline in rockpool biotope quality due to change in species composition or loss of notable positive indicator species allowing for natural succession/ known cyclical change.

Target 2: No decline in rockpool biotope quality due to change in species composition or increase in notable negative indicator species allowing for natural succession/ known cyclical change.

***Baseline*:** The supporting information for this attribute (Table 3.11) is essentially a sub-set of the survey literature that has been presented in previous sections. This attribute, however, focuses on the species component of the rockpool communities and in particular, attempts to evaluate change due to the loss or introduction of notable species to the rockpool communities.

Table 3.11 Summary of supporting information for the assessment of the species composition of rockpool biotopes**.**

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Lametry Beach	Species presence	Visual observation	1982	Single study	One location	Hiscock (1982)
Lametry Beach	Extent of *Bifucaria bifurcata*	Transect quantification	1984	Single study	One rockpool	Hiscock (1984a), Fowler and Pilley (1992a)
Devil's Kitchen, Rat Island	Species abundance	Visual observation and photography along a transect (rockpools)	1984, 1985, 1986, 1991, 1995, 1996	Annual for three years, then erratically	Seven rockpools	Hiscock (1984a, 1986a, b), Fowler and Pilley (1992a), Eno (1992b), Irving (1995), Munro (1996)
Devil's Kitchen, Landing Beach	None	Shore observation	1993	Single study	Two locations	A. Gibson (observation), Eno *et al.* (Eno *et al*., 1997)
North of landing beach, South Headland/ Quarry Beach, Quarry Beach boulders, North Headland/ Quarry Beach, Brazen Ward south, Brazen Ward north, Kittiwake Gully, The Pyramid, north side of Jenny's Cove	Unknown	Transect	2000	Single study	Unknown, but is likely to incorporate rockpool biotopes	Unpublished, but cited by Irving (2005)
East of new jetty, between old jetty & Landing Beach	Plant no.	Clearance	2005, 2006	Single study	Two sites	Hiscock (2008)

Of particular interest is the reported presence in rockpools at Lametry Beach of the southern algal species *Bifucaria bifurcata and Cystoseira tamariscifolia* (Hiscock, 1982, 1984a). These species occur sparsely around Lundy and no published observations exist since 1984.

In addition, rockpool communities may be vulnerable to the introduction of non-native species. For example, *Sargassum muticum* can become established in deep rockpools and exert a considerable modifying influence on the biological community. Similarly *Asparagopsis armata* (harpoon weed), the gametophyte stage of *Falkenbergia rufolanosa*, was recorded on Lundy in 1972, but was not seen again until 2001, when both life phases were observed subtidally. This species can, however, also become established in deep rockpools.

***Suggested Monitoring Interval*:** 3-6 years.

***Suggested Method*:** This attribute requires no specific methodology as the data will be delivered through the surveys undertaken for the rockpool biotope presence and species composition attributes.

***Timing of Survey*:** As for sections 3.2.4 and 3.2.5.

***Assessment of Change*:** A simple temporal comparison for each site or individual rockpool with a specific emphasis on the maintained presence of notable species or the maintained absence of non-native species.

***Estimation of Resource Requirements*:** There are no resources requirements for this attribute as is will be simultaneously addressed with others

***Comments and Observations*:** None

3.2.6 Attribute: Presence and abundance of climate change indicator species (Discretionary)

Note: This attribute has been included as a result of correspondence with Nova Mieszkowska (MBA) and Stephen Hawkins (Bangor University) following a request for information on the present status of the MarClim programme on Lundy.

***Target*:** Maintain the presence and abundance of the specified species.

The setting of a target for this attribute presents considerable problems since the species selected and the associated methodology is specifically orientated towards measuring ongoing change attributed to climate impacts. Any target based on quantitative criteria, such as species abundance thresholds, are therefore likely to be irretrievably breached at some point and, due to the fundamentally intractable nature of predicted climate change, there are unlikely to be management measures available to restore the feature back to a stated baseline condition. The CSM Guidance allows for consideration of ‘natural succession and known cyclical change’ but the treatment of a reported intertidal community modification caused by suspected climate shifts as a natural event requires a careful and consistent approach. From a broader condition monitoring perspective, this is an issue that Natural England will have to address in the future, but is outside the remit of this project.

In the interim, we suggest that a pragmatic approach be taken and that the ecological implications of species losses and gains should be examined as they occur and expert advice be sought on the likely implications in terms of adverse effects on the designated features.

Baseline: Quantitative surveys of a select group of gastropods with planktonic larvae were undertaken on Lundy in June/July of 1977, 1978 and 1980. Quadrat counts were made at various shore levels and subsequently reported in Hawkins & Hiscock (1983). Some of these species have since gained particular importance as possible indicators of climate change and were incorporated into the MarClim programme, a project established to assess the impact of climate change on the marine environment, principally through the examination of intertidal community changes. Eighty nominated monitoring sites have been established as part of the MarClim project and, although no formal sites were identified on Lundy, there are a number along the North Devon and Cornwall coast which continue to receive annual visits (S. Hawkins, pers. Comm.).

The present status of MarClim is unclear at the time of writing this report, but a single survey is known to have taken place on Lundy in 2008 as part of a wider project (N. Mieszkowska, pers. comm.). The survey protocol used on this visit is provided in Appendix 3. Summary details of both surveys mentioned here are given in Table 3.12.

Table 3.12 Details of surveys relating to climate change indicator species undertaken on Lundy.

Year(s)	Sites	Target species	Reference
1977, 1978, 1980	Gannet's Bay, Brazen Ward, Quarry Bay, Landing Beach, Flat Island, The Gates, Lametry, Battery Point, Jenny's Cove, Dead Cow Point	*Monodonta lineata*, *Gibbula umbilicalis*, *Littorina littorea, Patella vulgata*, *Patella depressa*	Hawkins & Hiscock (1983)
2008	Devil's Kitchen Battery Point (200m south of) Jenny's Cove Brazen Ward Rat Island (North side) The Cove old jetty The Cove old jetty (northside)	*Semibalanus balanoides, Chthamalus montagui, Chthamalus stellatus, Elminius modestus, Balanus perforatus, Balanus crenatus, Osilinus lineatus, Gibbula umbilicalis, Nucella lapillus*	N. Mieszkowska (pers. comm.)

Suggested Monitoring Interval: Five sites would be surveyed annually using quantitative methods for the assessment of abundance of a small suite of climate change indicator species, together with a broader semi-quantitative survey for up to 55 species using the MarClim protocols (See Appendix 3).

A further five sites would be monitored on a rolling five-year 'broad-scale' programme.

Suggested Method: The current MarClim methodology is given in Appendix 3.

Timing of Survey: As specified by MarClim.

Assessment of Change: The results would provide a simple measure of broader scale climatic responses in Lundy in the context of long term annual monitoring sites on the mainland which include Woolacombe, Hartland Quay, Duckpool and Bude together with another 20 sites that stretch from Swanage round to Woolacombe. Comparative data from these sites extend back some 60 years.

***Estimation of Resource Requirements*:** The annual survey component would require a team of three to undertake about 3-5 days of fieldwork (assuming good weather) with some additional support required from the Warden. Subsequent data processing would need a day allocated for each day's fieldwork and a further 2-3 days of write-up time each year.

The five-yearly 'broad-scale' monitoring would require about 5-7 days of fieldwork and a further five days for data processing and writing-up.

S. Hawkins (pers. comm.) indicates that this work can currently only be done by trained personnel who can identify limpets to species non-destructively in the field and are expert at identifying barnacles. The identification of some species can be undertaken after appropriate training, but the quantitative counts of trochids and barnacles, together with the limpet identification is reported to be difficult and requires the consistency that can only be supplied by specialist expertise.

***Comments and Observations*:** None

3.2.7 Attribute: Presence and abundance of the scarlet and gold star coral *Balanophyllia regia* and Devonshire cup coral *Caryophyllia smithii* (Discretionary)

***Target*:** Maintain presence and abundance of *Balanophyllia regia* and *Caryophyllia smithii*

***Baseline*:** The scarlet and gold star coral is a nationally scarce species which is known to have maintained a consistent presence on at least one littoral location on Lundy for over 28 years. Its presence on Lundy was first reported by Harvey (1951). *Caryophyllia smithii* is a common sublittoral species around the UK, but is present in the lower littoral zone on some Lundy shores.

The first *Balanophyllia regia* mapping and size measurement study was undertaken at Devil's Kitchen in 1970 (Table 3.13), and the site was later relocated in 1984 when both *B. regia* and *C. smithii* were measured and mapped on three separate occasions between April and August of that year (Hiscock, 1984c). A second site comprising two areas north of Gannet's Rock was also established from which site sketches and photographs were obtained. Both sites continued to be monitored intermittently until 1991.

Table 3.13 Summary of supporting information for the assessment of the biotope composition of littoral rock. Text in bold indicates a source of possible baseline data.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Devil's Kitchen and north	Abundance and size (diameter) of	Site relocation from photographic	1970, 1984, 1985,	erratically	Two sites, one station at Devil's	Hiscock (1984a, c), Eno (1992b),

of Gannets' Rock	*Balanophyllia regia* & *Caryophyllia smithii*	record and vernier callipers (assumed)	1986, 1989, 1991		Kitchen, two stations at Gannet's Rock	Fowler & Pilley (1992a)
Devil's Kitchen	Abundance and size (diameter) of *Balanophyllia regia* & *Caryophyllia smithii*	Site relocation from photographic record and vernier calipers	2002, 2003, 2004, 2005	Annually	Data available for one station ("site 2"),	Unpublished data available from the Lundy Warden
Devil's Kitchen	Abundance and size (diameter) of *Balanophyllia regia* & *Caryophyllia smithii*	Site relocation by Lundy Warden and vernier calipers	2009	Annually	One	**Unpublished data available from the Lundy Warden**

Fowler & Pilley (1992a) and Eno (1992b) comment on the difficulties in monitoring these locations, with the two sites at Gannet's Rock seemingly presenting a greater range of problems, most notably an inability to relocate individual corals in following years. Despite this, Fowler & Pilley (1992a) suggested that there was a *"…general impression of a reduction in numbers"* at the Gannet Rock site, with corals that were present in previous records missing from recognisable groupings.

The single small area which constitutes the Devil's Kitchen monitoring site proved to be more easily located and was therefore monitored with a greater degree of success, but Fowler & Pilley (1992a), when attempting to analyse the full 1970 to 1991 dataset, stated that the lack of regular monitoring visits left them unable to draw any conclusions.

A more recent dataset inherited by the Lundy Warden (N. Saunders, pers comm.) indicates that the Devil's kitchen site was relocated and re-surveyed annually between 2002 and 2005 inclusive. Size measurements of between 85 and 100 corals were collected, although there is no information on which species were included and we are therefore unable to determine whether the survey was selective for *Balanophyllia regia* only or included *Caryophyllia smithii*. We are also aware of another possible visit as part of a broader survey in 2008 (C. Pirie, pers. comm.), but we have been unable to confirm the site or obtain the data.

In February of 2009 the Devil's Kitchen site was relocated by the Warden (N. Saunders, pers. comm.) and a resumption of the monitoring programme initiated. A photographic record has been taken of the sample site and each coral present has been allocated and individual number and measured (Figure 3.5). The intention is to return to this site at regular intervals to determine whether the presence each individual coral has been maintained, whether new corals have become established and to monitor their growth. Almost all of the corals present at that time were identified as *Balanophyllia regia* while *Caryophyllia smithii* seems to be present at a very low abundance.

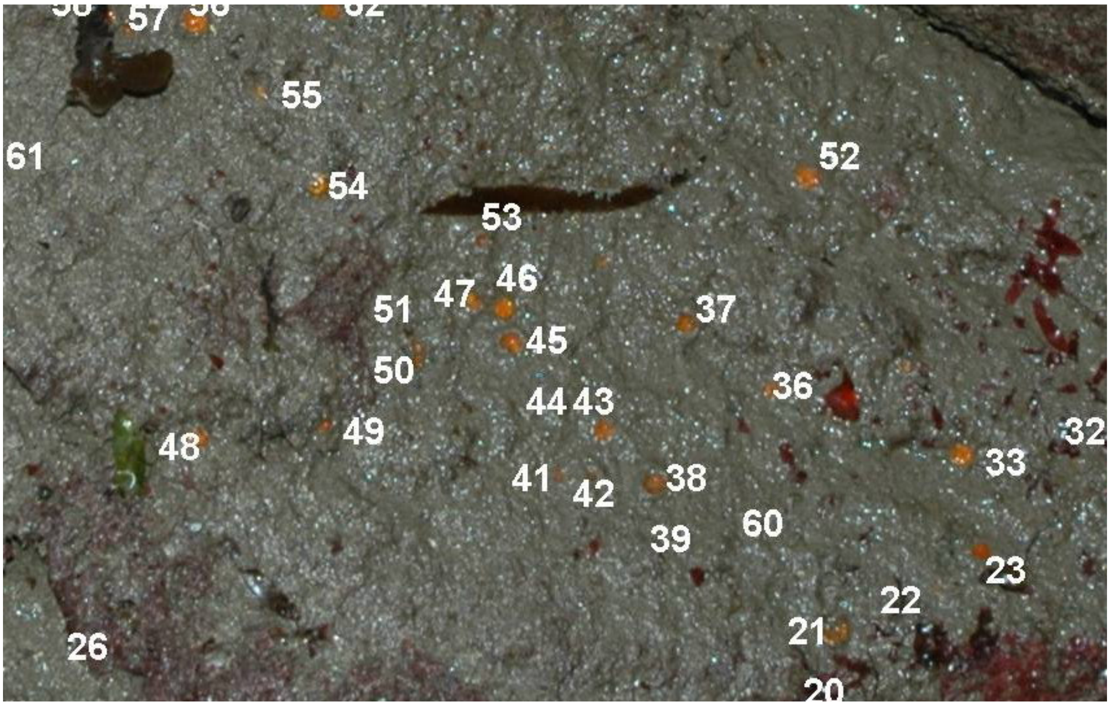


Figure 3.5 A section of the Devil's Kitchen *Balanophyllia regia* and *Caryophyllia smithii* monitoring site. Original photograph supplied ~~English Nature,~~

For future monitoring the Warden has taken steps to produce a relocation guide with photographs, but an accurate GPS position has not yet been established for the site.

Because of the uncertainty of the origin of the 2002 to 2005 dataset, we suggest that the 2009 Devil's Kitchen site data be considered the baseline for the attribute. Note that this is, however, only one of many locations where *B. regia* and probably *C. smithii* occur on the lower shore around Lundy.

***Suggested Monitoring Interval*:** The expectation is that the Devil's Kitchen site will be monitored at least annually by the Lundy Warden (N. Saunders, pers comm.).

***Suggested Method*:** The method has remained largely unchanged since the first study and should continue in its present form for the Devil's Kitchen site. It is probably likely though, that size measurements have achieved greater levels of accuracy for the later size measurements, as vernier callipers have been substituted for the original dividers and ruler.

There are, however, at least ten other locations where *Balanophyllia regia* is known to be present on the lower shore (N. Saunders, pers comm.). Topographical and access difficulties make these areas unsuitable for a survey of the complexity applied to the Devil's Kitchen site, but we suggest that a confirmation of presence and a simple rapid abundance estimation at relocatable stations (established by GPS and photographic documentation) may be appropriate for establishing a Lundy-wide presence and abundance estimate.

***Timing of Survey*:** Most of the more recent surveys have occurred around late August/early September, apart from the 2009 survey, which was undertaken in February.

The low shore position in which these species occur – the Devil's Kitchen site is reported to be 0.5 m above Chart Datum - requires that a survey be undertaken on a good low spring tide with favourable weather and correspondingly sympathetic daylight hours.

***Assessment of change*:** There are two levels of assessment of change that can be applied to the Devil's Kitchen data, the most basic of which is simple abundance. An examination of the data obtained between 2002 and 2009 (Figure 3.6), accepting an assumption that the counts may have included both *B. regia* and *C. smithii* on all occasions, strongly supports Hiscock's (2003) assertion that *B. regia* has retained a highly consistent presence at Lundy.

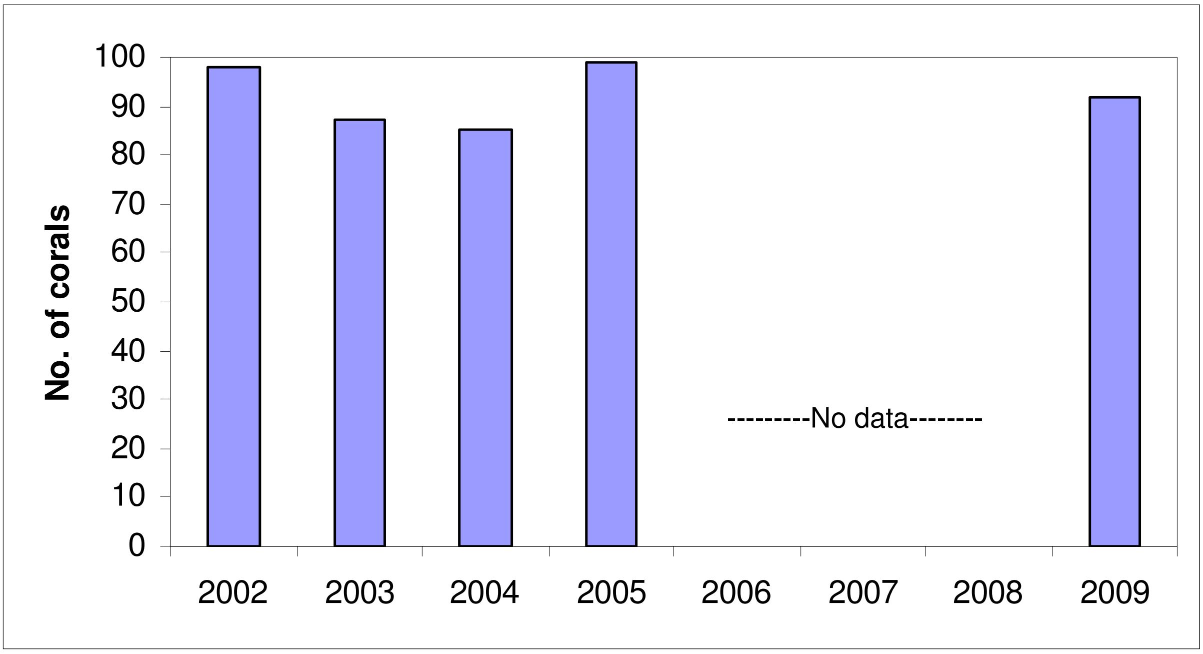


Figure 3.6 Combined *Balanophyllia regia* and *Caryophyllia smithii* counts at the Devil's Kitchen study site 2009 to 2009. Data supplied by Natural England.

The second level of assessment is an examination of the size-frequency characteristics of the population. A graphical interpretation of these data (Figure 3.7) indicates a broadly stable population reaching a median diameter of around 6-7 mm with the exception of the 2002 data which is skewed towards smaller sized corals.

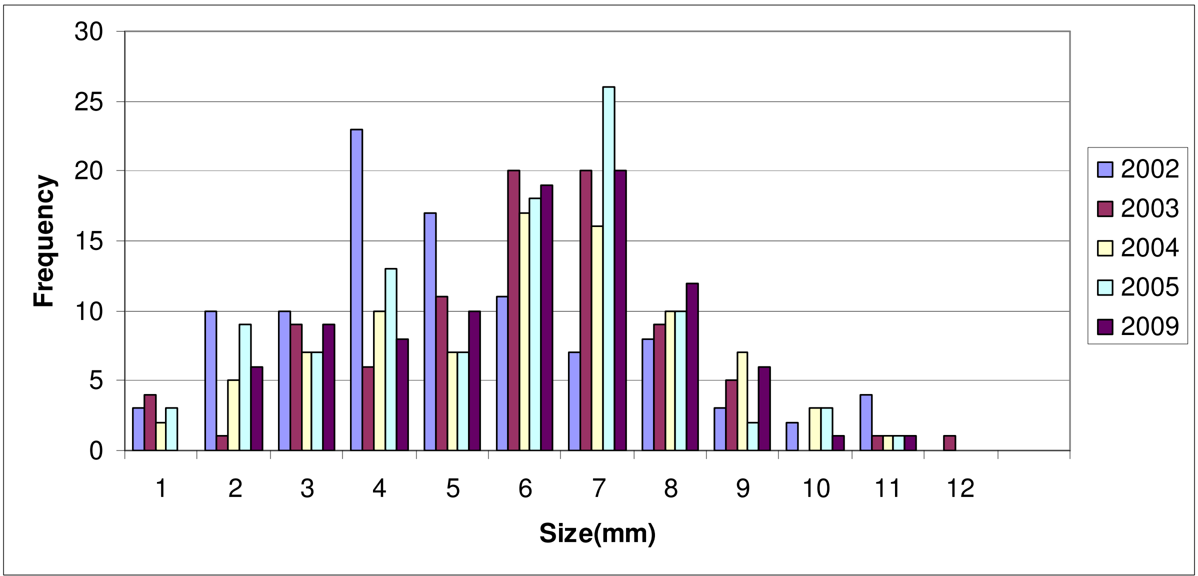


Figure 3.7 Size-frequency distribution of *Balanophyllia regia* and *Caryophyllia smithii (*2002 – 2009) at the Devil's Kitchen survey site. Data supplied by Natural England.

A Mann-Whitney Test can be used to test whether the median size of the population has changed significantly across the years. This is a non-parametric test and can be applied to skewed data. A comparison across each year (Table 3.14) indicates that the size-frequency distribution of the population has not changed significantly, although the 2002 distribution does appear to be distinct form all subsequent years, closely approaching the significant threshold at p=0.063.

Table 3.14 Results of the between-year Mann-Whitney test on the Devil's Kitchen *Balanophyllia regia* and *Caryophyllia smithii* size-frequency data. Data supplied by Natural England.

	p-value			
	2002	2003	2004	2005
2003	0.074	-	-	-
2004	0.081	0.754	-	-
2005	0.319	0.653	0.428	-
2009	0.063	0.705	0.988	0.372

This analysis is offered only as an example and the interpretation of these results can only be considered speculative because of the unknown history of the 2002 – 2005 dataset. If we assume, however, that the 2002 survey took place at the correct location, the results might indicate that this year fortuitously followed a relatively strong recruitment event, with the corals undergoing a rapid establishment and growth phase between September 2002 and September 2003. The age structure of the population appears to have remained constant since 2003.

***Estimation of Resource Requirements*:** At present there appears to be an expectation that the Devil's Kitchen monitoring will continue to be undertaken by the Lundy Warden and visits to additional sites to confirm presence and perform rapid abundance estimations could also be carried out by local staff. If, however, others were to be commissioned to carry out the work we estimate that the Devil's Kitchen site and ten additional 'rapid assessment' locations could be completed over six day period. This is based on working for the short time periods at low tide and surveyors would be left with a considerable part of the day to carry out other tasks. In periods of calm sea, surveys free of tidal constraints could also be undertaken using diving or snorkelling equipment, which would considerably reduce the number of days allocated.

Comments and Observations: The title of this attribute is selected to conform to the guidance and is concerned with maintaining the *presence and abundance* of the species. The data collected at Devil's Kitchen, at first sight, addresses a rather different factor, that of *size frequency distribution*, necessitating the use of a very much more complicated sample methodology. This, however, provides a very useful level of information for site condition monitoring purposes which is directly relevant the "*maintaining the presence…"* component of the attribute. The size-frequency curve, if collected on an annual basis, provides information on the population age structure and thus gives an indication of the recruitment status of the coral. This, in effect, provides us with a potential "early warning" system with which we can evaluate and predict the threat of a loss of the species through recruitment failure several years into the future. A size-frequency curve that shows an increasingly skewed bias towards the larger individuals would indicate an ongoing lack of recruitment and, with additional knowledge of the growth rate and longevity of the species, a simple model could be constructed that predicted the time over which the species would be lost if recruitment remained low or absent.

We have been unable to find growth curve data or establish the life-span of *Balanophyllia regia*[2], but the Mediterranean species *Balanophyllia europaea* is known to grow rapidly after settlement and have a maximum life-span of some 20 years.

3.2.8 Attribute: Presence and abundance of *Sargassum muticum*

***Target*:** Maintain a restricted distribution of *Sargassum muticum*.

***Baseline*:** Records of the presence of the non-native brown alga *Sargassum muticum* originate from a small number of sources (Table 3.15). The presence of *Sargassum* on Lundy was first reported by the Warden in 1993 (Eno *et al*., 1997) from the south-eastern tip of the Island; in Devil's Kitchen rockpools and beneath the Sentinels on the Landing Beach. Both Reach (2001) and Irving (2005), however, comment that no samples were taken and these observations may have been erroneous, possibly the result of a misidentification of a *Cystoceira* species.

[2] A paper in press at the time or writing may provide key information: Brahmi, C., Meibom, A., Smith, D.C., Stolarski, J., Auzoux-Bordenave, S., Nouet, J., Doumenc, D., Djediat, C., & Domart-Coulon, I. (In Press) Skeletal growth, ultrastructure and composition of the azooxanthellate scleractinian coral *Balanophyllia regia*. Coral Reefs.

Table 3.15 Summary of supporting information for the assessment of the presence and abundance of *Sargassum muticum*

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Devil's Kitchen, Landing Beach	None	Shore observation	1993	Single study	Two locations	A. Gibson (observation), Eno *et al.* (Eno *et al.*, 1997)
N side of Rat Island, Landing Bay	None	Diver observation	1999, 2000	n/a	Two locations	Reach (2001)
N side of Landing Bay	Plant no. & average size	Diver swim-search	2001	Single study	One site	Irving & Northen (2004)
East of new jetty, between old jetty & Landing Beach	Plant no.	Clearance	2005, 2006	Single study	Two sites	Hiscock (2008)

In 1999 a small number of plants were discovered beneath the new jetty and on the north side of Rat Island (Reach, 2001) and further searches in the summer of 2000 confirmed that Sargassum muticum was present across the south end of the Landing Bay between the new jetty and Hell's Gates and along the northern edge of Rat Island.

A directed search by divers in 2001 (Irving & Northen, 2004) confirmed the presence of *Sargassum* in the Landing Bay, with six isolated individual plants found, together with two further clusters totalling nine plants. The average size of each plant was 40 cm with the largest being 150 cm long. All were located on small boulders at a depth of around 6 m below sea level.

Hiscock (2008) attempted to clear plants from the shore around the new jetty and Landing Beach area in 2005 but on return in April of 2006 six plants were found (and removed) from the shore east of the new jetty and a further 24 from a rockpool between the old jetty and landing beach.

***Suggested Monitoring Interval*:** Annually.

***Suggested Method*:** A search for *Sargassum* should be undertaken through a low-tide census along the shore at specific suitable locations around Lundy.

The east coast of Lundy should be considered a priority as the *Sargasum* favours more sheltered locations. The optimum zone for *Sargassum* establishment is the extreme lower shore and sublittoral fringe, so a good low tide is essential, although plants can be found in eulittoral tide pools. If the tide pools are small and relatively shallow, smaller individuals may be present

If possible the number and length of plants should be recorded with an associated GPS position. This could be achieved by initiating a prescriptive search pattern or 'structured walk'.

Note that additional information on the presence of the *Sargassum* may come from sublittoral survey records.

***Timing of Survey*:** In southern England the growth rate of *Sargassum* can reach 4 cm per day between May and June, reaching reproductive maturity between July and September. The plants begin to break up from early August, with a rapid reduction in mass between October and November (Critchley, 1983). The optimum time to perform a search for *Sargassum* would therefore seem to be between May and August.

***Assessment of Change*:** A direct annual comparison of geographic occurrence around the Island.

***Estimation of Resource Requirements*:** A surveillance element for the distribution of *Sargassum* should be integrated into all of the intertidal monitoring surveys, such that each low shore station visited will log a presence or absence of *Sargasum*.

A broader assessment, incorporating shore surveys using a 'structured walk' format, could easily be undertaken by volunteers under the direction of the Warden.

If, however, a professional survey team was considered to be necessary we suggest that a team of four surveyors might be able to adequately cover the island in 1-2 days, particularly if equipped with a boat and a snorkelling capability.

***Comments and Observations*:** It seems clear that *Sargassum muticum* has become established on Lundy and it is highly likely that it will, or has, become a permanent component of the algal community around the Island. All previous attempts at eradication at other locations have failed and have sometimes increased density and dispersal rates (Critchley *et al*., 1986; Davison, 1999, 2009). As such, this attribute may become increasingly difficult to justify. We suggest that if, or when, extensive or dense colonies begin to appear, a study should be initiated to closely examine the implications of this event on the Lundy littoral and sublittoral rock communities, so that the potential effect on the other attributes can be fully examined.

3.3 Feature: Inshore Sublittoral Rock

3.3.1 Attribute: Extent of inshore sublittoral rock (Mandatory)

***Target*:** No change in extent of inshore sublittoral rock.

***Baseline*:** There are five studies that are specifically relevant to the extent of sublittoral rock (Table 3.16), one of which is highly likely to fulfil the requirements for the establishment of a baseline.

Table 3.16 Summary of supporting information for the assessment of extent of Inshore Sublittoral Rock. Text in bold indicates a source of possible baseline data.

Location/ Area	Measure	Method	Year(s)	Frequency	No. of stations/ sites	Reference
Lundy (to 1 km offshore	Habitats present	Diver observation with checklists (swimlines, drift dives, towed sledge)	1977	Single study	206 stations	Nash & Hiscock (1978)
Lundy	Habitats present	Diver observation & kelp stipe collection	1978, 1979	Single study over two years	50 sites (descriptive surveys at 13 locations)	Hiscock (1981)
Lundy	Acoustic return/ substrate hardness	Acoustic mapping/ RoxAnn & drop-down video	1996	Single study	n/a	Sotheran & Walton (1997)
Lundy	Multibeam sonar mapping	Multibeam sonar & drop-down video	2007	Single study	n/a	**Nunny & Smith (2008)**
Lundy	Presence of substrate and biological communities	Drop-down video in defined belt transect areas	2003, 2004	Single study over two years	130 stations	Mercer *et al* (2004)

A broad delineation of the distribution and extent of sublittoral hard substratum was first attempted by Nash and Hiscock (1978) and Hiscock (1981) as part of the *South-west Britain Sublittoral Survey*. Subsequent to these surveys, a map of sublittoral bottom types contained within the Voluntary Marine Reserve boundary was presented in Hiscock (1983) and is reproduced in Irving (2005), together with estimations of the area of sublittoral substratum (Table 3.17). The position-fixing for these surveys was, not unsurprising for the time, rather crude by today's standards and will not provide the level accuracy required for a measure of change.

Table 3.17 Area (approximate) of sublittoral rock substratum types within the Lundy Voluntary Marine Reserve. Taken from Irving (2005) (after Hiscock (1983).

Substratum type	Area (ha)
Bedrock and large boulders	592.7
Rock, small boulders and pebbles	159.3
Rock with sand patches	136.1
Rock, sand, small boulders and pebbles	54.6
Rock, small boulders, pebbles and gravel	29.8
Small boulders and pebbles	69.7
Gravel, small boulders and pebbles	51.7
TOTAL	**1093.9**

Data generated from later surveys, using acoustic mapping approaches are available from two sources.

A broad scale mapping survey was carried in 1996 using the RoxAnn seabed classification system coupled with video ground-truthing (Sotheran & Walton, 1997). The ability of this survey to discriminate between some types of hard and soft substratum habitat types has been questioned, however, and the use of the maps generated may have to be interpreted with caution when defining the extent of sublittoral rock (Irving, 2005).

A second broad scale mapping survey was undertaken around Lundy in August 2007 (Nunny & Smith, 2008) utilising high resolution multibeam sonar data collected for MESH in 2005, while higher resolution data obtained by the MCA in 2008 is also due to be retrospectively incorporated. This survey was specifically tasked to map and characterise sedimentary habitats, but the process of determining the areas to be excluded from sedimentary sampling has provided a comprehensive indication of the spatial distribution of hard substrata (Figure 3.8) and thus a good baseline for this attribute. The coverage is reported to be accurate and comprehensive, with a minor level of uncertainty in the southern end of Lundy, where the margin between rock and sediment has been difficult to determine (Nunny, pers. comm). The accuracy of the map is expected to be further enhanced by the addition of Marine Coastguard Agency multibeam backscatter data in the near future and some further work to incorporate historical biotope mapping data is also planned.

The data have been entered in the MapInfo GIS system and are therefore available in a form in which extent can be directly calculated.

Additional recent supporting information can also be gained for some areas from the substrate identification made during the drop-down video phase of the 2003-2004 monitoring survey (Mercer *et al.*, 2004) and was, in fact, used as secondary data in the 2007 broad scale mapping (Nunny & Smith, 2008)

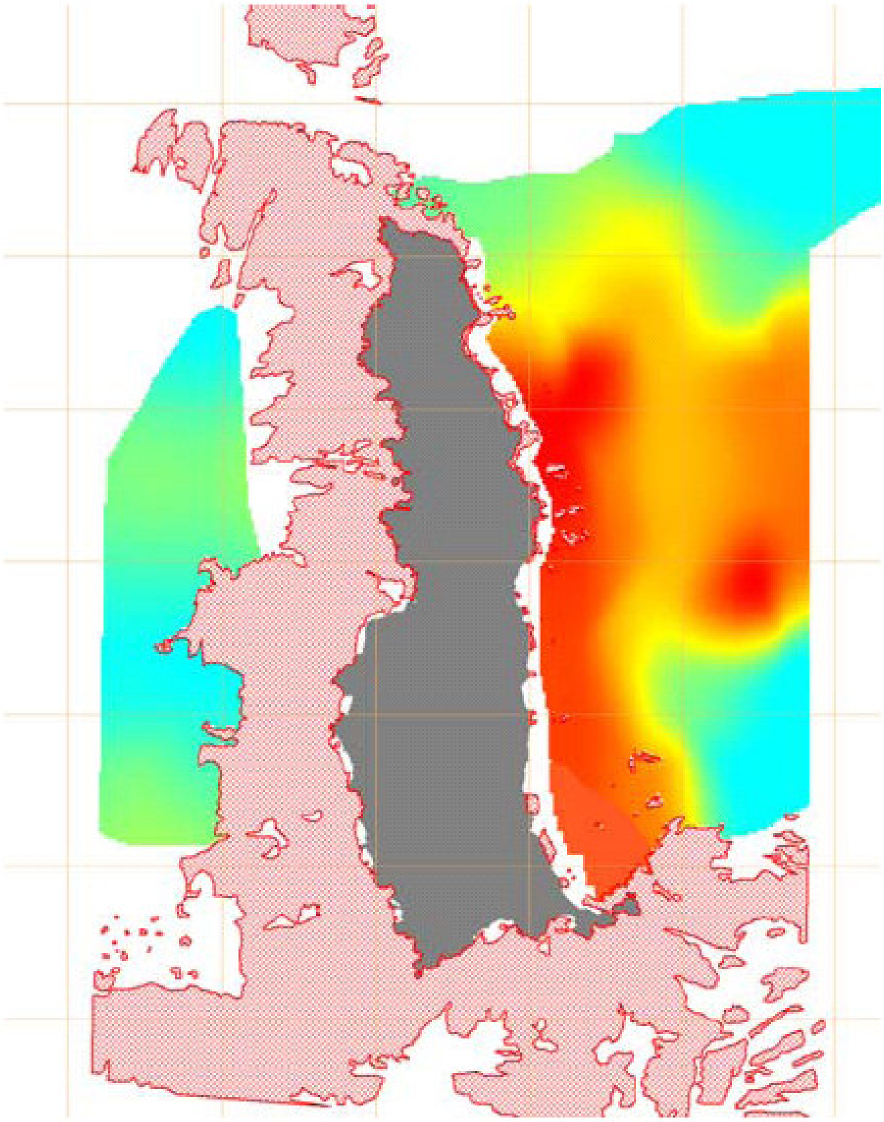


Figure 3.8 Distribution and extent of sublittoral rock around Lundy (pink area). Reproduced from Nunny and Smith (2008).

***Suggested Monitoring Interval*:** 18-24 years

***Suggested Method*:** Acoustic mapping and ground-truthing with drop-down video

***Timing of Survey*:** Sampling was undertaken at the end of August in the 2007 broad scale mapping survey. From a biological perspective this is more relevant to the inshore sublittoral sediment since grab sampling of infauna was the objective here. The next mapping survey should however be coordinated with both the sediment sampling and the sublittoral rock drop-down video programme to combine the groud-truthing required for both features. Mercer *et al.* (2004) carried out drop-down video monitoring over two years (2003 and 2004), with the majority of the drops being in June of both years and a few in September of 2004. We suggest that the sediment grab and drop-down video sampling programmes be aligned to occur in the months between late July and early September.

If we assume that the 2007 data are adequate for present CSM reporting, and the monitoring interval suggested in this report is adopted, then no further broad-scale data will be required for a further 16 to 22 years.

Assessment of change: Import into GIS and quantify area. Directly compare calculated areas against the 2007 baseline.

When making the comparison it is important to consider any difference in the resolution of each survey. Future advances in hardware and data processing, together with increased sampling intensity is likely to provide a greater resolution which may influence the result obtained for the total area.

Estimation of Resource Requirements: The acoustic element of this work was completed in 11 days in June of 2005. We therefore suggest that assuming favourable weather and with a margin for unforeseen difficulties, 12 days would be adequate to repeat the broad-scale mapping element of the survey.

An associated drop-down video programme will also be necessary for ground-truthing purposes and we estimate that an additional 2-4 days will be required to carry out this element.

Comments and Observations: Nunny and Smith (2008) have demonstrated that there is active sediment transport through wave and tidal action, with some fallout of fine sediments from suspension. It does not seem likely, however, that there is appreciable accretion or erosion, so a measurable loss or increase in reef extent is not expected.

3.3.2 Attribute: Biotope composition of inshore sublittoral rock (Mandatory)

Target: Maintain the variety of biotopes identified for the site, allowing for natural succession or known cyclical change.

Baseline: There are a substantial number of studies, often concentrating on specific species or habitats, that may provide sufficient information to allocate biotopes at particular locations, but very few that provide a level of spatial cover that allows a broader assessment of the Lundy sublittoral rock biotope composition. Only four surveys provide the broader geographical cover required (Table 3.18) and of these only two fall within the time period from which a baseline could be derived.

Table 3.18 Summary of supporting information for the assessment of biotope composition of the inshore sublittoral rock. Text in bold indicates a source of baseline data.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Lundy (to 1km offshore)	Habitats present, boundary and extent of kelp	Diver observation with checklists (swimlines, drift dives, towed sledge)	1977	Single study	206 stations (descriptive surveys at 13 locations)	Nash & Hiscock (1978)

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Lundy	Species presence and abundance	Diver observation	1978, 1979	Single study over two years	50 sites	Hiscock (Hiscock, 1981)
Lundy	Acoustic return/ substrate hardness. Presence of seabed types & lifeformes.	Acoustic mapping/ RoxAnn & drop-down video	1996	Single study	Not determined	Sotheran & Walton (1997)
Lundy	Presence of biotopes	Drop-down video	2003, 2004	Single study over two years	131 stations	**Mercer *et al.* (2004)**

Sotheran & Walton (1997) carried out an acoustic survey with drop-down video groundtruthing in 1996. We have been unable to obtain a copy of the report or dataset and therefore cannot comment directly on the coverage and level of detail. Irving (2005), however, indicates that the interpretation of the drop-down video data was restricted to seabed types and lifeforms, a coarse level of categorisation of a substantially lower level of detail than that the JNCC biotope classification system. Irving (2005), quoting English Nature sources, also states that there was concern that the maps produced from the combined acoustic and dropdown video results were not likely to be accurate for the prediction of the presence of some biotopes/communities. Bedrock with faunal turf habitats, in particular, may have been erroneously indicated as present at sedimentary locations.

A drop-down video survey, with the methodology specifically designed for site condition monitoring purposes, was carried out by Mercer *et al.* (2004) over 2003 and 2004. Six 'belt' transects of a width of approximately 1 km and extending out the boundary of the SAC were identified and further stratified into depth zones (Figure 3.9). The number of video drops for each zone was allocated on the basis of the expected presence of reef biotope, with a provisional maximum of 15 randomly generated positions. After completion, Mercer *et al.* (2004) also report that the data of Sotheran & Walton (1997) were incorporated into their final analyses.

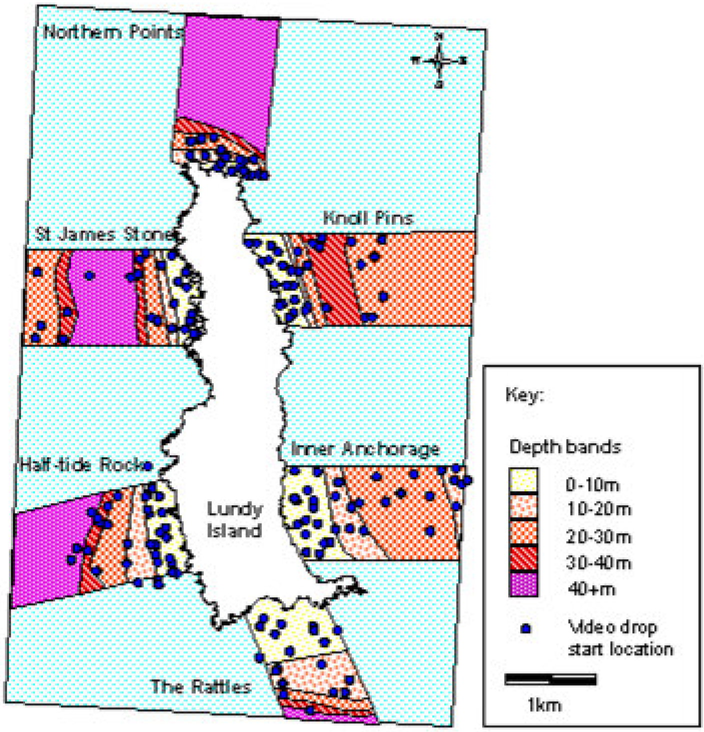


Figure 3.9 Arrangement of the 2003/4 drop-down video 'belt' transects with the positions of the drop-down video stations. From Mercer *et al.* (2004).

Mercer *et al.* (2004) reported that they recorded 37 discrete biotopes or higher level substrate entities from a total of 171 video drops, of which 30 were sublittoral rock biotopes. Table 3.19 provides a summary breakdown for each of the individual transects.

Table 3.19 Summary details of the 2003/4 drop-down video monitoring survey. After Mercer *et al.* (2004).

Transect	No. of video drops	No. of recorded biotopes	Biotopes/communities/habitats
The Rattles	19	15	LhypR.Loch?, LhypFt, HalXK, FoSwCC, ErSPbolSH, ErSEun, Flu.HbyS, AlcC, AlcMas, MytHAs, CCMob, Oph, PomByC, IGS, CGS
Inner Anchorage	35	10	HalXK, LhypLsac.Ft, XKScrR, FoR, FoR.Dic, ErSPbolSH, SNemAdia, IGS, IMX.An, CMX
Knoll Pins	34	11	LsacX, HalXK, LhypLsac, LhypR.Loch, FoR, ErSPbolSH, SnemAdia, IMX.An, IMS, IMX, CMX
Northern Points	25	13	Lhyp.TPk, HalXK, FoR.Dic, Flu.HbyS, CorCri, ErSEun, SnemAdia, TubS, Urt.Cio, AlcMas, Oph, PomByC, CGS
St. James's Stone	25	20	HalXK, Lhyp.TPk, LhypGz.Ft, LhypR.Loch?, XKScrR, FoR, FoR.Dic, FoSwCC, Flu.HbyS,

Transect	No. of video drops	No. of recorded biotopes	Biotopes/communities/habitats
			CorCri, ErSEun, ErSPbolSH, ScAsByH, SNemAdia, Urt.Cio, AlcMas, CC.BalPom, CCParCar, IGS, CGS
Halftide Rock	35	16	LhypR.Loch?, LhypR.Ft, LhypR.Pk, HalXK, FoR, FoR.Dic, SCAs.ByH, ErSPbolSH, AlcMas, ErSEun, Urt.Cio, Flu.HbyS, CorCri, PomByC, IGS, CGS

The results from the 2003/4 monitoring survey indicate that the sublittoral rock around Lundy appears to support a broad range of biotopes with a relatively uniform frequency distribution (Figure 3.10) with one exception. The biotope MCR.ErSEun[3], known to be largely confined to the south-west of England, tends to dominate, being well-represented in four of the six transects. It is important to note, however, that many of the records of this biotope were uncertain, with assignment sometimes being very close to the ECR.AlcMas biotope.

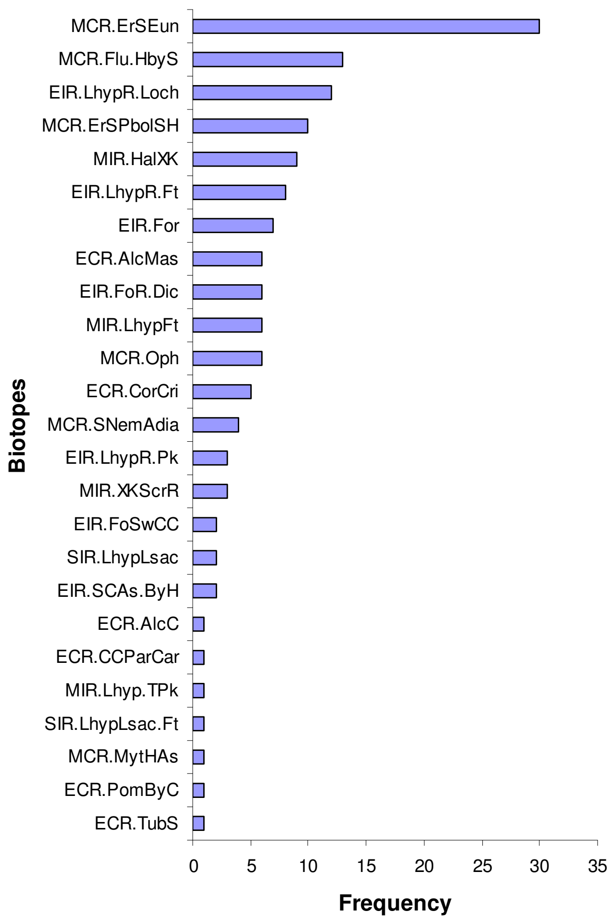


Figure 3.10 Frequency of recorded sublittoral rock biotopes from the 2003/4 drop-down video survey. Note that biotopes are as reported in Mercer *et al.* (2004) and conform to the older biotope classification system of Connor *et al.* (1997).

[3] Under the most recent biotope classification system this would be **CR.HCR.XFa.ByErSp.Eun**

The results of Mercer *et al.* (2004) are suitable as a provisional baseline for this attribute, although some further work will be necessary to convert the 2003/4 observations to the most recent biotope classification. In addition, we suggest that a more inflexible approach to the assignment of biotopes will need to be applied to allow a direct comparison of results between sampling events. This may require the introduction of 'intermediate' biotopes for comparative purposes, where samples are regularly very similar to two classified communities but cannot be placed in either.

Suggested Monitoring Interval: Six years.

We suggest that this task be synchronised with other attributes that are dependant on, or may benefit from, the use of remote video (see "*Timing of survey*" below).

Suggested Method**:** To maintain the ability to use the 2003/4 data as a baseline the methodology of Mercer *et al.* (2004) (with guidance from Davies *et al*., 2001) should be adopted. We recommend however, that the improvements in video quality be incorporated into a future survey and that the best practicable image definition be specified for this work.

Biotope assignment is notoriously arbitrary and subject to individual interpretation. To avoid the possibility of falsely detecting change caused by differences in biotope selection we recommend that sample biotope assignment be simultaneously carried out on *both the baseline and monitoring data for every monitoring event*.

Timing of Survey**:** Some floral and faunal species, particularly from the shallower locations, will have seasonal fluctuations in abundance and/or growth, potentially introducing an unwelcome variable into biotope assignment. For this reason any survey should be undertaken as close to the same time of year as possible. The timing adopted by the most recent survey was either in June, when most of the drops were made, or September. Although this particular monitoring element is a standalone event, a drop-down survey will also be required in support of the acoustic survey for the sublittoral sediment and rock extent attributes (Sections 3.3.1 and 3.4.1) and possibly for other tasks (Sections 3.4.5 and 3.4.7). To provide a degree of 'future-proofed' synchronisation we suggest that a combined drop-down video programme should, wherever possible be commissioned between late July and early September

Assessment of change**:** Change is assessed by a temporal comparison of the biotope composition of the entire site. This can be also, however, undertaken as a comparison for individual transects or depth zones, but the associated reduction in samples will inevitably reduce the overall power of any statistical test.

Change in biotope frequency can be statistically analysed in a number of ways, although a reduction or increase in particular biotopes will be almost certainly be easy to determine by simply visually comparing the frequency data.

Moore & Bunker (2005) suggest the use of the non-parametric Wilcoxon signed rank test, treating the individual biotope frequencies from the baseline and survey years as matched pairs.

An alternative method is chi-square, or goodness of fit, test (also non-parametric) in which the biotope frequency distribution is assumed to be identical for both the baseline and sample years. A comparison is thus made between the observed (survey) biotope frequency and the expected (baseline) frequency. This method is sensitive to sample size, however, and biotopes with an expected frequency of less than 5 should either be omitted from the analysis, or included within the group of a higher classification level.

Since this analysis is carried out on frequency values there is no requirement for a balanced number of samples, so the number of drops could be increased if more resources are available, or use fewer if deteriorating sea conditions prevent the completion of a full compliment of video drops.

Estimation of Resource Requirements**:** Mercer *et al.* (2004) obtained 171 video drops in four days. We suggest a target of 200 drops to be obtained in five days.

C*omments and Observations*: Mercer *et al.* (2004), in commenting on some of the practical issues associated with this method, note that some important Lundy habitats cannot be monitored by this type of survey method. Vertical and steeply sloping rock biotopes, in particular, are missed by this method, together with high-energy or tide-swept areas. It is predominantly for this reason that drop-down video sample cover of the west coast of Lundy remains less comprehensive than the east.

In addition, the 2003/4 sampling programme experienced difficulty in achieving drops in the correct depth band due to inaccurate bathymetric data during the generation of the random samples. Therefore some depth strata are poorly sampled in the baseline dataset and if frequency analysis by depth zone is considered necessary, some depth bands will have to be excluded from the first analysis. If the initial analysis (baseline vs second sampling) gives an overall result of 'no change' then the second sampling of the sparsely sampled strata could become the baseline. A substantially more accurate bathymetry of the area should be available for future sample programme planning from the acoustic survey undertaken by Nunny & Smith (2008).

3.3.3 Attribute: Distribution of algal community at specific locations[4] (Mandatory)

Target**:** No change in extent of algal communities (no change in the depth extent of the main algal zones at a specific location).

Baseline**:** Sublittoral algal communities are limited at depth by light penetration and change in water turbidity resulting from natural or anthropogenic events has been demonstrated to affect the maximum depth limit of particular species and the community as a whole.

The maximum depth distribution of algae has been recorded on a number of studies (Table 3.20), although all but one provide only a rapid diver estimates which cannot form the basis of a repeat measurement. Nash & Hiscock (1978) documented the depth of kelp and foliose red algae around Lundy from a large number of diver observations and Irving & Northen (2004) similarly documents work on the maximum depth of kelp and foliose red algae undertaken at various sites in 1996, 1997 and 2001.

In 1985 two sites, at Brazen Ward and the eastern extremity of the Knoll Pins, were investigated as possible locations for relocatable algal depth limit transects (Hiscock,

[4] We have taken this to be analogous to the guidance attribute “spatial pattern/arrangement of biotopes at specified locations”

1986a). The rock slope at Brazen Ward terminated at approximately 16 m below Chart Datum with a dense algal cover still present, but at the Knoll Pins, the slope, although uneven and broken in stretches, extended into the circalittoral.

Table 3.20 Summary of supporting information for the assessment of the distribution of algal communities at specific locations. Text in bold indicates a source of possible baseline data.

Location/ Area	**Measure**	**Method**	**Year**	**Frequency**	**No. of stations/ sites**	**References**
Lundy	Deepest depth of kelp and foliose red algae	Diver observation	1977	Single study	206 stations	Nash & Hiscock (1978)
Knoll Pins	Maximum depth limit of kelp. Maximum depth limit of foliose algae	Relocatable transects with photography	1985, 1986, 1987, 1988, 1990	Annually 1985-88	One site, three transect locations	**Hiscock (1986a, b), Howard (1987, 1988), Fowler & Pilley (1992a), Irving (1990)**
Lundy	Deepest depth of kelp and foliose red algae	Diver observation (volunteers)	1996, 1997, 2001	Two visits	Unknown	Irving & Northen (2004))

A series of four almost contiguous transects were established, running from 6.0 m at the shallowest end to 21.5 m at the deepest Figure 3.11. The relocation sketches for this transect are presented in Fowler & Pilley (1992b). The transects were documented by photography, but a great deal of difficulty was experienced in matching the photographs across years. Subsequent to inaugural survey of 1985, a further four visits were made in 1986, 1987, 1888 and 1990. Difficulties with photographic identification forced the surveyors to concentrate all of their resources on the lower transect, where the deepest distribution of foliose algae was present, from 1988 and thereafter.

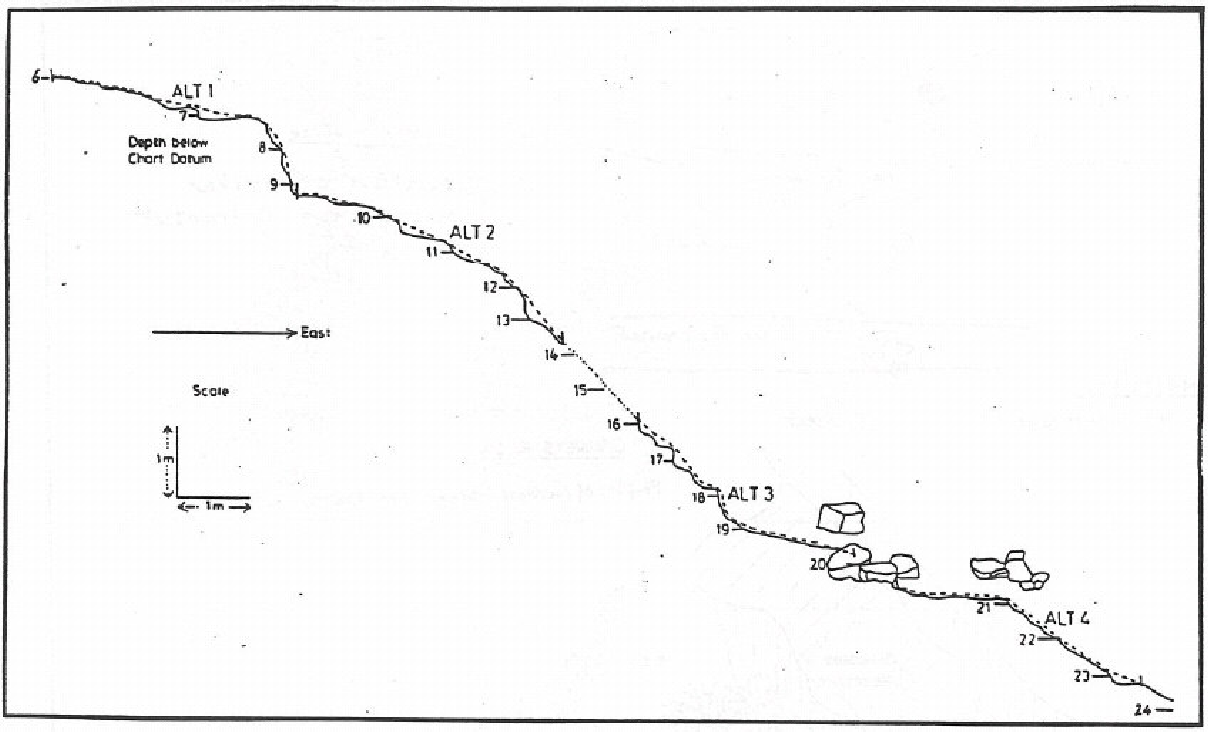


Figure 3.11 Sketch profile for the algal limits transects at the outer knoll Pin. Reproduced from Fowler & Pilley (1992b).

Fowler & Pilley (1992a) noted that the predictive tide tables, together with the diving depth gauges used to record depth were not completely reliable at that time and so there was inevitably a degree of potential error in the final depth values. This aside, however, Fowler & Pilley (1992a) were able to show change over the study period (Table 3.21) and tentatively relates a depth increase to a recorded reduction in turbidity in previous years. Irving (1996) revisited the location in June of 1996, although not exactly at the transect, he recorded a lower depth limit for kelp of 9.2 m and for foliose algae of 21.9 m.

Table 3.21 Lower depth limit of the main algal zones at outer Knoll Pins (depths are given in metres below Chart Datum). From Fowler & Pilley (1992a)

	1985	1986	1987	1988	1989	Mean
Lower limit of kelp	7.3	~7	10	-	-	8.1
Lower limit of very dense foliose algae	11.5	~12	14	Not surveyed		12.5
Lower limit of fairly dense foliose algae	13.5	~13	18	-	14.83	
Lower limits of all foliose algae	21.8	~22	22	22.8	21.5	22.02

Unless the Knoll Pins transect can be relocated with confidence these data should be considered as supporting information and new baselines established for specific transects at the first monitoring visit.

Suggested Monitoring Interval**:** Annually.

Suggested Method**:** Algal depth distribution will be influenced by a number of local factors, such as substrate character and complexity, hydrodynamic regimes and slope aspect and orientation, so any baseline value will be transect-specific.

We suggest that the Knoll Pins transect be relocated and re-established if possible, together with an attempt to locate at least three new sites of a suitable substrate, gradient, depth and algal density.

Observations by Fowler & Pilley (1992a) strongly indicate that the photographic recording of the transect was not a success when attempting a comparison between years. We suggest a modified methodology incorporating the benefits of digital photography:

A single transect line, comprising a sinking line marked at 1 m intervals, is laid by diver from a shallow relocatable point down the slope in a predetermined bearing. Once the end of the transect is reached the diver swims back up the line, recording the substrate depth and presence-absence of kelp and foliose algae at each 1m transect interval. On returning to the surface, the distance along the transect line where the lower limit of the kelp and foliose algae are reached is confirmed and a second dive team is deployed to target these areas for more detailed examination. At a point approximately 5 m depth above or below (depending on the desired direction of swim) the previously recorded limit (taking into account the tidal change between dives), and corresponding to the closest 1 m transect marker, a series of haphazardly placed photo-quadrats are taken within a defined area relative to the transect line (say within 2 m either side). A quadrat frame or some other device by which a consistent area is photographed should be attached to the camera. An equal number of haphazardly placed replicate photographs should be taken at half-metre intervals along the transect line covering the 10 m depth range spanning the previously determined two algal limit zones. The depth at each photographed interval is recorded, or a digital depth recorder or dive computer is incorporated into the quadrat frame, thus increasing accuracy while reducing error. Once the photographs have been downloaded they can be overlaid by a digitally generated grid (or the grid can be physically incorporated in the framer) and the number of grid intersects which correspond with the presence of live algal material are counted to give a measure which can be converted to percentage cover.

The digital image technique carries the advantage of being able to considerably enlarge the image to confirm algal presence, while each image carries date and time information (assuming this feature has been set correctly), so accurate correction to Chart Datum is always possible. In addition, with the addition of the replicated intersect counting method a quantitative approach is introduced to aid the definition of the algal depth limit. Note that the 0.5 m interval suggested provides a minimum depth resolution of 0.5 m, which would occur if vertical rock was encountered. Increased resolution could be achieved with shorter intervals and a smaller quadrat size

Timing of Survey**:** Seasonal changes in algal growth, density and community structure requires that repeat surveys be carries out in the summer months and as close to the same period as possible. The Knoll Pins transect was always surveyed between July and September and we suggest that this timing be adopted for any new monitoring programme.

***Assessment of Change*:** A maximum depth limit for both kelp and foliose algae is derived for each transect and compared against the transect-specific baseline.

***Estimation of Resource Requirements*:** Each transect would require at least two dives. We recommend that a minimum of four transects be established around Lundy. These would take four days to complete.

***Comments and Observations*:** Fowler & Pilley (1992a) identified a number of problems while attempting to analyse the Knoll Pins survey data. These were:

- *Transect relocation difficulties*: These are likely to have been considerably improved by modern GPS devices. In addition, deploying the transect as a single line from a shallow point of origin will remove the task of simultaneously attempting to locate multiple transects, so long as an intuitive and reasonably accurate direction can be achieved.

- *Depth gauge and tidal prediction unreliability*: This has since been vastly improved by the availability of digital dive computers and accurate tidal prediction software.

- *Inconsistent and inaccurate photographic documentation*: The date and time data held within a digital image coupled with a means by which depth information can be incorporated into an image will promote a considerably more reliable data capture programme.

3.3.4 Attribute: Species composition of kelp biotopes: kelp forest structure (Discretionary)

***Target*:** Maintain the kelp community structure of the site, allowing for natural succession or known cyclical change.

***Baseline*:** Only two surveys have provided indications of kelp community structure around Lundy (Table 3.22). Hiscock (1981) supplies a broad assessment of kelp occurrence and distribution obtained from a total of 50 survey locations.

Table 3.22 Summary of supporting information for the assessment of the Species composition of kelp biotopes. Text in bold indicates a source of baseline data.

Location/ Area	**Measure**	**Method**	**Year**	**Frequency**	**No. of stations/ sites**	**Reference**
Lundy	Presence and abundance of species	Diver observation	1979	Single study	50 sites	Hiscock (1981)
Rat Island, Gannet's Bay	Density of kelp species	Diver counts with 1 m^2 quadrat	2004	Single study	Two sites	**Mercer *et al.* (2004)**

The Lundy infralittoral supports five known kelp species *Laminaria hyperborea*, *Laminaria digitata*, *Laminaria ochroleuca*, *Saccorhiza polyschides* and *Alaria esculenta*. Both

Laminaria digitata and *Alaria esculenta* are largely restricted to the upper infralittoral fringe and of the remaining species. *L. hyperborea* is the dominant kelp forest-forming species on Lundy.

S. polyschides, a fast-growing opportunistic coloniser, was reported in 1981 to be rare to frequent on stable upper infralittoral rock and restricted to the east coast.

L. ochroleuca is a southern species that has become establish in south-west Britain as a suspected beneficiary of warming sea temperatures. Lundy presently represents the reported northern limit of this species. In 1981 it was found in low abundance at the lower limit of the kelp forest at three sites; two at the extreme south east and one to the north-east of the Island.

Both *S. polyschides* and *L. ochroleuca* are resistant to fouling, while *L. hyperborea* may support a considerable diversity and abundance of epiflora and fauna. A change in proportional abundance could therefore result in a reduction in infralittoral habitat quality.

Mercer *et al.* (2004), as part of the 2003/4 site condition monitoring survey established two sites to examine the composition of the kelp community. The site selected, Rat Island and Gannet's Bay, corresponded with the locations where Hiscock (1981) had previously reported the presence of *L. ochroleuca*.

In 2004, at both surveyed sites, *L hyperborea* remained the dominant kelp species, with comparatively few *S. polyschides* and *L. ochroleuca* present (Table 3.23). At both sites the ratio of mature *L hyperborea* to *L. ochroleuca* was very similar at 17:1 (Rat Island) and 16:1 (Gannet's Bay). The ratio for *S. polyschides* was less consistent, but nevertheless still comparatively close at 7:1 (Rat Island) and 11:1 (Gannet's Bay).

Table 3.23 Results of the kelp forest community structure survey conducted by Mercer *et al.* (2004) at two Lundy locations in 2004. The number of 1 m^2 quadrats used for each site was: 33 for Rat Island and 21 for Gannet's Bay.

	Rat Island		Gannet's Bay	
	No. of plants	Density (m^{-2})	No. of plants	Density (m^{-2})
Laminaria hyperborea	295	8.9	352	16.8
Laminaria digitata	6	0.2	0	0.0
Laminaria ochroleuca	17	0.5	22	1.0
Juvenile Laminaria spp.	26	0.8	66	3.1
Saccorhiza polyschides	41	1.2	31	1.5

We suggest that these ratios, as applied to these sites, be considered as a provisional baseline for this attribute, pending the results of a repeat survey to establish the variation in density that might be expected from this type of study.

Suggested Monitoring Interval: 3-6 years

***Suggested Method*:** The methodology employed ~~my~~ Mercer *et al.* (2004) is incompletely described in their report, stating only that sampling was "…undertaken in multiple (1 m^2) random quadrats in the vicinity of the transects". The transects referred to here are the survey sites which received separate detailed community studies using 0.25 m^2 quadrats and were therefore not used in any structured way for the kelp species abundance survey. The information supplied does, however, indicate that 10 m transects were laid at each location within an identified zone of gently sloping bedrock with the community approximating to a LhypR.Ft biotope. The Rat Island transect extended between depths of 0.3 m and 1.7 m BCD and the Gannet's Bay transect between 0.8 and 2.7 m BCD.

For a comparative assessment to be achieved for this attribute, both of the original sites will need to be relocated. The positions supplied in the report, together with the depth ranges, should allow the sites to be relocated with a reasonable level of accuracy. Assuming this is the case, we suggest that a 10 m transect (to remain within the original sampling zone) be used as a basis for a stratified randomised sampling design. Forty 1 m^2 quadrat sample stations are then generated by a randomised co-ordinate system e.g. selecting between 0 and 9 m along the transect, then between a right or left turn and then between 0 or 9 m (or fin strokes) distance laterally to the transect. In this way an area of 200 m^2 can be sampled.

***Timing of Survey*:** *Laminaria hyperborea* is a perennial plant with rapid seasonal blade growth between December and June. The life cycle of *L. ochroleuca* is thought to be similar to that of *L. hyperborea*, but *S. polyschides* is an annual plant with rapid growth in the summer months. To be confident of between-year consistency and to ensure that new plants are incorporated, repeat sampling should be undertaken between June and August.

***Assessment of change*:** A simple temporal comparison with the baseline ratios (*L. hyperborea*: *L. ochroleuca; L. hyperborea*: *S. polyschides*). We suggest that if the ratio of the former falls below 12:1 at either site then the feature should be considered unfavourable. An increasing presence of *S. polyschides* is more difficult to incorporate as a measure of condition because of its seasonal appearance and opportunistic behaviour. We advise that the numerical stability of this species be further examined before its incorporation as a condition indicator.

***Estimation of Resource Requirements*:** Assuming good weather and the ability to quickly relocate the previous sample sites, we anticipate that both locations could be completed with a team of four divers in a single day.

C*omments and Observations*: Mercer *et al.* (2004) commentsed that knowledge of the distribution of *Laminaria ochroleuca* around Lundy could be considerably enhanced by the targeting of kelp forest by a drop-down video survey carried out in slack water conditions.

3.3.5 Attribute: Species composition of representative or notable biotopes ((Discretionary)

***Target*:** No decline, due to change in species composition, in the biotopes IR.EIR.KFaR.LhypR.Ft, IR.MIR.KR.Lhyp.TFt, CR.MCR.XFa.ErSPbolSH, CR.MCR.XFa.ErSEun, CR.ECR.EFa.CorCri, CR.FaV, and IR.EIR.SG.SCAs.ByH.

Note that the biotopes presented in this target are in the older biotope classification format and will need to be converted into the recent formats for future condition reporting (see below).

***Baseline*:** Although there has been a broad range of studies on sublittoral rock communities since the late 1970s, very few rigorously quantitative studies have been undertaken and even fewer have concentrated their efforts within particular communities or biotopes. Only two wholly quantitative surveys for multiple species have been conducted within spatially defined locations around Lundy (Table 3.24), although each were designed for different purposes and therefore retain major differences in their approach.

Table 3.24 Summary of supporting information for the assessment of the species composition of representative or notable biotopes. Text in bold indicates a source of baseline data.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Rat Island, Gannet's Bay, Dead Cow Point, N. Quarry Bay, Knoll Pins, Gannet's Rock Pinnacle, Jenny's Cove, Battery Point	Species presence and abundance	Diver quadrats (0.5 m x 0.5 m = 0.25 m^2 & 0.3 m x 0.3 m = 0.09 m^2)	2003, 2004	Single study	Nine sites	**Mercer *et al.* (2004)**
N Brazen Ward, S Quarry Bay, Dead Cow Point, St. Philip's Stone, (2007 only: Halfway Bay, Gannet's Cove)	Selected species presence and abundance	Diver quadrats (0.75 m x 0.75 m = 0.56 m^2)	2004, 2005, 2006, 2007	Annually until 2007	Four sites, 24 transects	**Hoskin *et al.* (2004; 2006; 2009; 2008)**

Mercer *et al.* (2004) as part of their site condition monitoring programme identified and established nine individual survey sites around Lundy, each positioned to fall within a particular target biotope (Table 3.25), four of which were infralittoral (predominantly kelp-dominated) and the remaining five were circalittoral rock and boulder biotopes. In addition, the circalittoral communities were further differentiated by aspect or orientation, three being located on vertical rock and the remaining four on horizontal and upward-facing bedrock or boulder.

Table 3.25 Site and target biotopes (97.06 classification) for the 2003/4 survey conducted by Mercer *et al.* (2004).

Site	Target biotope
Rat Island	IR.EIR.KFaR.LhypR.Ft
North Quarry Bay	CR.MCR.XFa.ErSEun
Knoll Pins (horizontal)	CR.MCR.XFa.ErSPbolSH
Knoll Pins (vertical: *Leptopsammia*)	CR.FaV
Dead Cow Point	IR.MIR.KR.Lhyp.TFt
Gannet's Bay	IR.EIR.KFaR.LhypR.Ft
Battery Point (upward facing)	CR.MCR.XFa.ErSPbolSH
Gannet's Pinnacle (vertical)	CR.ECR.EFa.CorCri
Jenny's Cove (vertical)	IR.EIR.SG.SCAs.ByH

Note that these sites were chosen because they appeared to conform to the target biotopes. The year after this survey the revised biotope classification system was, however, released, resulting in the need for a simple reclassification of some of the selected biotopes and a major reassessment and reassignment of others (particularly the CR.FaV community at Knoll pins). Table 3.26 provides an indication of the direct conversion, or the possible options if a single alternative is not present. Time constraints did not allow an examination of the community composition for the reassignment of new biotopes in this project, but this would need to be done prior to any future fieldwork associated with this attribute, since the stated biotope targets are fundamental to focus of this element.

Table 3.26 Current equivalents of the biotopes selected during the 2003/4 monitoring survey.

Biotope code (97.06)[5]	Biotope Title	Biotope code (04.05)[6]	Biotope Title
IR.EIR.KFaR.LhypR.Ft	*Laminaria hyperborea* forest with dense foliose red seaweeds on exposed upper infralittoral rock	IR.HIR.KFaR.LhypR.Ft	*Laminaria hyperborea* forest with dense foliose red seaweeds on exposed upper infralittoral rock

[5] Connor, D.W., Dalkin, M.J., Hill, T.O., Holt, R.F.H., & Sanderson, W.G. (1997). Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 2. Sublittoral biotopes., Rep. No. Report No. 230. Joint Nature Conservation Committee, Peterborough.

[6] Connor, D.W., H., A.J., Golding, N., Howell, K.L., Lieberknecht, L.M., Northern, K.O., & Reker, J.B. (2004). The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough.

Biotope code (97.06)[5]	Biotope Title	Biotope code (04.05)[6]	Biotope Title
IR.MIR.KR.Lhyp.TFt	*Laminaria hyperborea* forest, foliose red seaweeds and a diverse fauna on tide-swept upper infralittoral rock	IR.MIR.KR.LhypT.Ft	Laminaria hyperborea forest, foliose red seaweeds and a diverse fauna on tide-swept upper infralittoral rock
		IR.MIR.KR.LhypTX.Ft	Mixed kelps and seaweeds on upper infralittoral mixed substrata
CR.MCR.XFa.ErSPbolSH (upward facing/ horizontal)	Cushion sponges *(Polymastia boletiformis*, *Tethya*), stalked sponges, *Nemertesia* spp. and *Pentapora foliacea* on moderately exposed circalittoral rock	CR.HCR.XFa.ByErSp.DysAct	Mixed turf of bryozoans and erect sponges with *Dysidia fragilis* and *Actinothoe sphyrodeta* on tide-swept wave-exposed circalittoral rock
CR.MCR.XFa.ErSEun	Erect sponges, *Eunicella verrucosa* and *Pentapora foliacea* on slightly tide-swept moderately exposed circalittoral rock	CR.HCR.XFa.ByErSp.Eun	Eunicella verrucosa and *Pentapora foliacea* on wave-exposed circalittoral rock
CR.ECR.EFa.CorCri	*Corynactis viridis* and a crisiid/ *Bugula*/ *Cellaria* turf on steep or vertical exposed circalittoral rock	CR.HCR.XFa.CvirCri	*Corynactis viridis* and a mixed turf of crisiids, *Bugula, Scrupocellaria*, and *Cellaria* on moderately tide-swept exposed circalittoral rock
		CR.HCR.XFa.SpAnVt	Sponges and anemones on vertical circalittoral bedrock
CR.FaV (vertical)	Faunal turf (deep vertical rock)	Records variously reassigned to vertical rock types within HCR, MCR and LCR	-

Biotope code (97.06)[5]	Biotope Title	Biotope code (04.05)[6]	Biotope Title
IR.EIR.SG.SCAs.ByH (vertical)	Sponge crusts, colonial (polyclinid) ascidians and a bryozoan/hydroid turf on wave-surged vertical or overhanging infralittoral rock	IR.FIR.SG.CrSpAsDenB	Crustose sponges and colonial ascidians with *Dendrodoa grossularia* or barnacles on wave-surged infralittoral rock
		FIR.SG.CrSpAsAn	Anemones, including *Corynactis viridis*, crustose sponges and colonial ascidians on very exposed or wave surged vertical infralittoral rock
		HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock

The survey strategy adopted by Mercer *et al.* (2004) was of a randomised quadrat design, with sampling taking place along either side of a 10 m long transect, except at Battery Point and North Quarry Bay where the irregular topography of the substrate was considered inappropriate for transect line deployment. A minimum sample size of 12 quadrats was selected on the basis of conclusions from a number of previous similar studies combined with the recent experience of the survey team surveying similar habitats elsewhere. The quadrat size used for this study was not the same for each site, however; with a 0.25 m^2 (0.5 m x 0.5 m) quadrat used for horizontal and upward facing habitats and a 0.09 m^2 (0.3m x 0.3 m) quadrat for vertical biotopes (see Table 3.26), presumably reflecting the high faunal density and abundance of the vertical rock communities. A quadrat size of 0.01 m^2 was indicated as being used at Jenny's Cove, but we suspect that this is a simple mistake that was incorporated during report production.

Species area curves were constructed for each site to determine the minimum number of quadrats required to adequately sample the species range present, arriving at a general figure of 15-20 for the 0.25 m^2 quadrats and 20-30 for the 0.09 m^2 quadrat.

Mercer *et al.* (2004) attempted to assess change at all of the sites they surveyed, but found that, although previous data had been collected at all sites, there were no comparable quantitative records. Past surveys at, or close to, the transect locations were largely restricted to reports of species presence, or in a form of abundance scales not appropriate for comparison with a percentage cover format. A simplified comparison was therefore conducted examining the species compliment correspondence between sampling events and reporting the results as a similarity percentage. The results clearly demonstrated the difficulty in attempting to compare such data, with similarities ranging from 9% to 64%, the differences largely due to the disparity of spatial scale and the targeting of different or multiple biotopes in previous surveys. This, in effect, provides an unassailable argument for the more spatially selective and discrete 2003/4 data to be adopted as a baseline for the biotopes identified, subject to assimilation into the most recent biotope classification system.

The study undertaken by Hoskin *et al.* (2009) was designed specifically to examine benthic community change associated with the establishment of the NTZ and similarly adopted a stratified random sampling approach using quadrats as the basic quantitative sampling unit. in contrast to the strategy used by Mercer *et al.* (2004) a sub-set of conspicuous, long-lived, species was selected for counting (Table 3.27) rather than enumerating the entire community within the quadrat. In addition, although a similar habitat type and substrate has been selected for their study *no biotope has been identified for their survey sites*, mainly because the small set of species under investigation is inadequate to be confident of an assignment and because it is largely inconsequential to the aims of the study. Of particular importance for this report is that the results of repeat sampling over four years are presently available.

Table 3.27 Species of long-lived sessile epifauna in circalittoral rocky habitats that were selected for monitoring potential effects of the Lundy NTZ. From Hoskin *et al.* (2009).

Phyla	Species	Common name
Porifera	*Axinella dissimilis*	branching sponge
	Axinella infundibuliformis	funnel-shaped sponge
	Axinella damicornis	erect, non branching sponge
	Homaxinella subdola	branching sponge
	Raspalia ramosa	branching sponge
	Raspalia hispida	branching sponge
	Polymastia boletiformis	cushion sponge
	Polymastia mammilaris	cushion sponge
	Cliona celata	Boring sponge
Cnidaria	*Alcyonium digitatum*	Dead men's fingers
	Alcyonium glomeratum	Red fingers
	Eunicella verrucosa	Pink sea-fan
	Anemonia viridis	Snakelocks anemone
	Aiptasia mutablis	Trumpet anemone

Phyla	Species	Common name
Bryozoa	*Pentapora fascialis*	Ross coral
Chordata	*Stolonica socialis*	a colonial sea squirt
(class Ascidacea)		

The sampling design was structured around four sample sites, two within the NTZ and on the east side of Lundy and two outside the NTZ and on the west side of the Island (Figure 3.12).

Prior to starting the sample programme a pilot study was undertaken to determine an adequate sample size and establish the statistical power of the methodology (Hoskin *et al*., 2004). Analyses of data from pilot work at Lundy suggested that 72 samples (12 quadrats from each of six transects) per site were sufficient to maximise the precision of mean estimates of epifaunal abundances per quadrat (for a 75cm x 75cm quadrat). Power analyses of the same data (Hoskin *et al.* 2004) indicated that with this level of replication, univariate tests on epifaunal abundances should have an 80% probability of detecting a 100% change in abundance due to the NTZ, if it occurred.

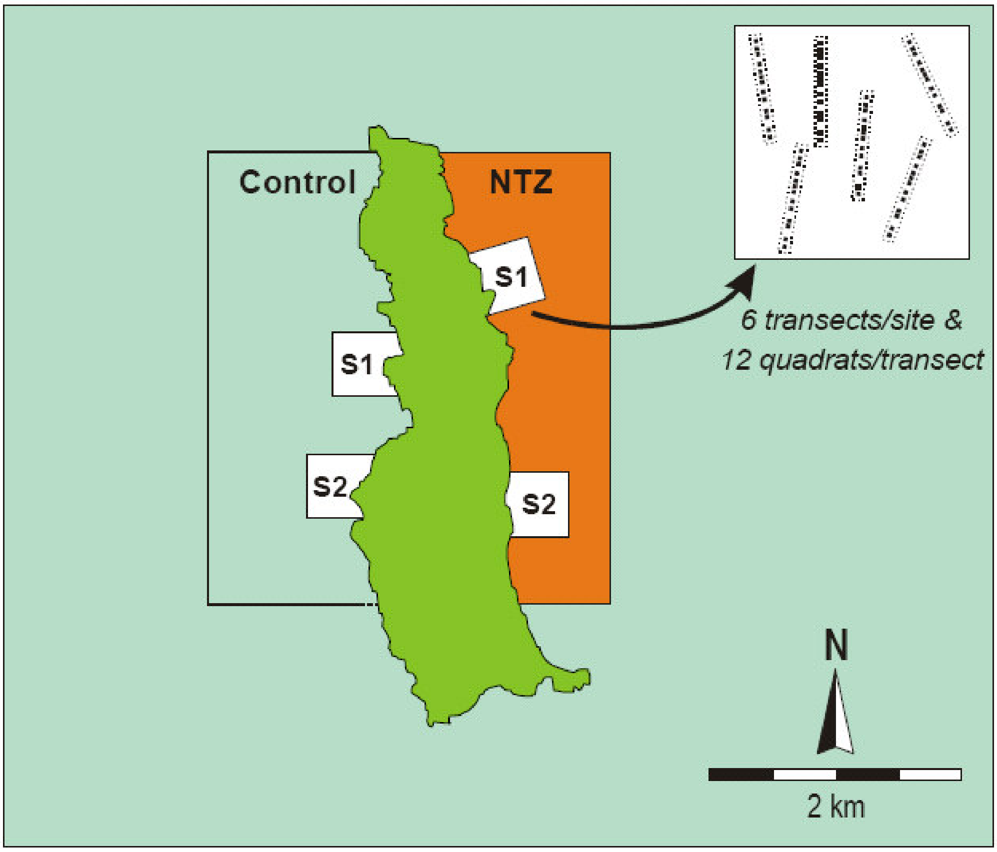


Figure 3.12 Sampling strategy for the NTZ monitoring using conspicuous epifaunal fauna. Reproduced from Hoskin *et al.* (2009).

Analysis of the data obtained between 2004 and 2007 are summarised below and in Figure 3.13:

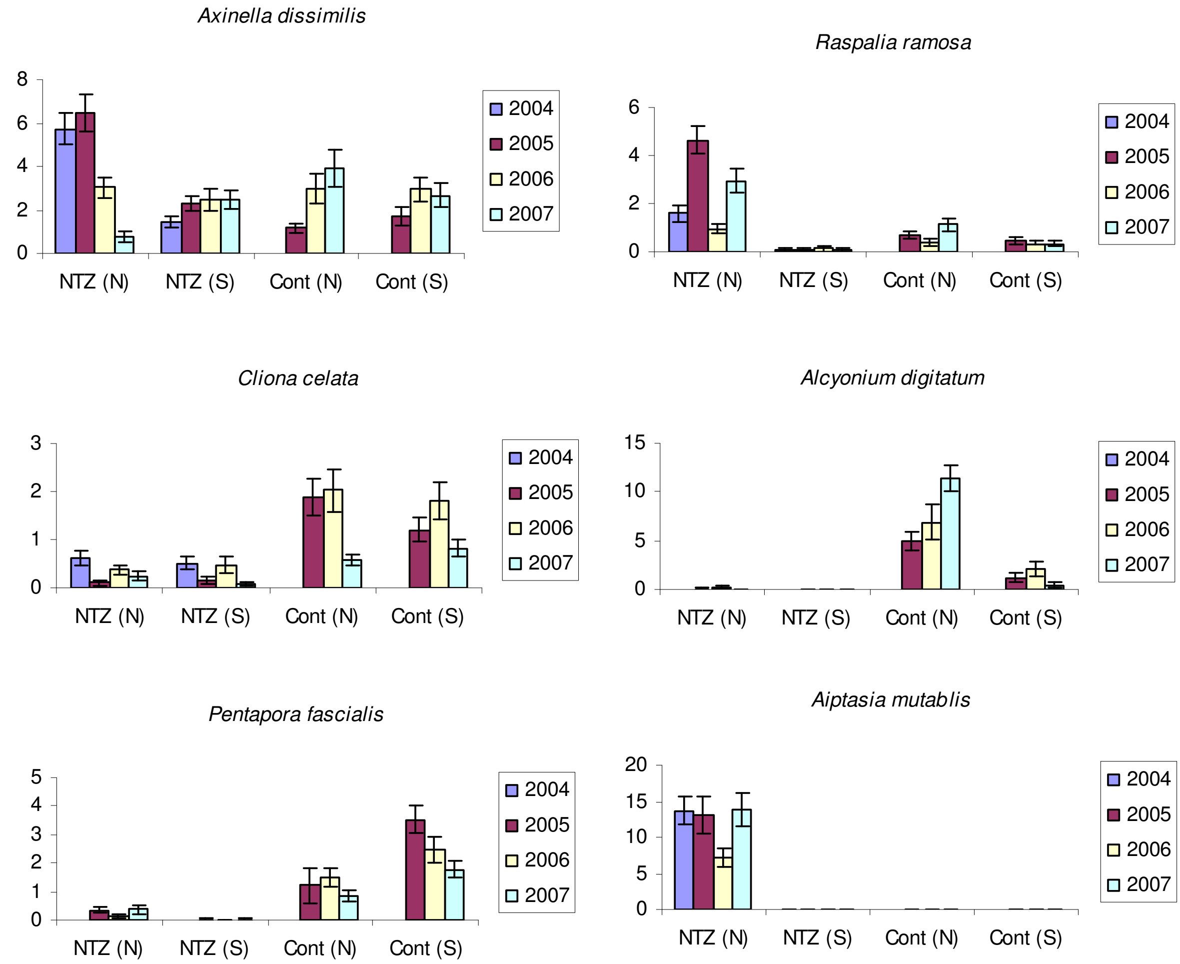
- Univariate analysis showed no significant change for any of the species between 2004 and 2007, although one species, *Raspalia ramosa*, appeared to decline significantly between 2005 and 2006 and then increase to close to the original abundance between 2006 and 2007.

- A multivariate comparison of the species assemblage composition showed that there were consistent and statistically significant differences in the west coast and east coast site communities and also between the north and south NTZ sites. The two control sites appeared to be most similar.

- Multivariate analysis using ANOSIM showed no change in composition at any of the sites between 2004 and 2007.

While the differences between the east and west coast communities may present some difficulties for the monitoring of the effects of the NTZ it is not an issue for monitoring the condition of the entire site.

Figure 3.13 Abundance of selected species at four sites between 2004 and 2007. Note that counts were not made in the control sites in 2004. Error bars indicate +/- standard error. Reproduced from data supplied by Natural England.



The surveys of both Mercer *et al.* (2004) and Hoskin *et al.* (2009), being similar in design and deployment, are both highly applicable to this attribute and are suitable for adoption as a baseline if the data are consistently applied to the individual sites in which they have been collected. If incorporated into the CSM programme, the sites established by Hoskin should be subject to a Phase II surveys to formally establish the 'notable biotopes' in which the sampling is undertaken.

Suggested Monitoring Interval: 3-6 years.

Suggested Method: The nature of this attribute requires that repeat surveys be conducted at established locations stratified by community type (biotope). The methods adopted by Mercer *et al.* (2004) and Hoskin *et al.* (2009), although different in design, essentially achieve the same objective. It seems likely that the power to detect change may be similar, simply because one method samples a smaller area but includes a much larger number of species and the other has a much larger spatial sample size but a much reduced species compliment.

We suggest that both methods are equally valid, although the NTZ monitoring method has the immediate advantages of four consecutive years of data, and the reduced requirement for taxonomic expertise. The NTZ monitoring is, however, potentially more expensive in terms of resources.

Note that integrating both studies into a CSM programme will require the use of three quadrat sizes, 0.56 m^2, 0.25 m^2 and 0.09 m^2, which will have to be carefully managed to avoid the risk of confusion and the accidental use of an inappropriate size by a contractor. Mercer *et al.* (2004) also make recommendations on the number of quadrats that should be used at each or their sites, based on their species area curve analysis (Table 3.28). We recommend that a consistent number be applied to each quadrat size and suggest a minimum per site of 15 for a 0.25 m^2 quadrat and 30 for a 0.09 m^2 quadrat. Sample numbers for the use of the 0.56 m^2 quadrat size is specified as 72 per site in the sample design of Hoskin *et al.* (2009).

Table 3.28 Quadrat size and number of quadrats used at each survey site by (Mercer *et al.* (2004) in 2003/4 with the number subsequently recommended from species-area curve analysis. Note that the small quadrat size used at Jenny's Cove may have been incorrectly reported and should be verified before any repeat visit.

Site	Quadrat size	Quadrat No. (2003/4)	Recommended Quadrat No.
Rat Island	0.25 m^2	14	15-20
North Quarry Bay	0.25 m^2	14	15
Knoll Pins (horizontal)	0.25 m^2	13	15-20
Knoll Pins (vertical)	0.09 m^2	19	20-25
Dead Cow Point	0.25 m^2	19	15-20
Gannet's Bay	0.25 m^2	22	15-20
Battery Point	0.25 m^2	27	15-20

Gannet's Pinnacle	0.09 m^2	34	30
Jenny's Cove	0.01 m^2 (?)	30	25

***Timing of Survey*:** With some of the biotopes incorporating an algal element and a weather consideration associated with diving activity, we recommend that this monitoring task be undertaken between June and September.

***Assessment of Change*:** Change can be assessed statistically by the use of both univariate and multivariate techniques. Temporal change in Individual species at each site can be examined by the use of ANOVA provided that there is a sufficient abundance to justify the use of this test. Temporal community change can be statistically determined by the use of the multivariate test ANOSIM (Analysis of Similarities – an element of the PRIMER package). Note that for both tests a transformation of the data may be required to reduce the influence of numerically dominant species. Hoskin *et al.* (2009), for example applied a Ln(x+0.01) transformation to the abundance data prior to an ANOVA test and a 4^{th} root transformation before subjecting the data to ANOSIM. Where statistical differences are present in the community analyses, the SIMPER routine should be applied to determine the species that most contribute to the difference.

An unfavourable condition judgement should be applied if a clear change in community structure can be demonstrated to be due to anthropogenic influences.

***Estimation of Resource Requirements*:** Mercer *et al.* (2004) indicate in their survey log that the nine sites that they surveyed took a total of 13 days using a four-person dive team. The greater sampling required for the programme undertaken by Hoskin *et al.* (2009) is reflected in the increased resource requirements with around 21-24 days of diving each year.

Comments and Observations: None

3.3.6 Attribute: Presence and abundance of *Eunicella verrucosa* (Discretionary)

***Target*:** Maintain presence and abundance of *Eunicella verrucosa*.

***Baseline*:** A number of locations around Lundy have been previously selected for *Eunicella verrucosa* density studies. Table 3.29 shows studies that specifically set out to address abundance or density and also other studies, included because of their indication of the numbers of *Eunicella* located at a particular location. Hiscock (1975) indicated a maximum abundance for any location around Lundy of around one colony per 10 m^2, while Irving (1995), using a series of 10 m x 10 m quadrats deployed at three locations reported the densities shown in Table 3.30.

Table 3.29 Summary of supporting information for the assessment of the presence and abundance of *Eunicella verrucosa*. Text in bold indicates a source of possible baseline data.

Location/ Area	**Measure**	**Method**	**Year**	**Frequency**	**No. of stations/ sites/ samples**	**Reference**
Lundy	Abundance of *Eunicella verrucosa*	Diver observation	Not determined	Single study?	Not determined	Hiscock (1975)
Quarry Bay	Growth rates of individual *Eunicella* fans	Diver survey	1984, 1985, 1986, 1987, 1988, 1990, 1995	Annually for 5 years then erratically	One site	Hiscock (1984c), Hiscock (1986b), Howard (1987), Irving (1990)
The Quarries, Gull rock, Brazen Ward, NNW of Gannets' Rock	Counts of *Eunicella verrucosa*: abundance of *Tritonia nilsodhneri*: Condition of individual *Eunicella verrucosa*	Diver survey (volunteer) using 10mx10m quadrats	1995, 1996	Two visits	Four sites	Irving (1995; 1996)
Lundy	Mapped extent of substratum & lifeforms	Acoustic mapping/ RoxAnn & drop-down video	1996	Single study	Not determined	Sotheran & Walton (1997)
Gannet's Rock, Brazen Ward, Gull Rock, The Quarries, Battery Point	Size of individual *Eunicella verrucosa*	*In situ* measurement by diver	1997, 1998, 1999, 2000, 2001	Annually for five years	Total of 485 sea fans	**Irvine & Northen (2004)**
Gannet's Rock, Brazen Ward, Gull Rock, The Quarries, Battery Point	Condition of individual *Eunicella verrucosa*	Diver assessment using a scale of comparative fouling	1997, 1998, 1999, 2000, 2001	Annually for five years	Total of 406 sea fans	**Irvine & Northen (2004)**
North of Quarry Bay	Abundance and condition of *Eunicella verrucosa*	Numbers in 10m x 2m contiguous quadrats	2003	Single study	Two sample areas (one 100m x 4m and the	**Mercer et al (2004)**

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites/ samples	Reference
		between the 12. 5 – 13.5m BCD depth contour			other 120m x 4m)	

Table 3.30 Density of *Eunicella verrucosa* recorded from three locations (Irving, 1995).

Location	Density per 10 m^2
The Quarries	7.7
Gull Rock	10.5
NNW of Gannet's Rock	3.0 (approx)

A broad distribution assessment by Irving (1995; 1996) provides an insight into the occurrence of *Eunicella* around Lundy (Figure 3.14).

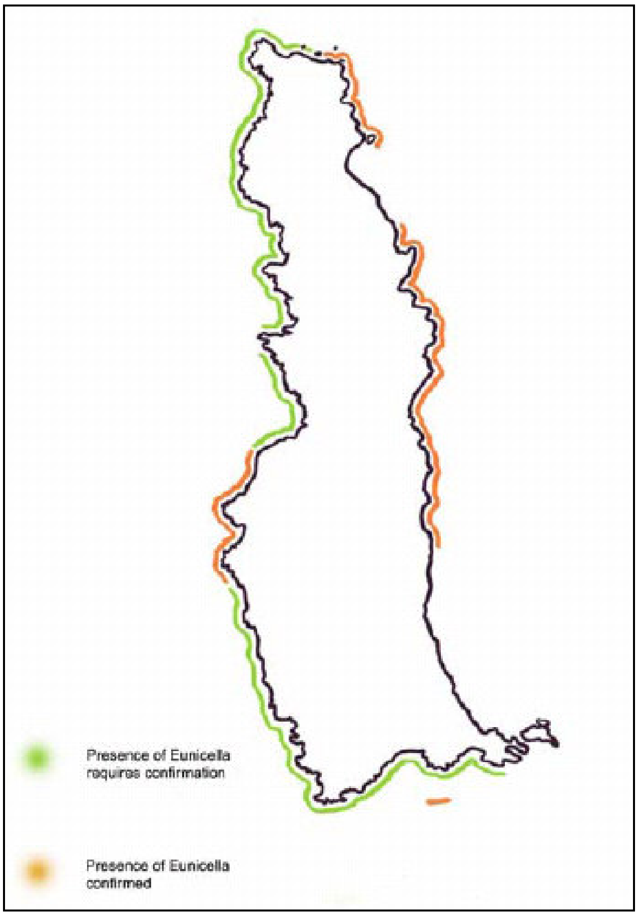


Figure 3.14 Distribution of *Eunicella verrucosa* based on data collected in 1995 & 1996. Reproduced from Irving & Northen (2004).

More recently, Mercer *et al.* (2004) surveyed a single location north of Quarry Bay (Table 3.31) as part a site condition monitoring survey, arriving at a mean density of 1.33 individuals per 10 m^2, a figure close to that originally recorded by Hiscock (1975).

It is not unreasonable to expect broad density variations between locations and we recommend that, for the purposes of condition assessment, baseline values be assigned to well-defined locations and that these locations are periodically re-surveyed using the method used by Mercer *et al* (2004). Accordingly, we suggest that the mean density of 1.33 per 10 m^2 reported from the 2003 monitoring survey be adopted as the baseline for the north of Quarry Bay site.

The density values reported by Irving (1995), although from a similar depth, were obtained using a different survey methodology and should be considered as valuable supporting data. The method adopted by Irving (1995) was slightly more complex than that that of Mercer *et* al (2004), requiring a greater dependency on diver compass navigation. In addition, future survey efficiency, a reduced scope for confusion and an ability to compare between sample sites with greater confidence would benefit from a single survey methodology for all sites. We therefore suggest that, if these locations can be reasonably accurately relocated, they should be resurveyed using Mercer *et al's* (2004) method and a baseline density value established from this survey. Both methods, however, presently provide an ability to express abundance as number per 10 m^2 and thus give broadly comparable indications of historical density estimations.

Table 3.31 Results of the 2003 *Eunicella verrucosa* density survey north of Quarry Bay (Mercer *et al.,* 2004).

Metric	Statistic
Area of seabed surveyed	880 m^2
Number of divers/surveyors	4
Total No. of *E. verrucosa* recorded	117
Average density per 10 m^2	1.33

***Suggested Monitoring Interval*:** 1-3 years.

There is presently a study underway to establish the genetic relationship between UK populations of *Eunicella verrucosa* (J. Stevens & L. Holland, pers. comm.). It is possible that the Lundy population may be genetically isolated and therefore vulnerable to inadequate recruitment and susceptible to disease. We suggest that if the results indicate an isolated population then a mandatory annual monitoring programme should be adopted.

***Suggested Method*:** We recommend that the method of Mercer *et al* (2004) be adopted for this attribute. This would consist of a diver pair repeatedly laying out a 10m transect line, while attempting to follow a single depth contour at between 12.5 m and 13.5 m depth BCD. All sea fans should be counted within a two metre wide strip on both sides of the transect line. The 10 m x 4 m transect would constitute the basic sampling unit.

One of the main problems with the 2003/4 method, however, is the lack of statistical independence of each 10 m section because the 100 m line is laid out end-to-end. To allow valid statistical analyses we suggest that a modification of the method where a randomly generated distance between each 10 m section is incorporated.

In addition, the presence and abundance of *Eunicella* will be influenced by substrate type and, as carried out by Mercer *et al.* (2004), an assessment of the presence of hard and soft substrata should be made within each lengthwise 10 m section of the transect. Areas of upward-facing rock are favoured by this species and this habitat should be specifically targeted for this survey method. If the rock component falls below 30% (the lowest composition encountered by Mercer *et al*, 2004) in any 10 m section, or a mean of 65% across the whole of the transect, then additional 10 m transect sections should be undertaken to replace the sediment rich sections.

***Timing of Survey*:** A *Eunicella* survey should ideally be around, or after, August, when the new recruits to the population will be visible to divers, having achieved a height of greater than 5 cm (K. Hiscock, pers. comm)

***Assessment of change*:** A simple comparison of mean density of *Eunicella* for each survey location will provide a coarse indication of reduction or increase in population. For the purposes of condition assessment a lower threshold value should be set, perhaps of the order of a 30% reduction as an indicator of the unfavourable condition of this feature. The ability to detect this level of change, however, may require a considerable increase in survey effort (see comments and observations below).

***Estimation of Resource Requirements*:** The survey undertaken by Mercer *et al.* (2004) required four divers, a dive pair each taking one dive to complete a 100 m x 4 m 'transect'. This effectively represents a half a day of survey time. The incorporation of a suggested randomised swim distance is likely to increase the number of dives required, but a single location could probably be completed in a single day. We suggest that an additional three locations be identified if suitable densities can be found and incorporated into the monitoring programme, although the implications of the power analysis outlined below will need to be considered before planning a sampling strategy.

***Comments and Observations*:** The *Eunicella* abundance results presented by Mercer *et al.* (2004) were obtained from two dives in 2003, the first 100 m in length and the second 120 m. It is unclear why the transects pairs are of unequal length, but on each side of the transect line the extended transect sections incorporated much increased numbers of *Eunicella* individuals, increasing the average density from what would have been 1.18 per 10 m^2 if all of the transects had been a uniform 100 m in length. This gives a hint at a possible issue with a confounding uneven sea fan distribution within the depth band stratification.

In an attempt to examine whether an increased statistical strength could be applied to Mercer et al's (2004) method we rearranged the data in a form that treated each 10 m length as a single 10 m x 4 m sample, resulting in 22 such samples. Although the samples are partly contiguous, and therefore not conforming to a strictly randomised design, we felt it was satisfactory for a coarse exploration of the power of the sampling design. Unfortunately, however, a preliminary assessment of the frequency distribution of the data (Figure 3.15) very obviously shows that the data do not conform to a normal distribution (although there is an approximate 'uniform distribution) and cannot therefore be examined by parametric power analysis techniques.

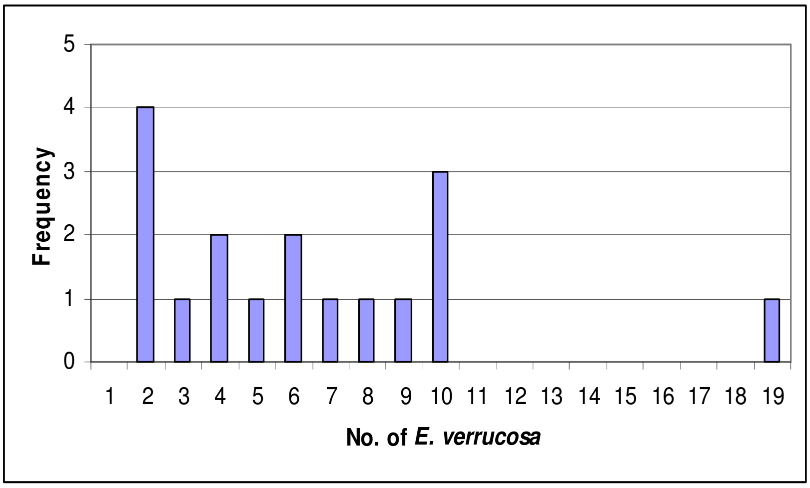


Figure 3.15 Frequency distribution of *Eunicella verrucosa* in twenty-two 10 m x 4 m quadrats taken from north of Quarry Bay in 2003.

We therefore performed a non-parametric power analysis for a Wilcoxon Ranked Sum test (a non-parametric equivalent of a t test) modified for a variable following a uniform distribution based on the 22 'replicate' 10 m x 4 m quadrats collected by Mercer *et al.* (2004) (Table 3.32).

Table 3.32 Results of a power analysis for a Wilcoxon Ranked Sum test based on the abundance of *Eunicella verrucosa* in twenty-two 10 m x 4 m quadrats taken from north of Quarry Bay in 2003. Power = 0.8, Alpha = 0.05.

Mean density (2004)	% change	Mean density (projected)	Replicates required
5.3	50	2.7	49
5.3	40	3.2	76
5.3	30	3.7	134
5.3	20	4.3	299

The analysis indicates that, with a power of 80% (conventionally considered the minimum acceptable to reliably avoid a failure to detect a real difference), 49 replicates (more than double the previous effort) would be needed to detect a 50% change in abundance between two monitoring events. The ability to detect greater change would require a substantial increase in sampling, with, for example, 134 quadrats predicted to be required to allow the detection of a 30% change in abundance. This would effectively amount to over a 6x increase in effort at the Quarry Bay site.

This is, as indicated previously, an estimation based on assumptions that are less than perfect in a statistical sense and we suggest that another sampling visit incorporating the modified methodology is probably required, with an increased number of transects, to further examine the power of this approach.

3.3.7 Attribute: Condition of *Eunicella verrucosa* population (Discretionary)

Target: Maintain the condition of *Eunicella verrucosa*.

Note: This attribute does not strictly conform to the CSM Guidance format as set out by JNCC (2004a). Attributes referring to particular species are conventionally concerned with the maintenance of abundance only. We have included a measure of species condition primarily because the data are available over a significant time interval and because this attribute can be justified as maintaining a credible relationship to the presence and abundance of the species.

Baseline: An examination of the degree of fouling on *Eunicella* individuals, as a measure of their health or condition, was initiated by the Marine Conservation Society in 1997 and continued until 2001 (Irving & Northen, 2004). Five locations, yielding a total of 406 individual sea fans, have been included in the annual surveys (Table 3.33), although none of the locations have been surveyed in every year.

Table 3.33 Summary of supporting information for the assessment of the condition of *Eunicella verrucosa*.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Gull Rock, N Quarry Bay, Brazen Ward, Gannet's Rock, Battery Point	Sea fan condition	Index of % fouling cover	1997, 1998, 1999, 2000, 2001	Annually	Five locations, 406 sea fans	Irving & Northen (2004) , Wood, (2003)
N Quarry Bay	Sea fan condition	% fouling cover	2003	Single study	One site, two transects	(Mercer *et al.* (2004)

The mean condition score for the period 1997 to 2001 was 2.9, but there was a degree of variation across that time period (Table 3.34). The overall condition was interpreted by Irving & Northen (2004) as broadly poor, but indicating a period of further decline between 1999 and 2001.

Table 3.34 Mean individual *Eunicella* condition scores, determined by a quantitative fouling index 1997-2003. Data up to 2001 are taken from Irving & Northen (2004) and the 2003 data from Mercer *et al.* (2004).

	Mean Condition Score					
	1997	1998	1999	2000	2001	2003
Gull Rock	3.3	3.8	4.0	3.0	3.0	
N. Quarry Bay	2.7		3.8	3.1	1.8	2.9
Gannet's Rock	2.1	3.8				

Brazen Ward	4.0	1.0
Battery Point	2.8	2.8

A wider survey comprising the south-west of England, South Wales, and the Channel Islands by Wood (2003) between 2001 and 2002 indicated that the Lundy population tended to carry a much greater degree of fouling than that encountered at any of the other locations surveyed.

A study of the possible causes of *Eunicella* susceptibility to fouling has strongly implicated an infection by a strain of the *Vibrio* bacterium (Hiscock, pers.comm.).

During the 2003 Site Condition Monitoring survey by Mercer *et al.* (2004) a measure of fouling was also undertaken for each of 117 sea fan individuals found at their N. Quarry Bay transects. Although their methodology recorded the extent of fouling in a different way, they were able to apply a correction that allowed them to arrive at a figure directly comparable to previous data (Table 3.34). The 2003 index value of 2.9 is exactly the same as the overall mean score arrived at by Irving & Northen (2004), although a substantial improvement over previous years if viewed as a result for N. Quarry Bay only.

At present, the data suggest that there is a locational difference in the severity and nature of the fouling (further discussed in Irving & Northen, 2004), indicating that a condition index baseline for the whole of Lundy may not be appropriate and site-specific value should be considered. The mean values calculated for each site across the years 1997-2001 (Table 3.35) should provide an adequate set of site-specific baselines for this attribute.

Table 3.35 Mean condition score for each location surveyed between 1997-2001. From Irving & Northen (2004).

Location	Mean condition score
Gull Rock	3.3
N Quarry Bay	2.9
Brazen Ward	2.5
Gannet's Rock	2.1
Battery Point	2.8

***Suggested Monitoring Interval*:** 1-3 years.

At present, there remains some concern that the Lundy population are particularly susceptible to a bacterial infection that promotes fouling. In view of this we recommend that initial monitoring should progress annually until it can be established that the population is in either a stable or recovery phase.

***Suggested Method*:** We suggest that the index given in Irving & Northen (2004) be adopted for this attribute (Table 3.36). In line with the recommended *Eunicella* abundance survey strategy, we anticipate that around four individual locations would yield sea fan condition data from a single survey visit.

Table 3.36 *Eunicella* condition index as measured by degree (%) of external fouling. From Irving & Northen (2004).

Score	Fouling cover (%)
1	>80
2	50-80
3	20-50
4	<20
5	<5

***Timing of Survey*:** Ideally, as in the method used by Mercer *et al.* (2004), this survey element can be completed simultaneously with the *Eunicella* abundance survey (Section 3.3.7), such that each individual counted is also examined and assessed for fouling.

***Assessment of Change*:** A direct comparison of the site-specific index value with the baseline value derived from the mean of the 1997-2001 data.

***Estimation of Resource Requirements*:** No additional resource requirements would be necessary since this assessment would be carried out as part of the abundance survey.

***Comments and Observations*:** None

3.3.8 Attribute: Presence and abundance of *Leptopsammia pruvoti* (Discretionary)

***Target*:** Maintain presence and abundance of *Leptopsammmia pruvoti*.

Note that this attribute is also used as a measure for the **Sea Cave** feature (section 3.1.5). The difference is purely a matter of location and the questionable scale of the cave attribute suggests that it might also be suitable for inclusion as part of this section.

***Baseline*:** A survey to attempt to establish the wider Lundy population size of *Leptopsammia pruvoti* was undertaken in 1999 and 2000 (Irving & Northen, 2004). Five locations were selected on the north-east side of Lundy and a single location on the west side, where previous reports had suggested a presence. A total of around 1,170 corals were found (Table 3.37), but the authors note that the survey was incomplete, with unsurveyed areas in the north-east and north of the Island that are of a suitable topography and are therefore suspected to support *Leptopsammmia*. No corals were found off the west coast.

Because of the broadly defined sample area and the necessarily imprecise method of coral counting, it is unlikely that this work could supply an accurate quantitative baseline. If, however, the sites can be relocated with any degree of accuracy, perhaps with the addition of permanent markers, a method with a greater precision might be applied to specific sample sites, perhaps selecting for the areas with the greatest recorded density.

Table 3.37 Recorded abundance of *Leptopsammmia pruvoti*. From Irving & Northen (2004).

Location	Site	Year surveyed	Abundance
Bobs's Bump (Surveyed as part of separate survey)	Within cave at ~ 36m BCD and on overhang at ~ 22m BCD	1997	40
Knoll Pins	N side of canyon (between Outer & Submerged Pin)	1999	127
Knoll Pins	S side of canyon	1999	220
Knoll Pins	E & S side of Outer Pin (above 20m)	1999	193
Knoll Pins	E & S side of Outer Pin (below 20m)	1999	0
Knoll Pins	E & N side of Submerged Pin	1999	16
Brazen Ward	On vertical face on north side of 1 m wide W-E gully @ ~ 12 m BCD	1999	20
Gannet's Rock Pinnacle	From base of cliff on NE side, north & westwards	1999	~68
Gannet's Rock Pinnacle	From base of cliff on NE side, south & eastwards	1999	187
Gannet's Rock Pinnacle	SE & E side of Pinnacle (to and including cave @ ~28 m BCD)	1999	4
Gannet's Rock Pinnacle northwards	On N side of cave @ ~28 m BCD to easternmost buttress, from boulder interface @ ~ 28 m BCD to ~18 m BCD	2000	10
Gannet's Rock Pinnacle northwards	On N side of buttress (28 m BCD) to start of gravel slope (~ 25 m BCD), up to ~ 18m BCD.	2000	120
Gannet's Rock Pinnacle northwards	On vertical cliff on S & W sides of gravel slope, from ~28 m – 18 m BCD	2000	24

Location	Site	Year surveyed	Abundance
Gannet's Rock Pinnacle northwards	On vertical cliff on S & W sides of gravel slope, above 18 m BCD	2000	33
Gannet's Rock Pinnacle northwards	On vertical/stepped cliff to W & N of gravel slope	2000	96
		Total	1,168 (+/- 50)

Suggested Monitoring Interval: 3-6 years.

Suggested Method**:** Irving & Northen (2004) defined the vertical limit of the sample area for each diver pair by depth range and the horizontal limit by two shot lines placed an arbitrary distance apart. Each diver pair began a search at the deepest depth and progressed in a 'zig-zag' search pattern across the rock face

On subsequent visits, assuming an ability to relocate the original search area, it would be difficult to exactly replicate this type of search pattern and it is therefore highly likely that any two visits would have a high degree of variability in abundance estimates. This would result in an unacceptable level of uncertainty if a low coral count was returned, since there would inevitably be significant doubt about whether the same area had been searched.

We suggest that a maximum of four of the sites that have previously been identified with a comparatively large number of corals be further investigated to examine the feasibility of establishing a more refined relocatable transect approach.

Timing of Survey**:** Previous surveys were undertaken between July and September, but would be largely limited only by the requirement for good diving conditions. Given the obvious overlap in location and task, we recommend that this element be integrated with the *Leptopsammmia* photo-quadrat work at the Knoll Pins cave site.

Assessment of Change**:** Simple numerical comparison of temporal data.

Estimation of Resource Requirements**:** The methodology reported by Irving & Northen (2004) required a maximum of two dive pairs for each survey site; one pair searching the 0-20 m range and the other concentrating on the 20 m+ zone. If four sites were established, this would require a minimum of four days for a four-person dive team.

Since there is presently no programme in place for this attribute a pilot survey would be necessary, in which prospective site would have to be located and verified as suitable for the monitoring task. We estimate that this would require a minimum of an additional four days of time assuming a four-person dive team.

Comments and Observations**:** The establishment and monitoring of four sites for the presence and abundance of *Leptopsammmia pruvoti* represents a considerable investment in survey time for a single discretionary attribute. If this is considered too costly in terms of resources the more quantitatively robust, but spatially restricted Knoll

Pins cave survey data (see section 3.1.5) could be used as a provisional proxy for the *Leptopsammmia* population.

3.3.9 Attribute: Presence and abundance of Lobster *Homarus gammerus*/ brown crab Cancer pagurus/ spider crab *Maja squinado*/ velvet crab *Necora puber* (Discretionary)

Target: Maintain presence and abundance of Lobster *Homarus gammerus*/ brown crab *Cancer pagurus*/ spider crab *Maja squinado*/ velvet crab *Necora puber*.

Baseline: These four species are considered for inclusion in the Lundy Common Standards Monitoring programme, primarily because of the existing NTZ monitoring and the opportunities afforded by the work undertaken over the five years between 2004 and 2008 (inclusive) and reported up to 2007 in Hoskin *et al.* (2009; 2008). This work examined the abundance and size of these species at six defined sites, nested within three broader locations around the island – two sites within the NTZ and four sites outside – together with a further two more distant reference locations (Figure 3.16). For the purposes of the Lundy site condition monitoring only the sampling undertaken within the SAC are considered here, although it is assumed that, should the programme continue, wider comparative assessments of population changes would be maintained where possible.

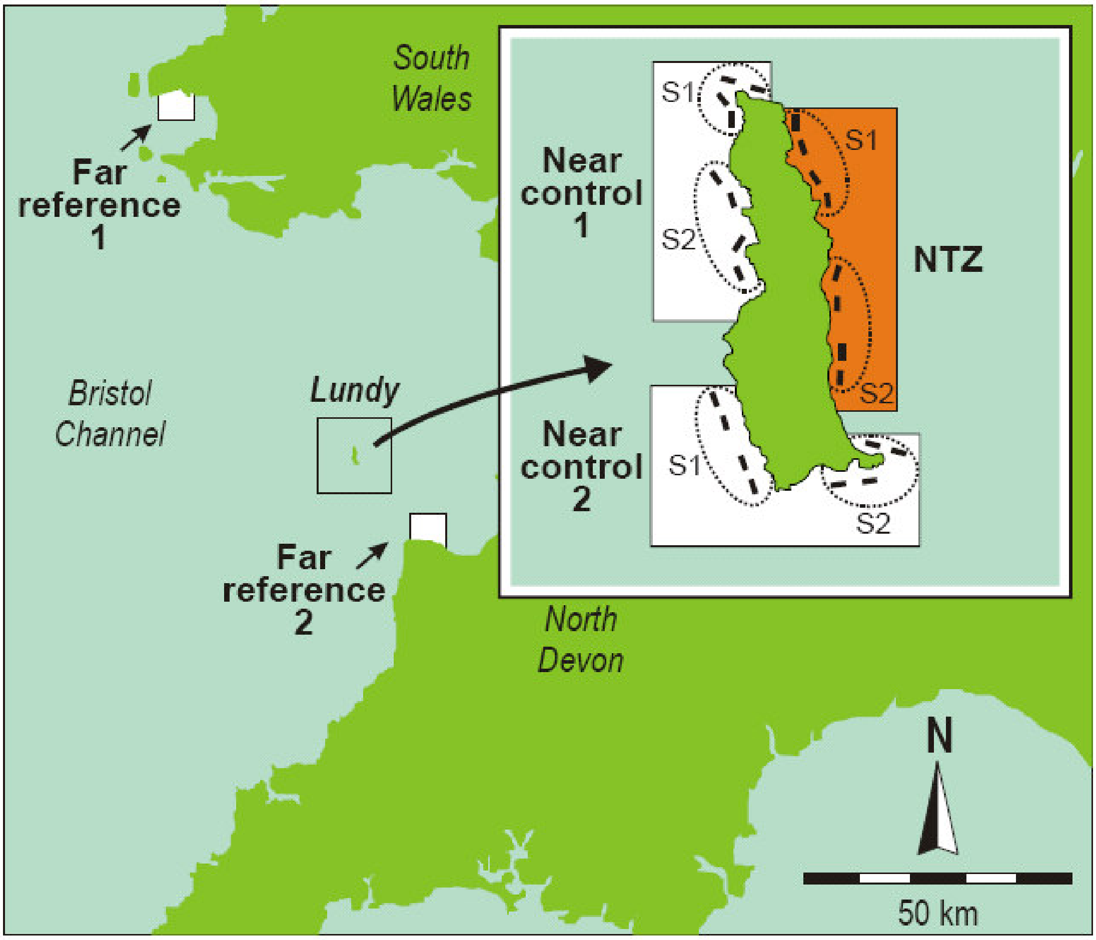


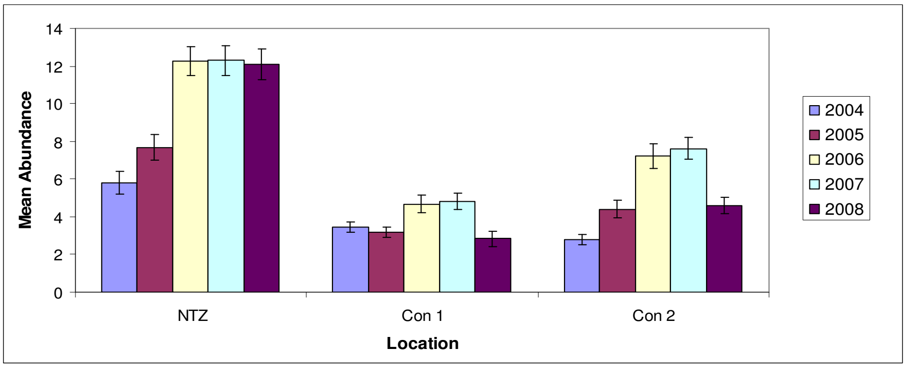
Figure 3.16 Survey sites and sampling arrangement employed to assess the effect of the Lundy NTZ on lobsters and crabs. Reproduced from Hoskin *et al.* (2008).

Results for the period 2004 to 2007 (Hoskin *et al.,* 2009; Hoskin *et al.*, 2008) indicate that:

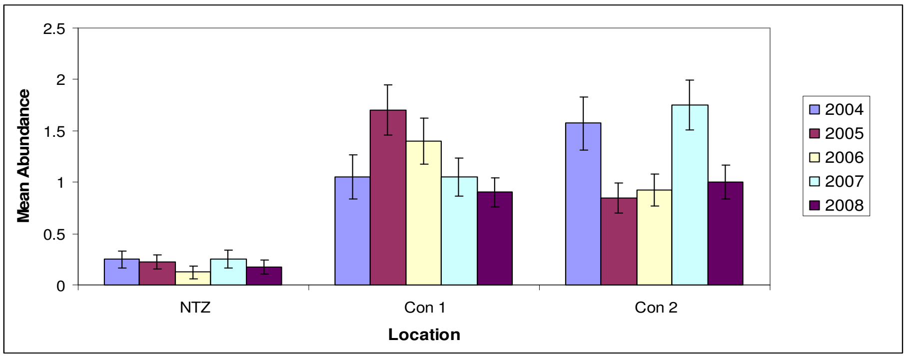
- the mean abundance of lobsters was already considerably higher within the NTZ at the start of the study;
- between 2004 & 2007 mean abundance of landable size lobsters continued to increase in the NTZ while remaining relatively static in the control sites;
- mean abundance of under-sized lobsters increased significantly in both the NTZ and the adjacent control locations;
- brown crabs showed no change in abundance;
- spider crab showed no significant change between 2004 and 2007, although there was a substantial increase in 2006. Hosking *et al.* (2009) points out that this species is highly migratory and thus large abundance fluctuations would be expected, simply reflecting the movements of a transient population;
- velvet crabs declined significantly between 2004 and 2007 and Hoskin *et al.* (2009; 2008) suggests that this decline may be due to increased competition and/or predation interactions with larger lobsters.

At the time of producing this report, further analyses incorporating the 2008 data were not available. To establish whether these data continue to remain broadly consistent with the reported trends we have, however, produced updated charts for each species (Figure 3.17, a-d).

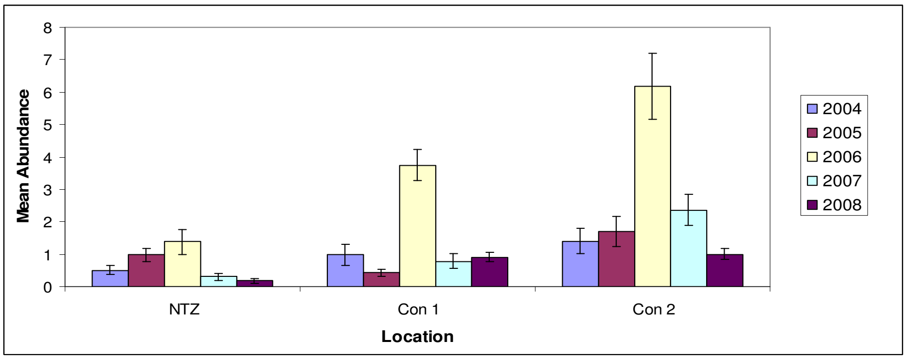
(a) Lobsters



(b) Brown crab



(c) Spider crab



(d) Velvet crab

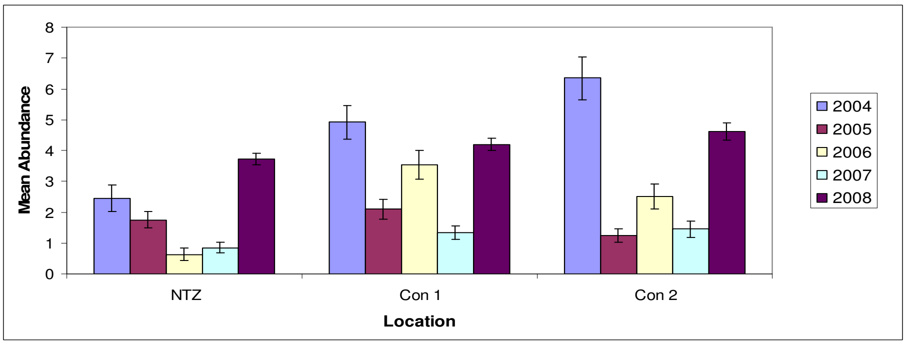


Figure 3.17 Mean abundance of lobster, brown crab, spider crab and velvet crab at each of the NTZ and two control locations 2004 – 2008. Data supplied by Natural England. Error bars indicate +/- standard error.

A full statistical re-analysis of the NTZ monitoring programme is outside the scope of this report, but the following general observations based on Figure 3.17 can be made:

- The mean abundance of lobsters (combined for all size classes), after increasing substantially between 2004 and 2006, have since remained stable up to 2008 in the NTZ
- The overall mean abundance of lobsters remains considerably higher in the NTZ when compared to control locations;
- In 2008 the mean abundance of lobsters within the control locations appears to have declined;
- Brown crab mean abundance is likely to continue to show no significant change in 2008;
- The highly variable pattern of annual spider crab abundance is maintained;
- The 2008 data indicate a comparatively large increase in abundance of velvet crab in both the NTZ and control locations for this year, potentially undermining the hypothesis that the abundance of this species is negatively correlated with lobster abundance.

Suggested Monitoring Interval**:** 1-3 years. To continue to examine the effect of the NTZ at its early establishment phase an annual sampling interval would obviously be desirable. For site condition monitoring however, this intensity of sampling is probably unnecessary for a discretionary attribute and 3-6 years might be more appropriate.

Suggested Method**:** For the maintenance of analytical and statistical consistency the field methodology followed throughout the 2004 – 2007 study and described in detail in Hoskin *et al.* (2009; 2008) would need to be continued. In addition, because of the complexities of the sampling strategy, the subsequent processing and statistical analyses of the data is not straightforward and care must be taken to avoid mistakes in data analysis and interpretation. Hoskin *et al.* (2009), for example, indicates that significant variability in the lobster and velvet crab samples forced a change in data treatment, such that the basic sample unit for these species is the mean abundance calculated from the total individuals taken from a single string of ten pots over five consecutive days. This modification was only possible because each string of pots was returned to the same area on each of the five days.

Moreover, it should also be noted that two levels of log transformation were applied to the data to reduce heterogeneity of variance, L*n*(X+1) for generally high abundant species and L*n*(X+0.1) for data where species were of low abundance.

Timing of Survey**:** All previous sampling has been completed between June and July.

Assessment of Change**:** Statistical analysis of temporal change using a two factor (site x year) ANOVA.

Estimation of Resource Requirements**:** Hoskin *et al.* (2009) indicates that all of the Lundy samples were recovered within the order of about 10 days. Their study also, however, included two 'far reference' locations in South Wales and North Devon requiring a further 5-6 days and 5-8 days respectively.

Comments and Observations**:** As a baseline for assessing change within the context of the inshore sublittoral rock feature, these data have a level of statistical replication rarely found in CSM programmes. Figure 3.17, however, provides an indication of the potential difficulties in establishing a meaningful *feature condition* baseline from these data. Two potential issues present themselves;

1. There are clear location (and probably site) differences for the majority of the species (although in some cases, because of low numbers and a high degree of sample variability, these may not be statistically significant). A large part of these differences are likely to be due to the spatial restrictions on the sampling design. The NTZ occupies the majority of the more sheltered east side of Lundy and both NTZ sample locations are thus unavoidably biased towards this type of location. Conversely, most of the control locations are restricted to the more exposed west side of the island, or at the northern and southern extremities. It is therefore not unexpected that the community character and thus abundance of specific species will differ across the sample locations.

2. High annual fluctuation for some species at some locations/sites is likely to make the nomination of any particular year as a monitoring baseline particularly challenging and prone to regular reassessment.

To avoid a considerable loss of spatial statistical resolution (point 1) we strongly recommend that, when using the NTZ study data, temporal species abundance change within the wider SAC continues to be evaluated for location and/or site separately, i.e. that the data are not pooled or combined for the whole SAC, but are reported individually for the sample locations.

The establishment of the baseline condition (point 2) for each of these species is unlikely to be a simple task. Since the sample locations support sometimes widely different abundance of each species an individual baseline will have to be applied to each location or site, depending on the level of analysis and statistical power.

A key factor influencing the ability to be able to use any of the NTZ study data to detect and assess change is whether there is sufficient abundance in each sample to justify selection as a CSM attribute. As a coarse evaluation we took the 2008 data and calculated the mean abundance and standard deviation for each species and each site (Table 3.38). These parameters provide a rough indication of the ability of the data to detect change, since a larger sample size and proportionately smaller standard deviation (i.e. spread of data) imply a greater statistical power.

Table 3.38 Mean abundance and standard deviation of the 2008 Lundy NTZ crustacean data for each sample site. Each was calculated from the total individuals taken from a single string of ten pots over five consecutive days (Hoskin *et al.*, 2009). Data supplied by natural England.

Site	Species	Mean Abundance	Standard Deviation
NTZ S1	Lobster	63.5	25.0
	Brown Crab	0.5	1.0
	Spider crab	7.8	8.5
	Velvet crab	16.5	1.3
NTZ S2	Lobster	57.3	10.6
	Brown Crab	1.3	1.3
	Spider crab	1.3	0.5
	Velvet crab	20.8	1.9
Con1 S1	Lobster	13.5	10.1
	Brown Crab	4.5	1.9
	Spider crab	2.0	0.8
	Velvet crab	20.3	1.5
Con1 S2	Lobster	19.0	8.2
	Brown Crab	4.5	2.1
	Spider crab	4.0	1.8
	Velvet crab	21.8	3.8
Con2 S1	Lobster	25.3	12.4
	Brown Crab	2.5	1.9
	Spider crab	2.5	2.6
	Velvet crab	20.5	2.1
Con2 S2	Lobster	19.3	7.0
	Brown Crab	7.5	2.1
	Spider crab	29.8	20.3

Site	Species	Mean Abundance	Standard Deviation
	Velvet crab	25.8	3.7

Table 3.38 confirms that the sample abundance of both brown crab and spider crab are very low with a comparatively broad standard deviation and are therefore very unlikely to provide a reliable ability to detect even large changes. Conversely, both lobster and velvet crab appear to have been sampled at a high abundance with a respectable sample distribution about the mean. It is perhaps also worth noting here that each captured crustacean specimen was released back to the site of capture quickly after counting and measuring, providing a possibility that some individuals may have been recaptured and counted more than once over the five-day sampling period. Hoskin *et al.* (2004) indicates that the recapture rate was experimentally examined using a mark-recapture method, but the report does not provide the results of the study. We have assumed that their analysis is based on the assumption that the proportional recapture rate is the same across all sites.

To retrospectively examine the power of the sample design to detect a change in lobster abundance, a single years' data from the two sample sites within the NTZ was selected. Data from 2008 was chosen for the analysis because any future measured change will relate most directly to these data, particularly since there is evidence for year-on-year increase. To compare between two monitoring events we considered a two factor ANOVA (site x year) and used a standard deviation averaged from both the NTZ sites. Based on the 2008 NTZ data, power analysis for a two factor ANOVA suggests that the present level of replication should detect a temporal change of the order of 45% at a power of 80%[7]. Table 3.39 further shows the number of replicates required to achieve up to a 10% change. A preliminary analysis of the lobster control site data indicated broadly similar detection abilities.

Table 3.39 Retrospective power analysis for a two factor ANOVA test for temporal differences in lobster abundance in the NTZ sample sites (2008 data). Power = 0.8, Alpha = 0.05.

Mean Abundance (2008)	% change	Mean density (projected)	Replicates required
60.4	10	54.3	70
60.4	20	48.3	18
60.4	30	42.3	9
60.4	40	36.2	5
60.4	50	30.2	4

A summary examination of the velvet crab 2008 data strongly indicated a greater ability to detect change, but given the presently unexplained temporal fluctuations in the

[7] As the sample sizes were large and variance not significantly different the test was performed on untransformed data

recorded abundance of this species (Figure 3.17d) we do not consider it a suitable candidate for use in condition monitoring.

Of the four species included in the NTZ monitoring programme we therefore conclude only the lobster results supply a level of numerical robustness suitable for possible use in condition monitoring. Even here, the present level of replication would only detect a relatively large change and an increase in the number of replicates strings would probably be required to provide robust support for any future unfavourable site condition judgment.

A further parameter, size frequency, measured as carapace length for lobsters and width for crabs, was also sampled by Hoskin (2009), but time constraints in this project did not allow an exploration of the applicability of this metric for Lundy condition monitoring. Since these data are an important tool in evaluating the effectiveness of the NTZ and are therefore likely to be continued to be collected, we suggest that this element could be incorporated as a separate attribute.

3.3.10 Attribute: Presence of other specified species (Discretionary)

Target 1: Maintain presence of each positive indicator specified species.

Target 2**:** Maintain a limited Lundy distribution of each negative indicator species.

This is a composite attribute incorporating species that have not been individually addressed in previous sections, (See, sections 3.3.6, 3.3.8 and 3.3.9).

We suggest a provisional suite of sublittoral rock-associated positive indicator species that are both conspicuous and potentially vulnerable, while considered representative of the Lundy rock habitats. These may include the following:

Axinella dissimilis
Axinella infundibuliformis
Axinella damicornis
Homaxinella subdola
Raspalia ramosa
Raspalia hispida
Polymastia boletiformis
Polymastia mammilaris
Cliona celata
Alcyonium digitatum
Alcyonium glomeratum
Eunicella verrucosa
Parazoanthus anguicomus
Parazoanthus axinellae
Aiptasia mutablis
Pentapora fascialis

In addition, other species may be selected as specifically undesirable, such as:

Sargasum muticum
Laminaria ochroleuca

Note that this attribute is also strongly linked to the attribute assessing species composition of specific biotopes (section 3.3.5) and differs only in the wider spatial scale over which it applies and a reduction in the emphasis on abundance determination. The presence/distribution of *Sargasum muticum* is also included as a littoral rock attribute (section 3.2.8).

Baseline: There are a range of surveys that provide information on the occurrence of the listed species around Lundy (Table 3.40), although there are considerable differences in the ability to be able to accurately establish the location at which they were observed. Four of the listed studies are likely to provide good baseline information.

Table 3.40 Summary of supporting information for the assessment of presence of specified species. Text in bold indicates a source of baseline data.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Lundy (to 1 km offshore	Habitats and species present	Diver observation with checklists (swimlines, drift dives, towed sledge)	1977	Single study	206 stations	Nash & Hiscock (1978)
Lundy	Species presence and abundance	Diver observation	1978, 1979	Single study over two years	50 sites	Hiscock (1981)
Lundy	Acoustic return/ substrate hardness. Presence of seabed types & lifeformes.	Acoustic mapping/ RoxAnn & drop-down video	1996	Single study	Not determined	Sotheran & Walton (1997)
Lundy	Presence of habitats, biotopes & species	Drop-down video	2003, 2004	Single study over two years	131 stations	**Mercer *et al.* (2004)**
Rat Island, Gannet's Bay, Dead Cow Point, N. Quarry Bay, Knoll Pins, Gannet's Rock Pinnacle, Jenny's Cove, Battery Point	Species presence and abundance	Diver quadrats (0.5 m x 0.5 m = 0.25 m^2 & 0.3 m x 0.3 m = 0.09 m^2)	2003, 2004	Single study	Nine sites	**Mercer *et al.* (2004)**
N Brazen Ward, S Quarry Bay, Dead Cow Point, St. Philip's Stone,	Selected species presence and abundance	Diver quadrats (0.75 m x 0.75 m = 0.56 m^2)	2004, 2005, 2006, 2007	Annually	Four sites, 24 transects	**Hoskin *et al.* (2004; 2006; 2009; 2008)**

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
(2007 only: Halfway Bay, Gannet's Cove)						

Both Mercer *et al.* and (2004) Hoskin *et al.* (2009) provide quantitative data, restricted in spatial cover by the nature of the stratified random sampling strategy adopted for those particular studies. They do, nevertheless, contribute to this attribute since the quadrat records still report the presence of the species within a specified area.

The drop-down video data collected in support of the 1996 broad scale mapping study undertaken by Sotheran & Walton (1997) was not available to us, but is likely to contain relevant information with a much broader coverage of Lundy. The drop-down video approach by Mercer *et al.* (2004) was similarly broad in scope, although the survey design constrained the sampling area to six 1 km wide 'belt' transects extending out the boundary of the SAC (see section 3.3.2). In addition, however, Mercer *et al.* (2004) indicated that during the analysis of their drop-down video survey they also incorporated observations from Sotheran & Walton's (1997) survey.

***Suggested Monitoring Interval*:** Six years

***Suggested Method*:** There are a number of ways in which species 'presence' can be represented for the site. These broadly fall into three categories of increasing detail:

1. The species is still present within the Lundy area;
2. The species is still present at particular areas or locations around Lundy; and
3. The abundance of the species is maintained around Lundy.

Option 3 is a quantitative assessment which can only realistically be addressed by a highly stratified sampling programme, where the abundance of a particular species is examined at discrete locations, which are then used as a proxy for the entire site. This is the basis for the 'species composition of biotopes' attribute (section 3.3.5), but the results from this would obviously also simultaneously inform the 'presence' element.

Option 1 and 2, however, may be determined by less intensive remote visual sampling methods, which may still include stratification over wider spatial scales in order to, for example, reduce the amount of unwanted sampling in sedimentary areas.

The use of a stratified drop-down video sampling design, such as that carried out by Mercer *et al.* (2004) between 2003 and 2004 should be able to provide the necessary data to concurrently address both the' biotope composition' and 'species presence' reporting requirements for the Lundy SAC. All of the species in the provisional list are sufficiently large and conspicuous to be identified by a video capture, although we recommend that the image quality should be maximised by the use of a digital high definition image system with lighting that is sufficiently powerful, evenly distributed and approximates to a daylight colour temperature.

***Timing of Survey*:** This attribute is addressed simultaneously with 'species composition of representative or notable biotopes'. See section 3.3.5.

***Assessment of Change*:** Species presence can be assessed and reported over two spatial scales; either by stratified location or as an aggregation of the data for the whole site. The simplest and coarsest measure would be a confirmation that at least one live individual of each species has been recorded within the Lundy SAC area. A greater resolution is, however, available if the sample numbers and sample locations are used as a comparative metric.

The full data set from the 2003/4 drop-down video survey was unavailable to us, but in order to provide an illustrative example of the type of comparative data available for this attribute, we examined the descriptive reports for each of the drop-down video samples obtained between 2003 and 2004 (Mercer *et al.,* 2004). These descriptions are brief and are highly unlikely to indicate all of the species recorded on the video, but do appear to list the most prominent or numerically abundant. By disaggregating the data to a simple presence-absence matrix for each transect and taking the number of video drops per transect into account, a metric which describes the abundance of each species in terms of an occurrence in a proportion of the video samples can be derived (Table 3.41). Note that the species list in Table 3.41 does not fully conform to the provisional list. The additional species, notably *Caryophyllia* app., *Nemertesia* spp. and *Flustra foliacea* are included here because they were consistently reported and appeared to dominate in some locations at the time of the survey. In addition, some taxonomic groups have had to be aggregated because they were only reported as a Genera or a higher taxonomic group.

Table 3.41 Species or taxon presence as a proportion (percentage) of video drop samples obtained at six 'belt' transects between 2003 and 2004. After Mercer *et al.* (2004).

	The Rattles	Inner Anchorage	Knoll Pins	Northern Points	St. James's Stone	Half Tide Rock	All Transects
Axinellid sponges	26	-	3	12	24	31	15
Polymastia spp.	-	-	-	-	12	9	4
Cliona celata	21	6	-	20	16	49	19
Alcyonium digitatum	21	-	-	4	28	17	11
Eunicella verrucosa	-	-	-	-	8	9	3
Carophyllia spp.	5	-	-	16	20	26	11
Aiptasia mutablis	-	-	3	-	-	-	1
Nemertesia spp	11	9	12	8	16	54	34
Pentapora fascialis	37	9	3	36	28	43	25
Flustra foliacea	16	-	-	20	20	3	8
Laminaria ochroleuca	16	-	6	-	16	6	6

In general, the preliminary observations from this survey suggest a high degree variation in faunal presence at each transect, largely reflected by the geographical location and associated exposure regime and sediment composition. There is, however, an encouraging indication of the relatively high abundance of some of the species proposed as positive indicators, with, for example, *Pentapora fascialis* being recorded in 25% of all of the samples, while *Cliona celata* was also well-represented, achieving nearly 20% of all samples and almost 50% in the Half Tide Rock transect.

These occurrence figures are maintained if the same type of analysis is applied to the 2007 quantitative survey of Hoskin *et al.* (2009), examining for presence in the six transects for each of the fours sites, plus two additional sites established in that year. Both *Pentapora fascialis* and *Cliona celata* were present in 70 % of all of the transects, while *Axinella dissimilis* was present in 94% of all transects and at all survey sites. It is important to remember, though, that their sites were specifically selected for high faunal abundance and that this type of analysis will not be actually necessary for these data since they are suitable for the more rigorous statistical analysis outlined in section 3.3.5.

We suggest that further work may be needed to refine the provisional list and fully determine which Lundy species can be reliably and consistently identified in video footage.

An important feature of presence-absence data that must be understood is that the failure to detect a species in the sampling programme *does not mean that the species is absent*; merely that the species was not found. Once a failure to detect a positive indicator species has occurred, further survey will be necessary to confirm the situation before declaring an unfavourable judgment.

***Estimation of Resource Requirements*:** This attribute is addressed simultaneously with 'species composition of representative or notable biotopes'. See section 3.3.5.

***Comments and Observations*:** We recommend that further use of presence-absence data should be explored, particularly in the use of drop-down video data, presently being employed in monitoring programmes to support broad-scale mapping and to determine biotope presence and distribution. There has been a considerable increase in interest in the use of presence-absence data for conservation management and although time constraints on this project meant that we could not devote any time to this area, we suggest that an exploration of the recent advances in this subject might improve and enhance the use of these data. (For further information see Joseph *et al*., 2006; MacKenzie, 2005; Pollock, 2006; Pollock *et al*., 2002; Royal & Nichols, 2003; Strayer, 1999; Vojta, 2005)

3.4 Feature: Inshore Sublittoral Sediment

3.4.1 Attribute: Extent of Inshore sublittoral Sediment (Mandatory)

***Target*:** No change in the extent of the inshore sublittoral sediment

***Baseline*:** The majority of the surveys that have either concentrated on the sediments or have a sediment component (Table 3.42) have been largely focused on biological sampling, either by core, grab or dredge. These surveys have been listed here because an ability to retrieve samples indicates the presence of sediment. The older surveys, however, will provide only a broad indication of distribution as the stated positions will not have been recorded with a high degree of accuracy.

Table 3.42 Summary of supporting information for the assessment of extent Inshore Sublittoral Sediment. Text in bold indicates a source of baseline data.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Bristol Channel	None	Dredge sampling	c.1850	Single study	Not determined	Forbes (1851)
Lundy (to 1 km offshore)	Habitats present	Diver observation with checklists (swimlines, drift dives, towed sledge)	1977	Single study	206 stations	Nash & Hiscock (1978)
Bristol Channel	Faunal abundance	Grab and dredge sampling	c. 1977	Single study	155 stations (Bristol Channel)	Warwick & Davies (1977)
East Lundy	Faunal abundance	Core & suction sampling	1975, 1978	Single study	Not determined	Hoare & Wilson (1977)
Lundy	Acoustic return/ substrate hardness	Acoustic mapping/ RoxAnn & drop-down video	1996	Single study	n/a	Sotheran & Walton (1997)
Lundy	Multibeam sonar mapping	Multibeam sonar & grab sampling	2007	Single study	n/a	**Nunny & Smith (2008)**
Lundy	Presence of substrate and biological communities	Drop-down video in defined belt transect areas	2003, 2004	Single study over two years	130 stations	Mercer et al (2004)

A broad delineation of the distribution and extent of sublittoral substratum was first attempted by Nash and Hiscock (1978) and Hiscock (1981) as part of the *South-west Britain Sublittoral Survey*. Subsequent to these surveys, a map of sublittoral bottom types contained within the Voluntary Marine Reserve boundary was presented in Hiscock (1983) and is reproduced in Irving (2005), together with estimations of the area of sublittoral substratum types (Table 3.43). The position-fixing for these surveys was, not unsurprising for the time, rather crude by today's standards and will not provide the level accuracy required for a measure of change.

Table 3.43 Area (approximate) of sublittoral sediment substratum types within the Lundy Voluntary Marine Reserve. Taken from Irving (2005) (after Hiscock, 1983).

Substratum type	Area (ha)
Gravel	197.9
Sand and gravel	209.1
Sand	28.9
Coarse sand	15.0

Substratum type	Area (ha)
Mud and gravel	6.7
Mud	48.4
TOTAL	**506**

A broad scale mapping survey was carried in 1996 using the RoxAnn seabed classification system coupled with video ground-truthing (Sotheran & Walton, 1997). The ability of this survey to discriminate between some types of hard and soft substratum habitat types has been questioned, however, and the use of the maps generated may have to be interpreted with caution when defining the extent of sublittoral sediment.

A second broad scale mapping survey was undertaken around Lundy in August 2007 (Nunny & Smith, 2008) utilising high resolution multibeam sonar data collected for MESH in 2005. This survey was specifically tasked to map and characterise sedimentary habitats (Figure 3.18) and is a good baseline for this attribute.

The coverage is reported to be accurate and comprehensive, with a minor level of uncertainty in the southern end of Lundy, where the margin between rock and sediment has been difficult to determine (R. Nunny, pers. comm). The accuracy of the map is expected to be further enhanced by the addition of Marine Coastguard Agency multibeam backscatter data in the near future and some further work to incorporate historical biotope mapping data is also planned.

The data have been entered in the MapInfo GIS system and are therefore available in a form in which extent can be directly calculated.

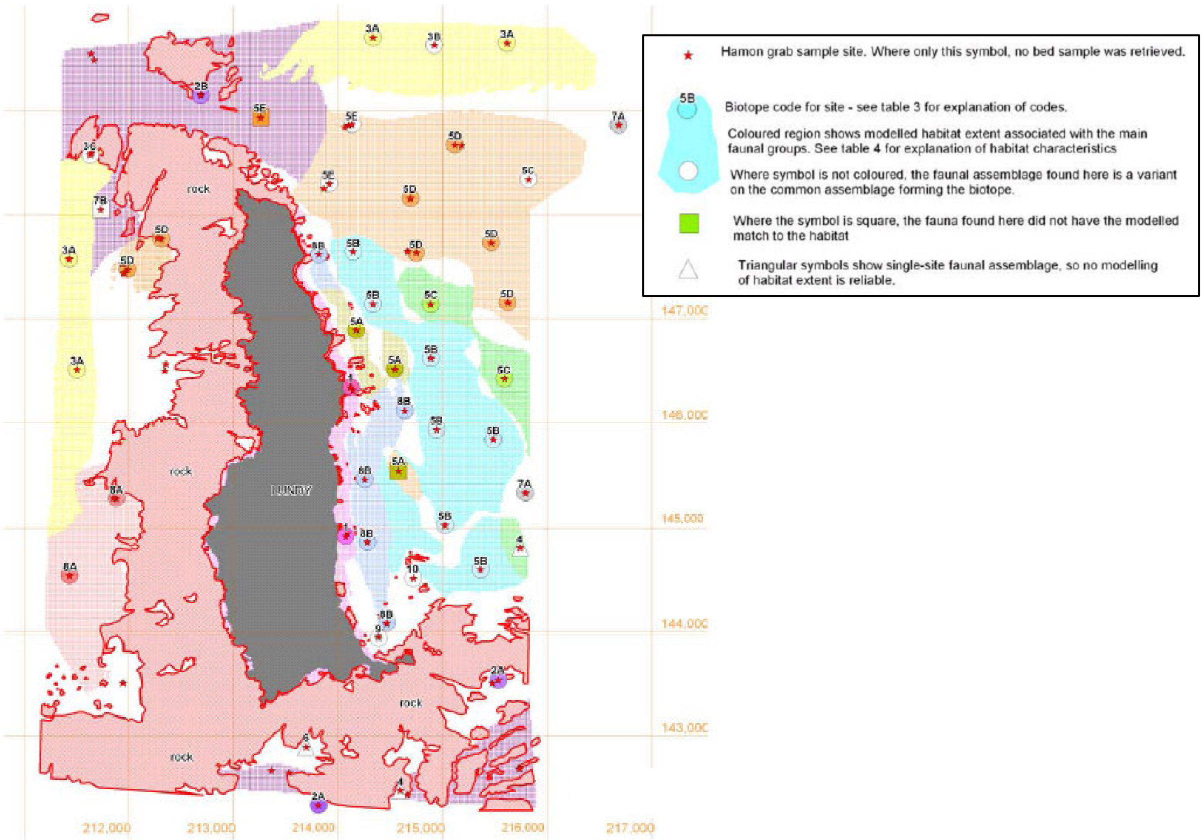


Figure 3.18 Distribution and extent of sublittoral sediment around Lundy. Reproduced from Nunny and Smith (2008).

***Suggested Monitoring Interval*:** 18 years.

***Suggested Method*:** Acoustic mapping and ground-truthing with grab sampling.

***Timing of Survey*:** Sampling was undertaken at the end of August in the 2007 broad scale mapping survey. The ground-truthing component of the sediment survey, which provides community/biotope information, was undertaken by grab sampling which, for comparative purposes, should be carried out at the same time of the year. The next mapping survey should, however, be coordinated with both the sediment sampling and the sublittoral rock drop-down video programme to combine the ground-truthing required for both features. Mercer *et al.* (2004) carried out their drop-down video monitoring over two years (2003 and 2004), with the majority of the drops being in June of both years and a few in September of 2004. We suggest that the sediment grab and drop-down video sampling programmes be aligned to occur in the months between late July and early September.

If we assume that the 2007 data are adequate for present CSM reporting, and the monitoring interval suggested in this report is adopted, then no further broad-scale data will be required for a further 16 to 22 years.

***Assessment of Change*:** Import into GIS and quantify area. Directly compare calculated areas against the 2007 baseline.

When making the comparison it is important to consider any difference in the resolution of each survey. Future advances in hardware and data processing, together with increased sampling intensity is likely to provide a greater resolution which may influence the result obtained for the total area.

***Estimation of Resource Requirements*:** The acoustic element of this work was completed in 11 days in June of 2005. We therefore suggest that assuming favourable weather and with a margin for unforeseen difficulties, 12 days would be adequate to repeat the broad-scale mapping element of the survey.

Nunny & Smith (2008) indicate that the grab sampling element of their survey was completed in three days. We suggest that assuming favourable weather and with a margin for unforeseen difficulties, five days would be adequate to repeat the ground-truthing element of the survey.

***Comments and Observations*:** Nunny & Smith (2008) have demonstrated that there is active sediment transport through wave and tidal action, with some fallout of fine sediments from suspension. Its does not seem likely, however, that there is appreciable accretion or erosion, so a loss or an increase in sediment area relative to rock is not expected in the medium to long term.

3.4.2 Attribute: Topography of Inshore Sublittoral Sediment (Mandatory)

***Target*:** No alteration in topography of the inshore sublittoral sediment, allowing for natural responses to hydrodynamic regime.

***Baseline*:** Bathymetric profiling is an integral part of the broad scale mapping process and is addressed simultaneously with the 'extent of Inshore Sublittoral Sediment' attribute. The data collected by Nunny & Smith (2008) is considered to be a good baseline for both attributes.

***Suggested Monitoring Interval*:** 18 years

***Suggested Method*:** Acoustically-derived bathymetry compared with baseline.

***Timing of Survey*:** As for the extent of Inshore Sublittoral Sediment.

***Assessment of Change*:** Assessment of the depth distribution/ profile of the inshore sublittoral sediment and periodic comparison with baseline conditions.

***Estimation of Resource Requirements*:** As for the extent of Inshore Sublittoral Sediment

***Comments and Observations*:** None

3.4.3 Attribute: Sediment character: sediment type (Mandatory)

***Target*:** No change in composition of sediment types across the feature, allowing for natural succession/ known cyclical change.

Baseline: Sediment type is conventionally defined by the proportional composition of standardised particle size fractions, requiring laboratory treatment, sorting and analysis.

Although historical sediment characterisation has been carried out, only the data collected by Nunny & Smith (2008) provides the level of positional detail and sampling intensity to establish a baseline condition. They set out to sample 52 sediment stations (Figure 3.19), but failed to recover suitable samples from nine of the stations, leaving 43 samples remaining for particle size analysis (PSA) determination. The geographical coverage is, however, adequate for evaluating change across the range of Lundy sublittoral sediment types, although an increased resolution incorporating more samples may be an option in the future.

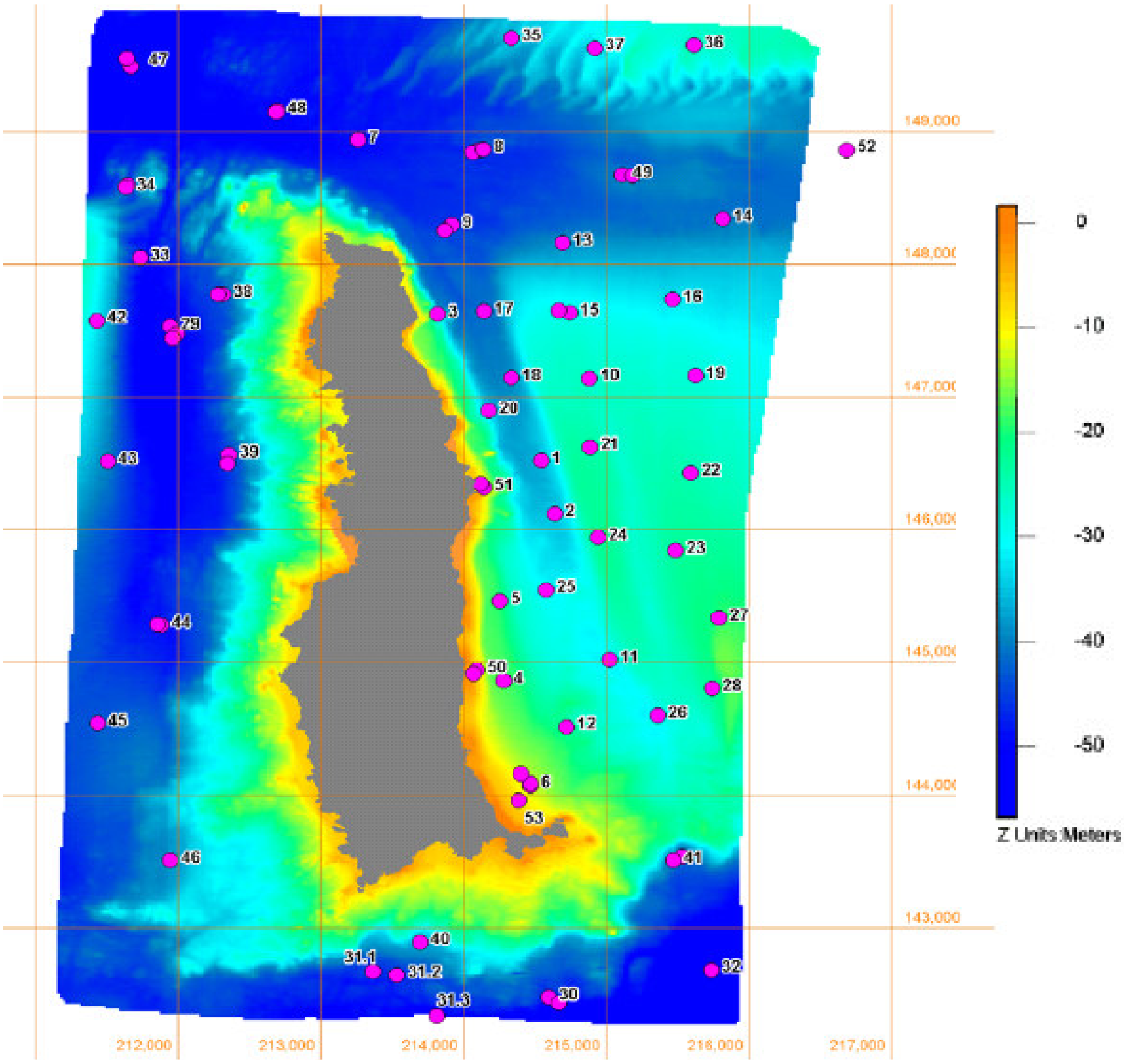


Figure 3.19 Sediment grab sampling stations, 2007. The colour scale represents depth in metres below Chart Datum. Reproduced from Nunny & Smith (2008).

***Suggested Monitoring Interval*:** Sediment samples for PSA will be simultaneously collected with biological samples and will therefore be dependent on the six-yearly interval established for this attribute.

***Suggested Method*:** Standard PSA sampling, processing and analyses methods are widely available and guidance for achieving constant results is published and followed by most survey practitioners. Standardised procedures should be requested and contracted laboratories should be part of a recognised QA scheme such as the European Biological Effects Quality Assurance in Monitoring Programmes (BEQUALM) or the UK National Marine Biological Analytical Quality Control Scheme (NMBAQC).

***Timing of Survey*:** Particle size analysis samples are likely to be sub-sampled directly from biological grab samples, thus they will be expected to be obtained between late July and early September.

***Assessment of Change*:** Assess change at each station in terms of the proportion (percentage) of each of silt/clay, fine sand, medium sand, coarse sand and gravel (Udden/Wentworth scale).

The proportion of each component should not deviate from baseline by +/- 10% at each station. *This figure is tentative* since we currently do not know the natural variation or the degree of change that might precipitate an unfavourable change in biological communities and future adjustments may be necessary.

More robust temporal statistical analyses (discussed in Eleftheriou & McIntyre, 2005) can be performed on derived descriptive parameters for each sample, such as:

- measures of central tendency (mean, median and mode)
- measures of scatter around a central value (dispersion, deviation, sorting)
- measures of the degree of asymmetry (skewness)
- measures of the degree of peakedness (kutrtosis)

These may, however, incorporate a level of detail unnecessary for CSM purposes and, as above, would be subject to future assessments and adjustments in the light of biological information.

***Estimation of Resource Requirements*:** As for 'distribution of inshore sublittoral sediment biotopes' attribute.

***Comments and Observations*:** None

3.4.4 Attribute: Distribution of Biotopes (Mandatory)

***Target*:** Maintain the distribution of biotopes, allowing for natural succession/known cyclical change.

***Baseline*:** From a monitoring perspective the habitats and species associated with the sublittoral soft substrata are poorly documented. Irving (2005), when reviewing the survey literature available for all of Lundy's habitats, observes that "…*there has been relatively little survey work undertaken investigating the habitats or fauna associated with the island's subtidal sandbanks*".

Of the few documented examples of direct sampling of infaunal communities (Table 3.20) only the survey of Nunny & Smith (2008) is sufficiently recent or of the required distribution and intensity to meet the criteria for a baseline data set.

Figure 3.20 Summary of supporting information for the assessment of biotope distribution of Inshore Sublittoral Sediment. Text in bold indicates a source of baseline data.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Bristol Channel	None	Dredge sampling	c.1850	Single study	Not determined	Forbes (1851)
Lundy (to 1 km offshore)	Habitats present	Diver observation with checklists (swimlines, drift dives, towed sledge)	1977	Single study	206 stations	Nash & Hiscock (1978)
Bristol Channel	Faunal abundance	Grab and dredge sampling	c. 1977	Single study	155 stations (Bristol Channel)	Warwick & Davies (1977)
East Lundy	Faunal abundance	Core & suction sampling	1975, 1978	Single study	Not determined	Hoare & Wilson (1977)
Lundy	Acoustic return/ substrate hardness	Acoustic mapping/ RoxAnn & drop-down video	1996	Single study	n/a	Sotheran & Walton (1997)
Lundy	Faunal abundance	Multibeam sonar & grab sampling	2007	Single study	49 grab samples	**Nunny & Smith (2008)**
Lundy	Presence of substrate and biological communities	Drop-down video in defined belt transect areas (mainly rock)	2003, 2004	Single study over two years	130 stations (mainly rock)	Mercer et al (2004)

The remaining, more recent, studies are dependant on remote video observation which provides an unknown, but probably limited account of Lundy's infaunal communities. Irving (2005) comments that the Sotheran and Walton broad-scale mapping survey, for example, was only able to distinguish four sediment-based 'life-forms' and he concluded it to be to be no more accurate than the habitat distribution data produced by Nash & Hiscock (1978).

Nunny & Smith (2008) used a mini Hamon grab (0.04 m^2), chosen to provide the best chance of acquiring reasonable samples of the coarse (gravel/cobble) substrates thought to be common around Lundy. Sample stations were planned to give a good geographical coverage in relation to an initial assessment of the likely biotope distribution. Sampling was undertaken in 2007, with adequate faunal grabs being obtained from 49 of the intended 52 stations (Figure 3.19 – prev. section).

***Suggested Monitoring Interval*:** 6 – 12 years. We suggest that the first monitoring visit should be set at six years or even less to allow an early determination of the stability and persistence of the baseline biotopes.

***Suggested Method*:** The recommended baseline data were collected using a sampling strategy that set out to support a broad scale mapping programme, with sample stations assigned in a non-random manner, principally distributed to cover the range of expected sediment types and associated biotopes. For future monitoring there are two alternatives that should be considered:

1. Randomise the future sample design, i.e. generate sample stations that are geographically randomly distributed. This would allow a statistically valid temporal comparison, with the ability to infer the proportional biotope composition of the site.

2. Maintain and re-sample the 2007 sample stations, making the assumption that the survey biotope cover is adequate for detecting change over the site as a whole. In practical terms this strategy would give an indication of change at *each sample station only* and this would have to be accepted as a proxy for indicating change throughout the whole site.

On balance, we recommend the latter option as this allows the 2007 sampling to be immediately utilised as an established baseline.

It should be noted that Nunny & Smith (2008) experienced some difficulty in assigning existing JNCC biotopes to their infaunal samples. Difficulties in achieving exact biotope matches from survey data are, in general, not unusual, but more common for sedimentary communities, which remain poorly characterised. This obviously presents a significant obstacle when attempting to determine whether undesirable infaunal community change has occurred.

To determine community groups Nunny & Smith (2008) subjected the grab sample data to cluster analysis (Bray Curtis Similarity, Figure 3.21), with the grouping subsequently confirmed using a non-metric multidimensional scaling ordination. Prior to analysis the data were log (x+1) transformed to reduce the influence of numerically dominant species. A further step of weighting the groups according to key species and substrate type was applied and 19 discrete community types, referred to as ‘proto-biotopes’ were identified. See Appendix 2 for the full list and associated characterising species.

We suggest that these ‘proto-biotopes’ be adopted as the baseline for the Lundy inshore sublittoral sediment biotope set, perhaps with an expectation that further refinement may be required in the future. If future samples are processed and treated in the same way as the 2007 samples, then cluster analysis can be applied to a combined data set and the similarity between baseline and repeat sampling station evaluated.

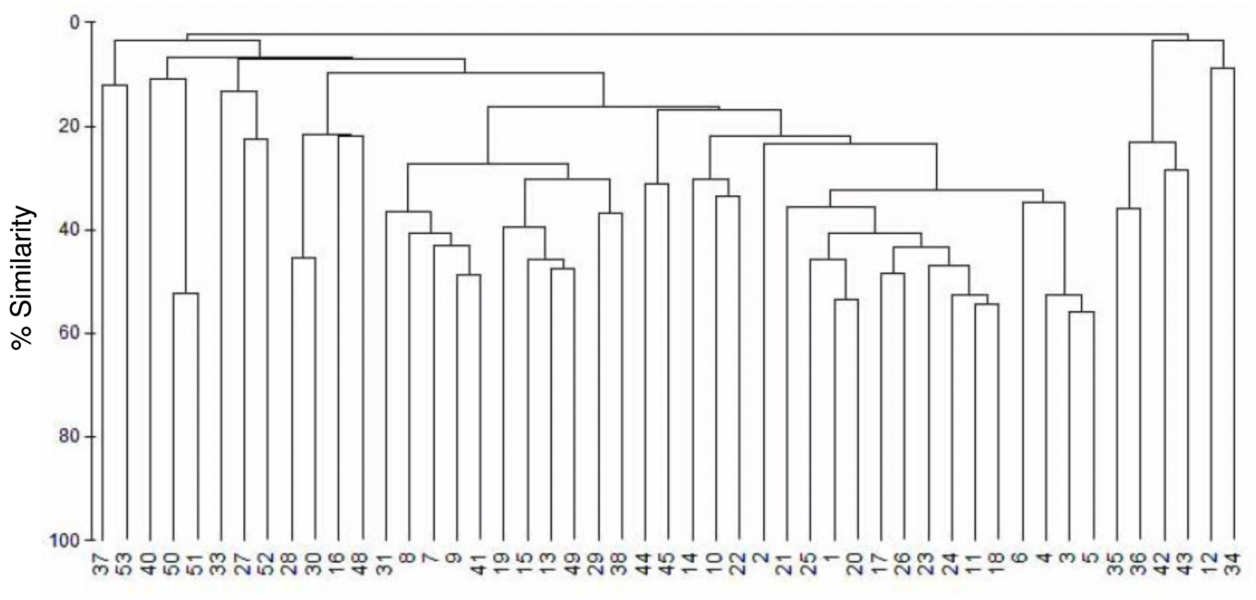


Figure 3.21 Cluster analysis (Bray Curtis similarity; log (x+1) transformed data) of infaunal grab samples collected in August/September 2007. Reproduced from Nunny & Smith (2008).

***Timing of Survey*:** It is important for subsequent surveys to repeat the grab sampling at the same time of year. Physical processes, such as winter storms, water temperature, nutrient cycling, coupled with species-specific breeding cycles, can result in large fluctuations in individual species abundance, particularly at times of juvenile recruitment, where transient population increases can temporarily change or obscure community structure.

The samples from which the suggested baseline is derived were collected in August/September.

***Assessment of Change*:** The maintained presence of 'proto-biotopes' should be evaluated at specified locations. If these communities prove resilient then a future formalisation step should be considered in which they are described and adopted as legitimate biotopes.

***Estimation of Resource Requirements*:** Nunny and Smith (2008) indicate that the grab sampling element of their survey was completed in three days.. We suggest that assuming favourable weather and with a margin for unforeseen difficulties, five days would be adequate to obtain repeat samples from each station.

***Comments and Observations*:** Nunny and Smith (2008) have demonstrated that there is active sediment transport around Lundy through wave and tidal action, with some fallout of fine sediments from suspension. The extent to which this is influencing change in community structure is unknown, but it seems sensible (for the next monitoring survey) to assume that a degree of equilibrium is maintained over the period of a monitoring cycle and that there is subsequently a good chance of recording similar community structure at each sample station on a repeated visit. More information is, however, needed on the long-term stability of each community.

3.4.5 Attribute: Extent of sub-feature or notable biotope(s) (Discretionary)

Target: No change in extent of the inshore sublittoral sediment biotope(s) or subfeature identified for the site allowing for natural succession/ known cyclical change.

Baseline: There is no baseline for this attribute.

Infaunal grab sampling is the method of preference for providing detailed descriptions of sedimentary communities. This method is, however, expensive and time-consuming because of the need to collect, process and identify infaunal samples. In general, as an alternative, remote visual sampling, such as drop-down or ROV video provides very limited information for sedimentary habitats since the majority of the biota is within the soft substratum.

It has been suggested (Hiscock per. comm.) that the sediments around Lundy have sufficient abundance of conspicuous epifauna/flora to justify considering the deployment of high-resolution drop-down video as part of a separate survey programme. Due to that lack of detailed information on sedimentary epifauna density around Lundy we are unable to comment on the degree of resolution this method would provide. Some previous studies (Table 3.44) may provide a coarse guide to density expectations and possible locations where this method might prove appropriate.

Table 3.44 Summary of possible supporting information for the assessment of extent of sub-feature or notable biotopes.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Bristol Channel	None	Dredge sampling	c.1850	Single study	Not determined	Forbes (1851)
Bristol Channel	Faunal abundance	Grab and dredge sampling	c. 1977	Single study	155 stations (Bristol Channel)	Warwick & Davies (1977)
Lundy (to 1 km offshore)	Habitats present	Diver observation with checklists (swimlines, drift dives, towed sledge)	1977	Single study	206 stations	Nash & Hiscock (1978)
Lundy	Acoustic return/ substrate hardness	Acoustic mapping/ RoxAnn & drop-down video	1997	Single study	No. of drop-down video station not determined	Sotheran & Walton (1997)
Lundy	Presence of substrate and biological communities	Drop-down video in defined belt transect areas (mainly rock)	2003, 2004	Single study over two years	130 stations (mainly rock)	Mercer et al (2004)

Suggested Monitoring Interval: 6 years

***Suggested Method*:** Either a stratified random sampling design to evaluate community/biotope distribution, or a directed survey to determine the distribution, presence and abundance of particular species or habits. Hiscock (pers. comm.) stressed that this method required the use of high resolution video.

***Timing of Survey*:** The timing of the survey will largely depend on the target species and communities. We suggest that this element could be included as an extension of the inshore sublittoral rock drop-down video monitoring programme and thus would be directly constrained by the timing of that programme.

***Assessment of Change*:** The ability of this particular method to detect change is difficult to assess at this point. The power of a stratified randomised design would be entirely dependent on number of habitats, communities or biotopes that could be identified and subsequently re-identified with confidence. We suspect that the ability to reliably achieve consistent results is likely to be limited and a more targeted approach either for a defined location and habitat with a known high epifaunal density, or a determination of the presence and distribution of a particular species, such as *Cepola rubescens* (see section 3.4.7).

***Estimation of Resource Requirements*:** We suggest that an initial pilot study of no more that two days' sampling may be appropriate. This should allow 80+ video samples to be collected.

***Comments and Observations*:** This is a 'speculative' attribute included at the suggestion of Keith Hiscock.

3.4.6 Attribute: Presence and abundance of great scallop *Pecten maximus*

***Target*:** Maintain presence and abundance of *Pecten maximus*.

***Baseline*:** Only two studies are relevant to this attribute (Table 3.45). Irving & Northen (2004) provides an account of an attempt to quantify scallop density in 1998 and 1999. They found that the densities within their search area were very low and only a total of 19 scallops were located over 10 search dives.

Table 3.45 Summary of possible supporting information for the assessment of extent of sub-feature or notable biotopes.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Lundy (east coast)	Scallop counts	Counts. along a 50m transect line in 198; spot dives in 1999	1998, 1999	Single study	10 sites	Irving & Northen (2004)
Lundy (east coast)	Scallop counts	Counts along a 10	2004, 2005,	Single study	Two locations,	Hoskin *et al.* (2004; 2006;

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
		m x 3 m transect	2006, 2007		four sites, 24 plots with four transects per plot	2009; 2008)

In 2004, Hoskin *et al.* (2008) established four survey sites to examine the effect of the No Take Zone (NTZ) on the abundance and size distribution of a number of species, of which one was *Pecten maximus*. Of the four study sites, two are within the NTZ and the remaining two are control or reference sites, outside the NTZ and located further to the east (Figure 3.22).

The NTZ sites are within the SAC boundary and are therefore available as possible indicators of site condition. Both of the control sites are likely to be outside the SAC and are thus technically irrelevant to the CSM programme, although changes here may also provide useful supporting information for future condition monitoring assessments.

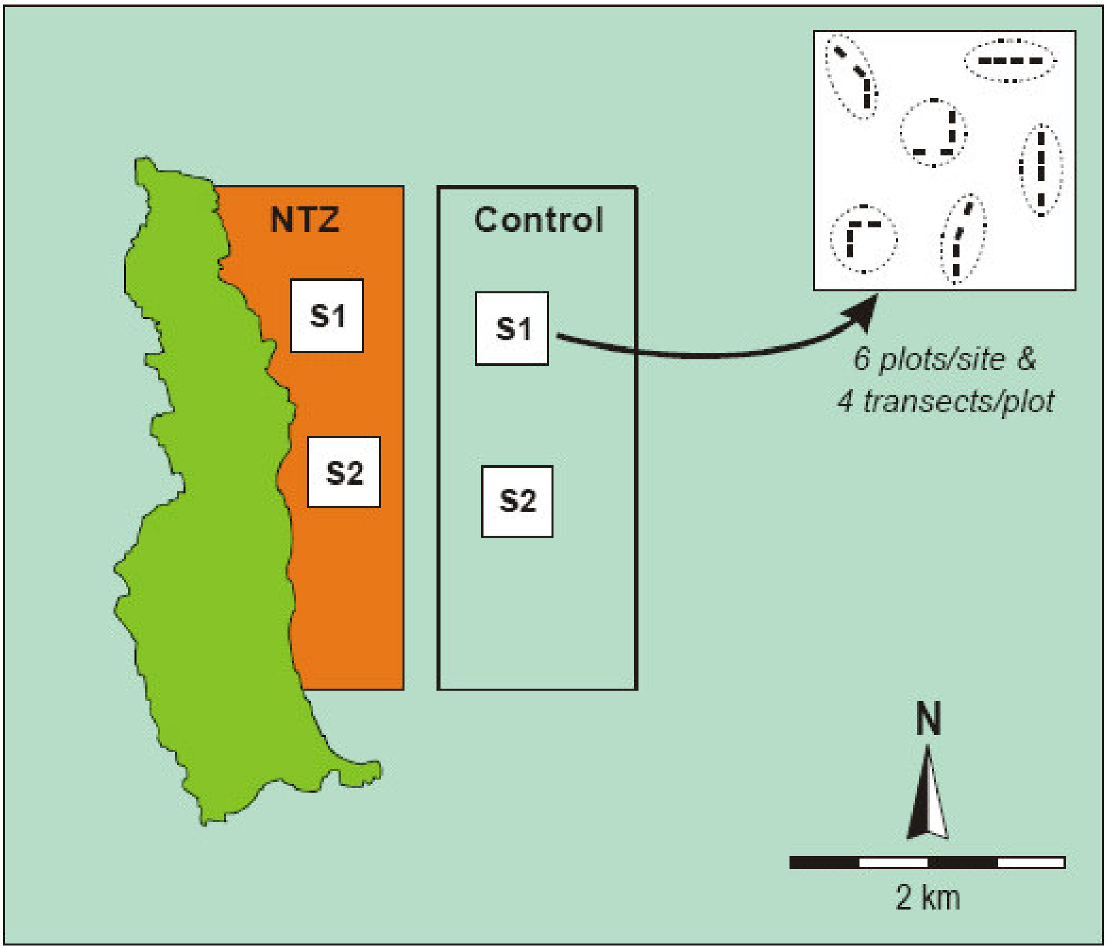


Figure 3.22 *Pecten maximus* sampling design for evaluating the effects of the NTZ, 2004 – 2007. Reproduced from Hoskin *et al.* (2008).

Transect sampling for *Pecten* abundance has been completed for each of four years: 2004, 2005, 2006, and 2007. Unfortunately, poor weather conditions forced a reduction in the number of samples taken in 2004, preventing a balanced ANOVA analysis unless samples were discarded from subsequent years. While this was considered desirable for the NTZ effect monitoring, for CSM the ability to retain the statistical power to assess change over the remaining three years is perhaps more important and the option to disregard the 2004 data should be considered. Indeed, Hoskin *et al.*(2009) tested for a difference between the 2004 and 2005 scallop data and concluded that there was no significant difference in mean abundance, thus allowing the use of the 2005 data as a baseline for subsequent analyses.

Although this programme was originally set up examine the possible positive effects of the NTZ on the scallop population as a two factor study (site x year), the temporal element alone may provide an opportunity to evaluate changes that may be directly related to the condition of the inshore sublittoral sediment feature, with the 2005 data similarly adopted as a baseline.

The pilot study (Hoskin *et al.*, 2004) reported a greater abundance of scallops in the NTZ sites in comparison to the control sites, but by 2007 the difference was less apparent. In both locations, however, the densities observed throughout the study have been very low (Figure 3.23) and there are clear abundance differences between sample sites within the NTZ.

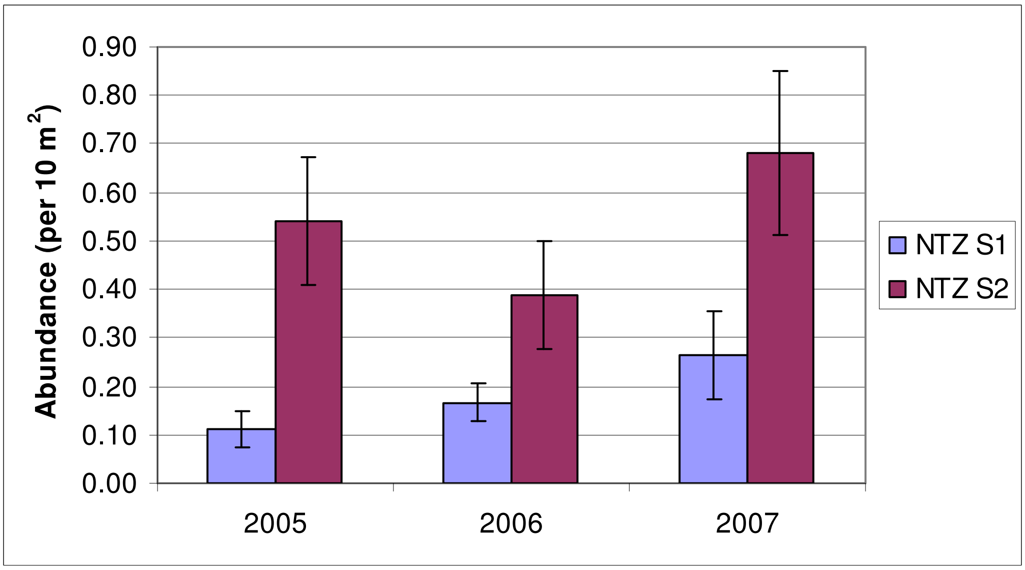


Figure 3.23 Mean abundance of *Pecten maximus* observed in the two NTZ sample sites between 2005 and 2007. Error bars indicate standard error.

Suggested Monitoring Interval: 1 - 6 Years. Subject to increased recruitment – see comments below.

Suggested Method: For the maintenance of analytical and statistical consistency the methodology followed by Hoskin *et al.* (2008) would need to be continued.

***Timing of Survey*:** The timing of the previous diving surveys are not given in the NTZ monitoring reports (Hoskin *et al.*, 2006; Hoskin *et al.*, 2008) although the report of the 2004 pilot studies (Hoskin *et al.*, 2004) suggest diver sampling was undertaken between August and September (at least for 2004). It is unlikely that the exact sampling time is critical for this attribute, but since diving is required it would be undertaken within a summer field season.

***Assessment of Change*:** Hoskin *et al.*(2008) used analysis of variance (ANOVA) (combined with pair-wise comparisons of means using the Student Newman-Keuls test) to assess statistical differences between samples from both different locations and different years and concluded that no change in abundance had occurred that could be attributed to the presence of the NTZ. There was, however significant variation attributable to the control locations, indicating that overall site variation may be an important complicating factor with this particular study.

***Estimation of Resource Requirements*:** The survey methodology was designed to allow one dive pair to complete one sample plot, comprising four 10 m x 3 m transects. With six plots in each of the two NTZ sites, a total of 12 dives would be required to complete the sites within the NTZ/SAC, requiring six days of diving with a four-person dive team. If the control sites were included then the resource allocation would have to be doubled.

***Comments and Observations*:** Hoskin *et al.* (2008) concluded that the power of this study to detect change is considerably less than that predicted from the power analysis applied to the 2004 pilot study and attributes this to the greater than expected spatial variation within replicate plots.

Unfortunately, the data are not normally distributed and are deeply skewed, such that a log-transformation is unlikely to improve the ability to analyse the data by parametric means. Moreover, pooling data to numerically enhance the dataset would not, from a cursory examination, restore the data to approximate normality. We suggest possible temporal comparison might be achieved by using the Mack-Skillings non-parametric analogue of 2-way ANOVA (sites x years), regarding each of the six plots within a site as a single replicate. The power of this test, would, however, need to be investigated further.

From a site condition perspective, the low abundance in the current samples and the degree of associated uncertainty, suggests that the present study is unlikely to provide a clear and reliable indication of the condition of the sublittoral sediment feature over and above the more infaunal community-orientated methods, such as a grab sampling programme. Hoskin *et al.*(2009) comments that unless significant recruitment occurs

"…*further monitoring is likely to continue recording low densities of mostly large (>10cm shell width) scallops in both locations. This would not be very informative or an effective use of resources.*"

They suggest an alternative strategy in which the present monitoring strategy is suspended and replaced by a scallop spat surveillance programme, which would indicate a recruitment event and thus the possibility of increased abundance. We endorse this approach, but caution that while this would directly benefit the NTZ monitoring programme, a careful examination of the overall contribution to the wider sublittoral sediment condition assessment would still be necessary.

Note: A second attribute; "Population structure of *Pecten maximus*", with the associated target; "Maintain age/size class" is also possible to address with data collected by Hoskin *et al.* (2008), as each recorded scallop was measured and growth curves for each site were constructed. This is not considered separately in this report as we consider that the comments above also apply to the age/size class data.

3.4.7 Attribute: Presence and abundance of red band fish *Cepola rubescens*

Target: Maintain presence or abundance of positive indicator species (*Cepola rubescens*).

Baseline: The red band fish *Cepola rubescens* was first recorded around Lundy in 1974. Generally considered a deep-water fish, preferring depth of greater than 70 m, the presence in sediments around the 12 m to 18 m depth range is very unusual and restricted to the south-west of Britain and Ireland.

In 1977 the population in the area of Halfway Bay and Gannet's Bay was estimated to be 14,000 individuals (Pullin & Atkinson, 1978), but due to suspected poor recruitment and natural mortality (Fowler & Pilley, 1992a) only a few small groups and isolated individuals have been observed since.

A number of studies have set out to establish the population status (Table 3.46), but sightings have been rare. None were found during intensive annual searches by the Nature Conservancy Council's monitoring team between 1984 and 1986 (Irving & Northen, 2004). In 1987 six individual fish and 12 burrows were discovered off Halfway Wall Bay (Irving, 1989) and since then a few fish or their burrows have been observed most years. Marine Conservation Society groups undertook searches 1995, 1996, 2000 & 2001. In both 2000 and 2001 a small number of burrows were located in muddy gravel to the north of the Outer Pin and 12 burrows, two occupied, were present on muddy sand and gravel to the south-east of the Submerged Pin. A single sighting was reported from the drop-down video survey undertaken by Mercer *et al.* (2004) in 2003.

Table 3.46 Summary of supporting information for the assessment of the presence and abundance of *Cepola rubescens*.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Lundy	None (observations on burrowing behavious)	Diver observations	1974	Single study	Not determined	(Atkinson et al (1977), Atkinson & Pullin (1977)
Not determined	None	Diver observations	1976	Single study	Not determined	Atkinson , (1976)
Lundy	Estimate of abundance	Diver observations	1977	Single study	Not determined	Pullin & Atkinson , (1978)
Gannet's Bay &	Estimate of abundance	Towed diver	1982, 1983	Repeat visit	Two sites	Hiscock (1984b),

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Halfway Bay						Fowler & Pilley, (1992a)
Gannet's Bay & Halfway Bay	Burrow and occupant counts	Towed diver searches & swim-line transects	1984 (Gannet's Bay), 1985 (Gannet's Bay), 1986 (Halfway Bay), 1987, 1988	Annually	Two sites	Hiscock , (1984c), Hiscock (1986a, b), Howard (1987, 1988), Irving (1990), Fowler & Pilley, (1992a)
Lundy	Burrow and occupant counts	Diver observations	1984 - 1988	Single study	n/a	Irving , (1989)
Knoll Pins	Burrow and occupant counts	Diver observation	2000, 2001	Two years	n/a	(Irving & Northen (2004)
Lundy	Species presence	Drop-down video	2003	Single study	171 stations (one observation of *C. rubescens)*	Mercer *et al.* (2004)

Because of the large population decline and subsequent infrequent sightings, there are no data that could be presented as a baseline for *Cepola rubescens* abundance.

There is some optimism that the presently small population of *C. rubescens* is stable at specific locations (Irving & Northen, 2004) and an interim monitoring programme in which only the presence of the fish is confirmed at specific locations may have some merit.

***Suggested Monitoring Interval*:** 1-6 years

***Suggested Method*:** All of the survey work to date has been carried out by diver observation, sometimes incorporating towed searches often combined with diver to surface communications systems and sometimes as a directed search of a particular area. Fowler & Pilley (1992a), in their appraisal of *Cepola* population monitoring up to 1991, comment that the work is hampered and ultimately constrained by the very large area that has to be covered to enable an accurate assessment of the population.

Both Fowler & Pilley (1992a) and Irving & Northen (2004) suggest that the low level of specialist knowledge required for a *Cepola* population survey lends itself to amateur or volunteer diver project, which could be undertaken under the direction of the Warden. Irving & Northen (2004) also suggests that a greater success of encountering *Cepola* may be obtained by diving at night when the fish are thought to leave their burrows to pursue prey.

Given the nature of the substrate (circalittoral mud, sands and gravels) there is perhaps a good chance that a remote video search strategy utilising a high definition drop-down video system would provide an efficient way of surveying a greater area than can be achieved by diver. Similar strategies have been used to evaluate *Nephrops norvegicus* densities and a single sighting was reported during 2003 Lundy monitoring drop-down video survey (Mercer *et al.*, 2004). This still, however, represents a relatively high resource commitment for a single discretionary attribute, unless it could be incorporated into a broader sedimentary drop-down video programme.

***Timing of Survey*:** There is no information on the seasonal habits of this fish, but it is assumed to be present all year round. From a practical perspective, though, any survey involving divers and boats would be best undertaken in the summer months.

***Assessment of Change*:** We suggest a simple confirmation of presence at specific locations. This does, however, present an additional problem of demonstrating 'proof of absence' when a location is suspected to have lost its population. In this case a more intensive survey may be considered necessary to confirm beyond reasonable doubt that the previously established population is no longer present.

***Estimation of Resource Requirements*:** We suggest that only locations known to support *C. rubescens* be surveyed (either by diver or drop-down video), over no more than a two-day period.

***Comments and Observations*:** Overall, we consider the technical difficulties and resource commitments to be too high for a task which, with the benefit of current knowledge, is unlikely to provide a numerical, and thus immediately comparative, result. Perhaps a more fundamental question is whether this unusual species occurrence ultimately provides an appropriate and meaningful measure of the sublittoral sediment feature condition.

We recommend that this attribute be considered of low priority and should concentrate on simply demonstrated the continued presence of *C. rubescens*, until a greater understanding of the distribution of the fish allows a more structured assessment of the population status.

3.5 Feature: Marine Mammals (grey seals)

3.5.1 Attribute: Grey seal pup production (Mandatory)

***Target*:** A stable or increasing number of breeding female grey seals in the SAC.

***Baseline*:** Studies carried out in 2008-2009 (Westcott, 2009) provide a comprehensive baseline for pup production and mortality on Lundy, although this study does not supply information on abundance and distribution of seals throughout the year. Table 3.47 lists the previous studies on grey seal and pup production on Lundy, the majority of which are published in the Lundy Field Society Annual Reports.

Direct counts recorded 38 births (of which 3 died prior to weaning) during the 2008-2009 season, the majority occurred during September (27 births recorded). The season of pup production extends from late August to mid-October, with a small number of pups born outside that period (until late January, in this survey (Westcott, 2009)). Based on these results annual pup production for Lundy is currently around 40 – 45, varying from year to year according to sea conditions. The annual moult takes place between December and March.

The work carried out by Westcott (2009) includes details of the locations of the main haul out and pupping sites. Earlier births were predominantly recorded at sea cave sites and only later in the pupping season were pups born at remote boulder beaches backed by cliffs. The main nursery site was Halfway Bay Beach, just south of Tibbett's Point, a wide boulder beach with small coves that remain uncovered at high water.

In a review by Irving (2005) production as high as 25 pups was reported in 1975 (Clark, 1977), with Willcox (1988a) later confirming 17 in 1986 and 1987. These pup production figures are consistent with more recent data when the increasing UK-wide trend in pup production is taken into consideration. Production rates have increased by over 6% per annum at most sites throughout the late 1980s and early 1990s (SCOS Main Advice 2008, SMRU).

Table 3.47 Summary of supporting information available for seal numbers and pup production.

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Lundy	Length of caves	Visual estimation	1996	Single study	Four caves	Heath (1996)
Lundy	Monthly figures of no. seals hauled out		1954-1957	Monthly figures over 4 yrs (Mar - Nov)	Unknown	Chanter, J.R. 1877
Lundy	Unknown	Unknown	Unknown	Unknown	Unknown	Lloyd, L.R.W. 1925 (quoted in Willcox, 1987).
Lundy	Seal numbers including pups	Counts at non-regular intervals (Mar - Oct 1957)	1957	Non-regular intervals	Unknown, although Seal's Hole and Hell's Gates are references	Anonymous. 1958.
	Monthly figures for seals hauled out (Mar – Nov) during 4 years (1954-1957)	Counts and reference to number of pups recorded	1954 - 1957	Monthly (Mar – Nov) for 4 years	Unknown, although all pups were recorded from Seals Hole.	Hook, O. (1963-4)

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
Lundy	Seal count	Unknown	1969	Single study	Unknown	Britton, R.W. 1970.
Lundy	Observations of seals, ID from previous years and pupping activity.	Count and observation	1973	Single study (14th Aug – 6th Sept 1973)	Unknown	Clark, N.A. & Baillie, C.C. 1974
Lundy	Observations of seals, identification from previous years number of pups and mortality	Count and observation	1974	Single study (27th Aug-24th Sept 1974)	Unknown	Clark, N.A. & Baillie, C.C. 1975.
Lundy	Information on pupping and seasonality	Report discussing composition and behaviour of seal colony on Lundy.	Unknown	Unknown	Unknown	Clark, N.A. 1978.
Lundy west coast	Number and lay-out of sea caves	Visual count & sketches of cave entrances and comments of suitability for seal pupping	1983	Unknown	21 caves	Hiscock, K. 1984a.
Lundy	Counts including pup production	A review of grey seal status and summary of 1987 and 1986 records.	1986/87	Unknown	Unknown	Willcox, N. 1987
Lundy	A review of the number and location of pups counted on one day.	Visual count	1987	Single study (28th Sept 1987)		Willcox, N.A. 1988a.
Lundy	Pup counts	Observation of pup counts by the Warden during the 1995 pupping season (26th	1995	Unknown	Unknown	Parkes, E. 1996

Location/ Area	Measure	Method	Year	Frequency	No. of stations/ sites	Reference
		Aug -18th Oct)				
Gannets' Rock and Seal's Rock	Vigilance in seals which are hauled out on rocks.	Observations	2000?	Single study	Four sites near north the end of Lundy (2 nr Gannets' Rock and 2 nr Seal's Rock	Chilvers, R., Colebourne, M., Grant, B., Oliver, R. & Lea, S. 2000
Lundy	Pup production, opportunistic photo ID, year round abundance and distribution	Count	2008/2009 season	Monthly	All of Lundy	**Westcott, 2009**

Suggested Monitoring Interval**:** Every 1-3 years

Suggested Method**:** For consistency the methods used to survey pup production should follow those used by Westcott (2009) to collect the baseline data. This requires seaward access by means of a small vessel, such as a 'wave ski' during the breeding season and undertaking direct counts of pups. The survey methods used during the 2008-2009 survey are fully described in Westcott 2008 *'Procedural guidelines for studying grey seals in southwest England'*.

During the 2008-2009 survey rough sea conditions caused considerable disruption to data collection especially on the exposed west coast. It was therefore concluded that future survey efforts should be based on Lundy to make best use of the available sea conditions.

The number of pups present should be recorded and, if circumstances permit, opportunistic identification images (pelage photos) of any adult seals present should be captured, entered into the island seal photo-database and shared with any national or regional scheme.

Although total grey seal population and abundance are not mandatory attributes for the SAC, adult seals numbers should also be recorded while conducting pup production surveys to provide abundance information which could later be supplemented to provide year round abundance data to fulfil the population size attribute discussed below. All counts should differentiate between males, females, yearlings, pups and 'unidentified'.

Seal population disturbance from human sources is thought to be increasing and seal monitoring surveys should also include a census of human disturbance or other anthropogenic impacts such as pollution. Such records will provide contextual information for the site and will help explain changing seal abundance and distribution when they occur. This information will also help to establish whether the level of protection afforded to the sites used by seals is sufficient to mitigate against the effects of leisure and commercial activities adjacent to the site, while also helping to inform advice given to water users (Westcott, 2009).

***Timing of Survey*:** Previous surveys (Westcott, 2009) have indicated pup production takes place from August to January with peak production in September. Known seal nursery sites should therefore be visited between July and December at intervals of not more than two weeks. During the 2008/2009 surveys (Westcott, 2009) all counts were made at up to 90 minutes either side of low water as this is considered to be the time at which the largest numbers of seals are likely to be hauled out on the shore.

***Assessment of change*:** There are two levels of assessment of change that can be applied to the pup production data, the most basic of which is a simple abundance comparison. Accepting an assumption that pup production rates will vary between years, a simple comparison of the pup counts to previous year's surveys will allow an estimation of change in pup production to be made. Regular pup production and mortality recording has also been carried out at the nearby Skomer MNR another island site (less than 50 miles away) since 1983. Given that pup production rates may naturally fluctuate, monitoring at Skomer could also be used to compare trends and variation in overall production rates.

The second level of assessment would be to assess pup production rates on Lundy as a proportion of the UK pup production estimates, produced annually by SMRU. This would more readily reflect change within a UK-wide context and indicate where natural variation may be exerting an influence, rather than site specific impacts or issues. It is recommended both levels of assessment are used to determine and examine changes to pup production rates at Lundy.

As females are assumed to give birth to one pup in any one breeding cycle, pup production can be used as a suitable indicator of breeding female abundance and can be used to calculate total population size.

***Estimation of Resource Requirements*:** Surveys carried out by Westcott (2009) on a wave ski indicate that Lundy can be circumnavigated in 3 hours. Based on two surveys a month, and commencing counts from July to December, approximately 12 days would be required to carry out the fieldwork. These surveys should also record information on distribution and accessibility of the sites for breeding, noting any human disturbances, impacts or pollution incidents.

Comments and Observations: Due to the sea conditions hampering the 2008-2009 survey it has been recommended that future monitoring be Lundy based. There are therefore potential time and cost savings to be made if Lundy staff and wardens are trained to carry out the monitoring surveys and can incorporate them into their work.

Because pup production rates are known to fluctuate annually there may be a need for a pragmatic approach when considering setting threshold targets for condition monitoring. A wide threshold target may need to be set which allows for the fluctuation in pup production between each monitoring cycle.

Declining pup production levels at a site may not always mean there is a direct threat and may just indicate changing site usage. Data for Skomer MNR, for example, indicate that the Island pup production has been declining since the late nineties, almost exactly mirroring a gradual increase in production on the mainland (Figure 3.24). If viewed in isolation the Skomer Island population could be seen as declining and unfavourable, but this appears to be a simple population redistribution between two locations within the Skomer MNR boundary and it is only with long term monitoring of both areas that the true picture becomes clear (Lock et al, 2009) indicating that total pup production for the whole MNR has remained stable.

Although not implied or discussed in the Skomer MNR 2008/09 monitoring report (Lock et al, 2009) these changes in site usage could reflect increased levels of disturbance to the island populations due to gradually increasing boat traffic and reiterate the importance of recording seal disturbance impacts during routine monitoring.

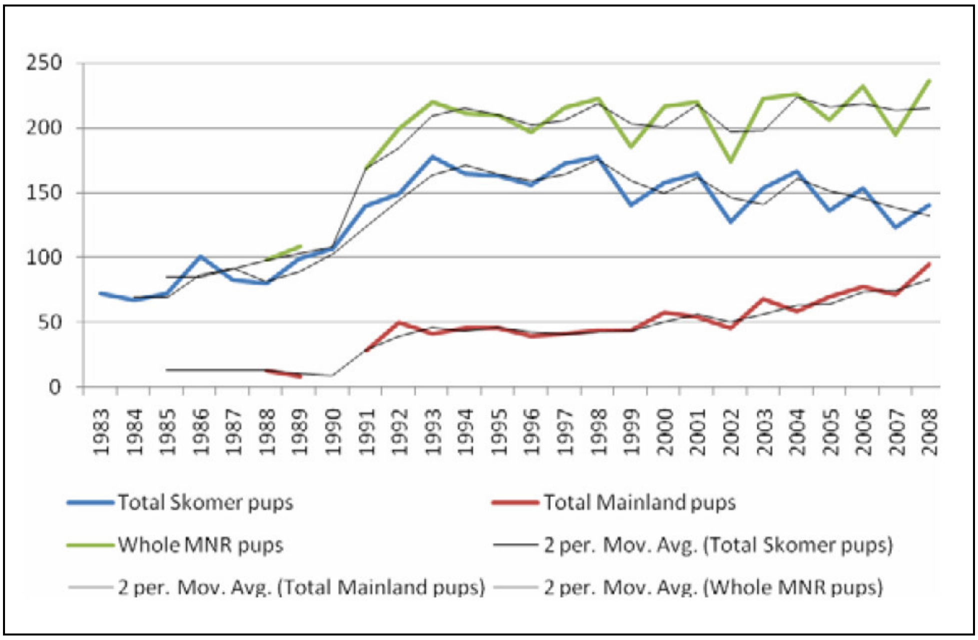


Figure 3.24 Number of seal pups born in Skomer Marine Nature Reserve 1983-2008. Reporduced from Lock et al. (2009).

For monitoring the Lundy site important lessons can be learnt from the Skomer monitoring which reinforces the view that the population should not be viewed in isolation and results from monitoring need to be compared to other adjacent sites. The benefit of Skomer is it is near the mainland, whereas Lundy is to a large degree quite disconnected with mainland sites, the nearest breeding colonies being located some distance away.

Wider studies have suggested (e.g. Hook, 1963-4) and more recently (Wescott, 2009) that the Lundy seal population freely associates with the populations and breeding colonies on Skomer, Ramsey, and Cornwall. These localised populations are likely to form part of a larger metapopulation with seal movements outside the breeding season leading to considerable overlap between individual home ranges.

The nearest neighbouring localities where relatively large numbers of grey seals assemble during at least part of the year include:

- The Boscastle-Cambeak coast in North Cornwall, approximately 30 miles away;

- Skomer and Skokholm, off the southwest Wales 50 miles away; and
- Ramsey, off southwest Wales coast approximately 60 miles way.

Geographically therefore, Lundy is likely to act as an important junction between the seals of southwest England and southwest Wales (Westcott, 2009).

The pupping data for Skomer Island is the longest running dataset for the area (beginning 1974, then annually since 1983), while the data for the Skomer MNR as a whole (Skomer Island and MNR mainland) extends from 1991 to the present. As such this data set should be recognised as an important comparative data source for future Lundy seal monitoring.

3.5.2 Attribute: Distribution of grey seal pups within the SAC (Mandatory)

***Target*:** A stable or increasing area of usage within the SAC as indicated by a map showing the distribution of pups within each site.

***Baseline*:** Data on the distribution of pups across the Lundy breeding sites were obtained during the 2008-2009 surveys and are presented in Westcott (2009). This information provides a good baseline for identifying the distribution and abundance of pups between the different pupping and nursery sites.

***Suggested Monitoring Interval*:** As for the pup production survey

***Suggested Method*:** Information on pup production numbers, age classification of pups, locations and distribution for different breeding sites round Lundy should be incorporated into a GIS which will the allow changes in distribution and production at each site to be monitored. The information required to monitor pup distribution will be obtained during the pup production surveys required to monitor the pup production attribute.

***Assessment of change*:** We suggest that a simple abundance comparison would be sufficient to establish whether there has been a change in the distribution of pups at the Lundy sites. If unexpected changes in site usage occur, reference should be made to pressures and impacts monitoring to try and establish the cause of the change.

***Estimation of Resource Requirements*:** None. Fieldwork and data collection would be undertaken as part of the pup production monitoring.

***Comments and Observations*:** None.

3.5.3 Attribute: Accessibility of the SAC for breeding (Mandatory)

***Target*:** There is no restriction on grey seal access to and from the breeding colony.

***Baseline*:** The monitoring carried out by Westcott (2009) did not indicate that there were any issues with accessibility to breeding sites at any of the locations assessed on Lundy. Much of the Lundy coastline is exposed and undeveloped with artificial barriers e.g. livestock fencing which may limit seal access to breading sites.

***Suggested Monitoring Interval*:** As for the pup production survey.

***Suggested Method*:** Information on access to breeding sites forms part of the pup production monitoring surveys. This information should document the preferred habitats and sites, and events such as cliff collapse which may impede access to breeding sites and disturbance events which could potentially limit access to important sites.

***Assessment of change*:** Compare the access and availability of breeding sites to those recorded in previous years. Sites may be lost as a result of natural processes such as cliff and sea cave collapse. Such losses should be seen as natural and should not have any bearing on the condition of the site.

***Estimation of Resource Requirements*:** As for pup production.

***Comments and Observations*:** Survey of accessibility of the sites would be recorded as part of the pup production surveys.

3.5.4 Attribute: Population size (Discretionary)

***Target*:** To maintain the Lundy grey seal population size subject to natural change

***Baseline*:** The study carried out by Westcott (Westcott, 2009) aimed to carry out a baseline study that would inform subsequent grey seal monitoring studies and monitoring on Lundy. One of the objectives was to identify the year round abundance and distribution of seals at haul-out sites and adjacent water resting places. The reasoning being that although overall population size can be estimated by extrapolating outwards from pup production data, fluctuations in seals numbers throughout the year cannot be deduced from pup numbers (Westcott, 2009). Due to adverse weather conditions this study failed in achieving these objectives and no complete baseline exists.

Total year round abundance and distribution counts were not possible during the 2008-2009 survey due to weather limiting the amount of visits to west coast sites. However, the site visits undertaken indicate that grey seal use the Lundy sites year round in numbers that appear to vary little from month to month. It is likely that seals present at any time number around 125 individuals, with females outnumbering males (Westcott, 2009). These estimates are similar to those made by Hook (1963-4) who suggests the island's seal population varies in size during the year, reaching a peak in late September of perhaps 120 seals (the number counted in 1955). This would coincide with the main breeding period, after the cows have had their pups. At other times, numbers seem to be in the region of 70-90 individuals. This figure is confirmed by both Britton (1970), who counted 80 seals all round the island on 5th July 1969, and also by Willcox (1987).

Determining the year round abundance and distribution of adult seals on Lundy could provide useful information for informing management strategies on Lundy aimed at limiting disturbance to certain seal colonies during vulnerable or sensitive seasons such as during pupping and moulting.

***Suggested Monitoring Interval*:** Every 3-6 years

***Suggested Method*:** We suggest that the method employed to evaluate population size should follow that initially proposed and undertaken by Westcott (2009) for the 2008/2009 monitoring. These survey methods are fully described in Westcott 2008 *'Procedural* *guidelines for studying grey seals in southwest England'*. The monitoring of population size could be incorporated into, and form a continuation of, one of the pup production monitoring cycles which are proposed to have a shorter monitoring interval.

***Assessment of change*:** We suggest that a simple abundance comparison would be sufficient to establish whether there has been a significant change population size.

***Estimation of Resource Requirements*:** Based on undertaking a full circumnavigation of Lundy at an interval of no more than two weeks, as suggested by Westcott (2009), a full year round survey would require 24 days. Westcott (2009) also notes that a boat based circumnavigation should take no more that 3 hours to complete, therefore if these surveys were to be Lundy based, as suggested, they could potentially be combined with other island based duties.

***Comments and Observations*:** Incorporating the population size monitoring into one of the pup production monitoring cycles would reduce the time requirements of this monitoring element and satisfy a number of attributes.

3.6 Additional Attributes

3.6.1 Attribute: Water Clarity (Discretionary)

***Target*:** Average water clarity should not decrease significantly from an established baseline allowing for natural variation or cyclical change.

***Baseline*:** There are no reliable direct measurements of water clarity available for Lundy and therefore no baseline data for this attribute. Irving (2005) indicated that sporadic Secchi disc measurements were taken in Landing Bay in 1983 but the inconstancy in the methodological approach rendered then useless for any form of comparative assessment.

The use of algal depth limits as an indirect measurement of water clarity is, however, incorporated in the 'distribution of algal community at specific locations' attribute in section 3.3.3.

3.6.2 Attribute: Water Temperature/Density

***Target*:** Average Water density/temperature will not deviate from an established baseline allowing for natural variation or cyclical change.

Although a target is stated here, at our present state of knowledge in respect of climate change there seems little prospect of establishing any meaningful threshold values that could be applied as an indication of the condition of the Lundy features. Regardless of the difficulties of setting a baseline temperature/density value, there are unlikely to be any sensible management actions that could be applied at the level of the Lundy SAC to restore this attribute back to a stated baseline condition. This attribute should therefore be considered as more of a surveillance programme, providing supporting information to add context to observed changes.

***Baseline*:** Sea temperature information has been intermittently collected around Lundy since at least 1973 (Table 3.48). Fowler & Pilley (1992a), in an extensive study, obtained monthly sea temperature data for the Lundy area for the period 1964 to 1991 and concluded that in the year leading up to the early 1980s there was little change with fairly small fluctuations in temperature. Between 1985 and 1989 sea temperatures declined, corresponding to record low winter temperature in 1985/86, after which they recovered and then exceeded the long term annual mean with an exceptionally warm summer in 1989. By 1991, however, the temperature had returned to the long-term annual mean.

Table 3.48 Summary of information relating to sea temperature around Lundy.

Location/ Area	**Measure**	**Method**	**Year**	**Frequency**	**No. of stations/ sites**	**Reference**
Landing Bay	Sea temperature	Mercury thermometer	Oct 1972, to Oct 1973	Two week intervals	One station	Hiscock & Drymond (1974)
Landing Bay	Sea and air temperature	Mercury thermometer	Jan 1986 to Dec 1987	Approx. weekly intervals	One station	Willcox (1988b)
Lundy area	Sea temperature	Light vessels and isotherm charts	1964-1991	Monthly	One location (‘Lundy area’)	Fowler & Pilley (1992a)
MV *Robert* wreck, 1 km E of Tibbett’s Point	Sea temperature	Temperature data loggers	1997 to 1998	Every six hours	One station	Irving & Northen (2004)
MV *Robert* wreck and Landing Bay	Sea temperature	Temperature data loggers	1998 to 2004 (MV *Robert*); 1998-1999 then 2007-2008 (Landing Bay)	Assumed as above	Two stations	Metadata supplied by Natural England

More precise and localised temperature measurements have been obtained using data loggers since 1997. Table 3.49 provides details on the time period over which they have operated, together with the location and instrument type.

Table 3.49 Details of sea temperature data-loggers deployed around Lundy. Information supplied by Natural England.

Start data	End date	Data logger location	Logger Type
12/08/97	08/05/08	MV Robert	Mini Log
12/08/97	08/05/98	MV Robert	Tinytag
23/5/98	21/06/99	Mooring , Landing Bay	Mini Log

16/08/98	21/07/99	Mooring , Landing Bay	Tinytag
21/07/99	01/08/01	MV Robert	Mini Log
04/09/99	08/08/00	MV Robert	Tinytag
01/08/01	12/05/04	MV Robert	Mini Log
11/07/07	07/08/08	Jetty, Landing Bay	Mini Log

Suggested Monitoring Interval**:** Not applicable

Suggested Method**:** Not applicable

Timing of Survey**:** Not applicable

Assessment of Change**:** Annual maxima and minima may provide contextual evidence to support short-term species fluctuations, but it is the longer-term data set, converted to seasonal, five-year or decadal running means that will be essential in determining the correlation between community change and sea temperature rise.

Estimation of Resource Requirements**:** Not applicable.

Comments and Observations**:** None.

4 DISCUSSION

The principle aim of this project was to develop and propose a robust monitoring programme that will deliver the means by which the condition of the Lundy SAC marine interest features can be assessed. In doing so we were also requested to integrate the Lundy marine SSSI and NTZ into the assessment process and provide an indication of how these areas might be addressed should prioritisation be necessary.

The Lundy marine environment has received considerable attention from both professional and volunteer survey groups over many years and we have undertaken a comprehensive assessment of the contribution this work could make to a Lundy Common Standards Monitoring programme.

The use of past survey data and methodologies has, however, had to be approached with caution. The monitoring of protected marine areas throughout the UK do suffer to a varying degree from continuously evolving or changing survey and monitoring methods that are often never fully compatible with previous efforts, subsequently attracting suspicion that an assessment of change is fundamentally flawed or based on incorrect assumptions. This is particularly acute when attempting to draw on older survey data, where survey locations or the level of taxonomic accuracy cannot be verified. In these cases there is often the temptation to treat any data as good data when under pressure to provide a definitive judgement on feature condition. In this report we have attempted to provide an accurate and honest assessment of the available data within the confines of the resources and time available for the task.

An early conclusion of this project was that the majority of the available previous surveys are either wholly or partly orientated towards sublittoral rock, with perhaps the greatest amount of survey effort expended on studies of individual species. While many of these studies give historical accounts of the status of a species or habitat, we concluded that many were likely to prove hard to replicate or adapt for suitability as an indicator of a feature condition.

Given the reported high species diversity on Lundy's rocky shores, we were surprised at the paucity of intertidal data and in particular the lack of more recent quantitative spatially-referenced surveys that could inform the initiation of a structured condition monitoring programme. There is likely to be further preliminary or exploratory work required in establishing a suite of appropriately sited survey locations.

We were less surprised, however, at the low survey intensity in the sedimentary areas around Lundy, since almost any type of study in these habitats generally requires a considerable commitment in both time and financial resources. Fortunately, the recent work of Nunny & Smith (2008) has provided a good foundation for future monitoring, although further work will be required to determine the stability and variability of sedimentary community structure to allow the establishment of robust and biologically meaningful targets.

Lundy's cave feature remains the element that has received least attention, and has clearly been considered of a low priority for reasons of both inaccessibility and a perceived reduced vulnerability to human impacts. We concur with these perceptions and our recommended monitoring intervals for some cave attributes reflect that low vulnerability. There will, however, be some immediate survey work required to establish the biological baselines for the cave attributes.

One of the more difficult aspects of this project has been the selection of an appropriate monitoring interval for each attribute. Determining a time scale over which the ‘extent’ of a feature needs to be assessed was the least problematic, since the morphology and distribution of caves, rocky reef and sublittoral sediments are under very little direct pressure from human sources and change for the most part is likely to occur over geological time scales. The suggested monitoring intervals are therefore correspondingly long, although the extent of cave and littoral rock has yet to be determined.

The biological dimension, however, was significantly more difficult to accommodate, particularly if realistic survey constraints and protocols were to be applied alongside the obligation for a six years CSM reporting cycle. In an attempt to provide some form of decision structure we considered three criteria:

- the degree of vulnerability of the communities, biotopes or species to a threat and the immediacy and known magnitude of that threat for Lundy.

- the longevity, recruitment status and known existing population size of a species

- the importance of the biological entity to the structure and function of the Lundy feature(s)

Using this, we determined the monitoring requirements in terms of a one, three and six year interval, although in many cases we felt that a range would be more appropriate to allow room for a later prioritisation process (Appendix 5). Clearly, in some cases, a lack of knowledge, particularly in relation to species populations inevitably forced decisions on the basis of an informed ‘best guess’ rather than scientifically informed judgement. Thus, it is important to understand that the intervals are largely the product of varying levels of subjectivity and as new information is discovered about the biological entities that make up the attributes there will almost certainly be a requirement to adjust the monitoring interval to achieve a balance between monitoring effort and the level of scientifically justified concern. The monitoring timeline is presented in Appendix 6 and uses the shortest intervals presented in the text of Section 3.

During the process of selecting and refining attributes we attempted to identify where dependencies may occur (i.e. where sequential tasks were required) and where resource consolidation or sharing might be appropriate.

In terms of littoral survey, both the littoral rock and littoral caves share taxonomic and methodological similarities and deploying a single team to undertake both tasks would seem sensible. Moreover, the composition, distribution and spatial pattern of littoral biotopes would be addressed by the use of the same intertidal survey methodology, while the two rockpool attributes also share a common method and could also conceivably be combined with a non-native species census.

When planning sublittoral rock surveys it would be advantageous to consider undertaking all of the tasks that require diver sampling or observation as a single project, since there are major considerations involved in the coordination of equipment and vessel transportation and supply. There may, however, be additional task-related factors to consider in relation to dive team deployment. Only one proposed attribute requires data that can only be collected by divers with advanced taxonomic skills. The others are concerned with the recognition of a single species or a small set of species, perhaps also providing opportunities for volunteer participation.

The use of remote sampling techniques is a requirement for a number of sublittoral rock and sediment attributes and involves varying levels of dependency and opportunities to combine resources. The determination of the extent of both sediment and rock features will require acoustic equipment together with drop-down video ground-truthing. Drop-down video will also be used for a range of additional sampling tasks and careful coordination may be needed to allow efficient completion of all of them. A summary of the sublittoral resource requirements for each attribute is provided in Table 4.1.

Table 4.1 Summary of resources required to assess status of the inshore sublittoral rock and sediment attributes.

Attribute Section No	Diver	Diver/ Taxonomist	Drop-down video	Grab sampling	Acoustic mapping
3.3.1			✓		✓
3.3.2			✓		
3.3.3	✓				
3.3.4	✓				
3.3.5	✓	✓			
3.3.6	✓				
3.3.7	✓				
3.3.8	✓				
3.3.9					
3.3.10	✓		✓		
3.4.1			✓	✓	✓
3.4.2					✓
3.4.3				✓	
3.4.4				✓	
3.4.5				✓	
3.4.6	✓				
3.4.7	✓		✓		

Although the proposed Lundy monitoring programme will provide strong evidence for (or against) localised change, we strongly recommend that a broader perspective for each attribute should also be taken wherever possible, both to provide valuable corroborative evidence and to give context or spatial scale for any suspected change. This is already implicit in the littoral rock attribute for climate change species because the methodology and rationale links directly with MarClim, a UK national programme. Other wider spatial comparisons will supply important information when attempting to determine whether change in a particular Lundy marine element is restricted to the Lundy locality and might therefore need a specific regional management action or additional site-specific surveillance effort.

Particularly good additional opportunities for comparative examination exist where parallel monitoring programmes are taking place in locations where similar habitats, communities and species are present. For Lundy this would include the Scilly Isles to the south-west and Skomer to the north-west.

Skomer, in particular, has a well-established monitoring programme that includes identical habitats and species to those present around Lundy. Their selection of survey and monitoring targets therefore maintains inevitable synergies with the programme proposed in this report. For comparative purposes we have compiled a summary of the Skomer programme based on the most recent report (Table 4.2). In general, the focus of their monitoring efforts is closely aligned to that of the recommended Lundy attributes, particularly in respect of the species selected for direct monitoring, and thus could provide complementary or supporting evidence for Lundy condition assessments. Some significant differences in approach are evident, though. There is a strong reliance on fixed quadrat monitoring or repeat surveys at selected sites at Skomer, which is why there are little or no statistical analyses, since there is no sample replication or randomised survey designs. Assessment of change for Skomer marine habitats and species is almost wholly dependant on direct temporal comparison of discrete location data. Notably, there is a substantial difference in the appraisal of scallop populations, with the Skomer results appearing considerably more robust than those from Lundy, despite a lack of statistical applicability. This is largely the result of demonstrably higher individual densities within the Skomer transects coupled with the use of large numbers of volunteer divers; some 40-50 in each of two monitoring surveys.

Table 4.2 Summary of the Skomer monitoring programme. After Lock et al. (2009).

Monitoring element	Method	Summary results
Littoral rock communities	Fixed position permanent quadrats at 10 sites using MarClim protocols. Some sites monitored from 1992.	Substantial lower shore abundance changes between 2003 and 2008 with *Semibalanus balanoides* being replaced by *Chthamalus montagui.*
Sponge assemblages	Counts in four fixed quadrats at one location from 1993.	High spatial variability in sponge diversity – no change detected.
Eunicella verrucosa growth rates and condition	Fixed frame photographic documentation of sea fans at 10 sites. Programme started in 1994.	Infrequent recruitment and possible recent small increases in sea fan necrosis. The growth rate study was discontinued due to methodological difficulties in 2001.
Alcyonium glomeratum population density	Fixed or sequential (transect) photo-quadrats or at six sites from 2002.	Broadly stable, although some abundance declines observed.

Monitoring element	Method	Summary results
Parazoanthus axinellae population density	Fixed photo quadrats at three sites from 2001.	Population stable.
Balanophyllia regia and *Caryophyllia smithii* population density.	Fixed (sublittoral) photo-quadrats at two sites since 1985 for *B. regia* and 1993 for *C. smithii*.	Broadly stable abundance with a possible increase for *B. regia* in 2007.
Pentapora foliacea population density and growth rate	Photography along transects at five sites from 1993. Measurement of growth rate and degree of damage.	Results inconclusive. Rapid growth observed, but entire colony disappearance common.
Pecten maximus population density and age structure	Scallop collection in 50 m x 2 m transects at seven sites, covering approx 10,000 m^2 in 2004 and 2008 (rolling four year programme)	Abundance stable in three sites and increasing in five sites. Age centred around a median of approx. seven years
Grey seal population	Number of pups recorded from birth to moult annually since 1983.	Overall a steeply increasing pup production until the early 1990s and then a stable number throughout the MNR at just over 200 until present.
Water temperature	Data loggers recording temperature at sea surface, seabed and intertidally	Temperature relatively stable since early 1990s
Turbidity	Secchi disc readings from 1992 and sediment sampler/traps.	Mean through-water visibility stable.

The Lundy SAC incorporates two additional conservation elements; the Lundy Site of Special Scientific Interest (SSSI) and the Lundy No Take Zone (NTZ). Natural England identified a requirement for being able to disassociate these elements should resource limitations force a concentration of effort into the NTZ in particular. A consideration of just the attributes associated with the SSSI is an easy matter, since the SSSI does not extend below low water and specifically incorporates both sea caves and littoral rock habitats. All of the attributes addressing these features therefore also apply to the assessment of the SSSI as a separate entity. By a similar logic, the NTZ is a wholly sublittoral designation and therefore will not incorporate any of the rocky shore and a large proportion of the cave attributes. When considering all of the sublittoral elements, however, an examination of the previous data selected as suitable for baselines and the location of recommended survey sites for each attribute needs to be examined for positioning within the NTZ boundary. Table 4.3 indicates our assessment of the proportion of survey effort for each attribute that would apply directly to the NTZ. As a consequence of the relatively sheltered location and extent of the NTZ a high proportion of previous and presently proposed survey sites fall within the boundary and could conceivably be monitored independently or as a discrete sub-set if required.

Table 4.3 The proportion of survey sampling within the NTZ area, assuming adoption of suggested baselines and the associated use of previously sampled locations or sites.

Feature	Attribute	Proportion inside NTZ (%)
Sublittoral Rock	Extent of inshore sublittoral rock.	~20
	Biotope composition of inshore sublittoral rock.	~25
	Distribution of algal community at specific locations	100
	Species composition of kelp biotopes: kelp forest structure.	50
	Species composition of representative or notable biotopes.	57
	Presence and abundance of *Eunicella verrucosa.*	83
	Condition of *Eunicella verrucosa* population	83
	Presence and abundance of *Leptopsammia pruvoti.*	100
	Presence and abundance of Lobster	33
	Presence of other specified species.	~42
Sublittoral sediment	Extent of inshore sublittoral sediment.	~20
	Topography of inshore sublittoral sediment	~20
	Sediment character: sediment type	44
	Distribution of biotopes	39
	Extent of sub-feature or notable biotope.	n/a
	Presence and abundance of great scallop	50
	Presence and abundance of red band fish	100 (?)

In conclusion, as a strategy for assessing the condition of Lundy's four designated features (Sea Caves, Littoral Rock & Inshore Sublittoral Rock, Inshore Sublittoral Sediment and Grey Seal) we have identified and examined 36 attributes. All attributes were selected for conformity to Common Standards Monitoring protocols and were, wherever possible, based on availability of data from previous studies to allow consistency of approach and the early establishment of comparative baselines. After subsequent careful consideration we have, however, concluded that one proposed attribute (scallop population abundance and elements of another (selected crustacean species abundance) were not appropriate for incorporation due to either unacceptably low abundance or unexplained high variability in annual population counts. We are confident that this will provide a robust basis for the future condition monitoring requirements for Lundy's unique and valuable habitats and species.

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APPENDIX 1. SUMMARY OF MONITORING RECOMMENDATIONS

Sea Caves

Attribute	Target	Baseline	Method	Measure/Metric	Monitoring Interval	Notes
Extent of caves.	No change in dimensions of a cave, allowing for natural change that is part of a wider coastal geomorphological management regime.	None.	Front to back transect line with laser measurements of dimensions.	Measured cave length and cross-section/ profiles at specified distances into cave.	12-18 years.	Unlikely to be able to achieve this measure for many caves. Probably better to maintain surveillance for human events and then assess impact to cave resource. Marine discharges or water quality events will be better measured on other features and extrapolated for cave biota. Large marine debris that may find its way into caves and damage communities by abrasion should be recorded.
Number of caves in site.	No reduction in the number of caves within a site allowing for natural change.	None.	Field inventory with photography and GPS positioning	Visual count (littoral)	18-24 years.	
Biotope composition of caves	Maintain the variety of biotopes identified for the cave, allowing for natural succession or known cyclical change.	Possible single littoral cave on Rat Island (surveyed 1984, 1985, 1986 and 1991)	See methods used by SNH and CCW.	Presence and distribution of biotopes with cave cross-section dimensions.	6 years.	Extent (limited cave dimensions) can be completed as an integral part of this methodology.
Presence of representative/notable biotopes.	Maintain the presence of the specified biotope, allowing for natural succession/ known cyclical change.	None, but suitable biotopes may be present in the Rat Island cave (as above).	See methods used by SNH and CCW.	Presence and distribution of representative/notable biotopes.	6 years.	Representative or notable biotopes should be identified at the next monitoring visit.
Presence and abundance of	Maintain the presence and	Repeat monitoring between 1983 and	Overlapping photography with	Abundance of *Leptopsammia*	1-3 years.	Given the dimensions of the Knoll Pins 'cave' its status within this feature category

Attribute	Target	Baseline	Method	Measure/Metric	Monitoring Interval	Notes
Leptopsammia pruvoti	abundance of *Leptopsammia pruvoti*.	1990 and reported in Fowler and Pilley (1992). Subsequent monitoring continued by Keith Hiscock.	digital mosiacing at the Knoll Pins 'cave' site.	*pruvoti*.		is questionable. It could equally be an attribute in the Inshore Sublittoral Rock feature.

Littoral Rock

Attribute	Target	Baseline	Method	Measure/Metric	Monitoring Interval	Notes
Extent of littoral rock.	No change in extent of littoral rock.	None currently available for spatial analysis, but a census of recent impacts and activities will allow an interim judgement..	Aerial photography/satellite imaging on a low spring tide. Area of littoral rock calculated using GIS spatial analysis on orthorectified images.	Change in area of littoral rock relative to baseline value.	18-24 years.	Suitable archive aerial photography or satellite images may be available commercially.
Biotope composition of littoral rock.	Maintain the variety of biotopes identified for the site, allowing for natural succession or known cyclical change.	Possible rockpool transect on Rat Island and an English Nature survey undertaken in 2000.	Relocatable transect, MNCR Phase II survey and levelling.	Presence of biotopes in all of the transects.	1-3 years.	
Distribution and	Maintain the	As above.	As above.	Change in biotope	1-3 years.	

Attribute	Target	Baseline	Method	Measure/Metric	Monitoring Interval	Notes
spatial pattern of biotopes at specific locations.	distribution and spatial pattern of the biotopes identified at specified locations allowing for natural succession/known cyclical change in biotope distribution.			complement and vertical extent in each transect.		
Presence of rockpool biotopes.	Maintain the presence of the specified rockpool biotopes allowing for natural succession/ known cyclical change.	Possible data from Rat Island and Devil's Kitchen rockpools (surveyed 1984, 1985, 1986, 1991, 1995 and 1996)	Species check-lists and semi-quantitative species abundance assessment at specific rockpool locations.	Maintained presence of rockpool biotopes.	1-3 years.	
Species composition of rockpool biotopes.	1. No decline in rockpool biotope quality due to change in species composition or loss of notable positive indicator species allowing for natural succession/ known cyclical change. 2. No decline in rockpool biotope quality due to change in species	As above	As above	Maintained presence of notable species or the maintained absence of non-native species.	1-3 years.	

Attribute	Target	Baseline	Method	Measure/Metric	Monitoring Interval	Notes
	composition or increase in notable negative indicator species allowing for natural succession/ known cyclical change.					
Presence and abundance of climate change indicator species	Maintain the presence and abundance of the specified species.	MarClim survey undertaken in 2008	Established MarClim survey protocol (Appendix 3)	Change in selected species abundance and a comparison with mainland long-term monitoring sites.	Annually for five sites and a rolling five year programme for a further 5 sites.	The CSM target for this attribute presents considerable problems (see comments in section 3.2.6)
Presence and abundance of the scarlet and gold star coral *Balanophyllia regia* and Devonshire cup coral *Caryophyllia smithii.*	Maintain presence and abundance of *Balanophyllia regia* and *Caryophyllia smithii*	Size and abundance data have been collected at a site in Devil's Kitchen between 2002 and 2005. A resumption of the monitoring was initiated in 2009.	Counts and size measurements of individual cup corals.	Change in abundance and size-frequency distribution of Devil's Kitchen population.	Annually.	We also suggest that a 'rapid assessment' of presence and abundance should be undertaken at selected shore locations.
Presence and abundance of *Sargassum muticum*	Maintain a restricted distribution of *Sargassum muticum*.	Known presence on North side of Rat Island and Landing Beach area.	Low tide census by structured search.	Change in distribution of *Sargassum muticum* around Lundy.	Annually.	

Inshore Sublittoral Rock

Attribute	Target	Baseline	Method	Measure/Metric	Monitoring Interval	Notes
Extent of inshore sublittoral rock.	No change in extent of inshore sublittoral rock.	Multibeam sonar from Nunny & Smith (2008).	Multibeam sonar with backscatter data and grab samples. GIS calculation of area.	Change in total area of sublittoral rock relative to baseline value.	18 – 24 years.	Nunny and Smith (2008) have demonstrated that there is active sediment transport through wave and tidal action, with some fallout of fine sediments from suspension. It does not seem likely, however, that there is appreciable accretion or erosion, so a measurable loss or increase in reef extent is not expected.
Biotope composition of inshore sublittoral rock.	Maintain the variety of biotopes identified for the site, allowing for natural succession or known cyclical change.	Drop-down video data from Mercer *et al.* (2004).	Stratified drop-down video sampling.	Change in biotope composition of entire site	6 Years.	Some habitats and associated biotopes, such as vertical rock and high-energy or tide-swept areas, are missed by this method.
Distribution of algal community at specific locations.	No change in extent of algal communities (no change in the depth extent of the main algal zones at a specific location).	Possible baseline transect at Knoll Pins (surveyed 1985, 1986, 1987, 1988 and 1990).	Diver transect and photo-quadrats.	Change in lower depth limit of kelp and foliose algal community.	Annually.	This also addresses the 'water clarity' attribute.
Species composition of kelp biotopes: kelp forest structure.	Maintain the kelp community structure of the site, allowing for natural succession or known cyclical change.	Possible baseline data from transects off Rat Island and Gannet's Bay (Mercer *et al.*, 2004).	Stratified diver transects with randomised quadrat sampling.	Change in the ratio of *Laminaria hyperborea* and *Laminaria ochroleuca*	3-6 years.	
Species composition of representative or	No decline, due to change in species composition, in the biotopes	Baseline data available for nine sites around Lundy	Stratified diver transects with randomised	Change in individual species abundance and change in	3-6 years.	Note that the biotopes presented in the target are in the older biotope classification format and will need to be

Attribute	Target	Baseline	Method	Measure/Metric	Monitoring Interval	Notes
notable biotope.	IR.EIR.KFaR.LhypR.Ft, IR.MIR.KR.Lhyp.TFt, CR.MCR.XFa.ErSPbolSH, CR.MCR.XFa.ErSEun, CR.ECR.EFa.CorCri, CR.FaV, IR.EIR.SG.SCAs.ByH.	in Mercer *et al.* (2004). Also data collected using a different sampling design by Hoskin *et al.* (2009) from six sites.	quadrat sampling.	community character at each sample site.		converted into the recent formats for future condition reporting. Note that the methods of Mercer and Hoskin differ in the quadrat size used.
Presence and abundance of *Eunicella verrucosa.*	Maintain presence and abundance of *Eunicella verrucosa.*	Possible baseline transect site north of Quarry Bay surveyed by Mercer *et al.* (2004).	Diver transects.	Abundance of *Eunicella verrucosa.*	1 – 3 years.	Some modification of the original transect methodology may be necessary.
Condition of *Eunicella verrucosa* population	Maintain the condition of *Eunicella verrucosa*.	Assessments are available from 5 sites in Irving & Northen (2004) and from 1 site in Mercer *et al.* (2004).	Diver transects with the application of a condition index.	Change in mean condition index at each site.	1 – 3 years.	
Presence and abundance of *Leptopsammia pruvoti.*	Maintain presence and abundance of *Leptopsammmia pruvoti*.	Counts from 15 locations are provided in Irving & Northen (2004)	Diver counts along transect	Change in abundance in a maximum of 4 sites	3-6 years	This is a companion to the *Leptopsammia pruvotii* cave attribute.
Presence and abundance of Lobster *Homarus gammerus*/ brown crab *Cancer pagurus*/ spider crab *Maja squinado*/ velvet crab *Necora puber*	Maintain presence and abundance of Lobster *Homarus gammerus*/ brown crab *Cancer pagurus*/ spider crab *Maja squinado*/ velvet crab *Necora puber*.	Abundance data available from 6 sites collected as part of the NTZ effect study Hoskin *et al.* (2009).	Stratified random sampling using lobster pots.	Change in abundance of specifies species.	1-3 years	A high degree of site and temporal variation in abundance suggests that only lobsters are likely to be a suitable species for this target.
Presence of other	1. Maintain presence of	Suitable data	Two different	Change in abundance	6 years	

Attribute	Target	Baseline	Method	Measure/Metric	Monitoring Interval	Notes
specified species.	each positive indicator specified species. 2. Maintain a limited Lundy distribution of each negative indicator species.	collected by Mercer *et al.* (2004) and Hoskin *et al.* (2009).	sampling methods: stratified drop-down video sampling and stratified diver quadrat sampling	of specified species and change in proportion occurrence in video samples.		

Inshore Sublittoral Sediment

Attribute	Target	Baseline	Method	Measure/Metric	Monitoring Interval	Notes
Extent of inshore sublittoral sediment.	No change in extent of inshore sublittoral sediment.	Multibeam sonar data from Nunny & Smith (2008)	Multibeam sonar with backscatter data and grab samples. GIS calculation of total area.	Change in area of sublittoral rock relative to baseline value.	18 years	Nunny and Smith have demonstrated that there is active sediment transport through wave and tidal action, with some fallout of fine sediments from suspension. Its does not seem likely however that there is appreciable accretion or erosion, so a loss or an increase in sediment area relative to rock is not expected.
Topography of inshore sublittoral sediment	No alteration in topography of the inshore sublittoral sediment, allowing for natural responses to hydrodynamic regime.	Bathymetry from Nunny & Smith (2008).	Acoustically-derived bathymetry compared with baseline.	Assessment of the depth distribution/ profile of the inshore sublittoral sediment and periodic comparison with baseline conditions.	18 years	
Sediment character:	No change in composition of sediment types across	Particle size analysis data from	Standard particle size	Repeat sampling of Nunny & Smith (2008)	6-12 years	

Attribute	Target	Baseline	Method	Measure/Metric	Monitoring Interval	Notes
sediment type	the feature, allowing for natural succession/ known cyclical change.	Nunny & Smith (2008).	analysis techniques.	stations.		
Distribution of biotopes	Maintain the distribution of biotopes, allowing for natural succession/known cyclical change	Community types ('proto-biotopes') derived from the grab samples obtained in 2007 by Nunny & Smith (2008).	Grab samples (mini- Hamon grab).	Repeat sampling of Nunny & Smith (2008) stations.	6-12 years	A reduced interval period before the first monitoring period should be considered to allow an early evaluation of the stability and persistence of the community groups or 'proto-biotopes'
Extent of sub-feature or notable biotope.	No change in extent of the inshore sublittoral sediment biotope(s) or subfeature identified for the site allowing for natural succession/ known cyclical change.	None	High-definition drop-down video sampling	A stratified random sampling strategy of directed sampling of targeted habitat (or species).	6 years.	This is a 'speculative' attribute included at the suggestion of Keith Hiscock.
Presence and abundance of great scallop *Pecten maximus*	Maintain presence and abundance of *Pecten maximus*.	Abundance data from 4 sites collected as part of the NTZ effect study by Hoskin *et al.* (2009)	Diver transect sampling	Change in abundance of scallops at sample sites.	1-6 years	Note: The low abundance reported by Hosking and others suggests that, at present, this method is unlikely to be able to detect a level of change that could contribute to a condition monitoring programme.
Presence and abundance of red band fish *Cepola rubescens*	Maintain presence or abundance of positive indicator species (*Cepola rubescens*).	None.	Diver searches or drop-down video.	The maintained presence of *Cepola rubescens* at specific locations.	1-6 years	We recommend that this attribute be considered of low priority and should concentrate on simply demonstrated the continued presence of *C. rubescens*, until a greater understanding of the distribution of the fish allows a more structured assessment of the population status.

Marine Mammals (grey seals)

Attribute	Target	Baseline	Method	Measure/Metric	Monitoring Interval	Notes
Grey seal pup production.	A stable or increasing number of breeding female grey seals.	Pup production count data from Westcott, 2009	Direct count during breeding season.	Change in pup production around Lundy or assessment as proportion of UK estimates.	1 – 3 years.	Sea conditions hampered the 2008-2009 survey and Westcott (2009) recommends that future surveys are Lundy based.
Distribution of grey seal pups	A stable or increasing area of usage.	Westcott, 2009	Pup production numbers, age classification of pups, locations and distribution for different breeding sites incorporated into a GIS.	Abundance comparison.	1 – 3 years.	
Accessibility for breeding	No restriction on grey seal access to and from the breeding colony.	Westcott, 2009	Direct observation of sites and habitat usage.	Direct comparison of access and availability of breeding sites to previous years.	1 – 3 years.	
Population size	Maintain grey seal population size subject to natural change.	Westcott, 2009	Direct count and observation.	Abundance comparison.	3-6 years	Due to adverse weather conditions the 2008-2009 survey did not manage to establish a full year round abundance and distribution dataset. Incorporating the population size monitoring into one of the pup production monitoring cycles would reduce the time requirements of this monitoring element and satisfy a number of attributes.

APPENDIX 2. SEDIMENTARY ‘PROTO-BIOTOPES’ IDENTIFIED FROM LUNDY GRAB SAMPLING, AUGUST/SEPTEMBER 2007. FROM NUNNY & SMITH (2008)

Biotope	Tax per grab (and total in biotope)	Characterising taxa	Nearest JNCC Biotope
1	24 - 41 (52)	*Laminaria hyperborea, Membranipora membranacea, Phycodrys rubens, Membranoptera alata. Helcion pellucidum, Odontosyllis ctenostoma, Jassa falcata, Eusyllis blomstrandi, Crisia eburnea, Obelia geniculata, Aora gracilis, Electra pilosa* and *Alcyonidium gelatinosum*	IR.MIR.KR.LhypTX *Laminaria hyperborea* on tide-swept, infralittoral mixed substrata
2A	60 – 100 (126)	Barnacles (mainly *Verruca stroemia*, also *B. crenatus*), Anomiidae (saddle oysters), *Pisidia longicornis, Amphipholis squamata, Eusyllis blomstrandi, Epizoanthus couchii, Pomatoceros triqueter* & *P. lamarckii*, *Pseudoprotella phasma, Modiolus modiolus, Amphilochus manudens*, Nudibranchs	Species rich version of SS.SCS.CCS.PomB *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
2B	23	Anomiidae, *Puellina venusta, Eusyllis blomstrandi, Abietinaria abietina, Electra pilosa, Escharella variolosa, Sertularia cupressina, Sertularia* spp. *Tridentata distans* and *Pomatoceros lamarckii*	Some similarities with SS.SCS.CCS.PomB *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles
3A	2 – 12 (18)	*Nephtys cirrosa*, often with *Glycera oxycephala, Magelona johnstoni* and *Scolelepis bonnieri*	SS.SSA.IFiSa.IMoSa Infralittoral mobile clean sand with sparse fauna
3B	3	*Magelona alleni, Magelona* sp. and *Echinocyamus pusillus*	SS.SSA.IFiSa.IMoSa Infralittoral mobile clean sand with sparse fauna
3C	4	*Caecum glabrum, Erichthonius* sp. *Lagis koreni*, *Mediomastus fragilis, Nephtys* sp. (juv) and the brittlestar *Ophiactis balli*	SS.SSA.IFiSa.IMoSa Infralittoral mobile clean sand with sparse fauna
4	7 – 26 (28)	*Modiolus modiolus, Sertularia cupressina, Dynamena pumila, Electra pilosa* and *Verruca stroemia*. Single specimens of hermit crabs (Paguridae) and *Amphioxus* (*Branchiostoma lanceolatum*) were recorded at Station 28	Similar to SS.SSA.IFiSa.ScupHyd *Sertularia cupressina* and *Hydrallmania falcata* on tide-swept sublittoral sand with cobbles or pebbles. Note that *Hydrallmania falcata* not recorded.
5A	46 – 66 (108)	*Ampelisca tenuicornis, Apistobranchus tullbergi, Parametaphoxus pectinatus, Eudorella truncatula, Nemertea* indeterminate, *Mediomastus fragilis, Lumbrineris gracilis, Praxillela affinis, Exogone hebes, Harmothoe* spp., *Paradoneis lyra, Nephtys kersivalensis, Tanaopsis graciloides, Spio decorata, Bodotria scorpioides* and *Spiophanes bombyx*	Station 25 had some similarities with SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrineris* spp. And venerid bivalves in circalittoral coarse sand or gravel, due to the presence of the venerid bivalve *Timoclea ovata*. Stations 1 & 20 shared many taxa with St 25, but

Biotope	Tax per grab (and total in biotope)	Characterising taxa	Nearest JNCC Biotope
			also had similarities with Biotope 8B.
5B	47 – 100 (217)	Characterising taxa: *Ampelisca tenuicornis*, *Apistobranchus tullbergi, Urothoe elegans, Poecilochaetus serpens, Lumbrineris gracilis, Gammaropsis cornuta, Glycera lapidum, Harpinia antennaria. Timoclea ovata* and *Mediomastus fragilis* usually present.	Most stations were a good match with SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrineris* spp. And venerid bivalves in circalittoral coarse sand or gravel
5C	32 – 63 (101)	*Abludomelita obtusata, Gammaropsis cornuta, Urothoe elegans Glycera lapidum, Echinocyamus pusillus, Nemertea indeterminate, Lumbrineris gracilis, Anoplodactylus petiolatus* and *Paradoneis lyra*	Stations 10 and 22 were a reasonably good match with SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrineris* spp. And venerid bivalves in circalittoral coarse sand or gravel. The venerid bivalves were *Timoclea ovata* (St 10) and *Circomphalus casina* and *Dosinia lupinus* | (both at St 22).
5D	23 – 78 (192)	*Gammaropsis cornuta, Glycera lapidum* and *Echinocyamus pusillus. Sabellaria spinulosa, Modiolus modiolus, Verruca stroemia, Anomiidae, Crisia aculeata, Achelia echinata, Prionospio banyulensis, Ampelisca spinipes, Syllis* sp. E and *Timoclea ovata* usually present.	Some stations were a reasonably good match with SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrineris* spp. And venerid bivalves in circalittoral coarse sand or gravel. The densities of *Sabellaria spinulosa* were moderately high at 5 of the 6 stations, and it may be that this grouping represents a biotope complex of SS.SCS.CCS.MedLumVen and S.SBR.PoR.SspiMx *Sabellaria spinulosa* on stable circalittoral mixed sediment.
5E	91 – 123 (208)	Anomiidae (saddle oysters), *Sabellaria spinulosa, Modiolus modiolus, Verruca stroemia, Pisidia longicornis, Harmothoe* spp., *Achelia echinata, Eusyllis blomstrandi, Crisia aculeata, Cressa dubia, Glycera lapidum, Phtisica marina, Amphipholis squamata*, Nudibranchia indeterminate, *Aora gracilis, Echinocyamus pusillus, Modiolarca tumida, Syllidia armata, Lumbrineris gracilis, Erichthonius punctatus, Sphenia binghami, Epizoanthus couchii, Hiatella arctica, Ampelisca tenuicornis, Ampharete lindstroemi, Callipallene brevirostris, Maera othonis, Gammaropsis cornuta, Parvicardium ovale, Crisia eburnea, Adyte pellucida, Pholoe synophthalmica* and	SS.SBR.PoR.SspiMx *Sabellaria spinulosa* on stable circalittoral mixed sediment.

Biotope	Tax per grab (and total in biotope)	Characterising taxa	Nearest JNCC Biotope
		Ampelisca spinipes usually present.	
6	25	Large number of the gammarid amphipod *Socarnes erythrophthalmus* and high diversity of foliose bryozoans (*Crisia aculeata*, *Crisia eburnea, Crisia denticulata* and *Crisidia cornuta*)	Unmatched to any JNCC biotope. The substrate was fine shell gravel, with the venerid *Clausinella fasciata* present. The substrate and presence of venerid bivalves suggests some similarities with SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrineris* spp. And venerid bivalves in circalittoral coarse sand or gravel, but *M. fragilis* and *Lumbrineris* spp. Were absent.
7A	13 – 30 (38)	*Glycera lapidum*, *Polygordius lacteus, Hesionura elongata, Pisione remota* and *Grania* spp.	Similar to SS.SCS.ICS.HeloMsim *Hesionura elongata* and *Microphthalmus similis* with other interstitial polychaetes in infralittoral mobile coarse sand. In these examples the polychaete *Microphthalmus similis* was not recorded.
7B	4	Single specimens each of *Glycera lapidum, Hesionura elongata, Amphilochus neopolitanus* and *Ophiura* sp.	Similar to SS.SCS.ICS.HeloMsim *Hesionura elongata* and *Microphthalmus similis* with other interstitial polychaetes in infralittoral mobile coarse sand. In these examples the polychaete *Microphthalmus similis* was not recorded.
8A	36 – 37 (53)	*Abra alba, Echinocyamus pusillus, Glycera lapidum, Spisula elliptica, Phaxas pellucidus, Sthenelais limicola, Sagitta* spp., *Callianassa subterranea, Lagis koreni* and *Polinices pulchellus*	No close match with any JNCC biotope. Intermediate between SS.SMU.CSaMu.LkorPpel *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud and SS.SSA.CMuSa.AalbNuc *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment
8B	30 – 52 (117)	*Tubificoides amplivasatus, Parametaphoxus pectinatus, Tharyx killariensis, Spio decorata, Nemertea indeterminate, Ampelisca tenuicornis, Ampelisca* spp. (juv) & *Lumbrineris gracilis*. Usually present *Harpinia antennaria, Eudorella truncatula, Abra alba, Pariambus typicus, Amphiura filiformis, Perioculodes longimanus, Phaxas pellucidus, Anoplodactylus petiolatus, Nephtys hombergii* and *Mediomastus fragilis*	No close match with any JNCC biotope. Intermediate between SS.SMU.CSaMu.LkorPpel *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud and SS.SSA.CMuSa.AalbNuc *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment.

Biotope	Tax per grab (and total in biotope)	Characterising taxa	Nearest JNCC Biotope
9	11	*Ampelisca brevicornis, Magelona alleni, Marphysa bellii, Aricidea minuta, Lumbrineris gracilis, Nephtys hombergii, Pariambus typicus, Phaxas pellucidus, Polydora socialis, Terebellides stroemi* and *Tharyx killariensis*	No close match with any JNCC biotope. Intermediate between SS.SMU.CSaMu.LkorPpel *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud and SS.SSA.IMuSa.SsubNhom *Spisula subtruncata* and *Nephtys hombergii* in Shallow muddy sand. Note that neither *Lagis koreni* nor *Spisula subtruncata* were recorded
10	14	*Hydroides norvegica, Epizoanthus couchii, Golfingia vulgaris vulgaris, Notomastus latericeus, Ampelisca spinipes, Amphiura filiformis, Euclymene lumbricoides, Mediomastus fragilis, Nematonereis unicornis, Notomastus* sp., *Photis longicaudata, Terebellides stroemi, Trichobranchus roseus* and *Upogebia deltaura*	Species-poor variation of SS.SMX.OMx Offshore circalittoral mixed sediment?

APPENDIX 3. MARCLIM SAMPLING PROTOCOLS 2008 (SUPPLIED BY N. MIESZKOWSKA, MBA)

Before you start at each site, record:

1. Site name and grid reference
2. County/Area
3. Date
4. Recorder
5. Lat long of access point (e.g. car park) and lat long of centre of survey area (e.g. midshore)
6. Exposure scale of the shore
7. Weather at the time of the survey, especially the visibility
8. Mark site on an OS Map

At each site: Semi-Quantitative Data

1. Identify area to be sampled (this might be up to 100m or more in extent)
2. Photograph approach to site
3. Photograph general view of the sample site
4. Photograph specific features of interest and any rare organisms/new records

   Photographs MUST be catalogued as you take them: date, site location and aspect (and zone if relevant)
5. Walk the whole of the sampling area and using the checklist allocate each of listed species listed to a ACFOR category (see Appendix). Use one or two quick quadrat counts to help in placing in the ACFOR category.
6. It is important to record *apparent* absences and the ACFOR category should be based on the locality in which the species is most abundant, this might be as small as 10m x 10m. DO NOT spend more than 30 minutes searching for species unless at a range edge. If more than 30 minutes is spent searching, record the time.
7. Use the notes section of the form for other species of interest..
8. Use GPS to record

   Midshore of the area sampled/searched

   Location of areas sampled for particular species (if different)

   Location of key features visible in the photographs
9. Note major features of the shore; bedrock, cobbles, boulders, sand scouring etc.

At each site: Quantitative Data

1. Replicated counts of limpets, barnacles, trochids will be made on each shore visit. If time is short and we are visiting a shore that has not been previously surveyed then trochids should only be recorded by ACFOR.
2. Avoid areas of heavy human disturbance.

Site selection and counting methods

Counting Barnacles

1. Count barnacles at *low, mid* and *high* shore levels. High shore is defined as that area 1m below the very top of the barnacle zone, mid shore in the middle of the barnacle zone, low 1m above the bottom of the barnacle zone
2. Use a 5 x 2cm or 2 x 2cm quadrat where barnacle cover is ≥ 50%. In areas where barnacles are sparse, 5x5cm or 10x10cm quadrats may be used. Or take digital photographs using the standard camera quadrat 5x5cm frame.
3. Take at least 20 samples in 2 independent patches at *each* shore height; the number should be consistent with habitat heterogeneity. True random sampling is unrealistic on a broken rocky shore hence samples should be stratified to encompass the full range of shore slopes. At midshore do two separate clusters of counts if time. If digital photography is used, back up by doing quick counts for SACFOR scores.
4. Place the quadrat and record % cover of bare rock and record any evidence of hummocking. Count and record the total number of:

   Adults Recruits

Semibalanus (1+ group)	*Semibalanus*
Chthamalus montagui	
Chthamalus stellatus	*Chthamalus* (Total)
Elminius modestus	*Elminius modestus*
Balanus perforatus	
Balanus crenatus	

5. The project will trial use of digital photography and image analysis for barnacle counting/identification. Photographs MUST be catalogued in the field so that shore levels (low, mid and high) can be separated.

Counting Limpets and Associated Fauna & Flora

1. Count limpets at both *low* and *mid shore* levels
2. Use a 0.5 x 0.5 cm quadrat. Where possible this should be strung at regular intervals to facilitate counting and estimation of % cover of barnacles.
3. Take at least 10 samples but not more than 20 at *each* shore height; the number should be consistent with habitat heterogeneity. True random sampling is unrealistic on a broken rocky shore hence samples should be stratified to encompass the full range of shore slopes
4. Areas with heavy shade, with pools and those that are heavily fissured should be avoided
5. Place the quadrat and record % cover of barnacles mussels, dominant algae and bare rock. Record the number of individuals of *Osilinus lineatus, Gibbula umbilicalis* and *Nucella lapillus* present in the quadrat.
6. Count the total number of limpets >10mm. Recount to estimate the abundance of the less common species. Ticking animals using chalk is a simple way to ensure that counts and species identification are accurate and consistent. Confirm the identity of *Patella depressa* through checking all features (white tentacles, black foot, shell morphology). Where rare (i.e. at range edges) take reference photographs.

Counting Trochids

1. Count Osilinus lineatus and Gibbula umbilicalis in the region of the shore that they are most abundant. *Osilinus lineatus* occurs **upshore** of *Gibbula umbilicalis* for a large part of the year.
2. The aim is to record abundance/ structure of populations. As adults and year classes 0-2 often live in slightly different habitats a detailed search is required
3. Make 5 replicated timed counts of 3 minutes duration at each shore.
4. Select a small area in the region of the shore where the species is most abundant. Pick all individuals off visible surfaces and sample under stones and in cracks and crevices for the juveniles. Search using this method for 3 minutes and place all individuals into a bag. Remember to write the length of the search time on the form. Count the number of individuals and measure the basal diameter to the nearest 0.1mm using dial calipers.
5. In shores where there is a relatively uniform distribution of rocks < 30cm it is possible to use a $1m^2$ quadrat to sample trochids. If this sampling method is used the operator moves across the quadrat and collects all animals on the visible surfaces. Once done, each rock is turned over and a separate search is undertaken for the younger animals that seldom move far from damp locations. A substantial proportion of the population may well be under stones. Again count the number of individuals and measure the basal diameter to the nearest 0.1mm.In addition, up to five random 0.5x0.5m quadrats can be thrown randomly to provide backup for SACFOR estimates.

Before leaving, have one last walk around the sample site to confirm first impressions and please check that all equipment and cameras have been collected from the shore

A: MarClim Recording Forms

Site name: …………………. Grid reference: ………………….
County: …………………. Lat long of access point: ………………….
Date: …………………. Lat long of centre of survey area: ………………….
Recorder: ………………….
Weather conditions: …………………. Exposure ………………….
Visibility …………………. Low shore availability ………………….

Species	S	A	C	F	O	R	Not seen	Comments
Codium spp.								
Laminaria hyperborean								
Laminaria digitata								
Saccharina latissima (L. saccharina)								
Laminaria ochroleuca								
Alaria esculenta								
Himanthalia elongata								
Sargassum muticum								
Ascophyllum nodosum								
Pelvetia canaliculata								
Fucus spiralis								
Fucus vesiculosus								
Fucus serratus								
Fucus distichus								
Fucus indet.								
Cystoseira spp.								
Halidrys siliquosa								
Bifurcaria bifurcate								
Mastocarpus stellatus								
Chondrus crispus								
Lichina pygmaea								
Undaria pinnatifida								
Halichondria panacea								
Anemonia viridis								
Aulactinia verrucosa								
Actinia fragacea								
Actinia equine								
Sabellaria alveolata								
Chthamalus stellatus								
Chthamalus montagui								
Semibalanus balanoides								
Balanus crenatus								
Balanus perforatus								
Elminius modestus								
Mytilus spp.								
Campecopea hirsuta								
Clibanarius erythropus								
Haliotis tuberculata								

Tectura testudinalis								
Patella vulgate								
Patella depressa								
Patella ulyssiponensis								
Patella pellucida								
Gibbula umbilicalis								
Gibbula pennanti								
Gibbula cineraria								
Osilinus lineatus								
Calliostoma zizyphinum								
Littorina littorea								
Littorina saxatilis agg.								
Melarhaphe neritoides								
Nucella lapillus								
Onchidella celtica								
Crassostrea gigas								
Crepidula fornicate								
Asterias rubens								
Leptasterias mulleri								
Paracentrotus lividus								
Strongylocentrotus droebachiensis								

B: Barnacle count photographs

Site name: ………………… Grid reference: ……………………………..

Quadrat size: ………………… Recorder: ……………………………..

Survey site habitat ………………… Biotope classification code: ……………………………..

Methodology

1. 10 replicate barnacle photographs should be taken at High, Mid and low shore. High shore is defined as the area 1m below the very top of the barnacle zone, mid shore in the middle of the barnacle zone, low 1m above the bottom of the barnacle zone
2. Digital photos should be taken where barnacle cover is ≥ 50% with the camera in macro mode. Images are best taken using a frame fixed to the camera with a 5cm × 5cm grid square field of view. Where this is not possible a 5cm × 5cm grid should be placed on the rock to create scale for the digital photograph. As a final resort a coin can be used to indicate scale.
3. Photographs taken must be catalogued in the field so shore levels can be separated.

Analysis of barnacle photographs to be recorded in section H of form.

Other site photos taken

Photo Number	Field comment	Final photo name

B: Barnacle count

Barnacle Count: Recorder: ………………….

Quadrat size: …………………. Lat long of centre of survey area: ………………….

Quadrat	Shore Height	% Cover barnacles	Adult count (1+)					Recruit count (O)			
			SB	CM	CS	EM	BP	SB		Total C	EM
								Cy	Sp		
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Recorder: ………………….

Quadrat size: …………………. Lat long of centre of survey area: ………………….

Quadrat	Shore Height	% Cover barnacles	Adult count (1+)					Recruit count (O)			
			SB	CM	CS	EM	BP	SB		Total C	EM
								Cy	Sp		
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Recorder: ………………….

Quadrat size: …………………. Lat long of centre of survey area: ………………….

Quadrat	Shore Height	% Cover barnacles	Adult count (1+)					Recruit count (O)			
			SB	CM	CS	EM	BP	SB		Total C	EM
								Cy	Sp		
1											
2											
3											
4											
5											

6											
7											
8											
9											
10											

C: Limpet Count

Shore height: …………………. Recorder: ………………….

Quadrat size: …………………. Lat long of centre of survey area: ………………….

Quadrat	x slope	% barnacles	% mussels	% algae	NL	OL	GU	Count		
								P. vulgata	*P. depressa*	*P. aspera*
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Shore height: …………………. Recorder: ………………….

Quadrat size: …………………. Lat long of centre of survey area: ………………….

Quadrat	x slope	% barnacles	% mussels	% algae	NL	OL	GU	Count		
								P. vulgata	*P. depressa*	*P. aspera*
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

D: Trochid count

Trochid Count: Recorder: ………………….

Quadrat/Timed Count: …………………. Lat long of centre of survey area: ………………….

Sample	Shore Height	Total Count	
		Osilinus lineatus	*Gibbula umbilicalis*
1			
2			
3			
4			

5			
6			
7			
8			
9			
10			

Notes:

F: Trochid size structure (measure basal diameter to the nearest mm)

Osilinius lineatus

Site name; ……………….. Grid reference: ……………………

Shore height ………………….. Quadrat size/ time of count ……………………

Habitat search undertaken: ………………..

***Osilinius lineatus* basal diameters**																			
Sample 1				Sample 2				Sample 3				Sample 4				Sample 5			

Gibbula umbilicalis

Site name; ……………….. …………………… Grid reference:

Shore height …..................... …………………… Quadrat size/ time of count

Habitat search undertaken: ………………..

***Gibbula umbilicalis* basal diameters**																			
Sample 1				Sample 2				Sample 3				Sample 4				Sample 5			

APPENDIX 4. SUMMARY OF FEATURE ATTRIBUTES EXAMINED IN THIS REPORT INDICATING CURRENT BASELINE DATA AVAILABILITY, WHETHER THE RECOMMENDED/SUGGESTED METHODOLOGY INCLUDES SAMPLE REPLICATION AND THE TYPE OF STATISTICAL ANALYSES THAT COULD BE APPLIED WHERE APPROPRIATE.

Key for baseline assessment:

x No baseline available
✓ Suspected or possible baseline data available
✓✓ Limited baseline data available. Restricted number of samples or locations or data not recent.
✓✓✓ Good baseline available

Feature	Attribute	Baseline	Sample replication	Statistical analyses
Sea caves	Extent	x	No	Direct comparison
	Number of caves in site	x	No	Direct comparison
	Biotope composition of caves	✓	No	Direct comparison
	Presence of representative/ notable biotopes	x	No	Direct comparison
	Presence and abundance of *Leptopsammia pruvoti*	✓✓✓	No	Direct comparison
~~Inshore~~ littoral rock	Extent	?	No	Direct comparison
	Biotope composition of littoral rock	✓	No	Direct comparison
	Distribution and spatial pattern of biotopes at specific locations	✓	No	Direct comparison
	Presence of rockpool biotopes	✓	No	Direct comparison
	Species composition of rockpool biotopes	✓	No	Direct comparison
	Presence and abundance of climate change indicator species	✓✓✓	No	Yes (MarClim to determine)
	Presence and abundance *Balanophyllia regia* & *Caryophyllia smithii.*	✓✓✓	No	Mann-Whitney Test
	Presence and abundance of *Sargassum muticum*	✓	No	Direct comparison
Inshore sublittoral rock	Extent	✓✓✓	No	Direct comparison
	Biotope composition of inshore sublittoral rock.	✓✓✓	No	Chi-square, Wilcoxon signed rank test
	Distribution of algal community at specific locations	✓✓	Yes	Chi-square, but a direct comparison would suffice
	Species composition of kelp biotopes: kelp forest structure.	✓✓	Yes	ANOVA, but a simple ratio may suffice.
	Species composition of representative or notable biotopes	✓✓✓	Yes	ANOVA, ANOSIM

Feature	Attribute	Baseline	Sample replication	Statistical analyses
	Presence and abundance of *Eunicella verrucosa*	✓✓	Yes	Wilcoxon Ranked Sum test/t test
	Condition of *Eunicella verrucosa* population	✓✓✓	Yes	Direct comparison
	Presence and abundance of *Leptopsammia pruvoti*	✓✓	No	Direct comparison
	Presence and abundance of Lobster *Homarus gammerus*	✓✓✓	Yes	ANOVA
	Presence of other specified species	✓✓✓	Yes	ANOVA
Inshore sublittoral sediment	Extent	✓✓✓	No	Direct comparison
	Topography of inshore sublittoral sediment	✓✓✓	No	No
	Sediment character: sediment type	✓✓✓	No	Direct comparison of descriptive parameters
	Distribution of biotopes	✓✓✓	No	Direct comparison
	Extent of sub-feature or notable biotope	x	No	Direct comparison
	Presence and abundance of great scallop *Pecten maximus*	Yes	Yes	No (insufficient abundance)
	Presence and abundance of red band fish *Cepola rubescens*	x	No	Direct comparison
Grey Seal	Grey seal pup production	✓✓✓	No	Direct comparison
	Distribution of grey seal pups within the SAC	✓✓✓	No	Direct comparison
	Accessibility of the SAC for breeding	✓✓✓	No	Direct comparison
	Population size	✓✓✓	No	Direct comparison

APPENDIX 5. ATTRIBUTE AND MONITORING PRIORITISATION

The monitoring priorities below are based on an estimation of how vulnerable an attribute is in the short to medium term and taking into consideration the impacts and activities outlined in the regulation 33 package.

Description of monitoring priorities

Priority	Description
High	The attribute is vulnerable, potentially under pressure and could be lost or damaged in the short term
Medium	There are indications of some potential change
Low	The attribute is not under threat and is not liable to change in the medium to long term

Feature attributes and monitoring priorities with a justification of ranking.

Feature / Attribute	Priority	Comments
Sea Caves		
Extent of caves.	Low	The extent is not likely to change or be impacted by anthropogenic influences and is therefore not considered a high priority. The monitoring of this attribute will be partially met by the monitoring of the cave biotope attribute below.
Number of caves in site.	Low*	The number of caves is not anticipated to change in the medium to long term, although a full baseline still needs to be established.
Biotope composition of caves	Medium	Apart form the oil spill in the Bristol Channel which initiated the original monitoring there is currently no indication that the biotope composition of this attribute would change in any way.
Presence of representative/notable biotopes.	Medium	There is not evidence that any of the current cave biotopes are under threat.
Presence and abundance of *Leptopsammia pruvoti*	High	There is some evidence to suggest that numbers have started to decline.
Littoral Rock		
Extent of littoral rock.	Low*	There is currently no reason to believe the extent of this attribute would change in the medium to long terms. A full baseline still needs to be established.
Biotope composition of littoral rock.	Medium	Although there is no evidence that there is an mediate threat to this attribute there is some indication that non native species are appearing.
Distribution and spatial pattern of biotopes at specific locations.	Medium	See above
Presence of rockpool biotopes.	Medium	See above
Species composition of rockpool biotopes.	Medium	See above
Presence and abundance of climate change	High	Although not directly related to the condition of the site this attribute is a potentially useful indicator of how rapidly

Feature / Attribute	Priority	Comments
indicator species		changes are occurring as a result of climate change. It may provide early warning and indicate to what extent structural changes in tidal communities are likely to occur.
Presence and abundance of the scarlet and gold star coral *Balanophyllia regia* and Devonshire cup coral *Caryophyllia smithii.*	High	There is evidence to suggest these populations are currently stable although there is a need to gain a better idea of the distribution of these species around Lundy. It is anticipated monitoring will be carried out under the direction of the warden.
Presence and abundance of *Sargassum muticum*	Medium	This is a non-native species that is known to be established on Lundy for a number of years. There is currently no evidence to suggest it is getting out of control and like climate change there is little that can be done.
Inshore Sublittoral Rock		
Extent of inshore sublittoral rock.	Low	A baseline has already been established and there is no evidence to suggest that the extent will change in the medium to long term.
Biotope composition of inshore sublittoral rock.	High	This provides a wide indication of community distribution.
Distribution of algal community at specific locations.		Provides an indication of upstream changes and impacts which may occur as a result of large engineering projects which may have downstream hydrological effects e.g. the Severn barrage. It can also provide an indication of large scale nitrification effects where plankton density may increase.
Species composition of kelp biotopes: kelp forest structure.	High	It is currently unclear what is controlling the abundance of these species; however the potential for a change in the current ratio of *Laminaria hyperborean* and *Laminaria ochroleuca* exists with the potential loss of biodiversity in kelp biotopes.
Species composition of representative or notable biotope.	High	Report directly on species abundance and community integrity.
Presence and abundance of *Eunicella verrucosa.*	High	There is some evidence to suggest there has been a decline as a result of infection. There is currently no clear indication of whether *Eunicella* are still under threat and we are still awaiting the results from genetic studies to indicate whether those found around Lundy constitute an isolated population.
Condition of *Eunicella verrucosa* population	High	See above.
Presence and abundance of *Leptopsammia pruvoti.*	Medium	Monitoring the wider distribution and abundance will allow us to determine whether the known population at Knoll Pins is declining or not.
Presence and abundance of Lobster *Homarus gammerus*/ brown crab *Cancer pagurus*/ spider crab *Maja squinado*/ velvet crab *Necora puber*	Medium	The crustacean populations are not known to be under threat but form part of the Sac community.
Presence of other specified species.	Medium	These are long lived sessile species vulnerable to physical damage. There is currently no known indication that they are under threat. These species form part of the communities

Feature / Attribute	Priority	Comments
		which make the Lundy site so special to conservation.
Inshore Sublittoral Sediment		
Extent of inshore sublittoral sediment.	Low	The extent is already known and there is evidence to suggest this attribute will not change in the medium to long term (see work by Nunny & Smith, 2008).
Topography of inshore sublittoral sediment	Low	The bathymetry is highly unlikely to change in the medium to long term.
Sediment character: sediment type	Low	There is not anticipated to be any change over the medium to long term. An indication of change can be obtained from the biotope attribute (see Section 3.4.4).
Distribution of biotopes	Medium	There is no evidence to suggest there is anything currently impinging on the sedimentary environment. Further monitoring is required to establish the persistence of the sedimentary communities around Lundy.
Extent of sub-feature or notable biotope.	Low	This is currently a speculative attribute suggested by Keith Hiscock and it is currently unknown if this will produce usable results. More information may be obtained through the grab sampling rather than drop-down camera as the later will only be able to distinguish surface species.
Presence and abundance of great scallop *Pecten maximus*	Low	It has been demonstrated that the abundances are too low for a realistic statistically supported monitoring programme.
Presence and abundance of red band fish *Cepola rubescens*	Low	The distribution is very patchy and a lot of survey effort may be expended for very usable data.
Grey Seals		
Grey seal pup production	Medium	Not currently considered vulnerable or under threat and there is no indication that pup production or grey seal populations are declining.
Distribution of grey seal pups within the SAC	Medium	See above.
Accessibility of the SAC for breeding	Medium	See above.
Population size	Medium	See above.

* = low priority but mandatory attribute not yet monitored so will require early monintoring to establish a baseline in the near future.

APPENDIX 6 (BELOW) PROPOSED MONITORING TIME-LINE. WHERE AN INTERVAL RANGE IS SUGGESTED IN THE TEXT THE SHORTEST INTERVAL IS USED. STIPPLED BOXES INDICATE YEARS WHEN TWO DIFFERENT MONITORING METHODS ARE USED TO ADDRESS A SINGLE ATTRIBUTE. THE COLOURS DIFFERENTIATE FEATURES.

APPENDIX 6 PROPOSED MONITORING TIME-LINE.

Attribute	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Extent of cave (s)																									
Number of caves in site																									
Biotope composition of a cave																									
Presence of representative/notable biotopes																									
Presence and abundance of *Leptopsammia pruvoti*																									
Extent of littoral rock																									
Biotope composition of littoral rock																									
Distribution and spatial pattern of biotopes at specific locations																									
Presence of rockpool biotopes																									
Species composition of rockpool biotopes																									
Presence and abundance of climate change indicator species																									
Presence and abundance of the scarlet and gold star coral																									
Presence and abundance of *Sargassum muticum*																									
Extent of inshore sublittoral rock																									
Biotope composition of inshore sublittoral rock																									
Distribution of algal community at specific locations																									
Species composition of kelp biotopes: kelp forest structure																									
Species composition of representative or notable biotopes																									
Presence and abundance of *Eunicella verrucosa*																									
Condition of *Eunicella verrucosa* population																									
Presence and abundance of *Leptopsammia pruvoti*																									
Presence and abundance of Lobster																									
Presence of other specified species																									
Extent of Inshore sublittoral Sediment																									
Topography of Inshore Sublittoral Sediment																									
Sediment character: sediment type																									
Distribution of Biotopes																									
Extent of sub-feature or notable biotope																									
Presence and abundance of red band fish																									
Grey seal pup production																									
Distribution of grey seal pups within the SAC																									
Accessibility of the SAC for grey seal breeding																									
Grey seal Population size																									