Marine Scotland

Scottish Marine Protected Areas (MPA) Monitoring Strategy

Supporting Annexes 1 to 6

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Riaghaltas na h-Alba

Annex 1: Detail on the key pressures for the different MPA feature monitoring groups

This annex provides summaries of key pressures that have been produced for other reports and assessments. The terminology and methods vary between the feature groups. Standardised terms have been used in Table 2 of the main Strategy document to provide an overview.

Marine mammals

Seals

Harbour and grey seals in the UK are particularly sensitive to a number of pressures[1] (see Table A1.1). Susceptibility to these pressures will also vary across species; for example, harbour seals are more susceptible to Phocine Distemper Virus (PDV) while bycatch in fisheries may pose more of a threat to grey seals.

Table A1.1. Key pressures on harbour and grey seals in the UK

Pressures
Anthropogenic disturbance - including increased ocean noise, boat traffic, disturbance from haulout sites
Bycatch (fisheries)
Climate change
Competition with other marine mammals
Deliberate killing (shooting)
Disease (infectious, non-infectious and toxins)
Entanglement in marine debris
Loss of habitat
Nutritional stress
Pollution
Predation
Prey availability (removal of target and non-target species)
Trauma - death or injury by collisions (with marine renewable energy developments)

Of the pressures identified above for harbour and grey seals, the following are considered the most significant: Harbour seals - competition with grey seals and other marine mammals, disease, trauma, pollution and anthropogenic disturbance; grey seals - competition with other marine mammals, disease, bycatch, pollution and anthropogenic disturbance (SMRU, *pers comm.)*.

Cetaceans

[1] http://www.smru.st-andrews.ac.uk/files/2015/10/CSD1-2_and_CSD2_Workshop_report_on_decline_in_abundance_of_harbour_seals.pdf

Macleod *et al* (2015) identified some of the key pressures to which cetaceans in the UK are particularly sensitive (see Table A1.2). Susceptibility to these pressures will vary across species and at different spatial scales.

Table A1.2. Key pressures on cetaceans in the UK

Pressures
Bycatch (fisheries)
Disease
Prey availability (removal of target and non-target species)
Contaminants
Underwater noise
Trauma - death or injury by collisions
Loss of habitats

Data derived from cetacean and seal strandings can be used to give an indication of some of the pressures in coastal areas, but specific studies are required to quantify the impacts (IAMMWG, 2015). For example, analysis of PCBs from blubber samples has shown that PCBs may have impacts on the reproductive success of cetaceans, leading to population level effects for certain species (Jepson *et al*., 2016). In addition, information on seal and cetacean bycatch is collected from fisheries monitoring[2].

The Marine Noise Registry[3] (MNR) has been established to record activities in UK seas that produce loud, low to medium frequency (10Hz - 10kHz) impulsive noise.

There is relatively little quantitative or even qualitative information on pressures in offshore areas compared to our knowledge for inshore waters.

Marine birds

Mitchell *et al.* (2010) identified a number of key pressures which impact seabirds and marine waterbirds in the UK (Table A1.3). These pressures act at both a local level (e.g. recreational disturbance, predation from non- native species) and wider scales (e.g. bycatch, industrial fisheries, pollution, climate change). Sensitivity and exposure vary; for example, guillemots and razorbills will be more sensitive to oil spills during their flightless late summer moulting period than during the breeding season when they are more mobile (Williams *et al.*, 1995).

At sea, the most important pressures are contamination by, or ingestion of hazardous substances (hydrocarbons, plastic); by-catch in static and mobile fishing gear and reduced prey availability, driven in part by climate change and in some circumstances, commercial fishing pressure. On land (especially at breeding colonies), key pressures are predation by non-native species; habitat loss and degradation; and displacement as a result of repeated / chronic disturbance.

[2] See - http://jncc.defra.gov.uk/page-5214
[3] See - https://mnr.jncc.gov.uk/

Table A1.3. Pressures identified by Charting Progress 2 (Mitchell *et al*., 2010) as having potential impacts on marine waterbirds and seabirds, along with the equivalent ICG-CE pressures and relevant activities. The CP2 assessment for waterbirds included shorebirds, so expert judgment was used to identify those pressures relevant to marine waterbirds only. Emerging pressures identified since CP2 also listed.

Pressures identified by Charting Progress 2	ICG equivalent pressure(s)	Example activities[1]	Marine waterbirds	Seabirds
Climate change	Not considered	Not considered	✓	✓
Habitat damage	Habitat structure changes - removal of substratum (extraction); Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	Renewable energy development; Aggregate extraction	✓	
Habitat loss	Physical loss (to land or freshwater habitat); Physical change (to another seabed type)		✓	✓
Siltation rate changes	Siltation rate changes	Aggregate extraction	✓	
Litter	Litter	Shipping; recreation		✓
Visual disturbance	Visual disturbance	Renewable energy development; shipping; recreation	✓	✓
Introduction or spread of non-indigenous species	Introduction or spread of non-indigenous species	Docks, ports, marinas	✓	✓
Removal of species (target and non-target species) by fisheries	Removal of non-target species [e.g. bycatch]; Removal of target species [e.g. licensed control, fishing of prey species]	Fishing; Aquaculture; Aggregate extraction	✓	✓
Hydrological changes (inshore/local)	Water flow (tidal current) changes - local; Emergence regime changes - local; Wave exposure changes – local	Aggregate extraction; dredging	✓	
Contamination by hazardous substances	Transition elements & organo-metal; Hydrocarbon & polycyclic aromatic hydrocarbons (PAH) contamination; Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	Hydrocarbon extraction; sewage disposal; waste disposal	✓	✓
De-oxygenation	De-oxygenation		✓	

Nitrogen and phosphorous enrichment	Nutrient enrichment	Sewage disposal; Industrial & agricultural discharges	✓	
Organic enrichment	Organic enrichment		✓	
Key emerging pressures identified as having potential impacts on marine birds since Charting Progress 2				
n/a	Death or injury by collision	Renewable energy development;	✓	✓
n/a	Barrier to species movements	Renewable energy development; Shipping; recreation	✓	✓

1 Example human activities for each pressure taken from the full list presented in Annex 2 of Eassom & Church 2013. Progress towards the development of a standardised UK pressures-activity matrix. Paper presented to HBDSEG, October 2013.

Two pressures not identified by Mitchell *et al*. (2010) are 'death or injury by collision' and 'barrier to species movements', have come to prominence in relation to marine renewable energy developments (e.g. Furness *et al*., 2013; Bradbury *et al*., 2014).

When considering any results from monitoring activities it is important to try to separate the effects of climate change (see Daunt & Mitchell 2013 and Pearce-Higgins & Holt, 2013) from other pressures which have more potential to be managed at a local level (see Frederiksen *et al*., 2004 for an example of how this might be attempted).

Fish

Fish are susceptible to a number of key pressures identified in Table A1.4 below. Of those species appearing as protected features under the MPA network, some will be more susceptible to certain pressures than others depending on a number of factors including: their life histories, behaviours, size reproductive and feeding strategies.

Table A1.4. List of key pressures on populations of marine fish in Scottish waters covered by the MPA network.

Pressures
Bycatch / entanglement
Collisions
Disease
Physical barriers to movement
Physical damage or loss to habitats
Pollution
Reduced prey availability

Seabed habitats

A list of priority pressures for seabed habitats at a UK scale (Table A1.5) was derived following the 2010 Charting Progress 2 (CP2) assessment of UK seas (Aish *et al.*, 2010; HBDSEG, 2011). Only high and medium ranking pressures are presented here. The list of priority pressures was derived from the OSPAR Intersessional Correspondence Group on Cumulative Effects (ICG-C) list. It is possible that there may be pressures affecting seabed habitats in Scotland which are of concern at an MPA level which are not captured by this list.

Table A1.5. List of priority pressures on seabed habitats at a UK-scale.

Pressure theme	Pressure	Pressure ranking
Biological pressures	Removal of target species	High
Physical damage	Habitat structure changes - removal of substratum (extraction)	High
Physical damage	Habitat structure changes - abrasion & other physical damage	High
Hydrological changes (inshore/local)	Water flow (tidal current) changes - local	Medium
Hydrological changes (inshore/local)	Emergence regime changes - local	Medium
Hydrological changes (inshore/local)	Wave exposure changes - local	Medium
Physical damage	Siltation rate changes	Medium
Physical loss	Physical change (to another seabed type)	Medium
Physical loss	Physical loss (to land or freshwater habitat)	Medium
Pollution and other chemical changes	Organic enrichment	Medium

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Annex 2: Examples of the four different monitoring types

Type 0 - Monitoring to determine the continued presence of a feature in a site

Type 0 monitoring is likely to be restricted to the intertidal zone; accessible nearshore areas (by snorkelling, diving or using cameras from boats); or, 'on the water' observations. For mobile species this may include data from surveys undertaken at a wider, regional seas scale e.g. sightings data for cetaceans. Data need not be quantitative and can take the form of presence or presence / absence data. The findings of this sampling may trigger more detailed monitoring (Types 1 - 3). Type 0 monitoring is appropriate for completion through citizen science projects and by non-specialists (e.g. see http://marinesightingsnetwork.org/).

Example: Seasearch volunteer diver observation scheme

Seasearch (http://www.seasearch.org.uk/) is a project for volunteer recreational divers who have an interest in marine life. Seasearch run courses to teach divers how to record different habitats and species on their dives. The data collected are used to help monitor and protect the marine environment. Seasearch has been running since the mid-1980's and volunteers dive regularly all around the Scottish coastline (as well as across the rest of the UK and Ireland). Seasearch is a partnership between the Marine Conservation Society (MCS), The Wildlife Trusts, SNCBs and others, co-ordinated nationally by MCS.

Seasearch data contributed to the identification and designation of MPAs in 2014 and continues to enhance our knowledge-base on the distribution and status of the protected habitats and species within and outside the Scottish MPA network. Summaries of Seasearch activities are available online[4].

Figure A2.1. Organ-pipe worms *Serpula vermicularis* with parchment worm tubes, sealoch anemones and brittlestars in Loch Ailort.

As well as recording the protected features of MPAs, recent Seasearch dives have also confirmed the presence of habitats of nature conservation interest in previously unrecorded areas. Professional marine biologists from the Orkney campus of Heriot-

[4] e.g. 2015 overview - http://www.seasearch.org.uk/downloads/ScotlandSummary2015.pdf

Watt University are regular Seasearch divers and in 2016 confirmed the presence of flame shell beds in the waters around Orkney for the first time. These records extend the Scottish geographic range of this Priority Marine Feature (PMF) which is perhaps best known from west coast sea lochs, where it is a protected feature within five MPAs.

In 2015, volunteer Seasearch divers recorded small, delicate reefs of colourful 'organ-pipe worms' *Serpula vermicularis* during a shore dive in Loch Ailort. Serpulid reefs have only been reported at a handful of locations in the world, making it one of the rarest marine habitats we have in Scotland.

Under the auspices of the Scottish MPA Monitoring Strategy, future Type 1 monitoring studies are proposed to track the status of the delicate reefs within the Loch Creran SAC and the Loch Sunart NC MPA. We will also continue observations of the aggregations recorded by Seasearch divers in Loch Ailort.

Figure A2.2. Top row - (left) A diver studying the serpulid reefs in Loch Creran SAC in 2016 - large reefs are still present in the loch but there have been decline in this habitat since the last full Type 1 survey in 2005. (right) An example of large collapsed reef in Loch Creran. The declines are believed to be linked to storm events. Bottom row - (left) Collapsed serpulid aggregations / serpulid tube debris on the seabed in the Loch Teacuis arm of the Sunart NC MPA in 2015. (right) Well-developed sugar kelp holdfasts mobilising a small serpulid aggregation in Loch Teacuis.

Monitoring examples of habitats in areas outside the MPA network (including the flame shell beds recorded by Seasearch divers in Orkney) will form a key element of

wider marine biodiversity monitoring and provide invaluable context for ongoing MPA-related studies.

Type 1 - Monitoring designed to assess the condition of a protected feature across a site.

This type of monitoring is quantitative (for example, density data or data that allows assessment of the status of populations of mobile species e.g. photo-ID) and statistically robust, allowing the rate and direction of change in the feature of interest over time to be quantified. The design of Type 1 monitoring should include consideration of known activities / pressures. The use of reference areas outside of MPAs may be considered to provide context for any changes observed. This monitoring provides data that are appropriate for the assessment of status against MPA feature conservation objectives - recovery (trajectory) and / or maintenance - informing management action and reporting obligations.

SNH has undertaken Type 1 monitoring in many of the MPAs in Scottish territorial waters over the last 15 years, as part of their corporate Common Standards Monitoring (CSM) programme[5]. Details of repeat Type 1 monitoring studies of inshore benthic habitats are available via the SNH publications catalogue[6] (e.g. Moore *at al*., 2015 & 2016 present the findings of recent work in the Sound of Arisaig & Loch nam Madadh SACs). Initial monitoring studies are now also underway on more recently designated sites (e.g. NC MPAs across Scottish waters and SACs in the offshore area). Details of Type 1 monitoring studies in Scottish offshore MPAs are available from the JNCC MPA monitoring webpage[7]. The UK monitoring options for deep sea and offshore habitats will inform the scope of future offshore MPA monitoring in Scottish waters.

Example: Monitoring grey seals at the Monach Isles SAC [material adapted from SCOS, 2016]

The Sea Mammal Research Unit (SMRU) at the University of St Andrews, conducts biennial aerial surveys of the major grey seal breeding colonies in Scotland (SCOS, 2016). The surveys are conducted during the pupping season when grey seals aggregate in breeding colonies. Digital images of the whole colony are taken and processed to make a composite image (Figure A2.3).

5 See - http://www.snh.gov.uk/protecting-scotlands-nature/protected-areas/site-condition-monitoring/
6 See - http://www.snh.gov.uk/publications-data-and-research/publications/search-the-catalogue/?q=commissioned%20report
7 See - http://jncc.defra.gov.uk/page-7049

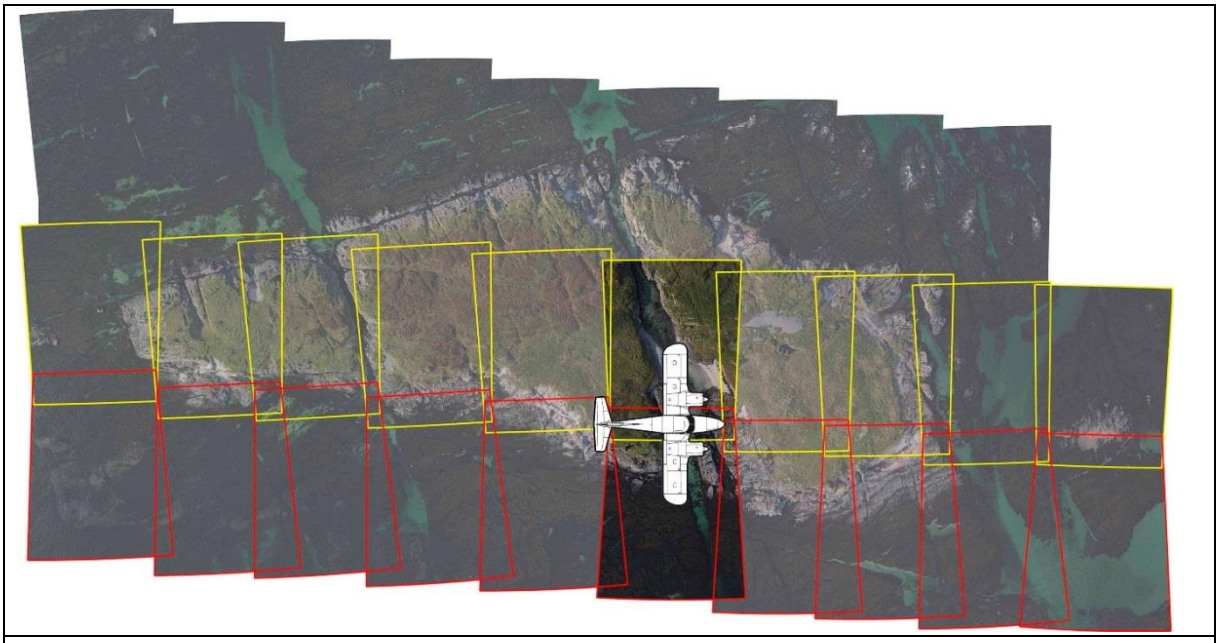

Figure A2.3. Images taken during a fly over of Eilean nan Ron, off Oronsay in the Inner Hebrides and stitched together.

From each composite image the number of whitecoat, moulted and dead pups are recorded (Figures A2.4 and A2.5), and the series of 3 to 5 complete counts is used to estimate pup production for each colony (using a model of the birth process and the development of pups).

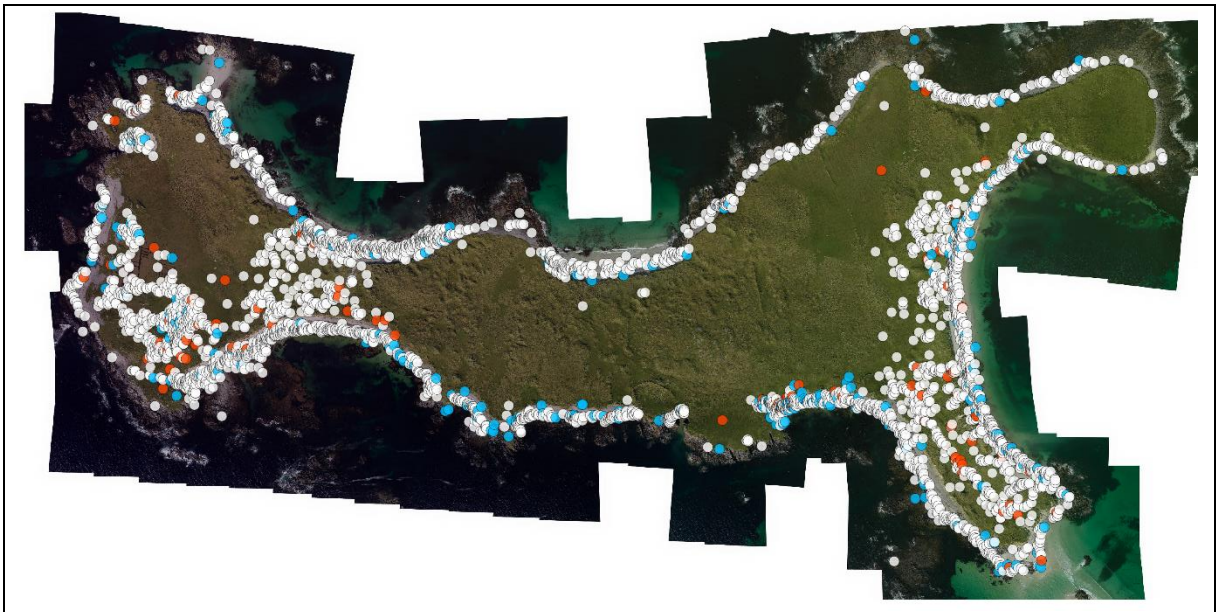

Figure A2.4. The largest grey seal breeding colony in Europe, Ceann Iar in the Monach Isles, Outer Hebrides. White circles represent whitecoats; blue circles represent moulted pups; red circles represent dead pups.

The quantitative data collected from these surveys allow for trends in pup production to be measured and these trends can be compared between colonies, regions (Figure A2.6) and different time periods.

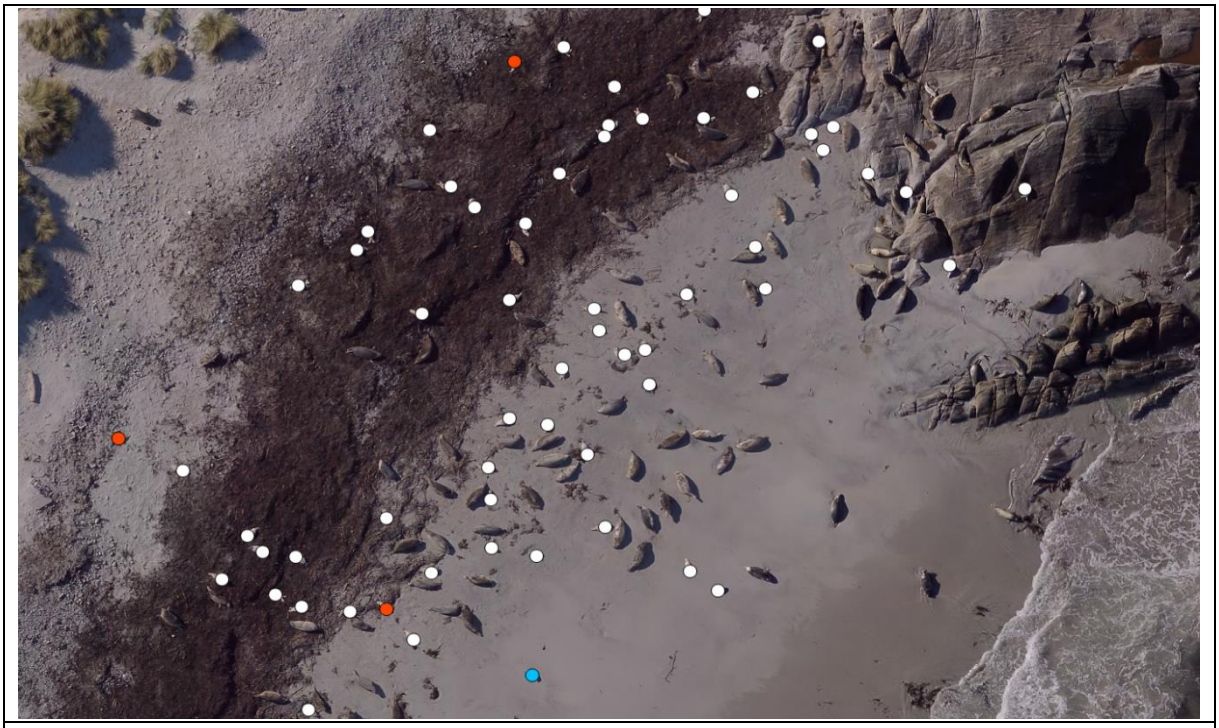

Figure A2.5. Zoomed in screenshot of Figure A2.4 showing the resolution of the image allowing for accurate counting of the different stages of grey seal pups.

Due to the spatial coverage of all major seal colonies in this survey, the data are used in population dynamic models to estimate the total grey seal population size in Scotland.

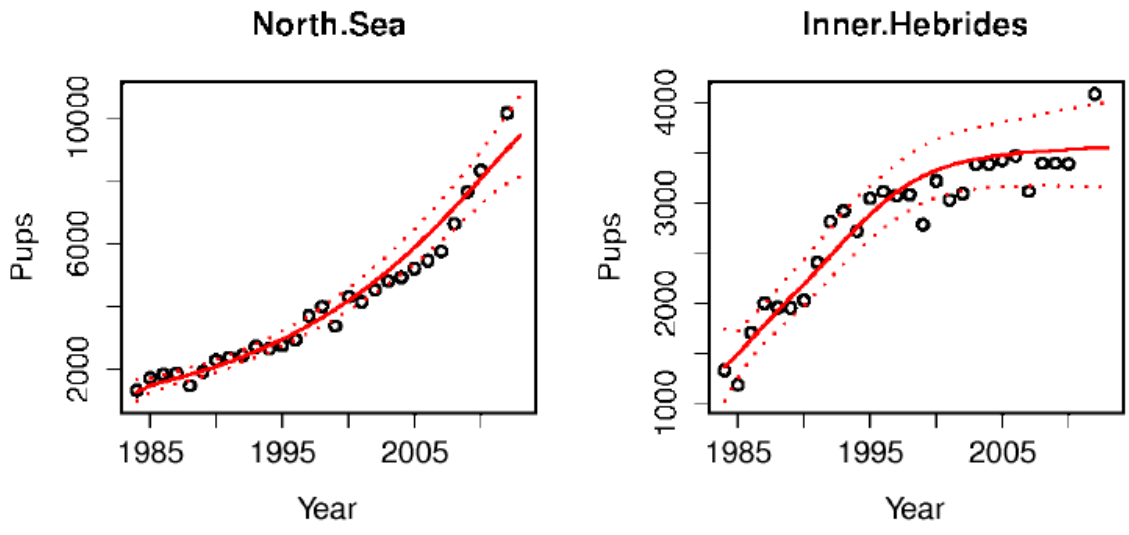

Figure A2.6. Mean estimates of pup production (solid lines) and 95% confidence intervals (dashed) from the model of grey seal population dynamics, fit to pup production estimates from 1984 - 2012 (circles) and a total production estimate for 2008.

The results of surveys inform reporting on the condition of grey seal SACs (via SNH commissioned research reports[8]) and the status of species across UK waters, fulfilling the surveillance requirements of the Habitats Directive.

Example: Monitoring the condition of seabed habitats in Scottish nearshore MPAs focusing on recent work in the Otter Narrows in Upper Loch Fyne

In 2015 SNH initiated monitoring within the management area put in place to support recovery of the flame shell *Limaria hians* bed in the Otter Narrows in Upper Loch Fyne (part of the Upper Loch Fyne and Loch Goil MPA).

Quantitative remote video transects and infaunal grab sampling were combined with *in situ* diver observations to validate the presence of flame shells and to more accurately delineate the extent of the bed (Figure A2.7). Relocatable dive transects were established and diver video footage was collected along each transect together with infaunal cores (in place of grab sampling to minimise damage to the bed). Cell count quadrats were carried out to determine coverage of flame shell nest material. In addition to the diver transects, flame shell nest percent cover was determined at a series of spot dive locations to supplement comparable work undertaken in 2012 (Moore *et al*., 2013).

Figure A2.7. A selection of the different sampling methods used to monitor the condition of the flame shell bed protected feature in the Otter Narrows, Upper Loch Fyne.

[8] e.g. http://www.snh.org.uk/pdfs/publications/commissioned_reports/929.pdf

The final results of the 2015 biological sampling will be used to interpret a full coverage acoustic multibeam dataset collected within the Otter Narrows management area in April 2016 by the British Geological Survey (see Figure A2.8 overleaf). Acoustic sampling may prove to be a useful monitoring tool in its own right for assessing changes in the extent of the flame shell bed habitat in this location (charting recovery) but ground-truthing techniques are likely to remain an essential part of any repeat surveys due to the cryptic nature of the flame shells themselves.

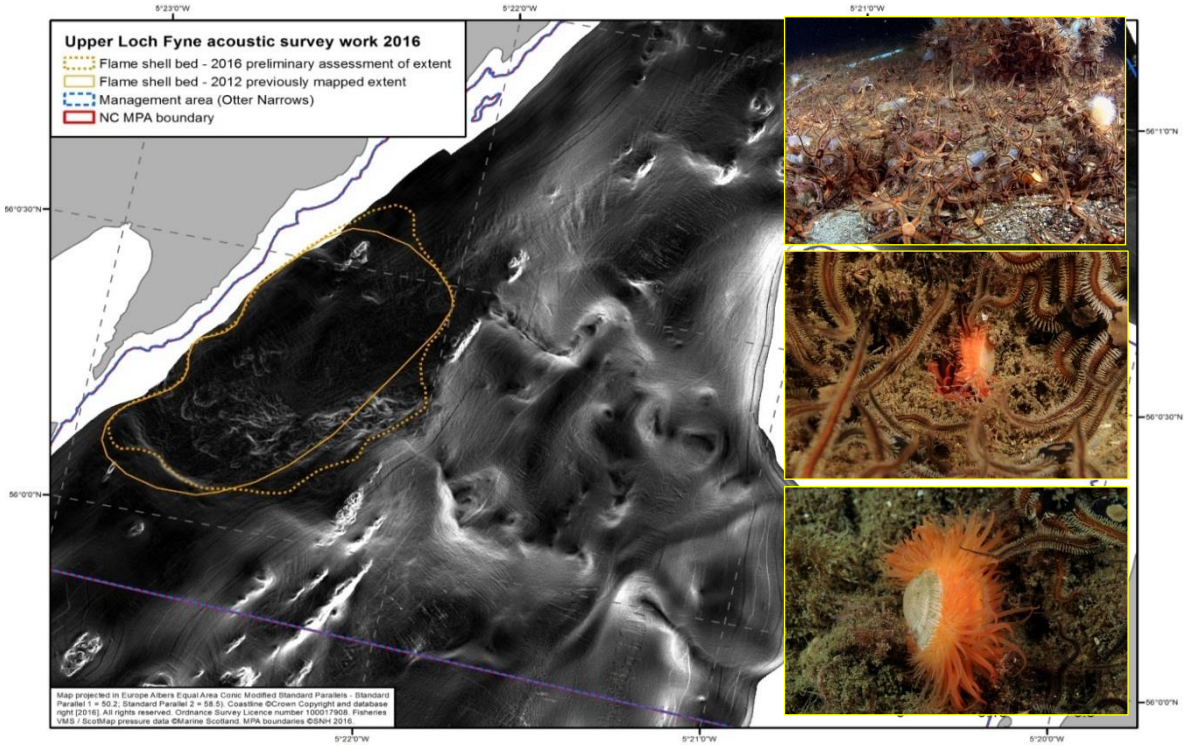

Figure A2.8. Acoustic multibeam mapping of the Otter Narrows (Cooper et al., 2016) showing the predicted extent of the flame shell bed protected feature. Inset images illustrate the 'cryptic' nature of the habitat - the flame shells are rarely visible at the seabed.

Type 2 - Monitoring or analyses undertaken to explore pressure state relationships

This monitoring is best suited to exploring the likely impacts of anthropogenic pressures on habitats and species. It allows testing of hypotheses about observed patterns, and is generally best applied in areas where a gradient of pressure is present (e.g. no pressure increasing gradually to 'high' pressure).

It relies on finding relationships between observed changes in biodiversity and observed variability in pressures and environmental factors. It provides inference but it is not proof of cause and effect. The spatial and temporal scale for this type of monitoring will require careful consideration to ensure inferences are reliable; for example, inference will be poor in situations where the presence of a pressure is consistently correlated to the presence of an environmental driver (e.g., a specific depth stratum).

Example: Monitoring the condition of seabed habitats in the Fladen Grounds across a gradient of fishing pressure

In 2014 JNCC and Cefas (Centre for Environment, Fisheries and Aquaculture Science) conducted a monitoring study at the Fladen Grounds. Targeted sampling was planned along a subsurface abrasion pressure gradient, informed using the spatial distribution of both UK and non UK demersal fishing effort acquired from Vessel Monitoring System (VMS) data (Murray *et al*., 2016). A gridded (0.05 dd) subsurface abrasion pressure layer from 2013 was created to identify areas across the site that had potentially been exposed to varying levels of physical abrasion pressure as a result of demersal trawling activities. The subsurface abrasion layer was initially split into 7 pressure categories. Two replicate cells ('a' and 'b') were identified for each category resulting in 6 cells in total. The number of categories and replicates was based on available time for this element of the survey along with experience derived from similar 'pressure-response' studies applied at comparable feature types. Ten replicate samples were randomly allocated within each cell, resulting in 100 samples taken in total along the pressure gradient.

Type 3 - Monitoring or analyses undertaken to explore the effectiveness of MPA management measures.

Monitoring that provides evidence of causality within a robust statistical framework, examining changes in the feature of interest against the onset of the putative impact (for example, the establishment of management measures that exclude fishing activity). The "beyond BACI" statistical methodology associated with this monitoring is rigorous, requiring multiple baseline surveys across multiple control and impact sites to be undertaken prior to the onset of the putative impact and thereafter (see Underwood, 1992 & 1994). However, conclusions from this monitoring may be applicable to other MPAs with similar habitats that exhibit similar trends (inferred from Type 1 monitoring).

Example: A beyond BACI study of the Small Isles MPA

MSS has conducted a Type 3 monitoring study at the Small Isles Marine Protected Area (MPA). Monitoring targeted burrowed mud habitats supporting the tall seapen Funiculina quadrangularis) presently known to be subject to demersal fishing pressure. To ensure the accurate targeting of F. quadrangularis, a high resolution map layer of predicted habitat suitably, produced by MSS (Greathead et al., 2014), was overlaid onto VMS data. Monitored sites were classified as impact sites, those that are likely to be closed to fishing by means of a Marine Conservation Order (MCO), and control sites, those lying outside the potential MCO, both inside and outside the boundaries of the MPA. In accordance with the beyond BACI methodology, multiple baseline surveys have been carried out in both control and impact sites prior to the establishment of the MCO. Data were collected in the form of quadrat images, taken from over 40 stations at each site. To avoid sampling at an inappropriate scale, the number of quadrats taken at each station, and hence the total quadrat area at each station, was dictated by densities of F. quadrangularis observed across the wider regional area. These density data were collected during the preliminary survey phase. The total number of stations recorded at each site was

based on available survey time and from statistical power calculations computed from similar, MSS quadrat studies in the Firth of Lorn and from preliminary survey data.

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Annex 3: Current MPA monitoring activity to date

Existing MPA-related monitoring activities are summarised in this annex under the broad feature groupings set out in the main body of the paper (e.g. seals, cetaceans, marine birds etc.). An additional sub-section covering other area-based measures contributing to the MPA network (see SNH & JNCC, 2012) presents a summary of relevant monitoring per area.

Background

SNH has an established corporate programme for monitoring the condition of nature conservation features of special interest on designated sites in Scotland - '*Site Condition Monitoring*' (SCM[9]) - which implements a commitment set out in a 1998 Statement on Common Standards Monitoring (CSM) (JNCC, 1998). CSM is a non-statutory programme of work that informs assessments against the Scottish National Performance Indicator '*Improve the condition of protected nature sites*'[10]. SNH's CSM programme contributes to delivery of the 2008 surveillance obligation for Habitats Directive features within MPAs.

SNH's marine CSM programme is delivered by SNH staff and contractors, as well as using monitoring results from other sources, such as the Seabird Monitoring Programme (SMP) and the Wetland Bird Survey (WeBS), to determine the condition of some natural features. Summary results of the CSM programme are available from the SNH Sitelink[11] pages and can be explored using the interactive tool on Scotland's Environment[12] web pages.

JNCC established a UK offshore MPA monitoring programme in 2014 which is mainly delivered by JNCC and MSS. An annual prioritisation exercise is undertaken for all offshore MPAs. JNCC does not follow any feature specific CSM guidance as these only exist for inshore habitats.

Results from Scottish offshore MPA monitoring surveys can be obtained from the JNCC MPA monitoring web page[13] and the relevant offshore Site Information Centres[14].

Mobile Species

For some MPA species, survey and monitoring programmes are underway that provide some level of baseline against which to be able to assess the current state and thus any trend in population numbers (e.g. for seals and bottlenose dolphins). For other species (e.g. harbour porpoise) fewer data are available. It is important to understand the limitations of any baseline set.

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9 See - http://www.snh.gov.uk/protecting-scotlands-nature/protected-areas/site-condition-monitoring/
10 See - http://www.gov.scot/About/Performance/scotPerforms/indicator/naturesites
11 See - http://gateway.snh.gov.uk/sitelink/index.jsp
12 See - http://www.environment.scotland.gov.uk/
13 See - http://jncc.defra.gov.uk/page-7049
14 See - http://jncc.defra.gov.uk/page-6895

Any assessment process must recognise that populations of mobile species using MPAs are naturally dynamic and numbers will fluctuate. As highly mobile species they have the capacity to move away from an area for a host of reasons either on a temporary or permanent basis. The magnitude of natural fluctuations is not fully understood and cannot be predicted. The magnitude of such fluctuations, however, can also be influenced by various anthropogenic pressures and it is therefore important to be able to distinguish between natural declines in numbers (e.g. due to a change in distribution) and those that are the result of other factors. In order to be able to do this it is important to have an understanding of the key pressures and some measure of the scale of such pressures which may be affecting the animals when they are beyond the boundaries of the protected site (as well as within). It is also essential that mobile species surveys are not restricted solely to MPAs to provide the wider context.

Seals

Harbour seals

Harbour seal SACs around the Scottish coastline represent 'key' haul-out sites within larger 'territories' and are occupied all year round. The SACs were selected on the assumption that individuals are relatively loyal to a 'set' of haul-outs, and this has largely been confirmed in recent years with the results of tagging work. It is also becoming more apparent that individuals from a given haul-out do not all necessarily exploit the same area when at sea, but each individual does appear, at least in part, to have their own preferred foraging areas. This means that when away from the designated site different individuals may experience different pressures that could affect their subsequent behaviour.

The focus of monitoring to date has been routine surveys around the coast during the annual moult in August. Surveys are restricted to a short time window of around 4-6 weeks and are conducted under strict conditions. These restrictions mean that it is not possible to survey the whole of Scotland's coastline in a single year and until recently the aim was to complete the monitoring over a 4-5 year period. Recent technological advances mean that the 'whole of Scotland' programme can now be completed in three years (from 2016). The surveys are undertaken by the Sea Mammal Research Unit at the University of St Andrews (SMRU) using either a helicopter-mounted thermal imaging camera for much of the rocky coastline of Scotland, or fixed-wing aircraft photography of the extensive sandbank haul-outs on the east coast. The work is undertaken in collaboration with SNH who provide financial support.

Surveys of the various SACs are completed as part of the wider programme of work undertaken to enable the Natural Environment Research Council (NERC) to deliver on its responsibilities under the Marine (Scotland) Act 2010.

Grey seals

Grey seals are much more wide ranging than harbour seals and are not tied to a single place throughout the year. Understanding of their movements and seasonal distribution is still somewhat lacking although the results from tagging studies are beginning to shed light on this. Grey seals do however, congregate in very large numbers at a relatively few places around the Scottish coastline during the pupping / breeding season and it is these locations that have driven the selection of the existing SACs for the species. Individuals are known to be loyal to these breeding sites over their life time with grey seal cows repeatedly returning to specific sites to pup. In many cases the key pupping sites are more-or-less abandoned outside the ~2-3 month breeding season (October to December).

Grey seal pup production was formerly measured on an annual basis through repeat aerial surveys of all major pupping sites. More recently however, these counts have been carried out on a biannual basis (with each pupping site surveyed 4-5 times within the breeding period). The surveys are undertaken by SMRU who then calculates the total adult grey seal population using a pup production model. In addition, the main grey seal pupping sites in Shetland are monitored annually by SNH staff and volunteers, following a methodology agreed with SMRU. These results are included in the pup production model.

The aerial surveys of the whole of the Scottish coastline that are undertaken to monitor the status of harbour seals (at their haul-out sites - see above for details) also generate information on the summer distribution of grey seals present on the shoreline. The SMRU-led grey seal monitoring work is undertaken to satisfy assorted obligations on assessing and reporting the conservation status of seals across UK waters.

Cetaceans

Bottlenose dolphins

The only SAC for this species in Scottish waters was identified on the basis of data from a long-running University of Aberdeen photo-id study of the animals in the Moray Firth.

The current monitoring programme for the Moray Firth SAC (which has been running since the mid-2000s) involves annual photo-id surveys that provide detailed information about the population structure, recruitment levels, etc. The photo-id work is undertaken by Aberdeen University and now represents one element of a wider regional-scale Marine Mammal Monitoring Programme (MMMP)[15] established in 2014 to explore the effects of marine renewables developments in the outer parts of the firth. SNH currently fund the photo-id work in one year out of three to inform SAC condition assessment and reporting obligations[16]. The photo-id surveys result in an annual estimate of the number of animals in the Moray Firth population as well as an estimate of the rates of deaths and births within the population.

Marine Scotland is a member of the MMMP consortium and in 2014 they installed an array of 30 passive acoustic monitoring devices around the coast, from Caithness in

[15] See - http://www.gov.scot/Resource/0049/00491512.pdf
[16] See - http://www.snh.org.uk/pdfs/publications/commissioned_reports/797.pdf

the north to Berwickshire in the south. Termed the East Coast Marine Mammal Acoustic Study (ECOMMAS[17]), the acoustic array collects information on the movement of dolphins and porpoises, as well as levels of underwater noise, to improve the evidence base for future decisions on developments in these nearshore waters. The MS array was integrated with other existing passive acoustic monitoring programmes in the area being run by St Andrews University (SAMMO network - Scottish Acoustic Marine Mammal Observatory) and the University of Aberdeen.

Marine Scotland also undertook high resolution aerial video survey[18] off the east coast of Scotland in 2014 for harbour porpoise and bottlenose dolphins. The results of the video sampling were used to validate with the results of the passive acoustic monitoring undertaken along this stretch of the coastline (Williamson *et al.* 2016).

Harbour porpoise

The Inner Hebrides and the Minches candidate SAC represents key habitat for harbour porpoise with a persistent high density of animals present. The SAC was identified on the basis of a reanalysis of available sea-based survey datasets from 1994 to 2011 collated under the Joint Cetacean Protocol[19 & 20] (JCP) and modelling of at sea sightings and acoustic data from the Hebridean Whale and Dolphin Trust (HWDT).

The main datasets underpinning the cSAC came from the SCANS II survey (Small Cetaceans in European Atlantic waters and the North Sea) undertaken in 1994 and 2005 and sightings and acoustic detections collected by HWDT during the summers of 2003 to 2008. SCANS surveys have taken place in UK waters on a roughly decadal basis with the latest survey (SCANS III[21]) completed in July and August 2016.

HWDT operate in the area of the candidate SAC and record any sightings of harbour porpoise (effort-corrected data). They also operate an on-line Community Sightings Programme (http://www.whaledolphintrust.co.uk/sightings-report-a-sighting.asp) which enables members of the public to report cetacean sightings (Type 0 monitoring - see also Annex 3). Whilst the latter provides useful information on the distribution of sightings it comprises incidental records and is not effort-related and as such cannot be used to estimate population size.

Marine Scotland installed an array of passive acoustic monitoring devices at locations across the Inner Hebrides and the Minches cSAC in May 2017, building upon their ECOMMAS cetacean survey work on the east coast (see bottlenose dolphin commentary above). The array will collect information on the presence / absence of porpoises and dolphins and supplement ongoing sightings work including any future broadscale SCANS-type events.

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17 See - http://www.gov.scot/Resource/0050/00507404.pdf
18 See - http://www.gov.scot/Resource/0045/00458980.pdf
19 The Joint Cetacean Protocol is a collaborative project managed by the JNCC that collates voluntarily submitted, effort-related cetacean survey data gathered by various governmental organisations, educational organisations, private sector companies and NGOs to inform consideration of historical trends in species distributions.
20 See - http://jncc.defra.gov.uk/page-5657
21 See - http://synergy.st-andrews.ac.uk/scans3/background/

In addition, Seawatch[22], SAMS[23] and WDC[24] all have had either short-term or localised projects specifically targeting porpoise.

Marine birds

This section describes the monitoring of seabirds and other marine waterbirds in Scotland.

Seabirds

Breeding populations at colonies on land

The Seabird Monitoring Programme (SMP), supplemented by periodic national breeding seabird censuses (covering all seabird species and colonies every ~10 to 15 years e.g. Seabird 2000[25]), delivers the majority of information available on breeding UK seabird population status.

The SMP has collected data from a subset of UK seabird colonies since 1986 (not a continuous subset[26]). A significant proportion of the annual SMP dataset comes from a series of key sites where detailed data on abundance, productivity and survival is gathered for a number of seabird species. The key sites include some of the largest seabird colonies in the UK. In Scotland sites monitored on annual basis include: Fair Isle, Isle of May and Canna; and on a triennial rotating basis St Kilda; Orkney Mainland and the Aberdeenshire coast. These areas all support multiple MPA designations for specified seabird species and / or assemblages (e.g. SPA & Ramsar sites underpinning by SSSIs). JNCC contract the SMP monitoring at some of the key sites. The work is undertaken on the Isle of May by the Centre for Ecology and Hydrology (CEH), on Fair Isle by the Fair Isle Bird Observatory Trust and on Canna by the Highland Ringing Group (see case study 6 in Annex 5).

The SMP has also promoted and extended the monitoring of abundance and breeding success at additional seabird colonies throughout Britain and Ireland. The amount of monitoring conducted outwith the key sites has increased steadily through individual volunteers and the monitoring activities of the SMP partners[27] (e.g. regular SNH monitoring of seabird populations at NNRs such as Noss, Hermaness and Rum). Not all of the seabird colonies covered by the SMP are monitored in any one year. However, trends for the whole sample are updated annually using statistical models, which analyse observed data from colonies that were monitored.

Accurate status assessments are generated for all 25 UK breeding seabird species every census. The SMP provides annual assessments for 13 species adequately covered by routine monitoring activity. SMP data, which includes abundance

[22] See - http://seawatchfoundation.org.uk/wp-content/uploads/2012/08/Marubini-et-al_2009.pdf
[23] See - http://www.int-res.com/abstracts/esr/v22/n2/p125-143/
[24] Brown, A. (2014). The Significance of the east coast of the Isle of Lewis for the harbour porpoise (*Phocoena phocoena*). MSc Research dissertation, Edinburgh Napier University.
[25] See - http://jncc.defra.gov.uk/page-1548
[26] Sites are often monitored on/sampled on an *ad hoc* basis, but their data remain in the database.
[27] A formal group comprising the statutory nature conservation agencies, JNCC and other conservation organisations (refer to http://jncc.defra.gov.uk/page-1550#partner for details).

information and productivity data, is maintained within a database that is hosted and managed by JNCC who also publish the latest trend information online[28]. SNH publish an annual Scottish seabird indicator[29].

Non-breeding population abundance on land

Information on trends in non-breeding seabird population abundance is limited to two NGO-led monitoring schemes, the Winter Gull Roost Survey (WiNGS) and Winter Atlas surveys, largely due to the level of effort and associated high cost required to monitor non-breeding population abundance around Scotland's coastline.

Breeding and non-breeding population distribution at sea

Seabirds at Sea data has been gathered in the past using a scheme known as European Seabirds at Sea (ESAS[30]). The ESAS database hosts this data. JNCC are currently assessing whether information could be collected using a low cost volunteer-based ESAS monitoring scheme. This would train voluntary surveyors and place them on Vessels of Opportunity (VoO) [see also Section 10 of the Scottish MPA Monitoring Strategy].

Marine waterbirds

There is currently no monitoring programme for marine waterbirds at sea, including sites that are classified (or proposed for classification) as SPAs.

Breeding populations

Marine waterbird breeding abundance is currently monitored through periodic surveys[31] funded by individual governments and NGOs. Of particular relevance to Scottish MPA interests are the surveys of breeding red and black-throated divers and common scoter and data on wigeon and other rare / scarce breeding waterfowl.

Non-breeding populations

Population abundance and distribution of non-breeding marine waterbirds is currently monitored by the Non-Estuarine Waterbird Survey[32] (NEWS) and the Wetland Bird Survey[33] (WeBS). WeBS counts are made annually at around 2,800 wetland sites around the UK, with the monitoring programme in Scotland encompassing marine waterbird qualifying features in a number of estuarine protected areas (e.g. Solway Firth, Moray Firth, Firth of Forth, Dornoch Firth, Cromarty and Beauly firths, Firth of Clyde etc.). NEWS focuses on areas of non-estuarine coastline which are known to be important for populations of species such as purple sandpipers and turnstone. However, these land-based schemes are only able to provide population-level trend information for species whose distributions are

[28] See - http://jncc.defra.gov.uk/page-3201
[29] See - http://www.snh.gov.uk/docs/B424907.pdf
[30] See - http://jncc.defra.gov.uk/page-1547
[31] SCARABBS see - http://www.rbbp.org.uk/downloads/SUKB_scarce_section.pdf)
[32] See - https://www.bto.org/volunteer-surveys/webs/taking-part/non-estuarine-waterbird-survey-iii
[33] See - https://www.bto.org/volunteer-surveys/webs

entirely within sight of land. There is currently no monitoring programme for waterfowl at sea, including sites that are classified (or proposed for classification) as SPAs.

Relationship with SNH's marine birds *Common Standards Monitoring* programme

Data collected within protected sites as part of the marine bird monitoring studies outlined above, feed into SNH's Common Standards Monitoring (CSM) programme (which in turn informs Birds Directive reporting obligations as well as annual assessments of the Scottish Governments NPI on Protected Nature Sites[34]).

Fish

Common skate

The Loch Sunart and the Sound of Jura Nature Conservation MPA represents key habitat for common skate with an apparent high level of residency, especially of large individuals (targeted by recreational sea anglers involved in tagging studies - see also Annex 5). Information on the level of residency, habitat use and depth usage in the Sound of Jura to Sound of Mull portion of the site was obtained in a MSS / University of Aberdeen study and used to inform management options. A subsequent MSS / SNH collaboration involving an acoustic array started in 2016 and will provide further data on residency and movements following the implementation of new fisheries management measures. A method using PIT tags to estimate survival rate for this species is being developed by MSS and SNH and through continued collaboration with relevant anglers' associations it should be possible to estimate the effects of the new measures on common skate mortality.

Other sampling methods that may affect the future direction of the NC MPA monitoring programme include the development of a photo-id catalogue based on spot patterns. The Scottish Association for Marine Science (SAMS) are hoping to take forward work on this pragmatic monitoring methodology in 2017. The approach is reliant on sea anglers taking an appropriate photo of their catch before it is released. A further advantage of the photo-id approach is that it offers the potential for a retrospective analysis of historical photos which could help establish a realistic baseline from which to assess current population status and trends. In combination with the PIT tagging study it should be possible to validate the approach and if successful it could offer a relatively cheap and easy way to monitor the status of common skate within the MPA.

All of the current sampling methods have the potential to provide data about the state of the adult population. They are based on anglers' catch and release data, but as anglers specifically target the large specimens at key fishing marks within the MPA the sample is potentially biased. At present there are few data on juvenile / immature specimens. A survey is planned in 2017 to assess juvenile skate within the MPA.

Sandeels

[34] See - http://www.gov.scot/About/Performance/scotPerforms/indicator/naturesites

Sandeels are currently a protected feature of four NC MPAs. Annual monitoring of the Turbot Bank sandeel population takes place under an EC-funded Data Collection Framework (DCF) winter assessment carried out by Marine Scotland Science (MSS). Data from this bank forms part of the dataset used in the ICES annual assessment for sandeels for Area 4, off the east coast of Scotland. Sandeel abundance was assessed in the Mousa to Boddam MPA as part of an SNH / MSS Alba cruise in 2014[35]. MSS also hold historical sandeel abundance data on these grounds prior to 2008.

Seabed habitats

Nearshore waters (0 - 12 nm)

The majority of marine habitat SACs in Scottish nearshore waters were formally designated in 2005. Much of SNHs benthic survey work between 1999 - 2005 focussed on building the case for designation of the SACs (supplementing studies from the 1980s and 1990s) and completing inventory mapping to inform site management requirements. Due to the number and widespread distribution of marine habitat SACs, these preliminary broadscale habitat mapping surveys continued until 2009.

SNH's seabed habitat CSM programme (primarily Type 1 studies to detect trends in the condition of the features and inform reporting obligations) started in 2002 to implement the 1998 Statement on Common Standards Monitoring (JNCC, 1998) on a suite of 43 SSSIs and subsequently, 30 marine SACs. Monitoring studies were undertaken alongside the ongoing programme of coarser resolution habitat mapping.

Further details of SNHs MPA-related seabed habitat monitoring work undertaken from 1999-2013 are provided in a UK-wide review published by the JNCC (McBreen *et al*., 2016). As part of this study a catalogue of reports associated with Scottish MPA monitoring was produced. The catalogue is available in a spreadsheet format from the JNCC website[36] (filter by SNH and also by JNCC to see relevant Scottish benthic survey reports from the Marine Nature Conservation Review spanning the late 1980's-90s). The SNH commissioned reports are available for download from the SNH online publications catalogue[37].

MS research vessel time has been allocated on an annual basis since 2011 to support the delivery of MPA habitat monitoring in territorial and offshore waters (see Table A3.1 for details of MS cruises linked to MPA studies and Table A3.2 under '*Offshore waters*'). Some aspects of the work are led by the SNCBs and some by Marine Scotland Science (MSS).

Since 2014, the primary focus of MPA-related seabed habitats monitoring work undertaken by all agencies has been on initiating more detailed studies (Types 2 & 3 which represent a shift from SNH's corporate CSM programme) in a small number of

[35] See back of - http://www.snh.org.uk/pdfs/publications/commissioned_reports/883.pdf
[36] See - http://jncc.defra.gov.uk/docs/121219_Appendix_7_SNCB_Report_Catalogue_v4.xlsx
[37] See - http://www.snh.gov.uk/publications-data-and-research/publications/search-the-catalogue/?q=commissioned%20report

sites to explore the effectiveness of new fisheries management measures (targeted at features where the effects of the measures are most likely to be discernible). The first round of new MPA measures came into force in Scottish territorial waters in February 2016 (Marine Scotland, 2016).

To date, the detailed Type 3 monitoring implemented by MSS at the Small Isles MPA and the South Arran MPA are the only studies in territorial waters that have been designed to utilise multiple control areas recorded over multiple time frames, both before and (in the future) after the implementation of management measures. The use of multiple time frames allows us to use statistical inference to say whether environmental changes are truly down to management measures.

Table A3.1 Scottish inshore MPA benthic habitat monitoring surveys undertaken on Marine Scotland research vessels. Relevant 2016 surveys are listed - further detail on these projects is provided in Annex 7.

MPA	Date of monitoring surveys	Type of monitoring	Organisation(s)	MSS cruise ID
Small Isles MPA	2012, 2013, 2014, 2015, 2016	Type 1, Type 3	MSS	1012a, 1213a, 1714a, 1515a, 1816a
South Arran MPA	2015, 2016	Type 1, Type 3	MSS/SNH	1415a, 1116a
Sound of Barra SAC	2016	Type 1, Type 2	SNH/MSS	0616a
Lochs Duich, Long and Alsh MPA	2015, 2016	Type 1, Type 2	MSS/SNH	1415a, 1816a
Mousa to Boddam MPA	2014	Type 1	SNH/MSS	1414a
Wester Ross MPA proposal	2013, 2014	Type 1	SNH/MSS	1213a, 1414a
Loch Sunart to the Sound of Jura MPA	2015, 2016	Type 1	SNH/MSS	1415a, 0616a
Noss Head MPA	2014	Type 1	SNH/MSS	1414a

Priority areas for work in 2012 (e.g. Luce Bay SAC) were unsuitable for *Alba* (and also the *Sir John Murray*) due to operational depth limits and SNH contracted out the required work (see Allen *et al*., 2014). Other SNH commissioned studies in 2012 included monitoring of saline lagoons in the Uists (Howson *et al*., 2014) and surveys of intertidal habitats at a number of west coast SSSIs (ASML, 2014).

Most nearshore MPA-related work, comprising mainly remote video, grabs and diver sampling, can be undertaken from quite small boats. SNH has a 6.5 m RIB used primarily for diving surveys and for shallow water drop-down video sampling. In many cases there are considerable benefits to hiring local boats and skippers who know their waters and seabed habitats intimately. This approach can help to develop relationships and trust between local communities, marine scientists and the wider

MPA processes. Diving work can only be undertaken from suitable small vessels. However, larger, more stable vessels such as *Alba* and the *Sir John Murray* are essential for future MPA monitoring work in deeper waters (e.g. the cold water coral reefs at the East Mingulay SAC and the fan mussel aggregations in the Sound of Canna etc.) and at more exposed sites (e.g. North Rona and St Kilda).

Offshore waters (12 - 200 nm)

SAC identification and designation for seabed habitats started later in the offshore area but was accompanied by a similar range of initial broadscale survey and mapping projects. Subsequent monitoring surveys undertaken for Scottish offshore MPAs are listed in Table A3.2. Monitoring reports are available from the JNCC MPA monitoring webpage[38]. Reports from previous surveys are available from the Evidence tab on the relevant offshore Site Information Centre[39].

Table A3.2 Scottish offshore MPA benthic habitat monitoring surveys

MPA	Date of monitoring surveys	Type of monitoring	Organisation(s)	MSS cruise ID
Fladen Grounds MPA	2014	Type 1, Type 2 and Type 3	JNCC/Cefas	n/a
East of Gannet Montrose MPA	2015	Type 1	MSS/JNCC	1515S
Norwegian Boundary Sediment Plain MPA	2015	Type 1	MSS/JNCC	1515S
Geikie Slide and Hebridean Slope MPA	2016	Type 1 & Type 3	MSS/JNCC	1016S

Other area-based measures

The European Union and the North-East Atlantic Fisheries Commission (NEAFC), advised by the International Council for the Exploration of the Seas (ICES), are implementing fisheries management measures. In some cases these are to aid fish stock recovery while in others they are for the protection of particularly sensitive marine habitats in offshore waters (that may include deep water sponges and corals).

The other area-based measures listed below are those considered to contribute to the Scottish MPA network (see SNH and JNCC, 2012 for further details). The list includes two areas (nos. 7 & 8), where measures were established solely to manage a fishery (for blue ling - a Scottish MPA search feature and Priority Marine Feature). A summary of survey and monitoring work undertaken to date is provided below for each area.

[38] See - http://jncc.defra.gov.uk/page-7049
[39] See - http://jncc.defra.gov.uk/page-6895

1. **North-east UK sandeel closure (CA1)**. Two monitoring programmes: i) The Scottish dredge survey conducted annually by MSS (December) since 2008. ii) A monitoring fishery carried out by the Danish sector under an ICES monitoring TAC of 5000t. Sampling under the latter since 2005 is sporadic and sufficient data for monitoring is unavailable for some years. (Source: ICES Advice 2015, Book 6).
2. **Lamlash Bay No Take Zone**. Three wide-scale, quadrat surveys have been performed by MSS (2009, 2010 & 2014). Four years of diver survey by York University have also been carried out (2010, 2011, 2012 & 2013).
3. **North West Rockall Bank**. Previous surveys are: MAREMAP JC060 NOC/JNCC/UoP survey 2011 (Huvenne, *et al*., 2011; Howell *et al*., 2014); JNCC/MSS Rockall haddock survey and seabed mapping 2011; MSS monkfish survey (towed camera); JNCC and UoP Rockall Bank habitat surveys 2005-2008 (Howell *et al*., 2008). See North West Rockall Bank Site Information Centre for more information[40].
4. **Darwin Mounds**. Previous surveys are: MAREMAP JC060 NOC/JNCC/UoP survey 2011 (Huvenne, et al, 2011; Howell et al, 2014); AMES survey 1999 & 2000 (Bett, 2007; Bett & Jacobs, 2007; AFEN survey 1998). See Darwin Mounds Site Information Centre for more information[41].
5. **West Rockall Mound**. No UK-led surveys since the original discovery of the mounds more than 10 years ago (which was made by either a German or Belgian survey).
6. **Hatton Bank**. Previous surveys are: DTI/JNCC 2005 & 2006 surveys (Narayanaswamy et al, 2006; Howell et al, 2008); ECOVUL/ARPA 2005 & 2007 surveys conducted by Spanish Instituto Español de Oceanografía. See Hatton Bank Site Information Centre for more information[42].
7. **Blue Ling management area - Edge of Rosemary Bank**. Monitored biannually under the MSS deep water survey (DCF funded). MSS MOREDEEP surveys (2014, 2016).
8. **Blue Ling management area - Edge of continental slope**. Monitored biannually under the MSS deep water survey (DCF funded).

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ASML. 2014. Baseline survey and mapping of intertidal features within selected Scottish SSSIs. *Scottish Natural Heritage Commissioned Report No. 754*. Available from - http://www.snh.org.uk/pdfs/publications/commissioned_reports/754.pdf

[40] See - http://jncc.defra.gov.uk/page-6538
[41] See - http://jncc.defra.gov.uk/page-6531
[42] http://jncc.defra.gov.uk/page-6535

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Annex 4: Monitoring methods - considered by feature groups

Mobile Species

This annex provides a summary of monitoring methods used for the different feature groups and provides links to further detailed information.

Marine Mammals

Seals

The methods used for monitoring harbour and grey seals in Scotland are routinely set out in the annexes to the annual SCOS (Special Committee on Seals) advice provided to government on matters related to the management of UK seal populations. The annual SCOS reports are available online[43].

The Sea Mammal Research Unit (SMRU) provide a summary of annual seal monitoring through the SNH commissioned report series[44]. SMRU are leading the development of the UK monitoring options for seals.

Cetaceans

Hammond *et al*. (2013) describe the aerial and shipboard survey methodologies used in the decadal, broad scale SCANS (Small Cetaceans in the European Atlantic and North Sea) surveys, undertaken to estimate the population abundance of the most common cetaceans (including bottlenose dolphins, harbour porpoise and minke whales). However, this large scale survey is a snapshot and cannot provide details on inter-annual variation, distribution or seasonal use

An overview of the different sampling methodologies relevant to cetaceans (and basking sharks) is provided in MacLeod *et al*. (2011). All future MPA-related cetacean studies should contribute to the Joint Cetacean Protocol (JCP) or subsequent collaborative data collation programme[45]. A combination of all methods may be needed to meet MPA monitoring and reporting obligations.

Bottlenose dolphins

Large scale surveys such as SCANS provide information about the overall abundance and distribution of bottlenose dolphins throughout their range. Additional focused methods are used for collecting data on individual movements and survival to understand how bottlenose dolphins are using the area. Details of the photo-ID survey protocols and associated mark-recapture analyses used in the Moray Firth SAC to monitor the status of the bottlenose dolphin population are set out in Cheney *et al*., (2014). Similar methods are used in the Tay by St Andrews University. The

[43] See - http://www.smru.st-andrews.ac.uk/research-policy/scos/

[44] http://www.snh.gov.uk/publications-data-and-research/publications/search-the-catalogue/?q=seals&cat=

[45] As part of the UK-wide marine biodiversity monitoring options identification process, there are proposals to refine the JCP and associated analytical methods as a means of determining trends in population abundance.

SAC monitoring is of sufficient resolution to detect trends in abundance and allow population demographics to be studied. The 2014 report also presents summary information on the role and design of passive acoustic monitoring (C-PODs) undertaken to enable a more detailed assessment of patterns of usage of the SAC. The current Moray Firth SAC monitoring programme was devised following a detailed review of different options as presented in Thompson *et al.* (2004).

Marine birds

Seabirds

Breeding populations on land - The SMP uses agreed methods as set out in the SMP Handbook[46]. This applies solely to breeding distribution, abundance, survival and productivity.

Non-breeding seabirds - Seabird population distributions at sea in the UK have been monitored previously under the ESAS. Agreed ESAS standards and protocols[47] typically involved bespoke surveys undertaken from suitable vessels. JNCC are currently assessing whether information could be collected using volunteers and a network of Vessels of Opportunity (VoO).

Marine waterbirds

Breeding populations - Surveys vary in the geographical coverage, though most focus on protected areas (especially SPAs and SSSIs). Methods vary between species and cannot be generalised, though most require a sampling regime (e.g. red and black-throated diver), often suitably stratified. Some surveys are carried out on the whole population (e.g. common scoter).

Non-breeding populations - WeBS surveys are volunteer based counts, usually (but not always) undertaken on a monthly basis. Details of the methods used for the Core Counts[48] and the Low Tide Counts[49] are available online via the BTO website[50].

NEWS surveys[51] are volunteer based counts, undertaken roughly every decade.

Surveys can either be undertaken by boat using ESAS-type survey methods, or using aerial surveys as carried by JNCC for SPA identification. Light aircraft can survey large and inaccessible areas in a short space of time. This reduces the risk of double counting and can sometimes be more cost effective than boat surveys. A line-transect sampling method is used which allows the use of distance sampling[52] to calculate more accurate population estimates. The sampling method allows bird distribution data to be collected at a very fine spatial scale. The line-transect method

46 See - http://jncc.defra.gov.uk/PDF/pub95_SeabirdHandbook.pdf
47 See - http://jncc.defra.gov.uk/page-4568
48 See - https://www.bto.org/volunteer-surveys/webs/taking-part/core-counts-methods
49 See - https://www.bto.org/volunteer-surveys/webs/taking-part/low-tide-counts-methods
50 See - https://www.bto.org/volunteer-surveys/webs
51 See - https://www.bto.org/volunteer-surveys/webs/taking-part/non-estuarine-waterbird-survey-iii
52 See - http://www.ruwpa.st-and.ac.uk/Research/DistanceSampling/

used by the JNCC Seabirds at Sea Team, and a full description of the methods used can be found in Dean *et al.* (2003)[53]. It should be noted that digital aerial survey methods have now largely superseded visual aerial survey methods, and there is evidence that the two methods can differ in their results (Buckland *et al*., 2012).

Fish

A range of survey methods can be utilised to monitor and study fishes within and outside MPAs. Two main types of survey method are available. Which is most appropriate will depend on the objectives of the study, reporting obligations and the particular environmental circumstances and conservation objectives.

1) Methods for collecting data on species diversity, abundance and distribution.

If the MPA is large and covers a range of environmental conditions (e.g. depths) and habitats then some form of fish capture methods are generally required. In some areas, trawling will yield the most representative sampling of fish. Good trawl data will give excellent information on species diversity, abundance and distribution. However trawling can be destructive and would not be appropriate for areas of high seabed sensitivity. Trawling is also not possible in some areas, e.g. very steep slopes or rock reef habitats. In such cases alternatives methods are required. These may include baited traps and cameras which will give estimates of those species attracted to bait (generally scavenger species). Fish traps are generally preferable as they provide reliable species identification and the same individuals are not repeatedly sampled which can be a problem with baited camera systems. Fish traps do however have the draw back that large species can consume smaller species within the trap and are restricted to relatively shallow areas. A less selective method that can be used is a towed camera system that will be unbiased with respect to species feeding habits. Towed camera systems can cover large areas, but can have problems with identification of species, most notably small species. Towed camera systems can be used to survey areas where trawl surveys are not possible or desirable (McIntyre *et al*., 2014) and do not cause adverse impact to the seabed. They can also be useful for identifying essential fish habitat, for example juvenile areas or areas where egg cases are deposited. Diver surveys (visual recording) of species can be effective in some situations, but have limitations of depth and sampled area.

Each of these methods carried out in a systematic way and over a suitably long time period can provide indices to monitor change in fish diversity and abundance. They are each subject to their own sampling caveats. Often a combination of methods is required to cover all areas within a site.

2) Methods for collecting data on individual movements and survival.

A range of tagging methods is available to study individual movements. Depending of the level of sophistication and expense these range from conventional ‘flag’ tags to electronic satellite tags. Simple flag tags can provide estimates of movement and

[53] See - http://www.jncc.gov.uk/page-2346

survival if catch and release is done in a systematic way (repeat sampling) and is carried out on a large number (> 100) of individuals over a long period of time (at least 6 sampling periods). PIT (passive integrated transponder) tags are a slightly more expensive, but more reliable way to infer survival probabilities than conventional tags. Electronic tags can provide much more detailed information of space use between release and recapture and give insight into habitat preferences, e.g. depth. Depending on the species and its range of movements different tags are preferable. For resident species, acoustic tracking with individually coded transmitters is the best option for defining home ranges and movements. If the species is more wide ranging and likely to move out of the study area then data storage tags or satellite tags provide a better option. However, these more sophisticated tags are very costly.

Common skate

A combination of all methods described above may be needed to meet MPA monitoring and reporting obligations. For example, recent work on common skate has relied upon trawl data to generate initial, broad-scale distribution maps. Within the Loch Sunart to the Sound of Jura MPA, finer resolution conventional flag tag and PIT tag studies have then been used to infer survival rates, with electronic tracking (acoustic and data storage tags) undertaken to explore habitat usage and home ranges (Neat *et al*., 2014, Pinto *et al*., 2016).

Photo-identification techniques (photo-ID) recently applied to manta rays (e.g. Marshall *et al*. 2009; Marshall *et al*. 2011) are also being explored to aid individual common skate identification and inform population dynamic studies (see also Annex 6).

Sandeels

There are no plans to monitor sandeels at inshore grounds. MSS have a long survey time series for the Mousa to Boddam MPA area prior to 2008. Any monitoring would only inform on environmentally driven changes in sandeel numbers.

MSS monitor the Turbot Bank MPA, where there can be a directed fishery, as part of a winter dredge survey of sandeel assessment area 4. Given the dynamic nature of sandeel habitat this is not monitored. There is no MSS monitoring of NW Orkney MPA as that is not fished. There have been occasional larval surveys - the last in 1994 and the area is partly covered by the Continuous Plankton Recorder (CPR) survey[54].

Seabed habitats and species

[54] See - https://www.sahfos.ac.uk

Details of methods applied in previous CSM work undertaken in nearshore MPAs is provided in relevant site or method specific reports published on the SNH website[55].

Noble-James *et al*., (*in prep*.) introduces a stepwise framework by which to plan and design a benthic habitat monitoring programme, from setting objectives to statistical analysis. Each section provides background information and guidance on best practice for each stage of the design process, with specific guidance for Type 1, 2 and 3 monitoring where appropriate.

Large-scale features

Five large-scale features of potential wider significance to the overall health and biodiversity of Scotland's seas were included in the development of the MPA network. These features are seamounts; continental slope; shelf deeps; shelf banks and mounds; and fronts[56].

Specific examples of each of these features are now incorporated within the existing site series in locations where evidence was available to suggest that they contribute to ecosystem function, for instance in terms of playing a key supporting role within the site or in supporting linkages within the network and across the wider seas.

In light of the significant scale, envisaged role and generally robust nature of the large-scale features themselves, future monitoring effort is directed at the habitats and species they support. For many of the examples currently represented within the network this entails work on specified benthic habitats mainly identified as protected features of the site in their own right (e.g. the fan mussel aggregation and burrowed mud protected features situated within the shelf deep at the heart of the Small Isles MPA).

Further consideration will be given on a site-by-site basis to the relative merits of monitoring persistent aggregations of mobile species if they are associated with the large-scale feature, for example due to the influence of local topography on hydrographic conditions and elevated productivity[57].

Pressure Monitoring

Mobile species

Strandings

Investigation of the major causes of death in marine mammals (cetaceans and seals) and basking sharks is monitored through the Scottish Marine Animal Strandings Scheme (SMASS[58]) and the UK Cetacean Strandings Investigation Programme (UK CSIP)[59] through targeted necropsy examinations and ad hoc biopsy sampling. The

[55] See - http://www.snh.gov.uk/publications-data-and-research/publications/search-the-catalogue/
[56] See - MPA Selection Guidelines - http://www.gov.scot/Resource/Doc/295194/0114024.pdf
[57] See - http://www.snh.gov.uk/docs/A1312703.pdf
[58] See - http://www.strandings.org/smass/publications/
[59] See - http://ukstrandings.org/csip-reports/

programmes are sufficient for determining and detecting changes in the relative causes of death for the most commonly stranded species, as well as providing an effective route for identifying any substantial new threats through surveillance on the incidence of disease.

Bycatch

The UK Bycatch Monitoring Scheme[60] undertakes observations of incidental cetacean bycatch by commercial fishing vessels in relation to EU Regulation 812/2004 and the Habitats Directive. The scheme is currently operated by SMRU and focuses on certain gears, areas and species with known bycatch or risk of bycatch.

Seabed abrasion and other pressures from fisheries activity

Abrasion pressure on the sea bed from demersal fishing gear is one of the primary pressures identified for sea bed habitats and needs to be inferred from data collected on the activity of the relevant fishing fleets. This is achieved using position data collected from vessel monitoring systems (VMS) required to be fitted to all registered fishing vessels operating in UK waters over 12 m in length (overall). These data are centrally collated by the Marine Management Organisation and Marine Scotland and can be used to infer vessel tracks and trawling activity using likely towing speed as a proxy. Individual "pings" of vessel location are transmitted every 2 hours, meaning that vessel tracks need to be inferred and that changes in direction by vessels can result in activity away from inferred tracks.

Monitoring of activity can be utilised in 2 ways:

a) *ad hoc* site specific analysis of "ping" data to infer the potential historic and current level of fishing activity relevant to a protected area. This can be used to consider for example prioritisation of monitoring effort and may be used to inform changes to management measures relevant to a feature or a site.

b) The development of a derived "pressure layer" for seabed abrasion which can be collated periodically (e.g., annually) and provides a quantified estimate of the abrasion experienced by a specific area of sea bed. Such an approach is being used as part of the process to assess whether sea bed integrity (Descriptor 6) is at "Good Environmental Status" for the Marine Strategy Framework Directive. This process involves combining the VMS data from appropriate portions of the fishing fleet where contact with the seabed is likely during trawling and calculation of indices of abrasion such as the "swept area ratio" (Church *et al*., 2015). The outputs are gridded at high resolution and can be used to provide an indication of any spatial or temporal changes to abrasion pressure (or other pressures directly relating to activity of portions of the fishing fleet) relative to protected areas or features.

Unfortunately, these data miss those vessels that have an overall length less than 12 m which also engage in fishing practices that result in abrasion of the seabed. Although the majority of vessels in this size class operate static gear with much lower pressure on sea bed habitats, different data would need to be used to monitor

[60] See - http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=18535

these pressures. “ScotMap” was an attempt to map the activity, value and spatial usage of the non-VMS fishing fleet in Scottish inshore waters and provides some data, but as no data on effort were collected it is not possible to directly or quantitatively derive pressure from the data set. The data were also collected as a snapshot in 2011 and is not planned to be repeated (Kafas *et al.*, 2017)[61].

Various efforts are underway to roll out new technologies for the recording of vessel position for inshore small vessels (<12 m) including the roll out of AIS (automatic identification system), allowing the future recording of position, tracks and speed from this previously unrecorded portion of the Scottish fleet. Such data together with information on the gear being used will allow improved monitoring of pressures from fishing activities on MPAs and PMFs.

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[61] See http://www.gov.scot/Topics/marine/science/MSInteractive/Themes/ScotMap

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Annex 5: Working with others

This annex summarises a number of recent collaborative projects undertaken to inform MPA-related assessment and reporting requirements in Scottish waters. These examples supplement those presented in the main body of the strategy and will be added to over time.

Case study 1 - Using ferries as a platform for science

Studying fan mussel larvae in the Small Isles

The fan mussel, *Atrina fragilis*, is the largest and rarest bivalve mollusc in Scotland, growing up to 50 cm in length. The fan mussel is listed as a Priority Marine Feature (PMF) in Scottish waters, and the only known UK aggregation is found in the Small Isles MPA. Little, however, is known about the ecology of the species and information on its early-life stages are particularly sparse.

Gathering information about the seasonality of spawning in the fan mussel required a program of sampling that posed difficult logistical challenges. The remote setting of Small Isles and the high frequency of the sampling regime meant that MSS's dedicated survey vessels would be unable to commit to such a project. These issues were addressed in a partnership between MSS and Caledonian MacBrayne ferries, whose vessels service the Small Isles. Zooplankton samples were collected between April 2014 and September 2015 on the MV *Lochnevis* passenger ferry (Figure A5.1).

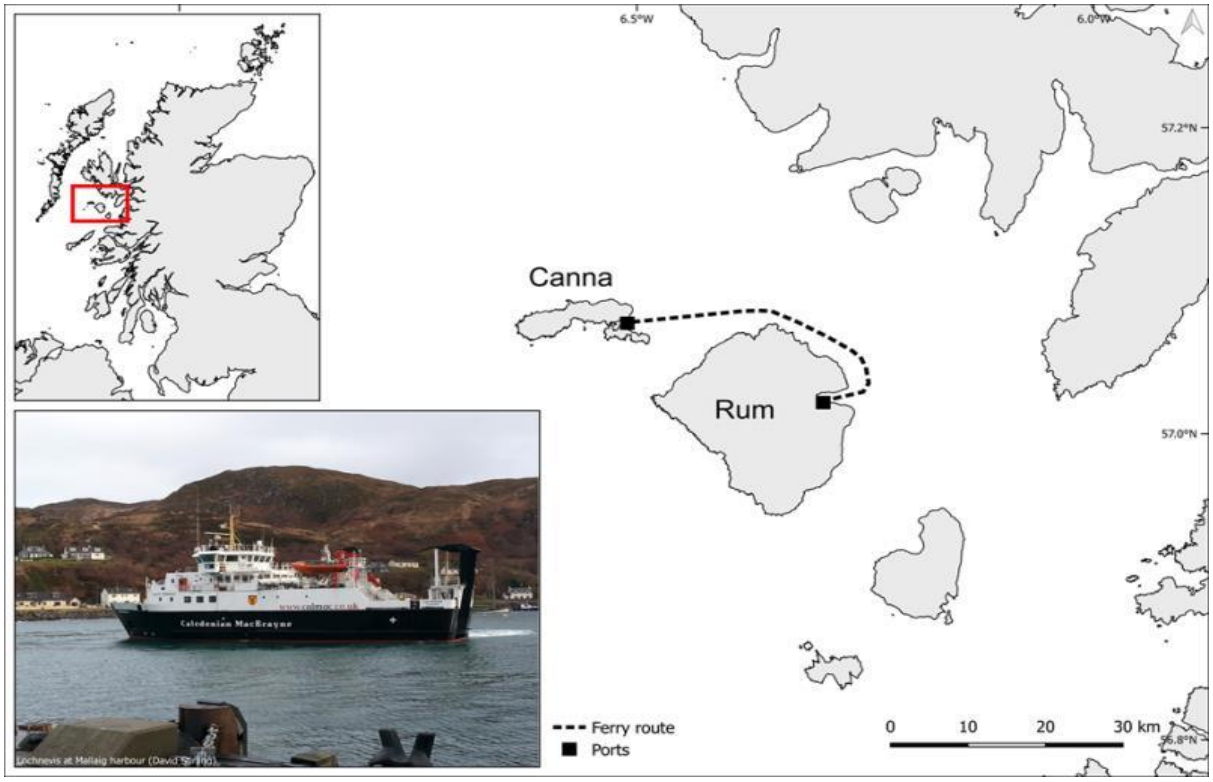

Figure A5.1. The Caledonian MacBrayne MV *Lochnevis* passenger ferry and the route from which zooplankton samples were collected between April 2014 and September 2015.

During the life of the project a total of 83 samples were collected using a custom built plankton sampler that was fitted to one of the ship's seawater pumps. Fan mussel larvae were identified successfully in these samples, with the highest concentrations observed during late summer to early autumn (Figure A5.2). These findings are the first reports on the early-life stages of this Priority Marine Feature and are presented in Stirling *et al*. (2016).

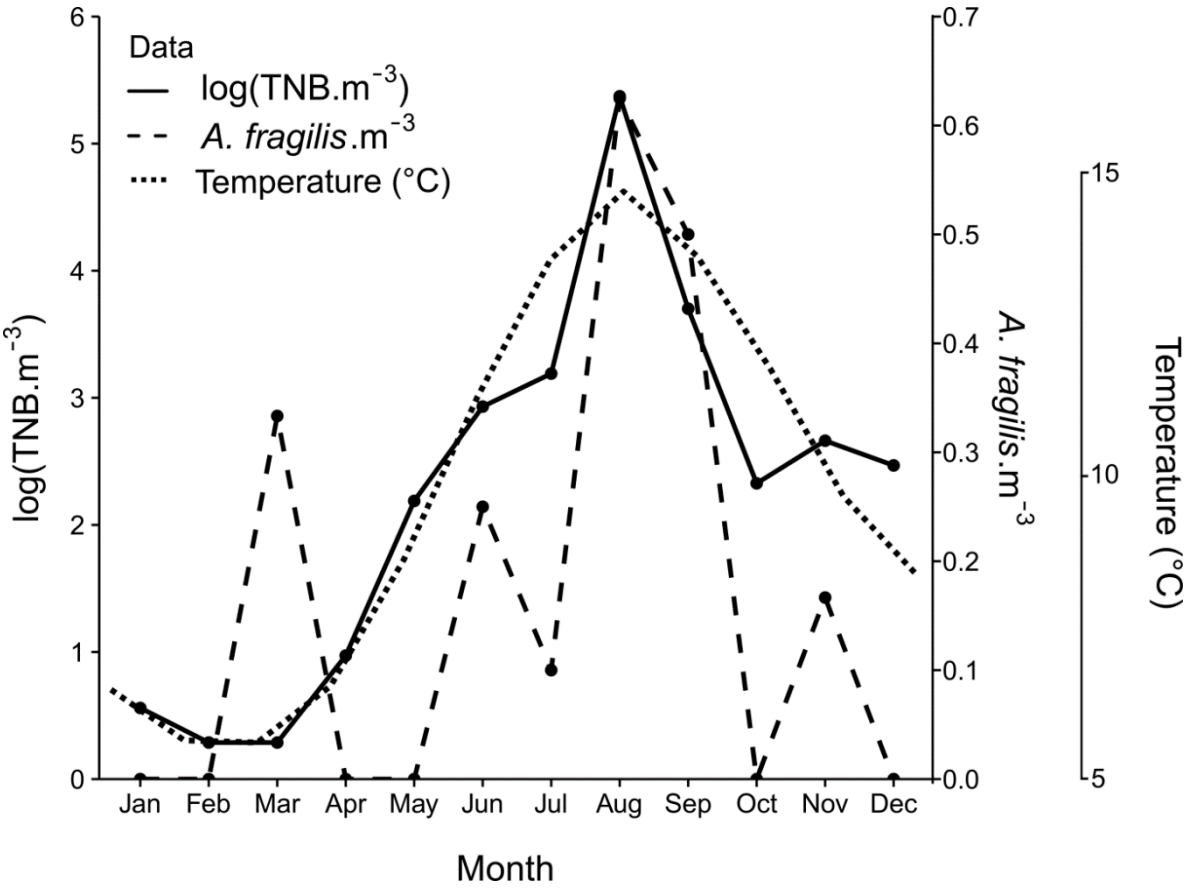

Figure A5.2. Time-series zooplankton samples collected by the ferry, showing the log of the total number of bivalves collected per m^3 ($log(TNB.m^{-3})$) and the total number of *A. fragilis* larvae observed per m^3 (*A. fragilis*.m^{-3}) for each month.

The use of ferries as *Vessels of Opportunity* (VoO) from which to undertake observations of marine birds, cetaceans and basking sharks is also under consideration as part of a new citizen science programme - for further details please refer to Section 10 of the Strategy.

Reference

Stirling D.A., Boulcott P., Bidault M., Gharbi K., Scott B.E. & Wright P.J. 2016. Identifying the larva of the fan-mussel, *Atrina fragilis* (Pennant 1777). *Journal of Molluscan Studies*, In Review.

Case study 2 - Working with industry and academia to monitor Noss Head MPA

Horse mussel beds are an OSPAR Threatened and/or Declining habitat (T&D) and an Annex I habitat under the Habitats Directive. They are protected in four MPAs and a number of Special Areas of Conservation (SACs - see Cunningham *et al*., 2015 for further details). They are also recognised as a Priority Marine Feature (PMF) across Scottish waters. Horse mussel beds provide a habitat for commercially important species and are an important blue carbon store. The Noss Head MPA protects the largest known horse mussel bed in Scotland (and possibly the UK). The bed was first recorded during a 2010 survey undertaken on behalf of Scottish Hydro Electric Transmission PLC (SHE Transmission) (MMT, 2010), to inform High Voltage Direct Current (HVDC) transmission cable development proposals in the area. This was followed up by a survey in 2011 (Hirst *et al*., 2012); a collaboration between scientists from Heriot-Watt University (HWU), SNH and Marine Scotland which confirmed the presence and extent of the horse mussel bed (Figure A5.3).

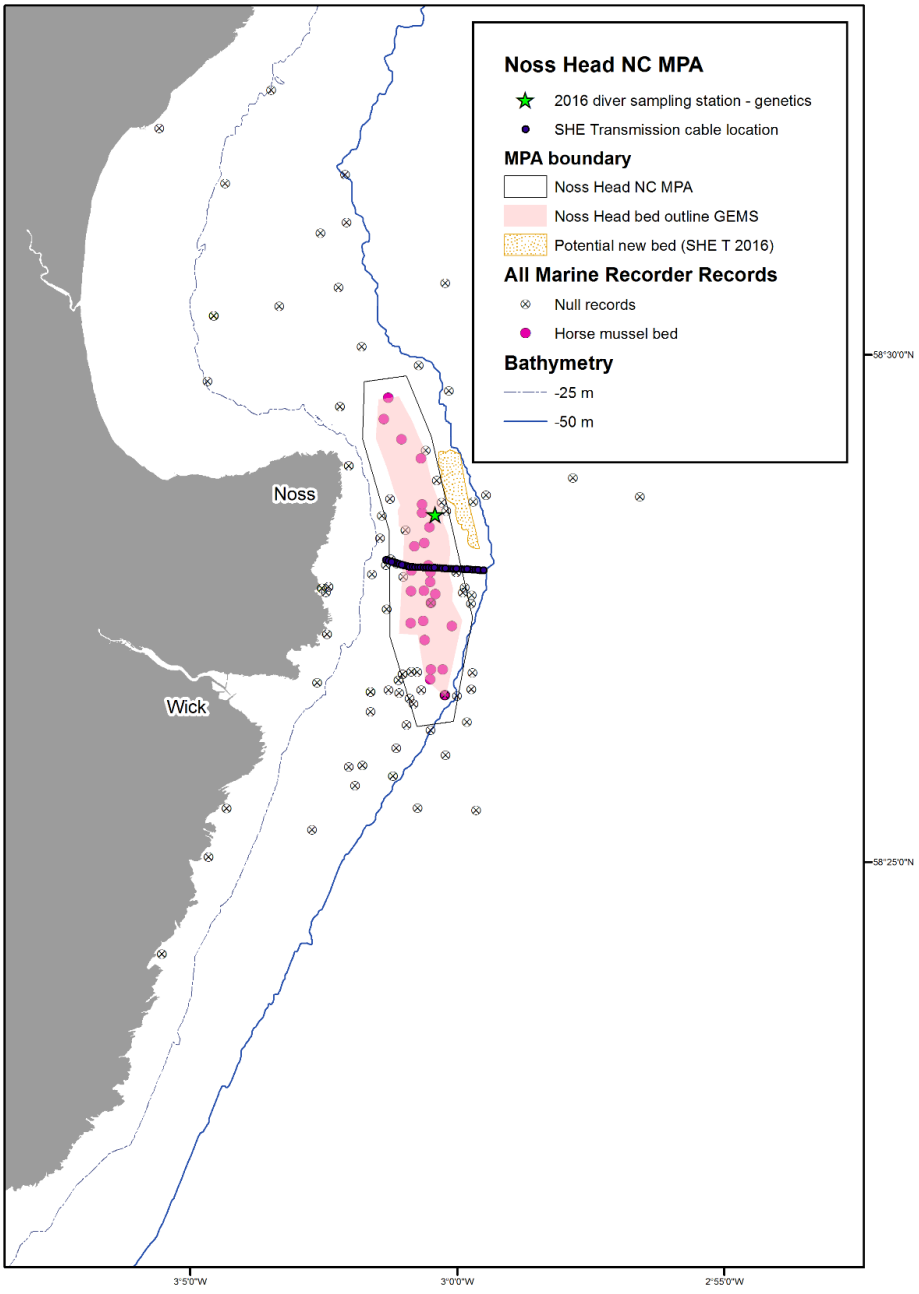

Figure A5.3. The Noss Head MPA horse mussel bed showing the SHE Transmission cable corridor, the 2016 genetics diver sampling location and the potential new horse mussel bed adjacent to the MPA boundary.

This part of the coastline is relatively under-studied (e.g. to the south of the Noss Head MPA - see Figure A5.3) and the information collected by SHE Transmission continues to provide valuable evidence to inform monitoring work and to assist with survey planning. The remote location and difficult working conditions (relatively deep, strong currents and an exposed coastline) makes this area difficult to survey, especially when *in-situ* methods (e.g. dive surveys) are required for detailed, non-destructive assessments of this vulnerable habitat (Cook *et al*., 2015).

On the basis of initial sampling in 2010, the horse mussel bed was estimated to cover an area of 4.5 km^2 (Moore and Roberts, 2011). This value was refined following additional drop-down video and acoustic multibeam survey work in 2011 (Hirst *et al*., 2012). At the time of designation in 2014, the bed was estimated to be 4.1 km^2 (pink polygon on Figure A5.3 - see SNH, 2014). Additional high resolution multibeam echo sounder (MBES) survey work (plus video and still camera sampling) was carried in 2016 on behalf of SHE Transmission to inform the HVDC cable routing. The mapping products enable finer resolution estimates to be made of the extent of the bed within the MPA and have also potentially identified an additional area of horse mussel reef to the east of the main bed (~0.56 km^2 - see Figure A5.5 overleaf). An SNH / Marine Scotland survey in July 2017 will determine the presence of horse mussel bed habitat here (see Annex 8 for details of the future MPA work programme).

In a parallel study, Heriot-Watt University has been working with SNH to assess connectivity of horse mussel beds in Scotland using genetic analysis. Samples from six sites were collected between 2011 and 2015 as part of a James Watt funded PhD project. The collaboration between HWU and SNH provided scope for diver sampling of the Noss Head bed in July 2016 (location indicated by a green star on Figure A5.3). Juvenile and adult horse mussels were collected from the different beds to inform a more in-depth analysis of horse mussel demographics, giving insights into reproduction and larval dispersal. The HWU divers observed juvenile gadoids and other fish on the Noss Head bed (Figure A5.4) and this has triggered follow-up studies on essential fish habitat and

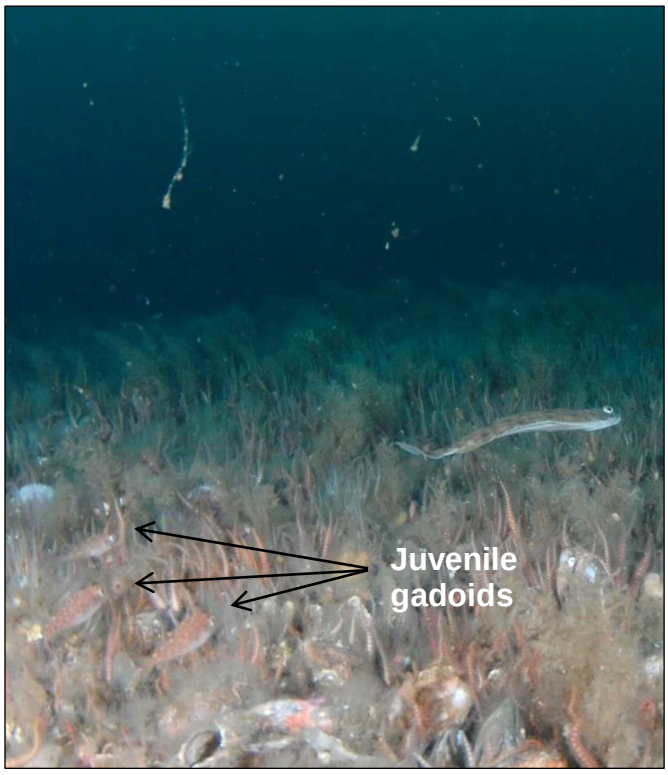

Figure A5.4. Juvenile gadoids and flatfish observed by divers on the Noss Head horse mussel bed. Photograph © Bill Sanderson, HWU.

ecosystem services, scheduled for July 2017 in collaboration with MSS and facilitated by MASTS (the Marine Alliance for Science and Technology for Scotland).

This case study demonstrates the added value that can be obtained through collaboration with industry and academic partners. Routine survey work by SHE T continues to feed into the evidence base for the MPA and is used by SNH for survey planning (Figure A5.5).

The collaboration with HWU has improved our understanding of horse mussel connectivity and the role of the Noss Head MPA in the Scottish MPA network and beyond (Gormley *et al*., 2015). Sharing data between parties can help with survey planning and understanding the linkages between beds at a regional and national level, helps target monitoring effort.

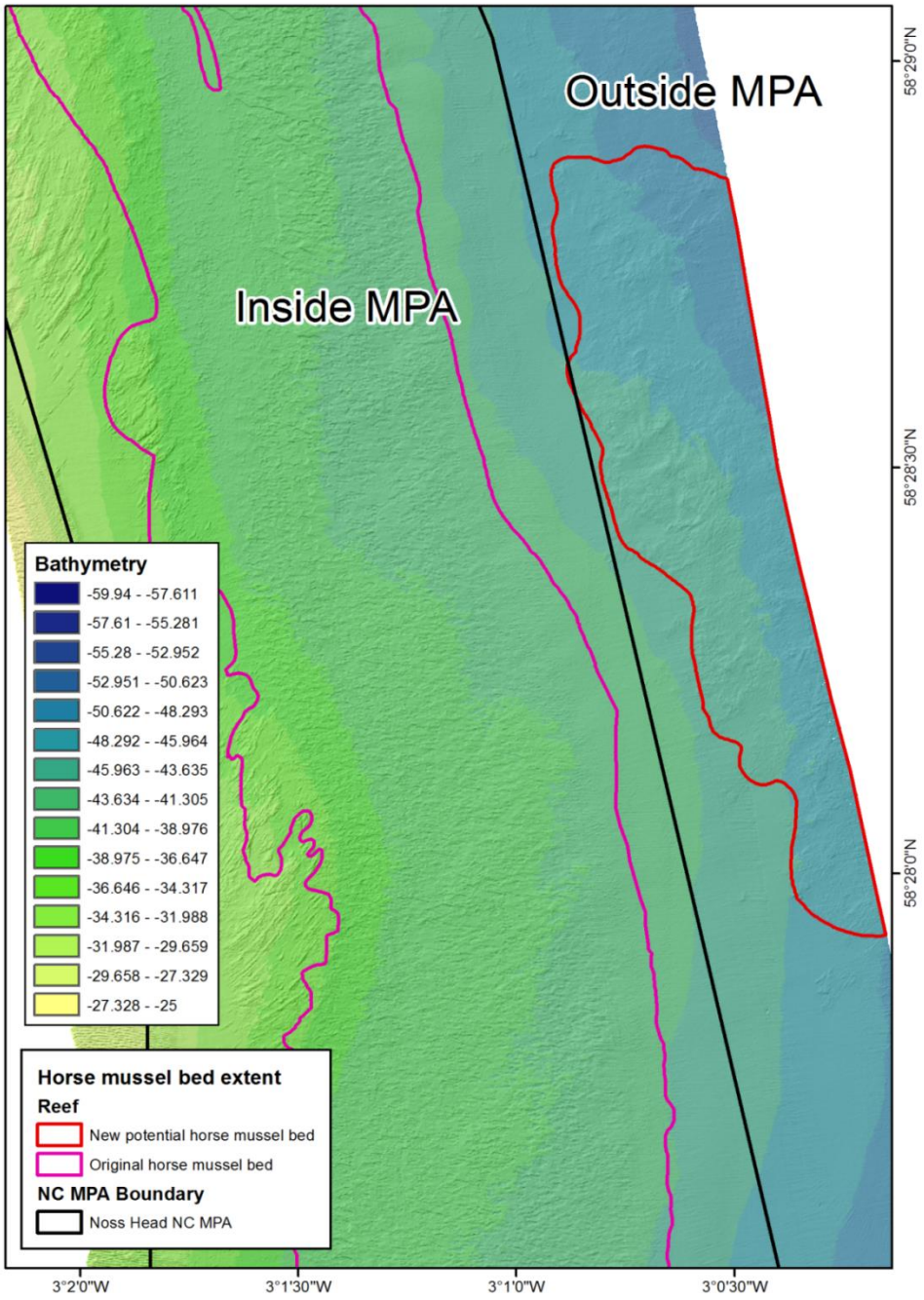

Figure A5.5. SHE Transmission multibeam survey data from 2016 showing the estimated extent of the horse mussel bed within the Noss Head MPA and the adjacent area outside the MPA where acoustic data suggests horse mussel bed habitat may be present.

References

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Case study 3 - Working with sea anglers to monitor common skate in a coastal MPA

The Loch Sunart to the Sound of Jura MPA originated from a third-party proposal submitted by the Scottish Sea Angling Conservation Network[62] (SSACN), who also run the Scottish Shark Tagging Programme (SSTP). Common skate tagging records (capture-mark-recapture) collected by recreational sea anglers as part of the SSTP were combined with historical records from Glasgow Museum and the UK Shark Tagging Programme to support the case for designation.

Sea anglers also worked with scientists from MSS to track movements of common skate in key parts of the site (using an acoustic array) and to gain an insight into the depth zones used by individual fish using detailed data storage tags (Neat *et al*.,

[62] See - http://www.ssacn.org/

2014). The MPA was subsequently designated in 2014 and new fisheries management measures were introduced in 2016[63].

Since 2016, recreational anglers and local creel fishermen have been helping SNH and MSS implement follow-on studies[64] to help refine initial estimates of survival rates for the common skate within the site (setting a baseline against which to determine the effectiveness of the new fisheries management measures). The work has involved the use of PIT tags, tiny electronic tags which are invisible externally like those used for pets, as well as acoustic tags combined with a more sophisticated detection array to confirm how much time the fish spend in different parts of the MPA. Receivers were positioned in the Sound of Mull, the Firth of Lorn, Loch Linnhe, the Lynn of Lorn and Loch Etive. The receivers record each time an individual fish passes within range. Sea anglers have been taught to PIT tag and have been provided with relevant equipment (including scanners to allow caught fish to be checked for existing tags) to enable this new monitoring method to be rolled out across the MPA (and beyond). Anglers have also been provided with tarpaulins so that they can lift skate safely back into the water after capture (see Figure A5.6).

Figure A5.6. Scanning a tagged common skate (left) and lifting the skate back into the water with a tarpaulin (right).

SNH have also been discussing a proposal from the Scottish Association for Marine Science (SAMS) to develop a photo-ID library and database for skate in Scotland. Scientists at SAMS have been analysing a set of 400 photos provided by a skate charter skipper as part of an initial feasibility study. If successful the project will be rolled out further, collecting historical and new photos from anglers. SSACN have offered their support in reaching their members to support this exciting new project. A series of example images illustrating six recaptures of the same fish are shown in Figure A5.7 (overleaf).

[63] See - http://www.gov.scot/Resource/0049/00491429.png

[64] See - http://www.snhpresscentre.com/news/worlds-largest-skate-and-small-shark-followed-in-new-west-coast-tagging-study

Figure A5.7. Images showing six recaptures of the same common skate by recreational anglers within the Loch Sunart to the Sound of Jura NC MPA between 08/04/2014 and 13/05/2015.

References

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Case study 4 - Contingency sampling - UK-wide agency collaboration

Scottish nearshore waters include sheltered sea lochs, embayments and firths, which provide useful contingency areas for vessels on offshore research cruises. For example, in December 2015 Cefas were carrying out work in Northern North Sea but poor weather conditions confined the vessel to coastal areas. Communication with SNH identified a series of seabed habitat sampling locations to improve general coverage within the Moray Firth. Positions were sent through directly to the vessel for video and grab sampling. Cefas worked through the locations (Figure A5.8) and infaunal samples and seabed imagery data were supplied to SNH free of charge.

SNH commissioned analysis of the video and grab samples and the results of this work have been published in Moore (2016) [Moray Firth video samples], Axelsson *et al*., (2017) [Southern Trench grab samples] and Moore, 2017 [Southern Trench video samples]. The products of this partnership have improved our understanding of the distribution of seabed habitat features within the existing and proposed protected areas. The 2015 data has informed the development of new predictive mapping products for both areas (Natural Power, *in prep*.) which will inform future site management discussions.

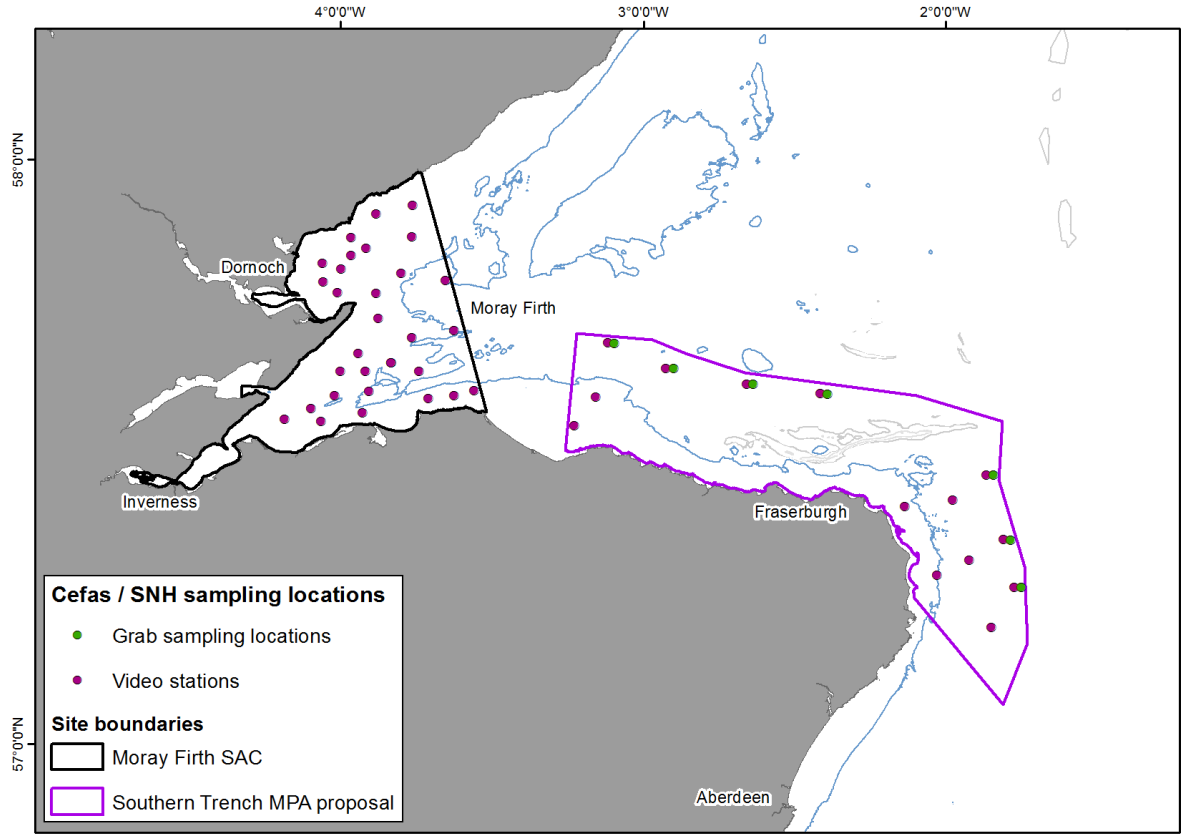

Figure A5.8. Contingency sampling locations (video and grab) surveyed by Cefas on behalf of SNH in December 2015.

Samples revealed records of potential *Sabellaria spinulosa* reefs off Fraserburgh (Figure A5.9) and build on 2014 records from survey work undertaken in this area in

relation to a development proposal (as part of an environmental impact assessment - survey records were supplied to SNH on request). Deep sandy mud in the north-west corner of the MPA proposal supported a moderate density of megafaunal burrowers including *Nephrops norvegicus* and *Pennatula phosphorea* (Moore, 2017).

Sabellaria spinulosa reefs are an OSPAR Threatened and/or Declining habitat (T&D) and an Annex I habitat under the Habitats Directive. The information obtained through this example of collaboration between agencies, and from industry in relation to development casework, extends the known range of this feature in UK waters.

Defining aggregations of *S. spinulosa* as a 'reef' is not always straightforward (although guidance is provided by Hendrick and Foster-Smith, 2006). Therefore additional sampling off Fraserburgh will be undertaken in 2017 to improve our understanding of the extent of this habitat (refer to Annex 8 for a forward look at the Scottish MPA-related survey programme).

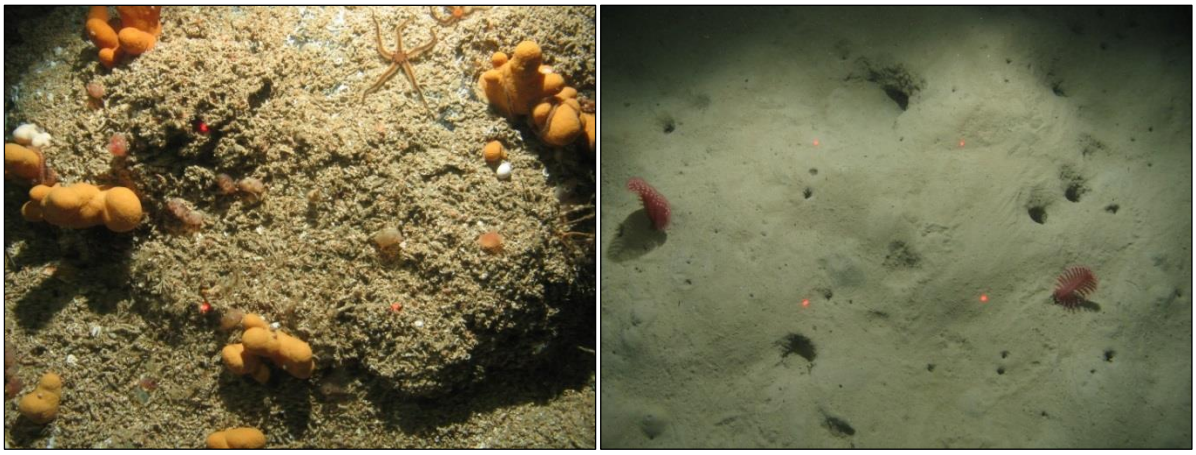

Figure A5.9. Seabed imagery collected by Cefas in 2015: Sabellaria spinulosa encrusted circalittoral rock (left) and burrowed mud (right) from the Southern Trench MPA proposal.

References

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Case study 5 - Volunteers & long-term monitoring - Canna seabird studies

Long-term studies on seabirds are something of a rarity. Across the World, there are only a handful of studies that have seen over 40 years of sustained effort.

The Canna seabird study which began in 1969, continues to reveal new information on seabirds. It is one of three key monitoring sites in Scotland alongside Fair Isle and the Isle of May. Every year a small, dedicated team visits the island to study its seabirds. The team of volunteers come from a range of backgrounds, and all have a passion for seabirds.

The information was vital when it became apparent that rats were having a significant effect on Canna's seabirds. It is heartening to see puffins, razorbills and guillemots returning to breeding in areas that rats had effectively extirpated them from.

Advances in technology have allowed seabirds to be tracked, using miniature-tracking devices attached to guillemots, razorbills, kittiwakes and fulmars. These are beginning to show some fascinating results on where our seabirds go in the winter months and will hopefully help others conserve seabirds further afield by identifying important sites at sea.

More information on the Canna Seabird Study can be found at:
Canna Seabird Studies Report 2015[65]

Case study 6 - Community based seabed monitoring in Wester Ross

Coastal community groups have great potential for undertaking marine monitoring. They are able to access their local waters year-round, and have useful skills, knowledge and motivation. Bringing communities into the data collection process also has the potential to increase trust in decision-making. To deliver on this potential there needs to be guidance and training from scientists and an understanding in communities about what constitutes usable evidence.

[65] See - https://www.researchgate.net/publication/309292023_Canna_seabird_studies_2015

Figure A5.10. Screenshots from diver video footage collected as part of a community-led citizen science programme in the Wester Ross MPA (images provided courtesy of Sea Change © Andy Jackson).

The University of Glasgow has been working with the community group Sea Change to help them develop a community-based monitoring programme for the Wester Ross MPA. So far this has resulted in the constriction of prototype drop camera systems, which can also be used as baited remote underwater video systems (BRUVS). The Sea Change group has been carrying out pilot surveys, including experimenting with camera drops from kayaks.

Case Study 7 - Working with Universities to examine benefits to commercially fished stocks

A further aspect of monitoring the protected seabed habitats within the MPAs is to understand the extent to which associated fish communities may be benefiting. For example, studies have shown that habitats recovering from physical disturbance become more structurally complex, which makes them more attractive to fish for feeding and shelter (and this may be particularly important for juveniles). Where these fish are of commercial interest, then there is the potential for protection of seabed habitats within MPAs to contribute positively to the sustainability of fisheries.

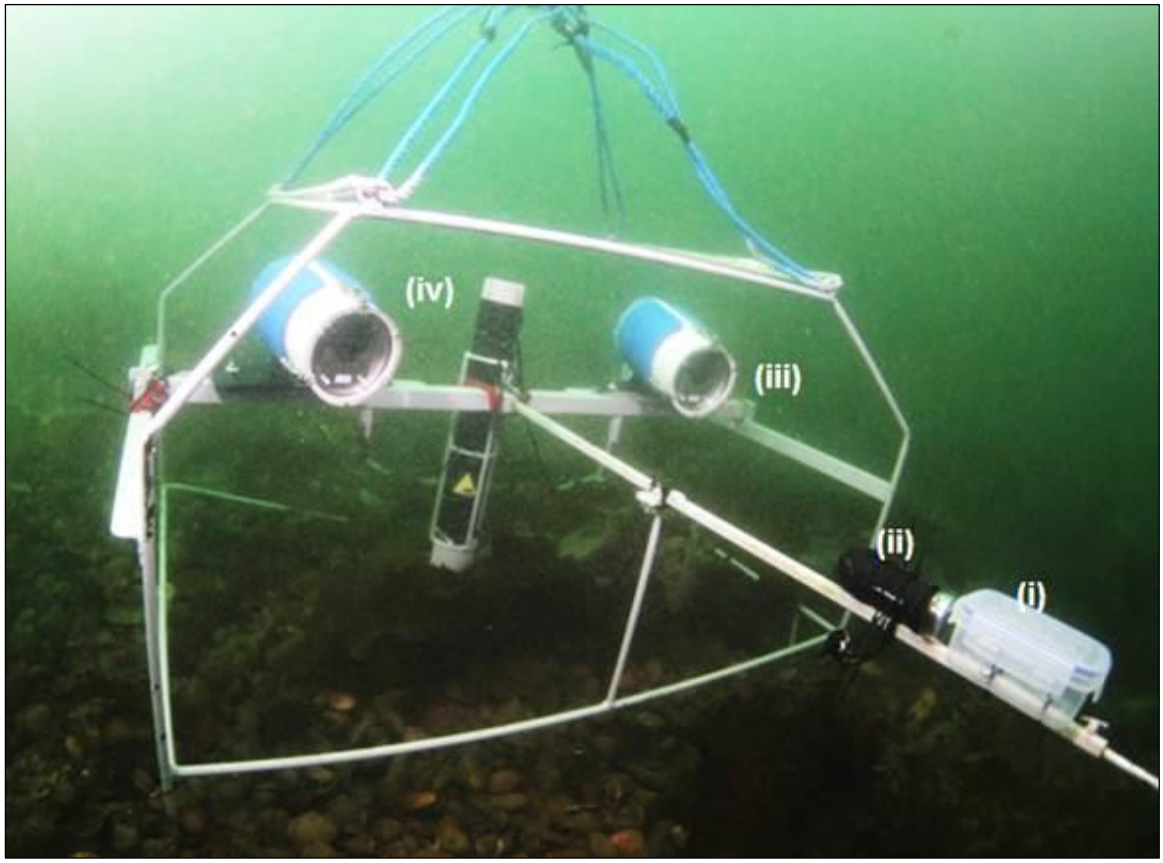

Figure A5.11. One of the three SBRUV units used by the University of Glasgow team in the South Arran MPA. The marked parts are (i) bait box, (ii) strobe used to synchronise the cameras, (iii) the left camera of the stereo setup, (iv) acoustic current meter.

The University of Glasgow carried out photographic surveys of juvenile gadoids within the South Arran MPA in 2013, 2014 and 2016. The methods used were Stereo Diver-Operated Video (SDOV) transects and Stereo Baited Remote Underwater Video (SBRUV) deployments (see Elliott *et al*., 2016; & Elliott *et al*., *in press* for further details). These studies identified the seabed types with which different gadoid species are associated and found that, within each seabed type, fish abundance is higher where there is higher benthic biodiversity. In collaboration with the University of Strathclyde, a predictive seabed map was created using the camera images. As well as developing our understanding of the ecology of important commercial species, these surveys provide a permanent and quantitative record of the state of

the MPA around the time of its designation and the implementation of management measures.

* This work was funded by the Scottish Government ClimateXChange Centre of Expertise, Marine Scotland Science, Scottish Natural Heritage and NERC.

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Elliott, S.A.M., Heath, M.R., Turrell, W.R. & Bailey, D.M. (*in press*). Juvenile gadoid habitat and ontogenetic shift observations using stereo-video baited cameras. Marine Ecological Progress Series. doi: 10.3354/meps12068.

Annex 6: Data management

Data collected as part of the Scottish MPA Monitoring Strategy will be managed in accordance with existing Marine Environmental Data Information Network (MEDIN) standards and practices in use for marine monitoring data.

The approach adopted here also complies with Scottish Government Information Management Principles[66] and the Data Vision for Scotland[67]. Each competent monitoring authority will follow their own organisations data management strategies and plans.

These are outlined in more detail following the key steps in the "Data Management Lifecycle" of *Acquire*, *Organise*, *Use*, *Share* and *Maintain* (adapted from IOC Manuals and Guides No. 73. 2016. *Guidelines for a data management plan*[68]).

Acquire

Data acquisition will follow Standard Operating Procedures where available, and where such do not exist they will be created to allow consistent procedures to be followed. Quality Assurance Procedures (QA) will be applied to monitoring methods and where available external quality assurance schemes will be implemented to ensure inter-comparability between organisations and operators. These are available from international organisations such as BEQUALM[69] and in the UK the National Marine Biological Analytical Quality Assurance Quality Control Scheme (NMBAQC[70]). Currently, external Quality Assurance is available for several strands of sample collection and analysis, but others are lacking and efforts will be made to fill these gaps (e.g. the potential development of external QA of underwater video collection and analysis under NMBAQC).

Organise

Data will be collated alongside explanatory metadata in accordance with MEDIN metadata discovery standard for individual datasets: http://www.oceannet.org/marine_data_standards/documents/medin_schema_doc_2_3_8.pdf

Use

Each organisation will apply its on Standard Operating Procedures for use and interpretation of monitoring data, making use of MEDIN standards (compliant discovery metadata and MEDIN Data Guidelines)[71] where appropriate.

66 http://www.gov.scot/Resource/Doc/923/0062022.pdf
67 http://www.gov.scot/Topics/Economy/digital/digitalservices/datamanagement/dmbvfs/dmbvfspdf
68 http://www.ioc-unesco.org/index.php?option=com_oe&task=viewDocumentRecord&docID=16859
69 http://www.bequalm.org/about.htm
70 http://www.nmbaqcs.org/
71 http://www.oceannet.org/marine_data_standards/medin_disc_stnd.html

Share

Specific monitoring reports will be published and made available by each competent monitoring authority on their own public facing web pages. Marine monitoring programmes metadata will be submitted to UKDMOS[72]. In accordance with the Scottish Government Open data Strategy[73] and INSPIRE legislation[74] and Scottish legislation[75] processed and collated monitoring data will also be made available on open data portals including Marine Scotland Information (MSI)[76], Scottish Natural Heritage interactive (SNHi)[77] and EMODNet seabed habitats portal[78] and relevant MEDIN DACs with feature records also being submitted to the National Biodiversity Network (NBN) Atlas Scotland[79] for collation and public access.

Maintain

Long-term data storage and archiving of MPA monitoring data will make use of the relevant Data Archive Centres[80] (DACs) associated with MEDIN, in particular the Data Archive on Seabed Species and Habitats (DASSH), the Data Archive Centre for geology, geophysics and backscatter (BGS)[81]. Marine bird's data will be archived in the databases administered by JNCC. Where possible and appropriate data will be formally published using the Digital Object Identifier (DOI) portal to allow use and citation of the data underlying assessments.

72 http://www.ukdmos.org/
73 http://www.gov.scot/Publications/2015/02/6614
74 See relevant links from - https://data.gov.uk/inspire
75 http://www.legislation.gov.uk/ssi/2009/440/contents/made
76 http://marine.gov.scot/
77 http://www.snh.gov.uk/publications-data-and-research/snhi-information-service/
78 http://www.emodnet-seabedhabitats.eu/
79 http://www.als.scot/
80 http://www.oceannet.org/data_submission/
81 http://www.bgs.ac.ul/services/NGDC/management/marine/MEDINDataArchiveCentre.html

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