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Engaging the Fishing Industry in Marine Environmental Survey and Monitoring

Scottish Marine and Freshwater Science Vol 12 No 3

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European Maritime and Fisheries Fund Project SCO 1500
Final Report

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Marine Scotland is the directorate of the Scottish Government responsible for the integrated management of Scotland's seas. Marine Scotland Science provides expert scientific and technical advice on marine and fisheries issues. Scottish Marine and Freshwater Science is a series of reports that publishes results of research and monitoring carried out by Marine Scotland Science. It also publishes the results of marine and freshwater scientific work carried out for Maine Scotland under external commission. These reports are not subject to formal external peer-review.

This report presents the results of marine and freshwater scientific work carried out for Marine Scotland under external commission.

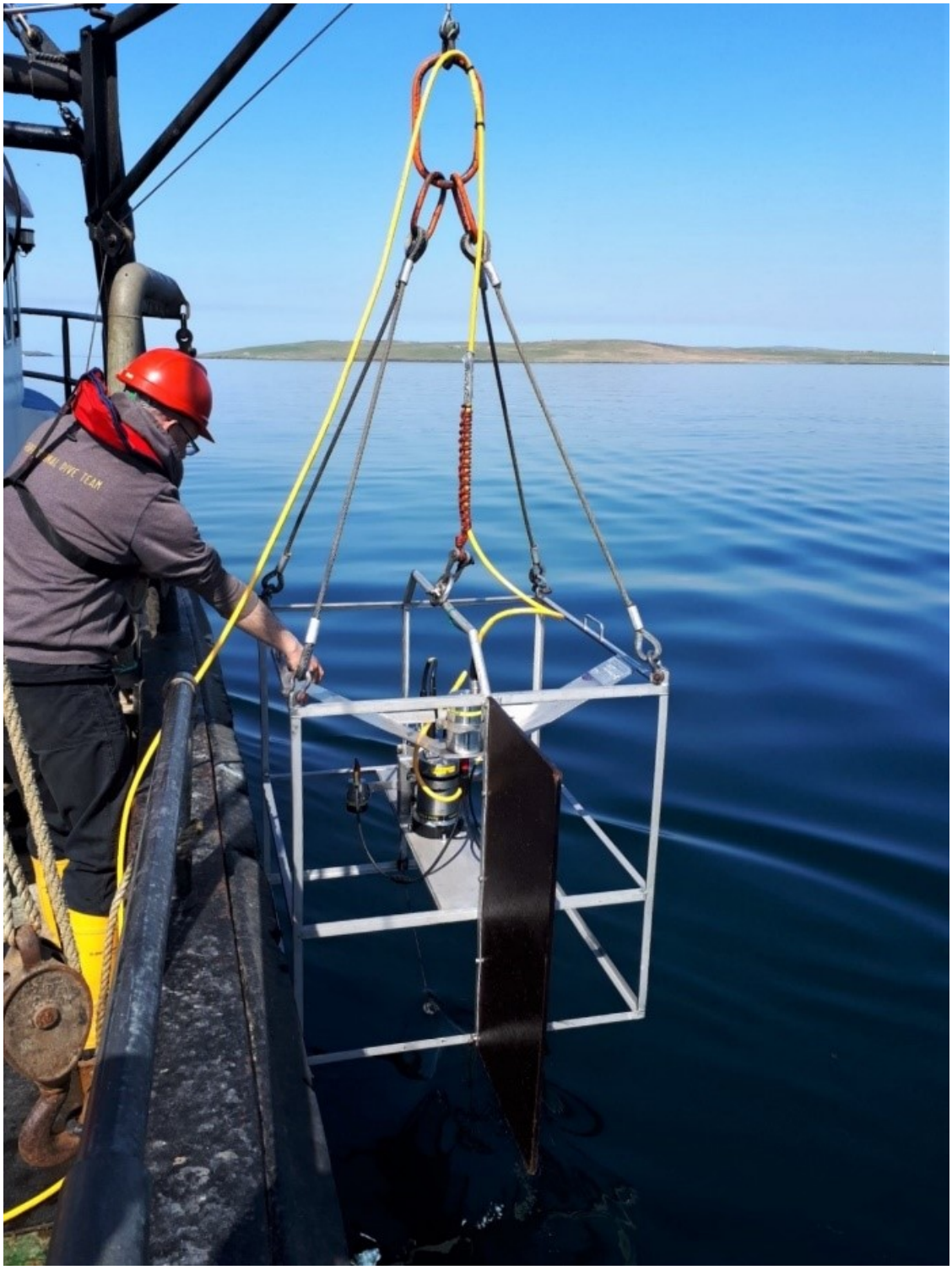

Figure 1: The C-Technics drop-down video (DDV) system being deployed from a commercial fishing vessel.

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European Maritime and Fisheries Fund Project SCO 1500
Final Report

G Pasco[1], B James[2], L Burke[3], C Johnston[4], K Orr[5], J Clarke[3], J Thorburn[6], P Boulcott[3], F Kent[2], L Kamphausen[2] and R Sinclair[2]

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1 Introduction

Scottish Government gained funding through the European Maritime and Fisheries Fund (EMFF) to provide opportunities for the fishing industry to engage and collaborate with the scientific community, Statutory Nature Conservation Bodies and Government departments in Scotland, to carry out evidence gathering and marine monitoring to help deliver national and international requirements in relation to the protection and restoration of marine biodiversity (with a particular focus on Marine Protected Areas - MPAs). The project supported three main survey types, those being drop-down video (DDV) monitoring, juvenile fish surveys and investigations into the movement ecology of flapper skate (*Dipturus intermedius*) within and adjacent to Marine Protected areas. The objectives of the surveys using these three methods are discussed in more detail below.

The project was led by the Scottish Government with support from NatureScot (formerly Scottish Natural Heritage - SNH), with a project steering group to oversee the work. Project management services were provided by Seascope Fisheries Research Ltd., with assistance from Crangon Ltd. and Marine Consulting. The project began in May 2017 and ended in October 2020.

The project had four aims:

1. Involvement of the fishing industry in the evidence gathering and monitoring process, with the purpose of increasing their general awareness of the marine nature conservation, including the MPA designation process and subsequent development of management measures.

2. Develop and test a robust and straightforward underwater video camera that could be used by the fishing industry in the future for evidence gathering.
3. Improve knowledge of the distribution of seabed habitats across a number of marine areas. Work undertaken within MPAs will help inform assessments of whether conservation objectives are being met (in terms of conserving / maintaining or recovering the protected features), and also the efficacy of new management measures.
4. Provide a working framework for how evidence gathering using fishing vessels can be expanded in the long-term to other areas.

The aims were developed with the purpose of bringing the following benefits:

- Provide the fishing industry with the opportunity to engage in the nature conservation processes, including MPA condition assessments through evidence gathering.
- Provide the opportunity of financial gain to the wider fishing industry through chartering their vessels.
- Increase the general awareness of nature conservation processes and the subsequent development of management measures among the fishing industry.
- Maximise opportunities for stakeholders, including the fishing industry, to undertake marine environmental survey and monitoring work.
- Provide information on the condition of Scottish MPAs and Priority Marine Features (PMFs) that can feed into the reporting and assessment process at a national and international level.

2 Engagement with industry

During the project the team engaged widely with stakeholders through a number of initiatives. In the early stages, flyers were developed to provide accessible information about the project and raise awareness among potential participants within the fishing industry. The flyers explained the purpose of the work and the chartering process. More detailed information was then disseminated via the Regional Inshore Fisheries Groups (RIFGs) on how vessels could obtain either a Load Line Exemption or a Workboat code (including contact with the Maritime and Coastguard Agency (MCA) and Royal Yachting Association (RYA)), which were necessary for participation. Fishers were also contacted directly to find out if there were any specific barriers to tendering for the survey work, and the application criteria and online application process was then revised and simplified to make the project more accessible. The fishing industry were then notified of upcoming tender

opportunities via the RIFG network, either by attending meetings in person or by circulating information via email.

Stakeholders in the project included the fishing industry, Non-Governmental Organisations (NGOs), academics and government organisations, as well as any other individuals who expressed an interest. Information about project progress and preliminary results were communicated to stakeholders in a number of ways, including: the production of a banner for display at the Inshore Fisheries Conference (5 October 2018); publication of three newsletters for the summer of 2018, autumn 2019 and winter 2019/2020, an update in the Seafish e-newsletter (published online February 2019); and the development of three blogs that were published on the Scottish Government website, one of which included a four minute video showcasing a 'typical' survey trip, with interviews of survey team and underwater footage obtained from the drop-down video (DDV) system (Figure 1). Newsletters and blogs were circulated to stakeholders via email and posted on social media sites for wider dissemination (e.g. Marine Scotland Twitter page).

Links to the blogs and newsletters are provided below:

Blog Part 1: https://blogs.gov.scot/marine-scotland/2019/01/24/engaging-the-fishing-industry-in-marine-environmental-survey-monitoring/

Blog Part 2: https://blogs.gov.scot/marine-scotland/2019/04/30/engaging-the-fishing-industry-in-marine-environmental-survey-and-monitoring-part-2/

Blog Part 3: https://blogs.gov.scot/marine-scotland/2019/10/11/fishing-industry-marine-environmental-survey-and-monitoring-part-3/

Summer 2018 newsletter: https://www.gov.scot/publications/emff-newsletter-summer-2018/

Autumn 2019 Newsletter: https://www.gov.scot/publications/emff-newsletter-autumn-2019/

Winter 2019 Newsletter: https://www.gov.scot/publications/emff-newsletter-winter-2019/

3 Drop-down video camera development

Due to the unique nature of the EMFF project, where non-specialist vessels were used to deploy high definition (HD) drop-down video (DDV) systems at depth, part of the project required the design of a suitable HD camera system. Marine Scotland Science division (part of Scottish Government) issued a competitive tender in 2017 for the supply of two complete systems. These units were required to record in HD format, operate at depths up to 200 m, and to be suitable for operation from a small A-frame or jib (typically found on under 12 m vessels). Due to the fact that dedicated engineers would not be on the surveys, the unit was required to be “plug and play” with a single, waterproof control unit providing both power and control mechanisms. The unit was also required to have the capacity to record > 8 megapixel (MP) HD video locally, send a standard definition video feed to a video display unit located in the wheelhouse to aid deployment, and be able to take digital still images, with shutter control operated from the surface. Lighting was to be provided to the digital still images via a flash, with continuous light needed for the video footage, provided by two 100 w LED lights. The provision of lasers to help estimate the field of view during deployment was also requested. At the time of tendering, no commercially available off the shelf system was within the budgetary limits of the project. The competitive tender was awarded to C-Tecnics Ltd, who developed a prototype unit that was able to meet both technical and financial requirements. Due to the prototype nature of the initial unit, further testing and refinement took place between the project team and C-Tecnics during 2018 and early 2019. Finalised units were delivered in the late spring of 2019.

3.1 EMFF DDV system overview

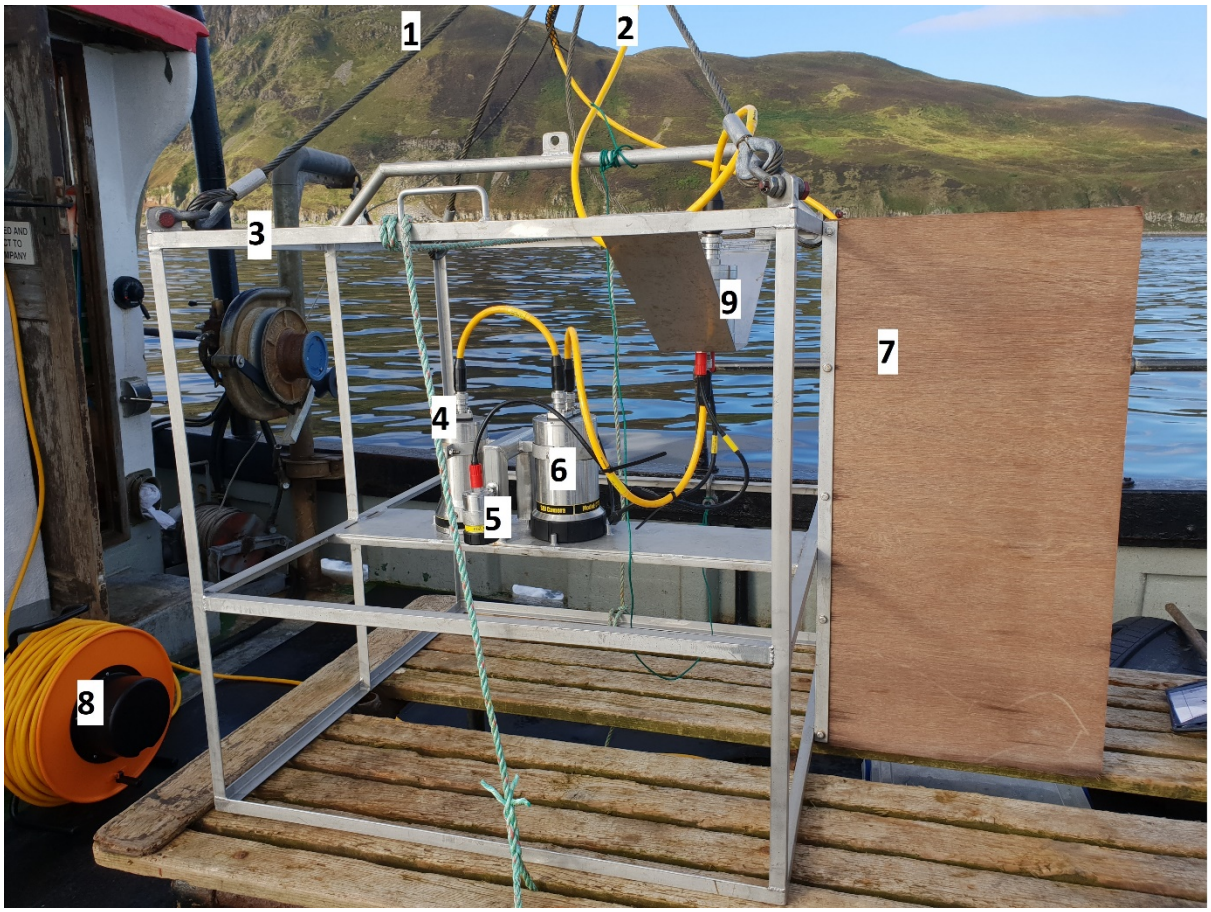

Figure 2: View of the DDV system procured through this project, ready for deployment aboard chartered vessel (*Lady Nicola*). Components as identified numerically are described below.

Figure 2 shows the submersible parts of the DDV system fixed within the frame (3) and ready for deployment. The individual components described in Figure 2 are:

1. Lifting harness.
2. Umbilical cable (connects the submersible parts of the system to on-board components - including a Standard Definition video feed - and power supply).
3. Stainless steel frame (width=100 cm, depth=100 cm, height=120 cm) to protect components.
4. Camera flash unit (CT4015 flashgun).
5. Left-hand external light pod. Right-hand light pod obscured in the photo above by the camera unit.
6. Main camera unit (CT3023 SLV full HD video camera with built in red lasers for reference scaling of plants and animals on the seabed - set 100 mm apart

in a 316 stainless steel housing). The camera records at 1080 pixels (p) at 60 frames per second (fps) with 20.8MP resolution digital stills.

7. Stabilising fin.
8. 100 metre umbilical roller (a 300 m umbilical cable was also available for deeper stations).
9. Junction pod. Provides connection point for umbilical then distributes power etc. to the various components making up the system via waterproof interconnecting cables - and also houses integral pressure sensor.

The above submersible components, coupled with the surface control unit (SCU), (connected via the umbilical cable) comprise the majority of the system. The SCU provides the interface and allows the operator to control video and stills image recording (start/stop) along with lighting and flash settings (Figure 3).

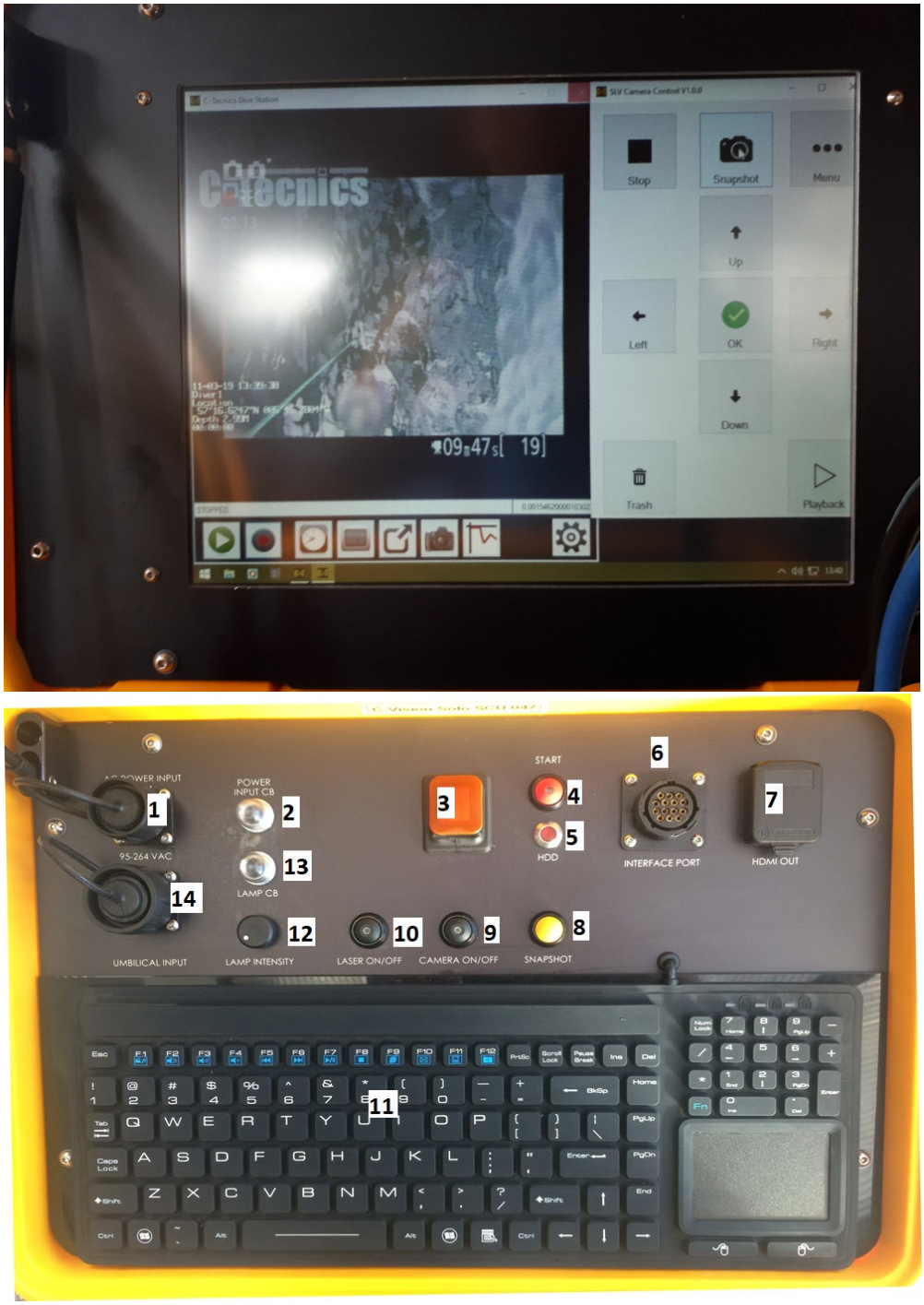

Figure 3: (Top) The display screen of the C-Tecnics Surface Control Unit (SCU), showing live SD video feed along with some of the controls available to the operator. (Bottom) SCU control panel, numbered items described below. Bottom image adapted from Drop Frame Camera System- User Manual, supplied with system when purchased.

The controls of the SCU control panel shown in Figure 3 are:

1. Connection point for AC power supply.
2. Power input circuit breaker.

3. Main power switch.
4. System start button.
5. HDD activity LED indicator.
6. Interface port (facilitates connection of GPS and external data storage devices).
7. HDMI out socket, to connect additional viewing screen.
8. Snapshot button, to collect HD still images as required.
9. Camera on/off switch.
10. Laser on/off switch.
11. Keyboard controls with integrated mousepad.
12. Lamp intensity adjustment dial.
13. Lamp circuit breaker.
14. Umbilical connection socket.

In general operations the SCU records an independent GPS feed from a GPS puck attached to the unit via USB, which is overlaid onto the SD video feed displayed on the SCU and saved. The SCU is capable of running an additional screen (displaying the same camera view as the SCU) that allows another scientist to monitor the collected video stream and make observational notes in real-time. The SCU assembly is all housed within a rugged Hardigg Storm case housing, measuring 411 x 322 x 168 mm.

3.2 NatureScot's mini-DDV system overview

NatureScot's mini-DDV camera system was used as a back-up for the first survey of the project in the Inner Sound and Loch Alsh in July 2018 (see Section 4.2.1 below). The system (shown in Figure 4) was used for four of the five days of survey work due to technical issues with the main camera after the first survey day. The portable camera system, designed primarily for use in shallow coastal areas uses a GoPro Hero 4 camera in a deep water housing (Group B Scout Pro). The camera was set to collect HD footage at 60 fps (saved onto the camera memory card) - it was not possible to collect still images at the same time on this setting. The most noticeable difference in the footage collected compared to the EMFF camera system is that the NatureScot camera is angled to be slightly forward facing rather than vertical (directly down). The system has two white LED light clusters and Outland Technology UWL-810 red line scaling lasers set 100 mm apart. An SD feed from the camera is carried to a topside unit via a 100 m umbilical where a GPS overlay is merged and recorded onto the SD footage.

Figure 4: The NatureScot mini-DDV system used as a back-up on the first survey of the project, deployment from chartered vessel (*Lady Nicola*) and surface control unit in the wheelhouse (black peli-case on the seat).

4 Drop-down video surveys

4.1 Survey planning

DDV surveys were planned by the project partners using expertise and knowledge from NatureScot and Marine Scotland Science. The broad survey areas were selected on the basis of MPA boundaries, accessibility, and previous sampling effort. Areas needed to encompass a suitable range of water to allow for contingency – e.g. open coast and those more sheltered - in potentially variable weather conditions. Individual survey sampling locations (stations) were often determined by combining seabed mapping data (e.g. from multi-beam sonar) with existing records of habitats and species in the area (including anecdotal accounts).

Within the chosen survey areas, fine-scale sampling fulfilled a number of different objectives, which varied from area to area and within each area:

- Inventory sampling to enhance understanding of the distribution and extent of seabed habitats both within and outside MPAs.
- Targeted survey of specific habitats and species of interest (e.g. PMFs), including to confirm presence - where NatureScot had been informed of potential occurrence (for example by fishers or local environmental groups).
- Repeat-sampling of locations within MPAs to determine current habitat status.

In all surveys a greater number of sampling locations (stations) were planned than could realistically be completed in the survey period. This was to allow for flexibility in

delivery around poor weather. Sampling of survey stations in the less accessible, more exposed and deeper locations were prioritised during periods of good weather.

Information on potential development proposals and areas of possible interest for future development was sought from NatureScot and this guided some station placement, allowing the results to inform subsequent discussions with industry and decisions by consenting bodies. Draft survey plans were approved by the project steering group prior to survey.

Once draft survey plans were completed, Scottish Government invited tenders from interested vessel owners and skippers. Vessels for each survey were chosen independently by competitive tender process. Seascope staff engaged with the successful charter vessel owners/skippers to finalise the most suitable ports to operate from in order to best meet each survey's sampling priorities. Particularly in relation to 2019 surveys, which were all ten days in duration, this often included selecting two or more main ports of operation. Consideration to vessel berthing facilities, access to fuel and water, local amenities and access to medical facilities and accommodation all factored into this process. All surveys were staffed with at least one Seascope representative and one representative from NatureScot, along with the minimum required vessel crew (specified as three in the competitive tender process).

4.2 Summary of 2018 and 2019 DDV surveys

Table 1

Chronological summary of DDV surveys completed 2018-2019.

Survey area	Survey dates	No. of video tows	Hours of video footage	No. of still images
Inner Sound and Loch Alsh	16-20 July 2018	76	7:28	90
Wester Ross	30 July-4 August 2018	130	13:20	1280
Small Isles	13-17 August 2018	87	10:42	1135
Arran and Clyde Sea	2-7 September 2018	134	13:56	1916
Inner Sound and Loch Alsh	12-20 March 2019	151	20:30	2451
Orkney	8-17 May 2019	228	21:55	2827
Shetland	23 May-1 June 2019	175	21:31	2513
Sounds of Islay and Jura	21-30 June 2019	225	21:12	2464
Total		1206	130:34	14,676

Table 1 describes the locations of the various DDV surveys conducted throughout 2018-2019, along with a summary of the data collected. Figures 5 and 6 show the locations of individual surveys by year.

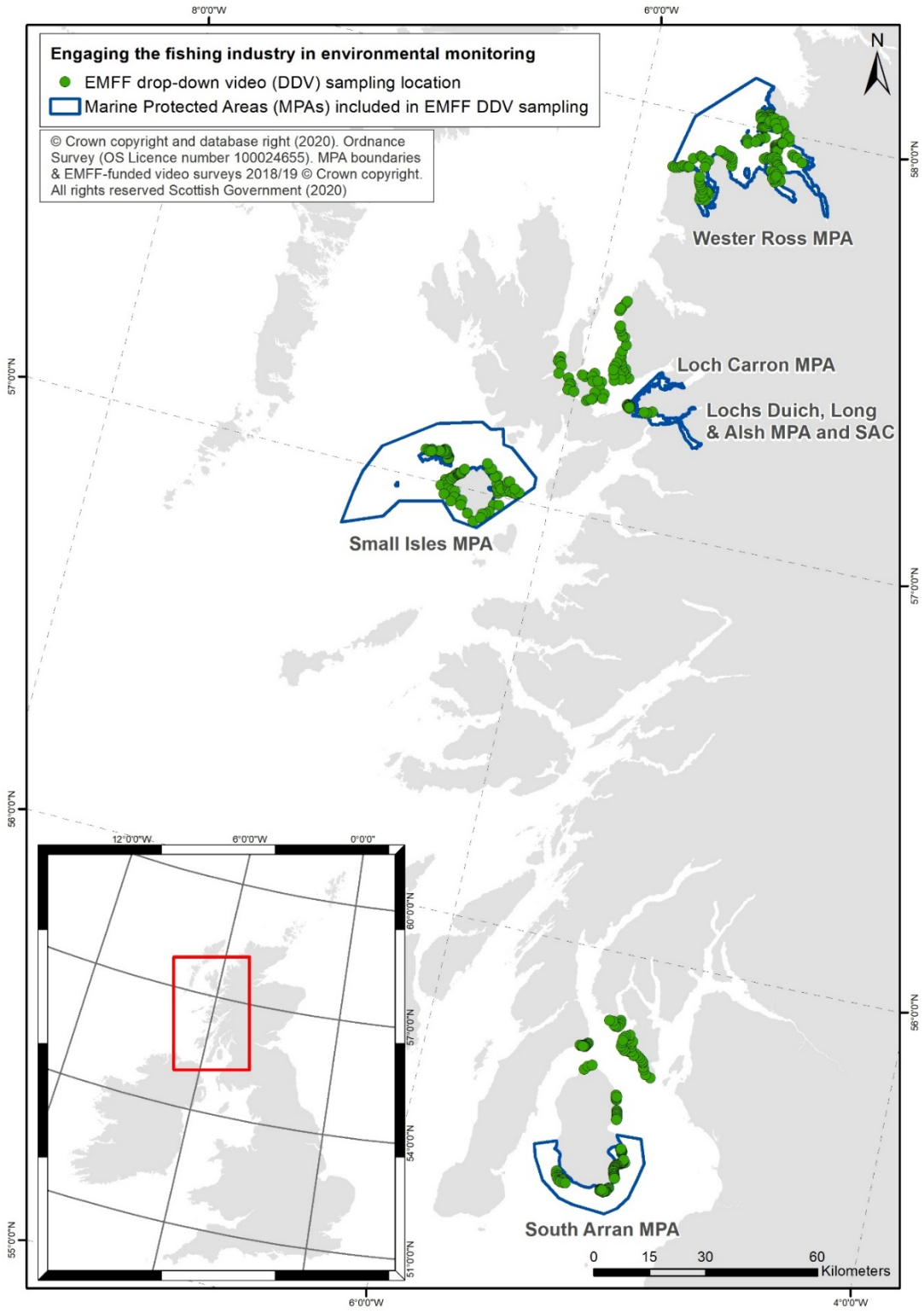

Figure 5: Marine Protected Areas where drop-down video sampling was carried out in 2018.

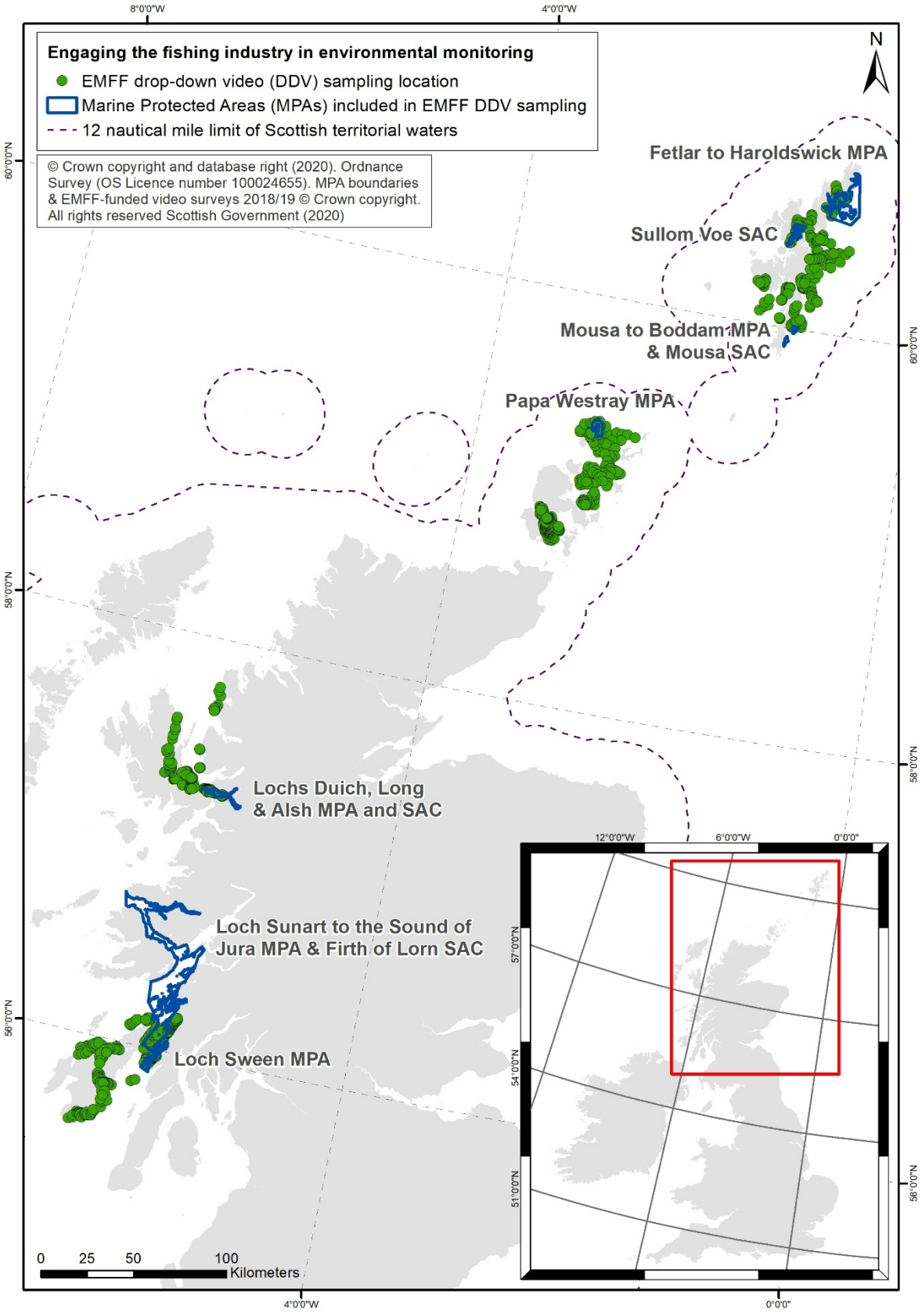

Figure 6: Stations sampled in 2019 in Inner Sound and Loch Alsh, Islay and Jura, Orkney and Shetland.

The following sections describe each survey in more detail. All DDV surveys were carried out aboard the chartered FV *Lady Nicola,* after competitive tender exercises were run for each survey.

4.2.1 Inner Sound and Loch Alsh (2018)

The focus of this survey was to gather footage to help determine the location and condition of flame shell (*Limaria hians*) beds, burrowed mud, maerl and 'biogenic' reefs, which are created by animals such as horse mussels (*Modiolus modiolus*).

This was the first DDV survey of the project and was used by the survey team from Seascope Fisheries Research Ltd. and NatureScot to test the newly developed DDV camera system. In total, 76 sites were surveyed within the Lochs Duich, Long and Alsh MPA and the Inner Sound of Skye. The crew of the charter vessel had good local knowledge of the seabed and tides, which proved very helpful to the survey. A few technical glitches were experienced with the EMFF camera (which can be expected for a first trial), so the NatureScot mini-DDV system was used for the majority of the work whilst the other camera underwent repairs. This meant that only sites shallower than 70 m could be visited (due to a shorter length camera 'umbilical cable'). Figures 7 and 8 show some of the organisms and substrate found in this area, as recorded on the NatureScot system.

Figure 7: Sea squirts and rugose squat lobsters on silty mixed sediments off the coast at Toscaig, Inner Sound of Skye, 2018.

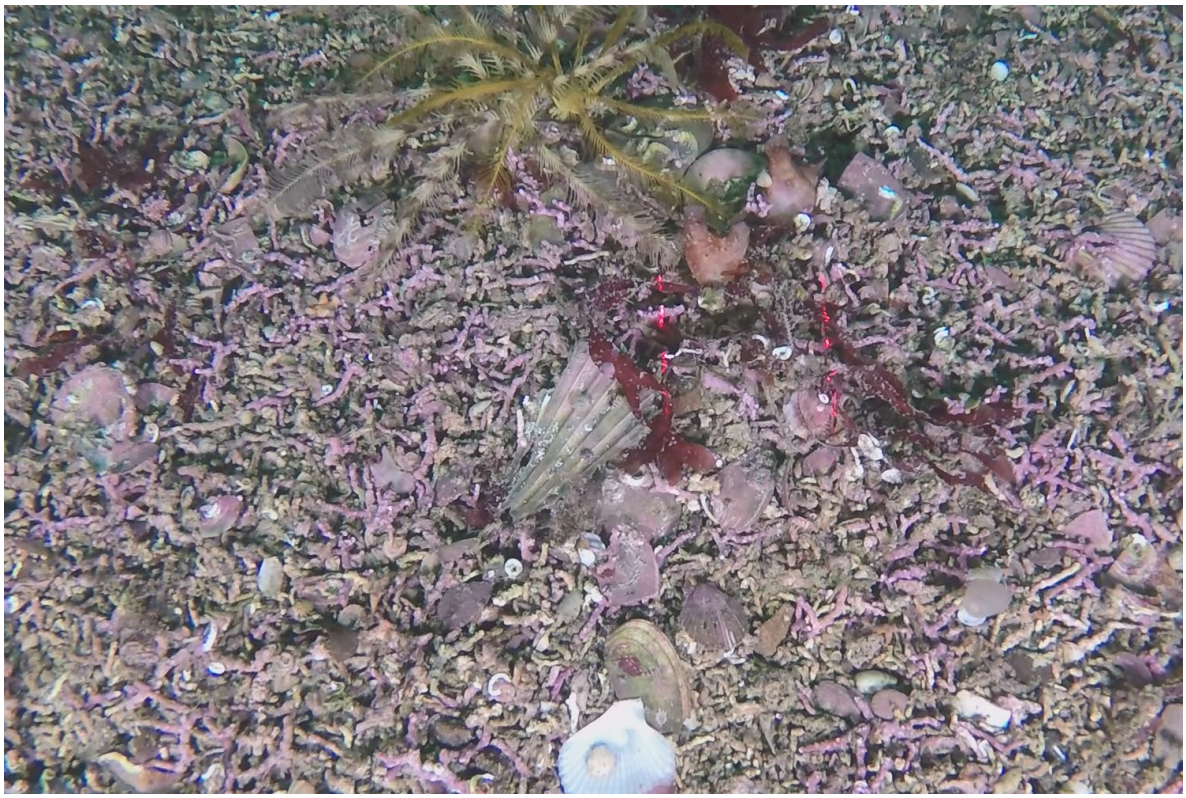

Figure 8: Maerl with shells, feather stars and sparse red seaweeds in 24 m depth, off the coast of Applecross, Inner Sound of Skye 2018.

4.2.2 Wester Ross (2018)

The focus of this survey was to gather footage of maerl beds and northern feather stars (*Leptometra celtica*), as well as other protected features of the Wester Ross MPA, and record any change in their extent and condition since fisheries management measures were introduced in 2016. This included surveying areas previously exposed to fishing gear that is towed on the seabed.

Footage of the seabed was collected from 130 locations using the DDV camera system deployed from a chartered fishing vessel. Strong westerly and south-westerly winds (Force 3-5) meant that the vessel was restricted to working in the more sheltered areas to the east of land masses and islands. Footage was also gathered of other seabed habitats to improve knowledge of their broad distribution in the area. The team had originally hoped to survey some more wave exposed sites outside the MPA too as part of a 'gap filling exercise' to identify other areas with maerl beds (shallower than 35 m), but the poor weather prevented access to these areas. Figures 9 and 10 show seapens and maerl waves recorded during the survey.

Figure 9: Phosphorescent seapens *Pennatula phosphorea* in burrowed mud, Loch Ewe 2018.

Figure 10: Maerl 'waves' at Tanera Mor, Summer Isles 2018.

4.2.3 Small Isles (2018)

The focus of this survey was to improve our understanding of the distribution of protected features within the MPA such as northern sea fans (*Swiftia pallida*), northern feather stars and burrowed mud habitats. The survey also included sites around Rum and Canna where there was little existing information on seabed habitats and species. The results will help refine habitat maps for the MPA.

A total of 87 sites were surveyed from the chartered fishing vessel. Several sites north-east of Rum were visited to find out if northern sea fan and sponge communities were present, and some sites east of Rum were surveyed to look for fan mussels. In addition, several nearshore sites were explored for maerl and flame shell beds. The team had planned to visit some deep water sites to test the EMFF DDV camera system at depth and to explore historical records of cold-water corals (e.g. off south-east Rum), however, poor weather prevented this. Similarly, due to prevailing south-westerly winds throughout the survey period, and moderate swells, additional sampling stations were added north of Canna, to maximise the data collected during the survey. Example still images from the survey are given in Figures 11 and 12.

Figure 11: Tall seapen *Funiculina quadrangularis*, Eastern Rum.

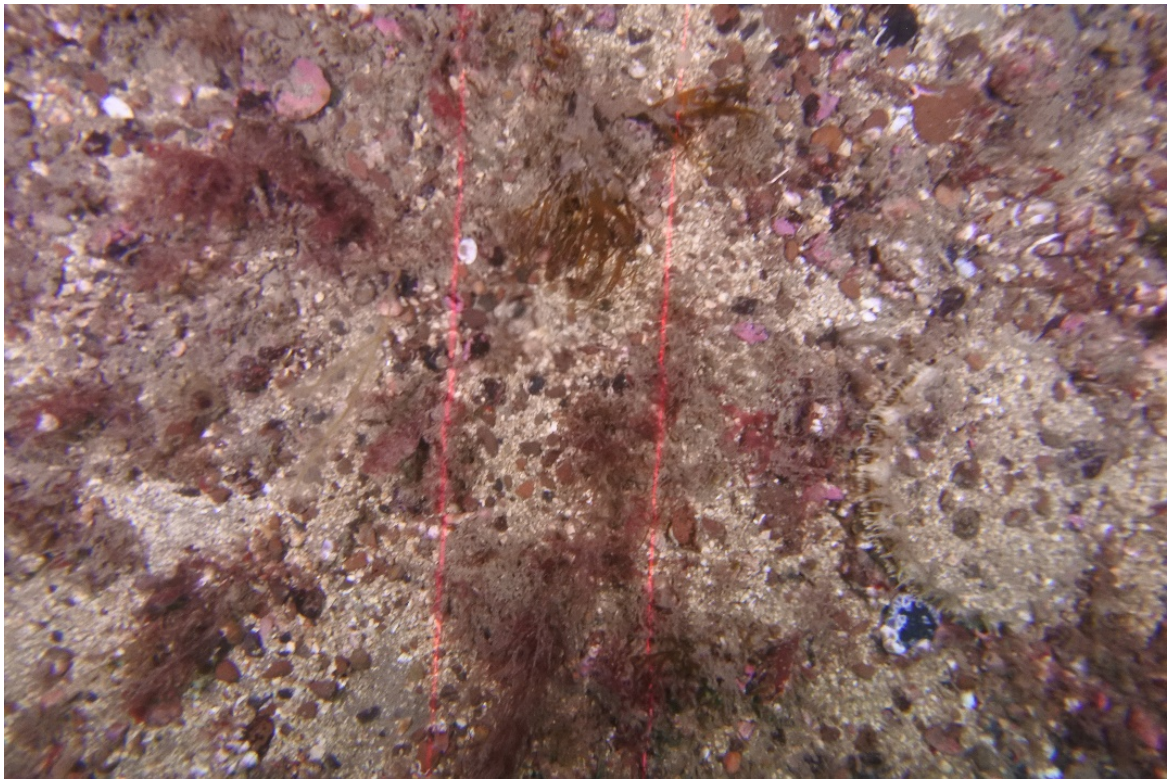

Figure 12: A well camouflaged king scallop *Pecten maximus* (bottom right) amongst sand-pebble substrate. Note laser lines, used to determine relative size within images.

4.2.4 South Arran and Clyde Sea (2018)

The focus of this survey was to monitor the condition of seabed habitats in areas formerly exposed to towed fishing gears prior to the implementation of fisheries management measures in 2016. Video footage will also be used to measure the extent and status of seagrass (*Zostera spp.*) and maerl beds, and develop an inventory of the different habitats found within and outside the South Arran MPA.

Video footage and photographs were recorded of seabed habitats and PMFs at 134 stations in South Arran MPA and surrounding waters by a chartered fishing vessel. The survey started off with fairly strong south-westerly winds and moderate swell, forcing the team to focus on sheltered sites to the east of Arran. However, the weather calmed over the duration of the survey allowing the vessel to work in shallower water and more exposed areas, including around Pladda, Holy Isle, off the Iron Rock Ledges and the Inchmarnock area to the north-east of Arran. Towards the end of the scheduled time, surveys were conducted off Skipness (Mull of Kintyre) and in Loch Ranza. Deteriorating weather and the north westerly winds meant that the vessel could not visit all sites in this area, so the team returned south to survey

the sheltered waters of Whiting Bay. Figures 13 and 14 illustrate the variety of habitats recorded during the survey.

Figure 13: An octopus and a king scallop with sugar kelp over pebbles.

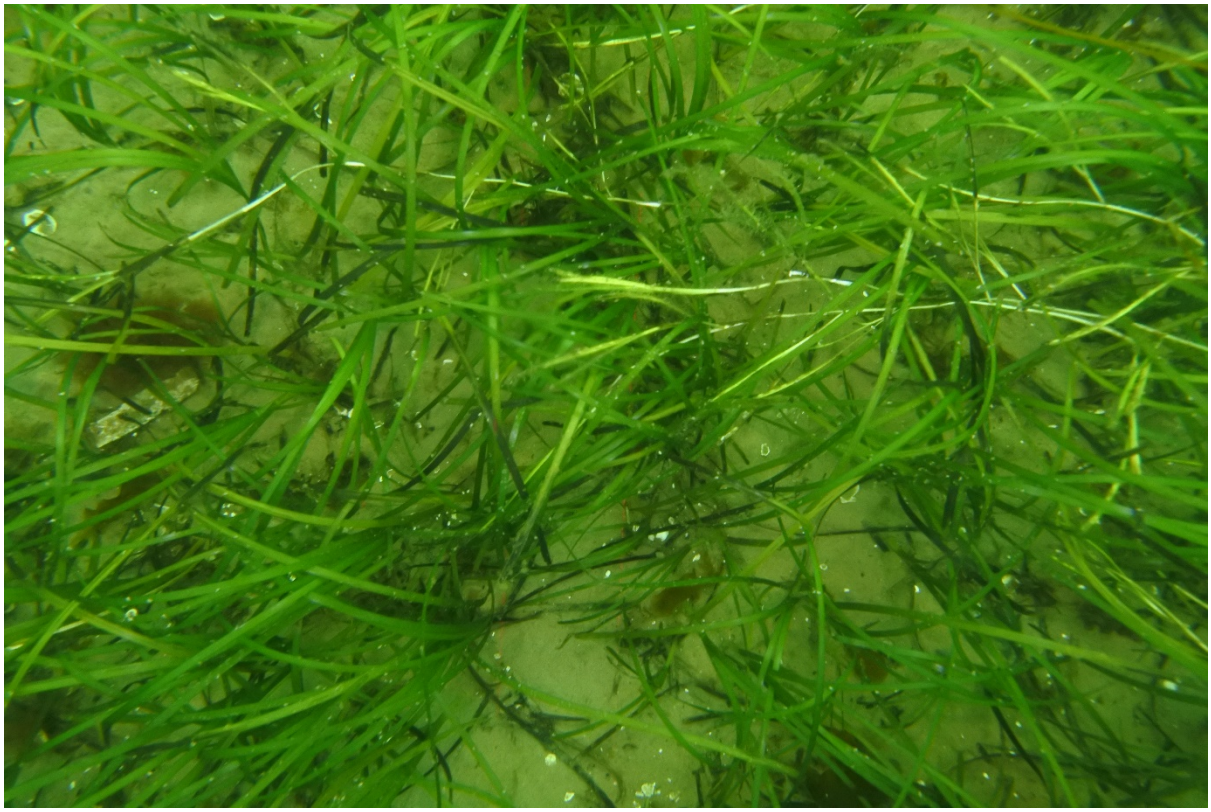

Figure 14: Shallow subtidal seagrass at Whiting Bay, South Arran.

4.2.5 Inner Sound and Loch Alsh (2019)

The focus of this survey was to confirm the presence and condition of PMFs such as maerl beds, horse mussel beds and flame shell beds within the Inner Sound of Skye and Loch Alsh, and explore seabed habitats in an area where herring (*Clupea harengus*) were reported to spawn in Wester Ross.

This survey took place in challenging weather conditions, but was specifically timed to hopefully coincide with herring spawning activity in Wester Ross. In total, 151 sites were surveyed over ten days, covering a diverse range of habitats from flame shell beds and horse mussels to burrowed mud. Flame shell beds were filmed in a number of new locations within the Inner Sound, which confirmed observations submitted to NatureScot by scallop divers. The strong south-westerly winds during much of the survey forced the team to survey the most sheltered leeward locations (along the eastern border of Skye). During a brief break in the weather the survey vessel was able to travel up to Wester Ross, and the highlight of the trip was recording herring spawn that had settled onto maerl beds and coarse gravel habitats in a thick jelly-like mat at locations just north of Loch Torridon (Figure 15).

This was the same location where herring were filmed spawning on the 2019 series of Blue Planet UK (BBC)[1]. Figure 16 shows typical flame shell bed surface signs (woven byssus mat with nest 'openings' visible amongst red algae and a kelp holdfast), from Kyleakin channel in Loch Alsh.

[1] https://www.bbc.co.uk/programmes/p074qrg7

Figure 15: Herring spawn (blue/grey coloured mat) with feather stars overlying maerl gravels, north of Loch Torridon.

Figure 16: Flame shell bed habitat around a kelp holdfast, Kyleakin Channel.

4.2.6 Orkney (2019)

The focus of this survey was to improve understanding of the distribution and condition of PMFs such as maerl beds, horse mussel beds (*Modiolus modiolus*), fan mussels (*Atrina fragilis*) and flame shell beds – the beds at Scapa Flow are thought to be the most northerly in the UK (first recorded here by Seasearch divers and scientists at Heriot-Watt University in 2013[2]). The video footage will be used by NatureScot to refine existing habitat mapping for the area, building on work from previous years. In contrast to the Inner Sound survey, the weather in Orkney was excellent, allowing the team to survey a variety of locations around the islands, including the North Sound and to the north and west of Papa Westray. A total of 228 stations were surveyed over a ten-day period, targeting areas that had not been surveyed previously and areas known to support PMFs where further information was needed to determine the current extent of relevant habitats.

Initial analysis of images from stations within western Scapa Flow showed promising signs of flame shell beds (Figure 17) and a follow-up dive survey by NatureScot (outside of this project) was conducted in October 2019, confirming the presence of extensive areas of flame shell beds within Gutter Sound (Figure 18).

[2] SNH. 2019. *Review of PMFs outside the Scottish MPA network - Flame shell beds*. Available from - https://consult.gov.scot/marine-scotland/priority-marine-features/supporting_documents/Review%20of%20PMFs%20outside%20the%20Scottish%20MPA%20network%20%20FINAL%20%20Flame%20shell%20beds.pdf

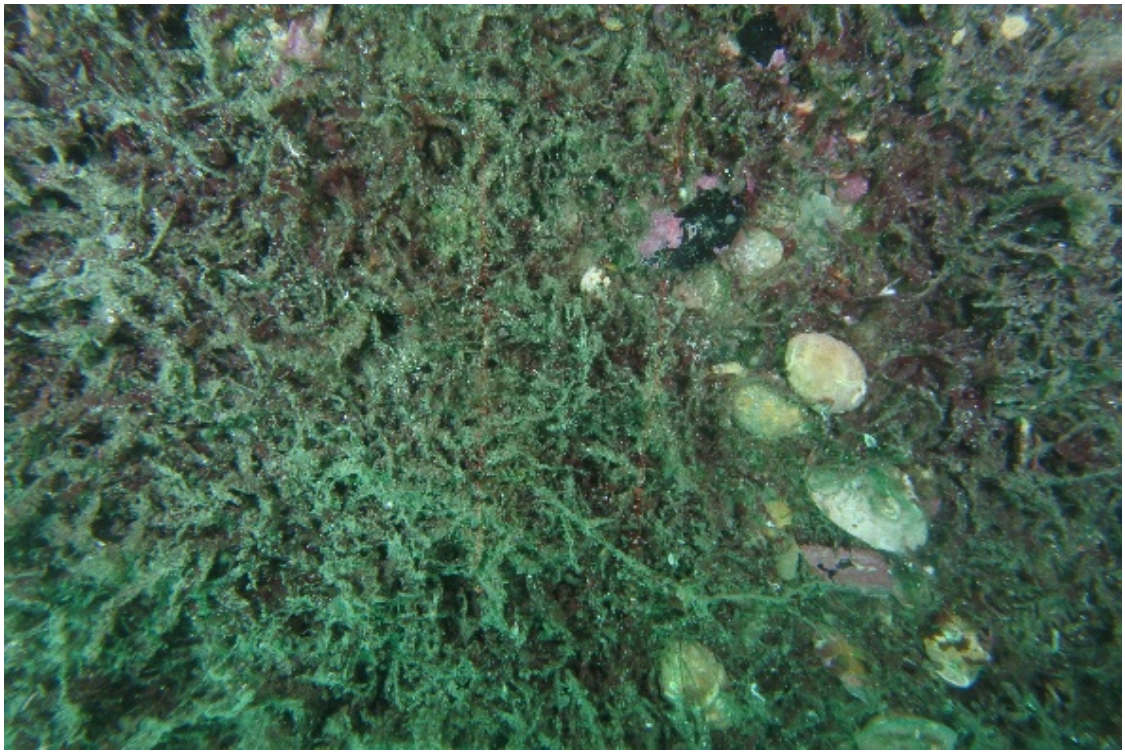

Figure 17: Potential flame shell habitat identified in DDV survey of Scapa Flow.

Figure 18: Follow-up dive survey image (courtesy of Lisa Kamphausen, NatureScot) of a flame shell amongst red algae in Gutter Sound, West Scapa Flow.

4.2.7 Shetland (2019)

The focus of this survey was to gather footage in areas with historic or uncertain records of PMFs and survey the seabed in areas not visited before. Habitats of interest include maerl beds, horse mussel beds and fan mussels in and adjacent to MPAs around the Shetland Isles.

A total of 175 stations were surveyed in and around the Shetland Isles, from Yell in the north down to Mousa in the south as well as sites off the south west coast. Predominant westerlies limited opportunities to survey locations on the west coast, where time was limited to two of the ten survey days. Several rich maerl beds were recorded (including one that was also surveyed a few years ago off Mousa). New footage of horse mussel beds and maerl beds (see Figures 19 and 20, respectively) was also gathered in areas where there was no prior record of their existence, which has added to our knowledge of the distribution and extent of these PMFs. Much of the sampling around Shetland focussed on habitats in nearshore areas (generally seabed shallower than 50 m), however, some deeper sites were also visited to explore the distribution of PMFs (to a maximum depth of 150 m).

The North Atlantic Fisheries College (NAFC) also provided local knowledge in the survey design, which helped prioritise sampling areas.

Figure 19: Horse mussels, brittlestars and a common urchin in a rock crevice. NE Bressay.

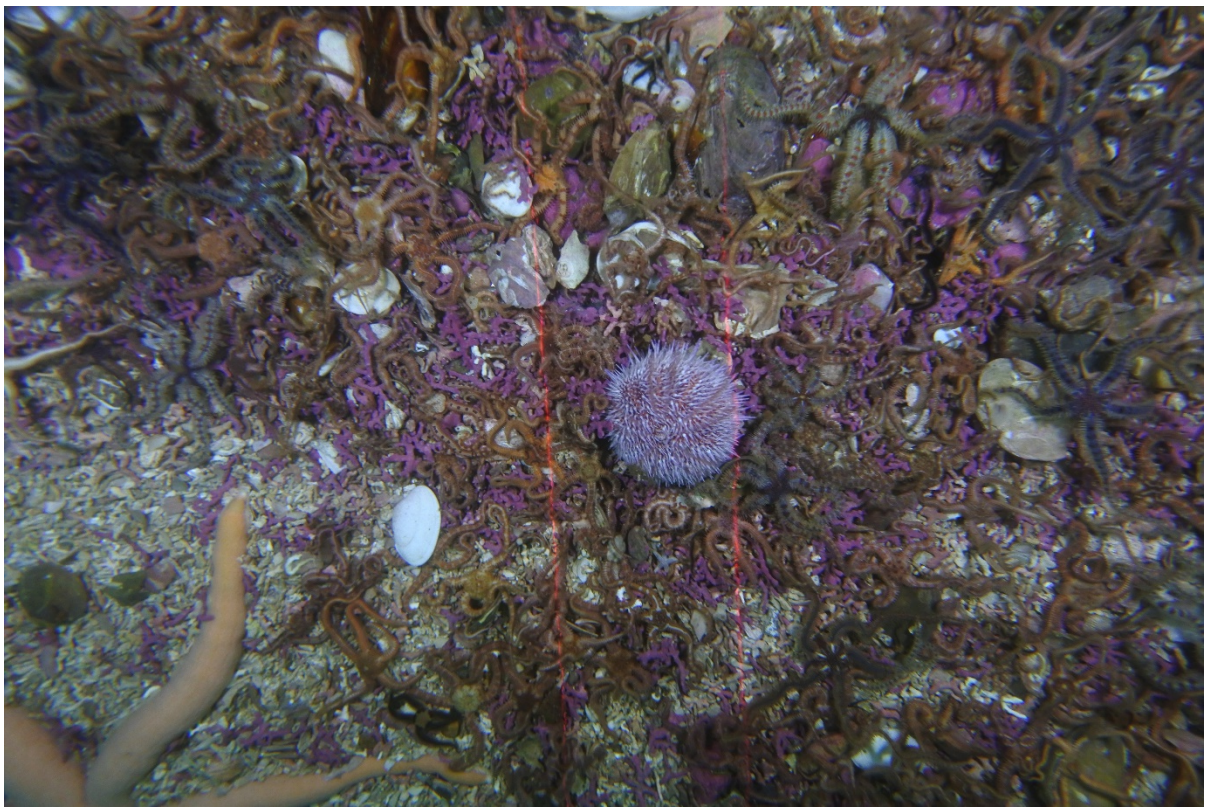

Figure 20: A new maerl bed with brittlestars and echinoderms, Sound of Yell.

4.2.8 Jura and Islay (2019)

The focus of this survey was to gather video footage of the seabed in and around areas where there are already records of PMFs such as horse mussel beds, maerl beds and northern sea fan and sponge communities, and establish how much of the seabed is currently covered by these habitats. Areas where these habitats are predicted to occur were also surveyed.

A total of 225 sites were sampled around the islands of Jura and Islay, including the very tidal Sound of Islay, Sound of Jura, and just west of the Corryvreckan whirlpools off the northern tip of Jura. In addition, the survey team gathered video footage in Loch Sween MPA to monitor the condition of its protected features including burrowed mud, which supports the volcano worm (*Maxmuelleria lankesteri*). Favourable weather resulted in flat calm seas so the main challenge was keeping the camera steady just above the seabed in the strong tides around the islands.

Highlights of the survey included finding widespread areas of sponges and dead-men's fingers (*Alcyonium digitatum*) on silty bedrock/boulders (Figure 21) throughout the survey area. Similarly, patches of northern sea fans and football squirts (*Diazona violacea*) (Figure 22) were observed on the east and west of the Sound of Jura and to the west of northern Jura. Observations of the burrowed mud habitats with volcano worms in Loch Sween were also noteworthy, as was an abundance of seapens in the mud in Loch Craignish. Pilot whales were spotted whilst transiting off north-west Jura, and porpoises were seen in the Sound of Jura.

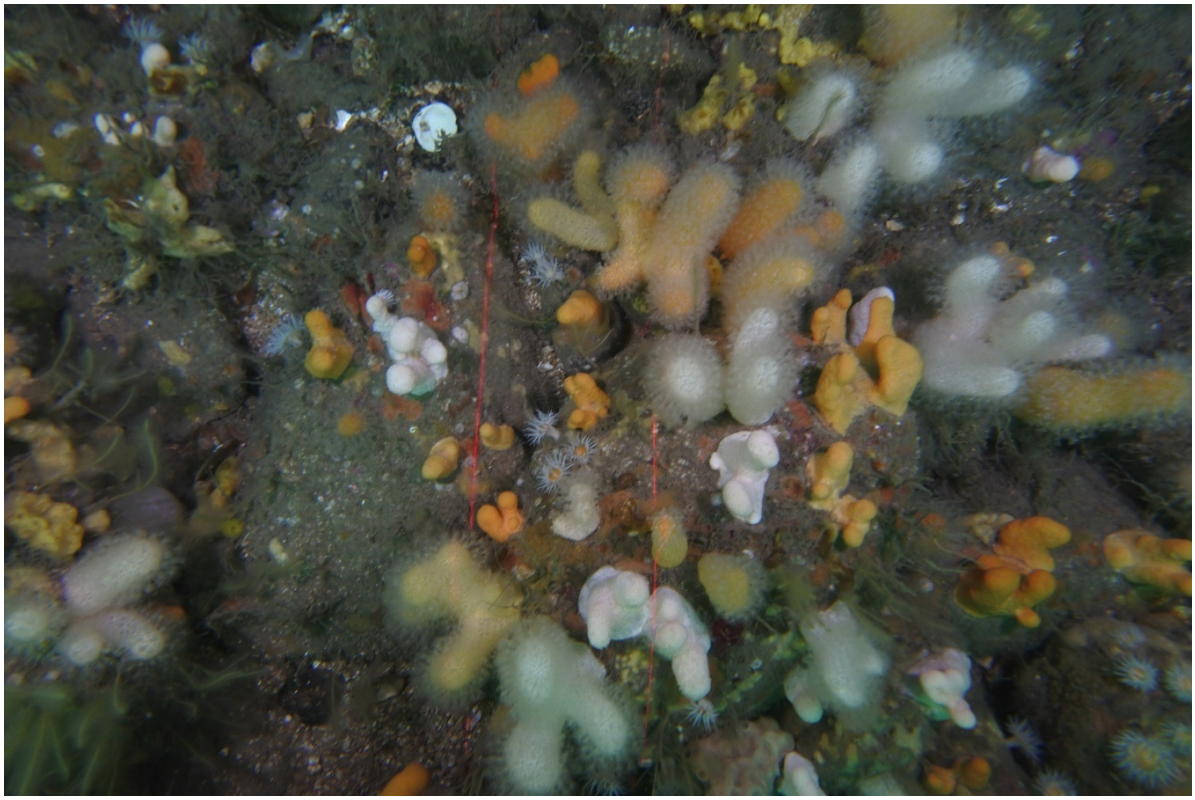

Figure 21: A patchwork of dead men's fingers, sponges, hydroids and fried egg anemones (*Actinothoe sphyrodeta*).

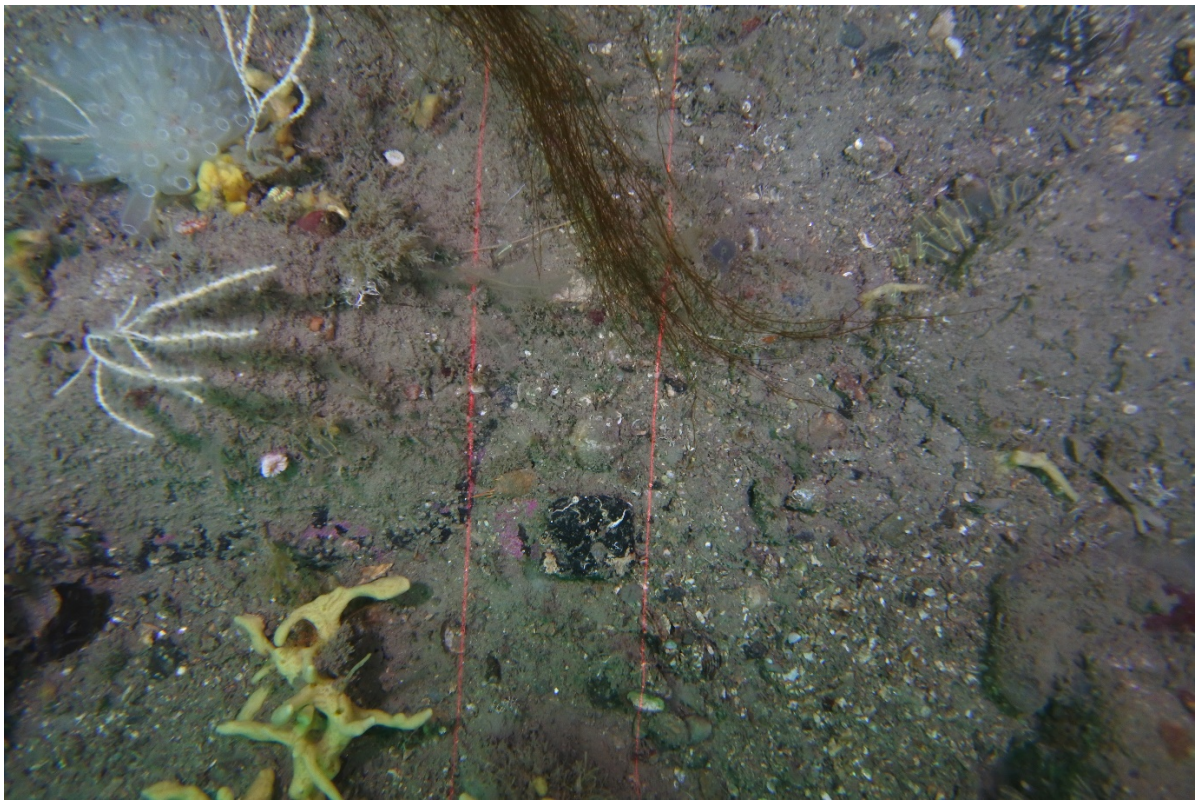

Figure 22: Northern sea fans, football sea squirt (top left), lightbulb sea squirts (upper right), hydroids, seaweed and yellow sponges on silty boulders.

4.3 Results from DDV surveys

After the surveys, the video footage and still images were analysed to identify the species and habitats present in each survey area and to record their abundance and map the detailed locations where they occur. Analysis of the video footage was awarded by competitive tender, so 2018 and 2019 surveys were analysed by different companies following standardised guidance.

All surveys were analysed using similar methods. The first step in the analysis was to scan through the still images and 'clean' the data, discarding poor quality images that could not be analysed further. Poor quality images were those where the image was too blurred (often as a result of the camera moving too quickly over the seabed), or too light or too dark for species and habitats to be identified, or where the seabed was temporarily out of camera view. Each video tow was then viewed at slow speed to enable identification of the seabed type (e.g. burrowed mud, rocky reef), the particular species present and a measure of their abundance using a semi-quantitative scale. The still images were used to help identify species seen on the videos. Biological communities observed were then classified according to the Habitat Classification for Britain and Ireland (JNCC, 2015[3]). Any changes in habitat were noted according to the time elapsed on the video, so that the tow could be split into different 'samples' representing different habitat types. Using the GPS location data obtained during the survey, the 'track' of the camera was then mapped, and the type of habitat for each track or part of the track was recorded separately.

For some survey locations, more detailed analysis was carried out on the still images, to count individuals or calculate the percentage cover of species for use in future monitoring studies of particular habitats within the MPAs (e.g. maerl beds, seagrass beds, flame shell beds).

The detail of the biotopes and PMFs recorded from the analysis of video and still images sampled in 2018 and 2019 are summarised below and published as part of the Scottish Marine and Freshwater Science report series[4].

---

[3] JNCC. (2015). *The Marine Habitat Classification for Britain and Ireland Version 15.03*. [Date accessed]. Available from: https://mhc.jncc.gov.uk/

[4] https://data.marine.gov.scot/group/scottish-marine-and-freshwater-science-reports

4.3.1 Inner Sound and Loch Alsh

The 2018 survey, which comprised of a total of 76 sampled stations, identified two different protected features (PFs) within the boundaries of either Loch Carron or Loch Alsh MPAs (those being burrowed mud and flame shell nests), along with the following PMFs, also observed within the MPA boundaries.

- Kelp and seaweed communities on sublittoral sediments.
- Northern feather star aggregations.

Additionally, the following PMFs were observed at locations outside the MPA boundaries.

- Maerl beds.
- Burrowed mud.
- Kelp and seaweed communities on sublittoral sediments.
- Kelp beds.

Figure 23 describes the distribution of the observed PMFs and protected features within the areas surveyed in 2018.

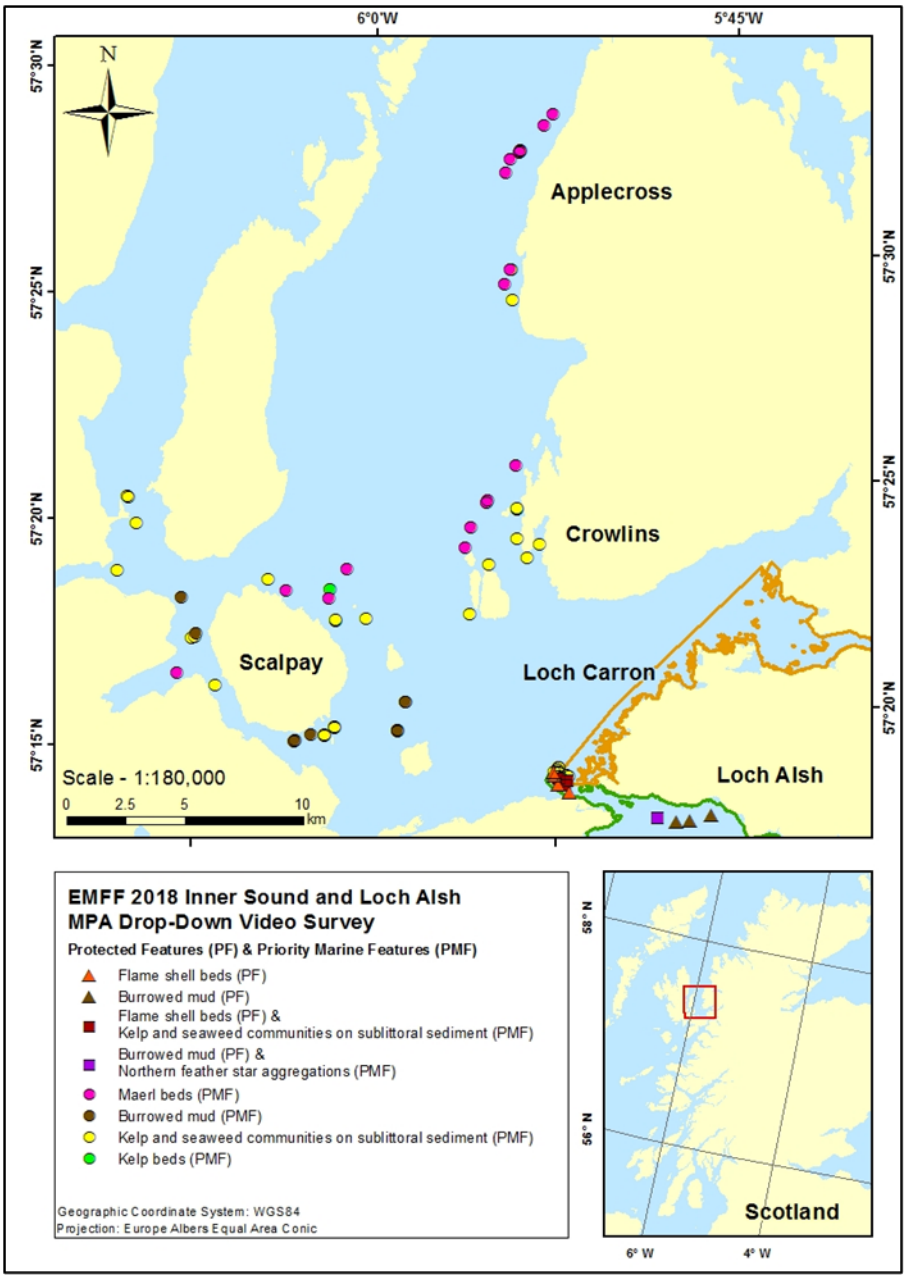

Figure 23: Protected features and PMFs recorded from Inner Sound and Loch Alsh in 2018. Contains open source OS data © Crown Copyright and database right (2020). Contains public sector information licensed under the Open Government Licence v3.0. MPA boundaries updated 20/05/2019.

In 2019, a total of 151 stations were sampled, to both supplement and extend the range of data collected in 2018. As in 2018, both protected features of the Lochs Duich, Long and Alsh MPA (burrowed mud and flame shell beds) were observed in 2019. More extensive surveying outside the MPA in 2019 produced observations of the following PMFs within the Inner sound.

- Flame shell beds.
- Kelp beds.

- Kelp and seaweed communities on sublittoral sediments.
- Maerl beds.
- Maerl or coarse shell gravel with burrowing sea cucumbers.
- Burrowed mud.
- Northern featherstar (*Leptometra celtica*).
- Sandeels.
- Common skate eggs.
- Atlantic herring eggs.

Figure 24 shows sample locations in Inner Sound where PMFs were observed in 2019.

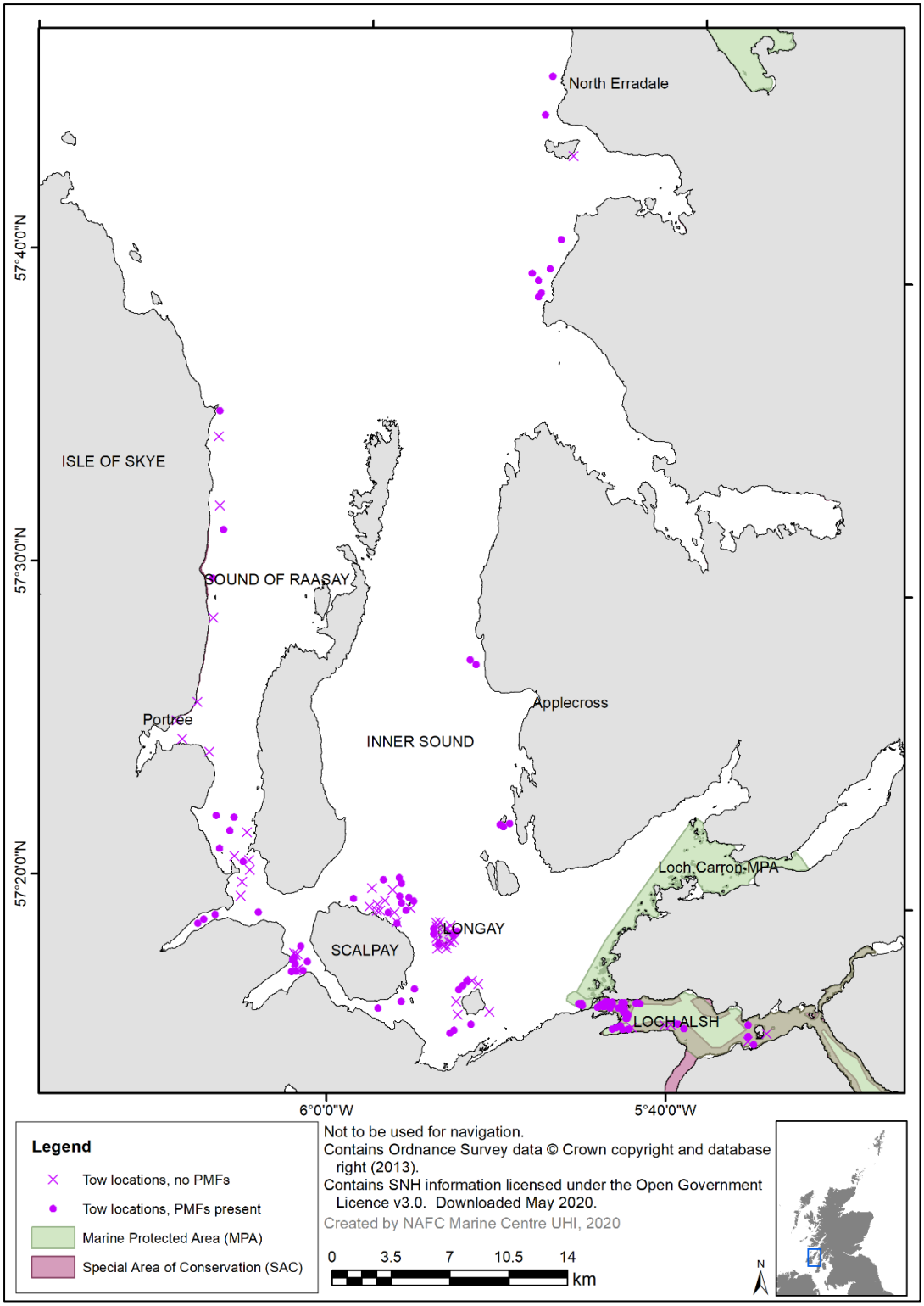

Figure 24: Locations of Priority Marine Features (PMFs) recorded from Inner Sound and Loch Alsh in 2019 (shown as filled circles). Sampled locations where no PMFs were observed shown as crosses.

4.3.2 Wester Ross

All 130 locations sampled as part of the 2018 Wester Ross survey were located within the Wester Ross MPA. Analysis of the available video and stills imagery identified the following protected features within the survey area.

- Maerl beds.
- Maerl beds associated with kelp and seaweed communities on sublittoral sediment.
- Kelp and seaweed communities on sublittoral sediments.
- Burrowed mud.

Kelp beds (PMF) were also observed within the survey area. Figure 25 describes the distribution of both the protected features and the kelp beds within the MPA, as observed in the 2018 survey.

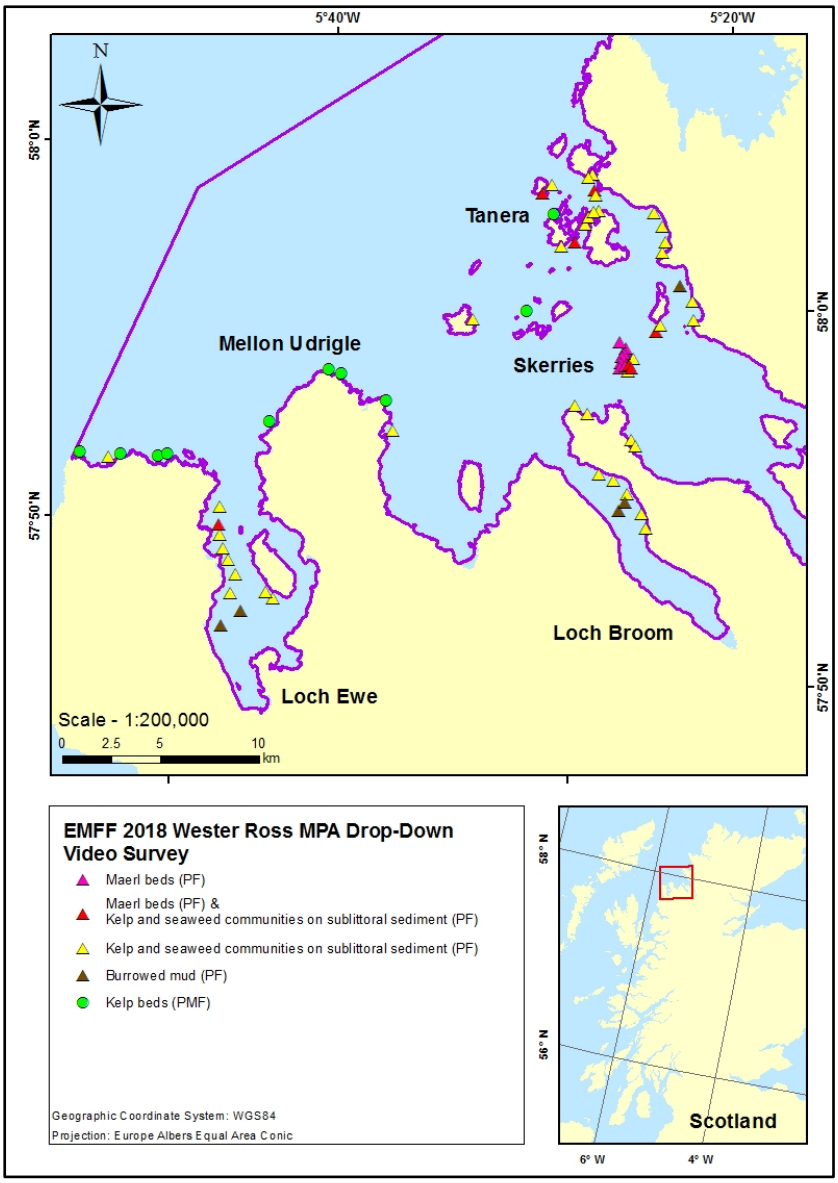

Figure 25: Protected features and PMFs recorded from Wester Ross MPA in 2018 Contains open source OS data © Crown Copyright and database right (2020). Contains public sector information licensed under the Open Government Licence v3.0. MPA boundaries updated 20/05/2019.

4.3.3 Small Isles

All 87 video tows completed during this 2018 survey were within the Small Isles MPA. The following protected features were observed in various locations throughout the survey.

- Northern sea fan and sponge communities.
- Northern sea fan and sponge communities associated with White cluster anemones (*Parazoanthus anguicomus*).
- Burrowed mud.

- Burrowed mud and Northern sea fan and sponge communities.

Additionally, a number of PMFs were also observed throughout the survey area, and are listed below for reference.

- Maerl beds.
- Kelp and seaweed communities on sublittoral sediments.
- Kelp beds.
- Shallow tide-swept coarse sands with burrowing bivalves.

The distribution of the above protected features and PMFs throughout the survey area is shown in Figure 26.

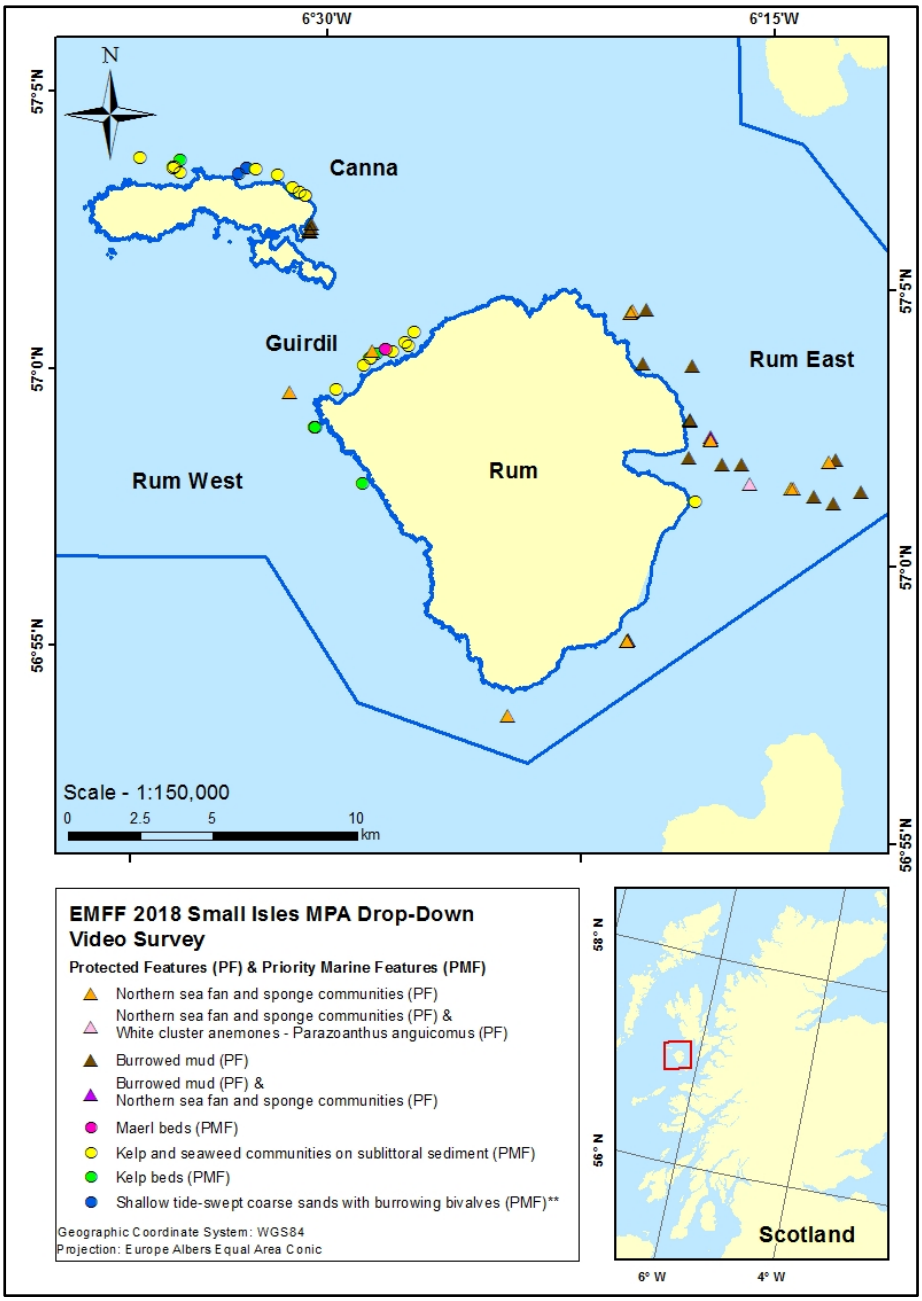

Figure 26: Protected features and PMFs recorded from Small Isles MPA in 2018. Contains open source OS data © Crown Copyright and database right (2020). Contains public sector information licensed under the Open Government Licence v3.0. MPA boundaries updated 20/05/2019.

4.3.4 South Arran

During the 2018 South Arran survey, a total of 134 stations were sampled, from both within and outside the boundaries of the MPA. Within the MPA boundaries, the following protected features were identified.

- Maerl beds.

- Maerl beds and Kelp and seaweed communities on sublittoral sediment.
- Maerl or coarse shell gravel with burrowing sea cucumbers.
- Kelp and seaweed communities on sublittoral sediment.
- Seagrass beds.

Outside of the MPA boundaries the following PMFs were also observed.

- Maerl beds.
- Burrowed mud.
- Kelp and seaweed communities on sublittoral sediments.

These features and their distribution within the survey area are shown in Figure 27.

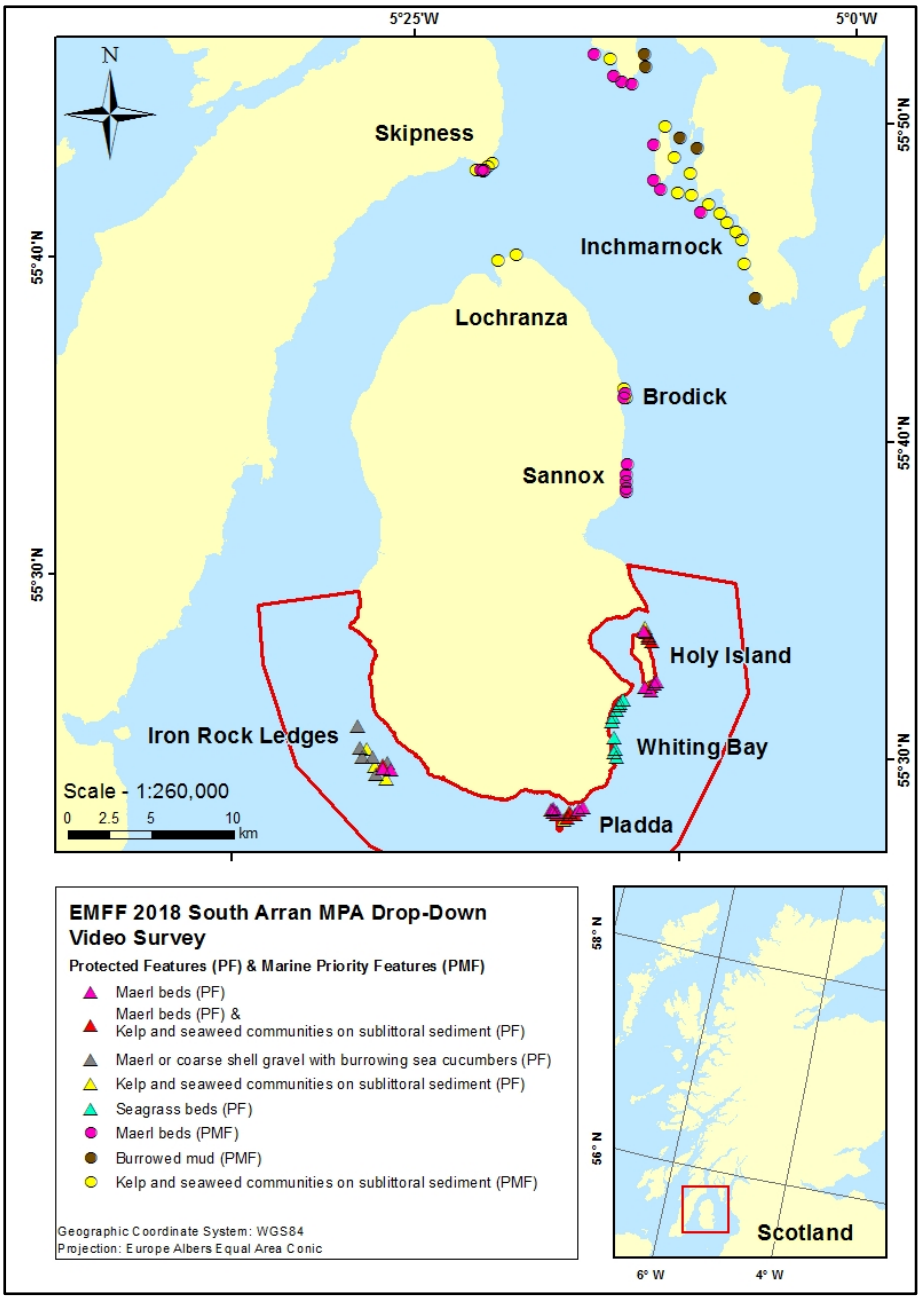

Figure 27: Protected features and PMFs recorded from South Arran and the Clyde Sea in 2018. Contains open source OS data © Crown Copyright and database right (2020). Contains public sector information licensed under the Open Government Licence v3.0. MPA boundaries updated 20/05/2019.

4.3.5 Orkney

Seven PMFs were identified from the 228 video tows carried out in Orkney in 2019, those being:

- Burrowed mud.
- Horse mussel beds.

- Maerl beds.
- Flame shell beds.
- Kelp and seaweed communities on sublittoral sediments.
- Kelp beds.
- Sandeels.

Figure 28 shows sample locations in Orkney where PMFs were observed in 2019.

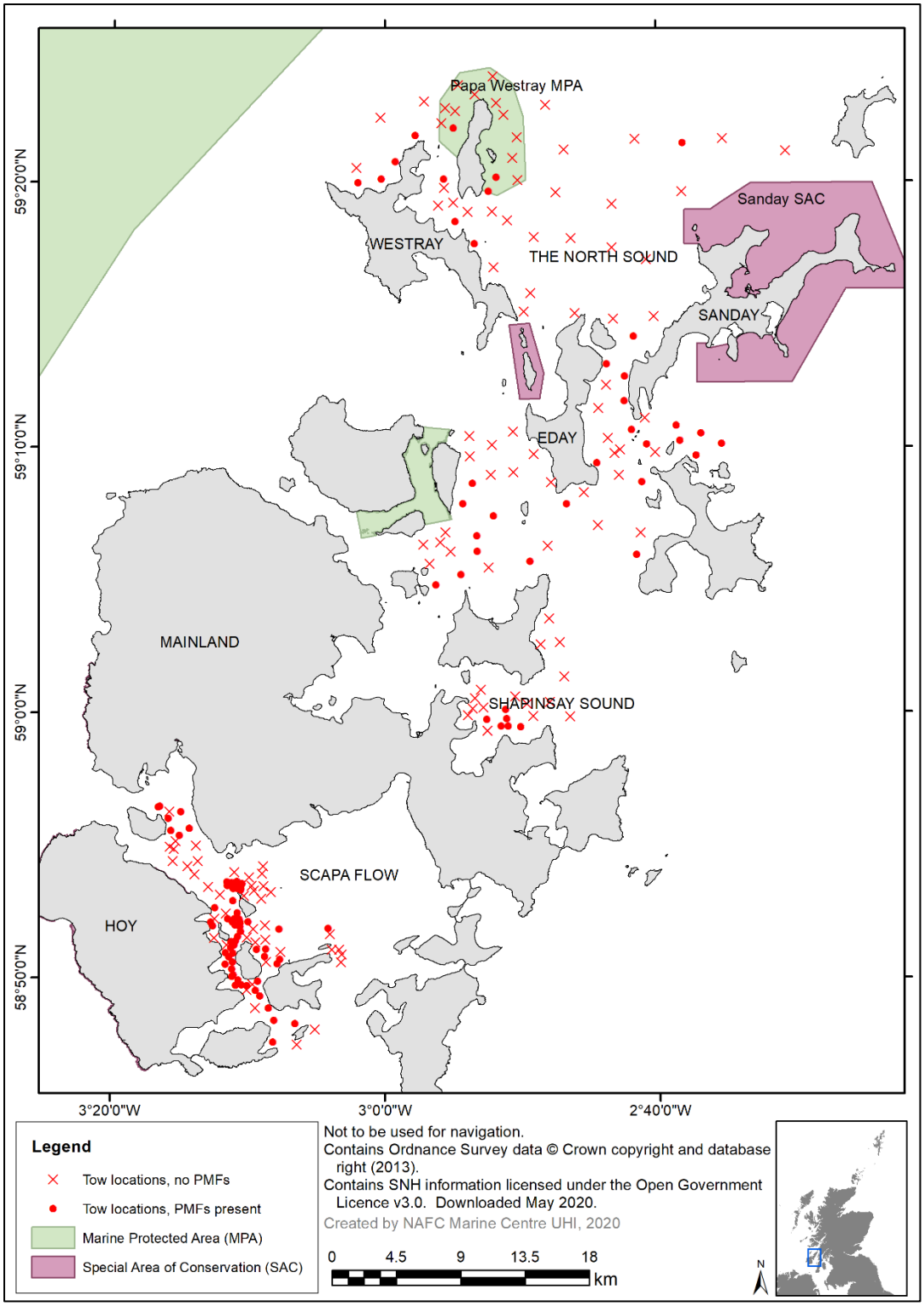

Figure 28: Locations of Priority Marine Features (PMFs) recorded from Orkney in 2019 (shown as filled circles). Sampled locations where no PMFs were observed shown as crosses.

4.3.6 Shetland

A total of 175 video tows were undertaken within the Shetland survey area in 2019. These included sites within the Fetlar to Haroldswick and Mousa to Boddam MPAs. The only protected feature observed (within the Fetlar to Haroldswick MPA) was maerl beds. The following PMFs were observed at various sites within the survey area.

- Kelp beds.
- Kelp and seaweed communities on sublittoral sediment.
- Horse mussel beds.
- Maerl beds.
- Maerl or coarse sand gravel with burrowing sea cucumbers.
- Anglerfish (monkfish)
- Common skate (eggs)

Figure 29 shows sample locations in Shetland where PMFs were observed in 2019.

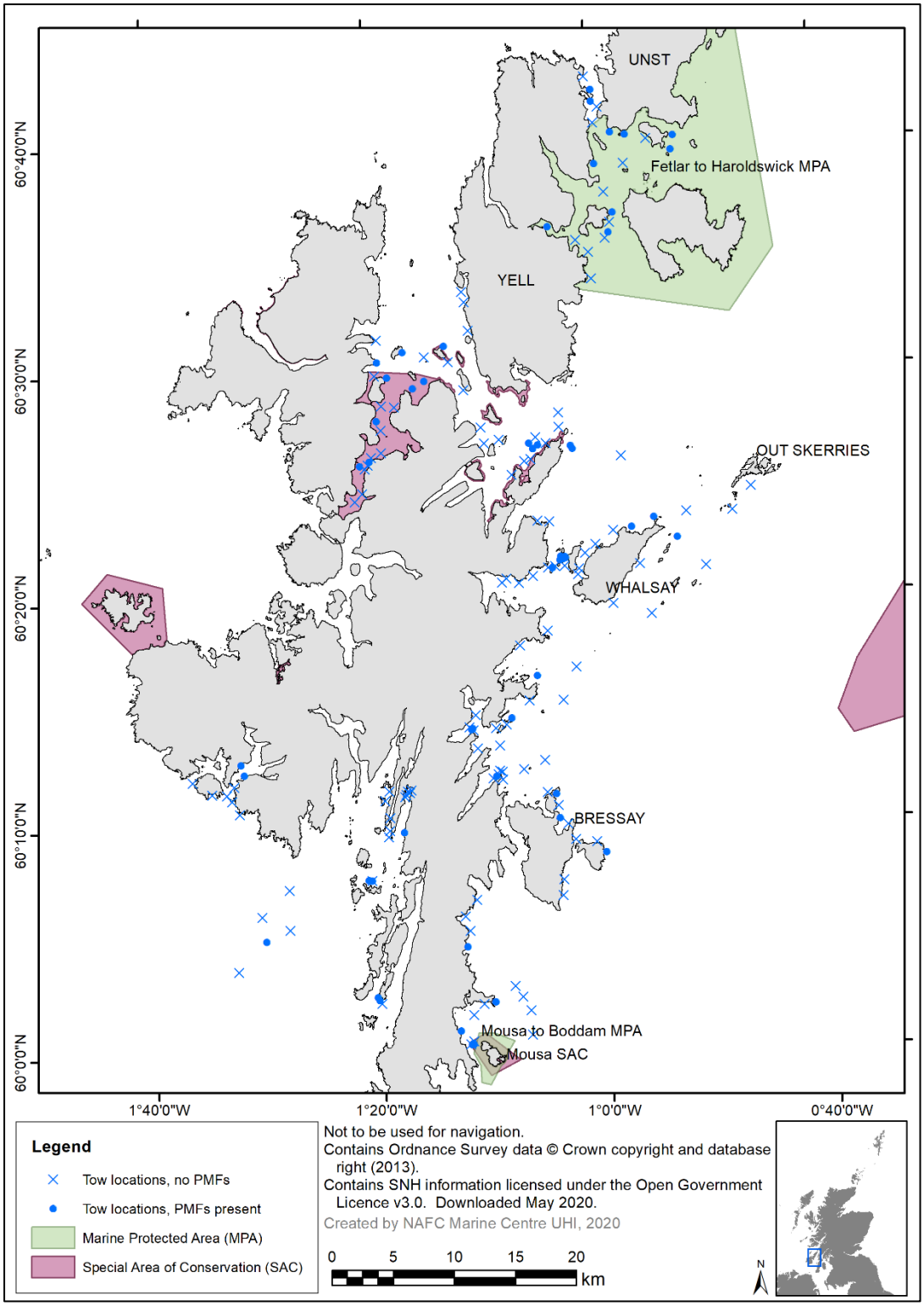

Figure 29: Locations of Priority Marine Features (PMFs) recorded from Shetland in 2019 (shown as filled circles). Sampled locations where no PMFs were observed shown as crosses.

4.3.7 Jura and Islay

In total, seven PMFs were recorded from survey locations within the 2019 Jura and Islay survey area, which encompassed both the Loch Sween and parts of the Loch Sunart to Sound of Jura MPAs. A total of 225 video drops were completed during the survey. The PMFs observed are listed below.

- Kelp beds.
- Kelp and seaweed communities on sublittoral sediment.
- Burrowed mud.
- Maerl beds.
- Maerl or coarse sand gravel with burrowing sea cucumbers.
- Northern sea fan and sponge communities.
- White cluster anemone.
- Northern featherstar (*Leptometra celtica*).
- Sandeels.
- Common skate eggs.

Figure 30 shows sample locations in Jura and Islay where PMFs were observed in 2019.

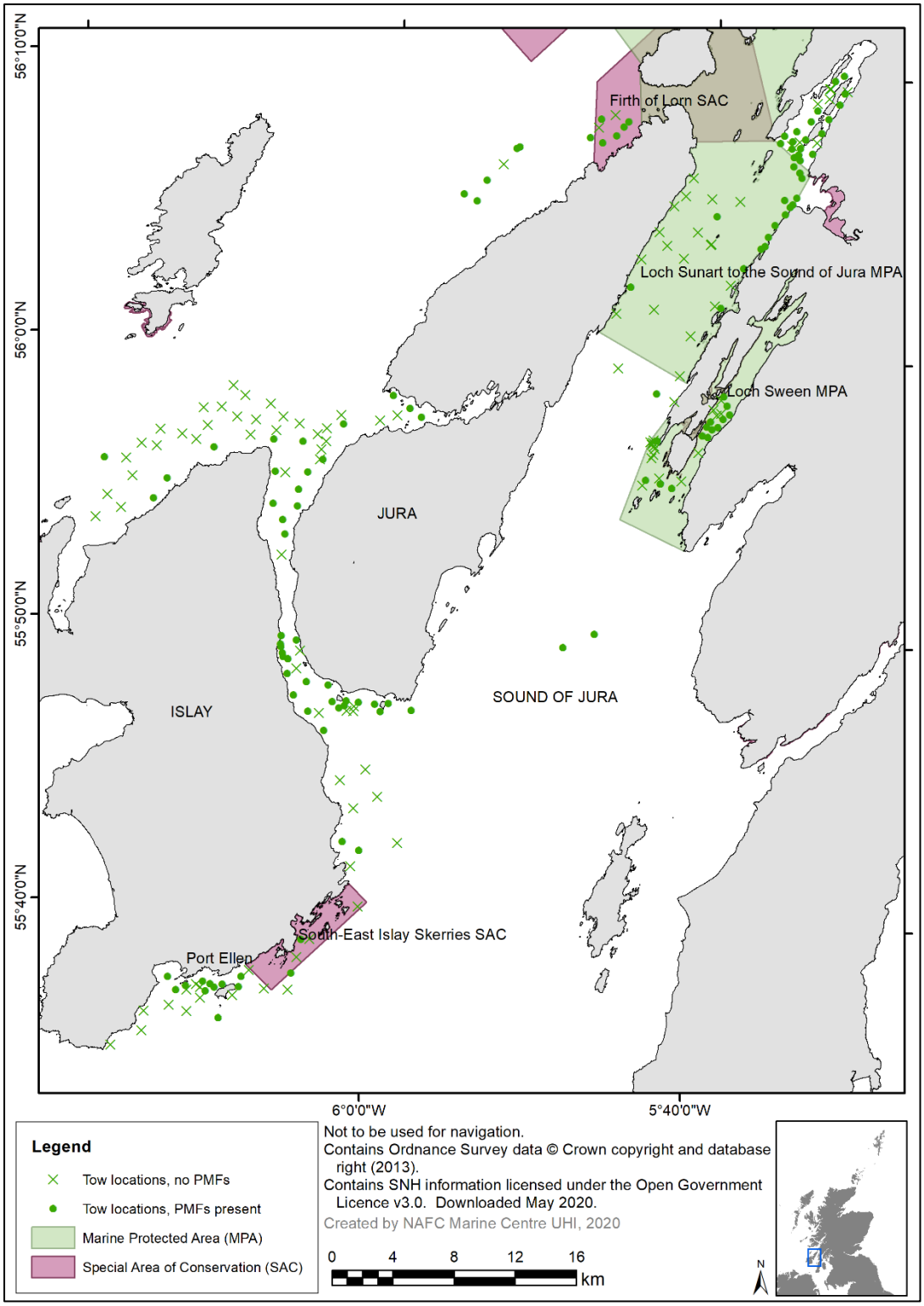

Figure 30: Locations of Priority Marine Features (PMFs) recorded from Sound of Jura and Islay in 2019 (shown as filled circles). Sampled locations where no PMFs were observed shown as crosses.

4.4 Data management and accessibility to survey products

The results of the DDV analyses have been incorporated into Marine Recorder, a benthic survey data management system used widely within the UK's statutory nature conservation bodies to store and query seabed habitat data across UK waters. NatureScot regularly extract records of from Marine Recorder and adds these to an existing collation termed the Geodatabase of Marine features in Scotland (GeMS)[5]. The information on distribution of PMFs, and the broader contextual information on survey effort from Marine Recorder are available via the Scottish Government's National Marine Plan interactive (NMPi)[6] portal.

Information on the distribution and extent of seabed habitats and species plays an important role in delivery of a range of nature conservation policies from the identification and management of MPAs through to informing licensing and planning decisions on development proposals such as ensuring that these do not have a significant impact on the national status of PMFs (as required by Scotland's National Marine Plan).

The conclusions of the detailed analyses of the footage collected in 2018 and 2019 will be used to inform future MPA status assessments (including the next MPA Report to Parliament[7] due in 2024) and wider state of the seas reporting (e.g. Scotland's Marine Assessment 2020).

Good data management is as important as initial data collection procedures and following clear data management guidelines throughout this project helped deliver on the '*collect once, use many times*' principle often promoted in relation to marine data due to the considerable expense entailed in its initial collection. If other stakeholders are unaware that survey work has been undertaken in a sea area and cannot find or access the data then the products will likely have less impact and there is a risk that the survey work will be duplicated in future.

To that end, the EMFF DDV survey methods followed the Marine Environmental Data and Information Network (MEDIN) data guidelines[8] and a single MEDIN discovery metadata record was produced for each survey. These metadata records

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5 https://gateway.snh.gov.uk/natural-spaces/dataset.jsp?dsid=GEMS-PMF
6 http://marine.gov.scot/maps/nmpi
7 https://www.gov.scot/publications/marine-protected-area-network-2018-report-scottish-parliament/
8 https://www.medin.org.uk/data-standards/medin-data-guidelines

have been published online (to the MEDIN portal and Open Data[9]) to enable others to 'discover' the data and the scope of the recent surveys. This step essentially documents that a survey has taken place within an area of interest. A metadata record does not provide others with the results of the surveys, but it does let others know the dataset exists, what it contains and how they can access it (see MEDIN portal[10]). A MEDIN guideline formatted record was also generated for each survey. This provides the results of the sampling (i.e. the species and habitats information) in a spreadsheet format. These records have been submitted to the DASSH UK Data Archive Centre (DAC) [11].

The video clips and still images from the 2018 surveys have been supplied to DASSH for use in a small MEDIN 'proof of concept' project that is exploring technological solutions to allow stakeholders to browse and download archived media files. In advance of a browsable system being available via the UK benthic data DAC, the 2018 and 2019 EMFF DDV files will also be made available on either Marine Scotland[12] or NatureScot[13] data portals.

5 Juvenile fish abundance surveys

5.1 Introduction and methods

'Nursery areas' are habitats where young fish can find food and shelter from predators while they are growing. Demersal fish such as cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) spend the early stages of their life cycle in the water column, but as the larvae grow they start to settle on the seabed where they develop into adults. This transition to seabed habitats is critical, and the growth and survival of juvenile fish (Figure 33) in their inshore nursery areas helps build and sustain healthy populations of fish.

As part of this project, scientists chartered local vessels to investigate the types of seabed habitats that are preferred by juvenile cod, haddock, whiting (collectively known as gadoids) and other demersal fish within several MPAs.

9 data.gov.uk
10 https://portal.medin.org.uk/portal/start.php
11 www.dassh.ac.uk/
12 Marine Scotland Data Publications
13 SNH - SNH Natural Spaces - GeMS - Scottish Priority Marine Features (PMF)

To carry out this research scientists from Marine Scotland Science set fish traps (Figure 31) and baited underwater video cameras over various habitat types within MPAs on the west coast of Scotland.

Fish traps: The research team would start each day by deploying up to 12 fish traps on the seabed (usually a single fleet of two traps per station), each time using a small drop-down camera to record the seabed habitats where the traps had been set. The traps were then left for a minimum of six hours each day before they were collected and emptied. Gadoid fish such as cod, haddock and whiting that were assumed to be age 0 were recorded and preserved, and all other fish were identified and measured. Any invertebrates caught in the traps were also counted. Marine Scotland Science, in conjunction with the University of Glasgow, will use the otoliths (ear bones) from the sampled juvenile fish to determine daily age by counting the growth increments. These data will be used to infer growth rates and survivability of juvenile fish caught over the different habitat types sampled within the MPA.

Figure 31: Fish traps being offloaded from vessel.

Baited underwater cameras: Stereo Baited Remote Underwater Video Camera (SBRUV) frames (Figure 32) were used to measure fish abundance and length frequency over different habitat types. Bait was attached and the frames were

lowered to the seabed, where high-definition video was recorded for about 1.5 hours per site.

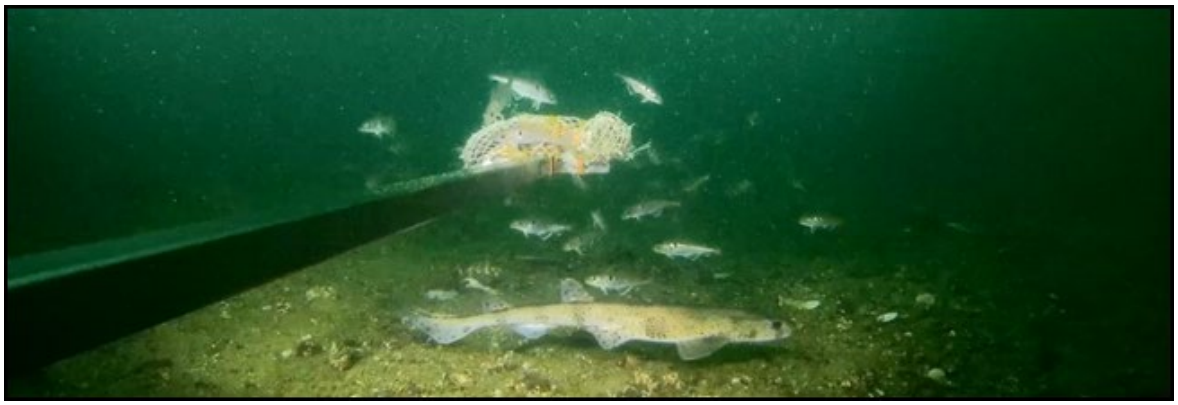

Figure 32: Snapshot of footage from baited camera.

Figure 33: Juvenile Pollack (*Pollachius pollachius*) swimming over maerl. Graham Saunders.

5.2 Surveys

5.2.1 2017

Two MPAs were surveyed in 2017 at two different times (summer and autumn). These surveys concentrated on testing the newly constructed fish traps and baited frames within the Small Isles and South Arran MPAs. The methodology for handling

and working with the fish traps and SBRUV frames was refined at sea and standardised operating protocols were produced.

5.2.1.1 Small Isles July 2017

Gadoids were either absent or caught in low quantities (Figure 34) with juvenile whiting seen only twice during the survey - once over sand and again in shallower sandy mud, to the east of Canna. The SBRUV frames were deployed 18 times, capturing, in total, 29 hours and 29 minutes worth of footage.

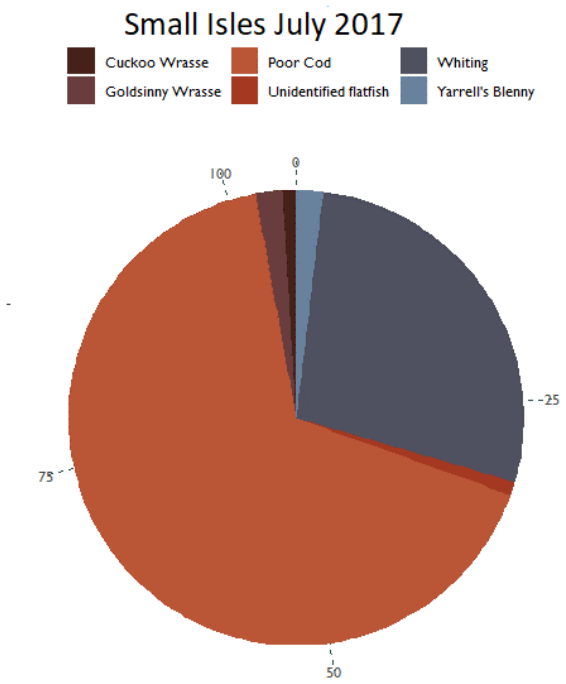

Figure 34: Small Isles juvenile fish catch, July 2017.

5.2.1.2 South Arran August 2017

Gadoid catch rates were mixed (Figure 35), with poor cod (*Trisopterus minutus*) the most abundant of any species observed during the survey; however, they were not present in traps placed in the centre of the MPA. Haddock were virtually absent from traps during the first two days, appearing in relatively moderate numbers on the third deployment (over sand), to the north of Lamlash Bay, and in lesser quantities to the south east of Arran, at depths > 20 m. Juvenile cod were rarely found in the traps, although tended to be caught more when traps were positioned in shallower waters. Whiting were the dominant species over mud with highest densities at depths > 20 m, although the occasional juvenile was observed over harder ground. Each SBRUV frame was deployed ten times in depths ranging from 5.1 to 39.8 m. A combined

total of 31 hours 57 minutes worth of footage was captured. Preliminary analysis showed haddock were the most abundant gadoid, dominating most of the video taken on the east side of Arran.

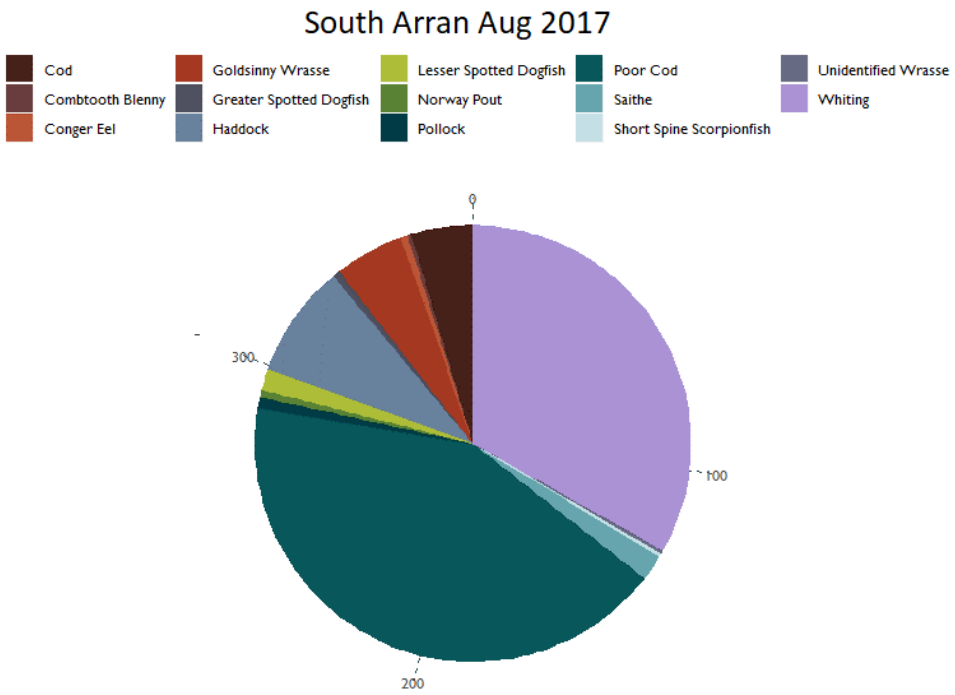

Figure 35: South Arran juvenile fish catch, August 2017.

5.2.1.3 Small Isles October 2017

Gadoid catches were dominated by whiting and poor cod. Whiting were the most abundant of any species observed during the survey (Figure 36), occurring in high numbers along the northern coasts of both islands, although none were present in traps set below the western extent of Rum. Cod were only captured on the first day of the survey, in the Sound of Canna, off Kilmory Bay. Similarly, saithe (*Pollachius virens*) were rarely encountered, with the exception of the final day of the survey, close to the sandy bay at Camas na Pliosgaig, although numbers were still relatively low at this location. No haddock were caught in the traps. In total the SBRUV frames captured 31 hours and 26 minutes' worth of footage. Deployments on harder ground were characterised by saithe, pollock (*Pollachius pollachius*), wrasse, and the twin spot goby (*Gobiusculus flavescens*). Deeper stations positioned near or within less complex habitats were characterised by shoals of whiting and poor cod.

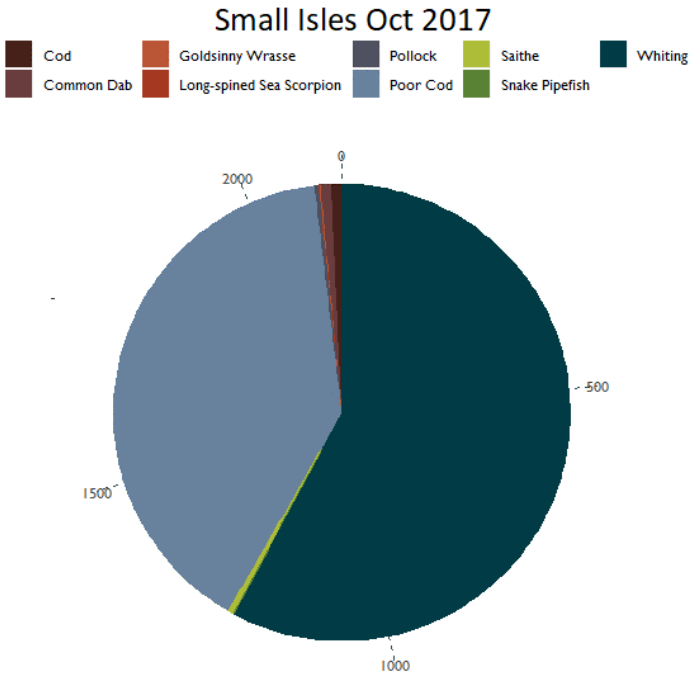

Figure 36: Small Isles juvenile fish catch, October 2017.

5.2.1.4 South Arran October/November 2017

Catches of commercial gadoids were dominated by whiting, however poor cod were present throughout the survey area in numbers that were an order of magnitude greater than any other species. Whiting were found throughout the MPA (Figure 37), except for close to the westerly extent of the protected area, off Drumadoon Point. Cod were most abundant on the first day of the survey, in traps positioned at depths around 27 m, and were retained at higher quantities throughout the survey compared to earlier in the year. Recorded length frequencies suggested the captured fish included young-of-the-year (i.e. age 0; those born within the past year). Thirty hours and 17 minutes worth of footage was captured by the SBRUV systems and showed decreased occurrence of fish species around the majority of deployment positions. Haddock occasionally appeared, in particular to the south of Arran and within the no-take zone, north of Lamlash Bay.

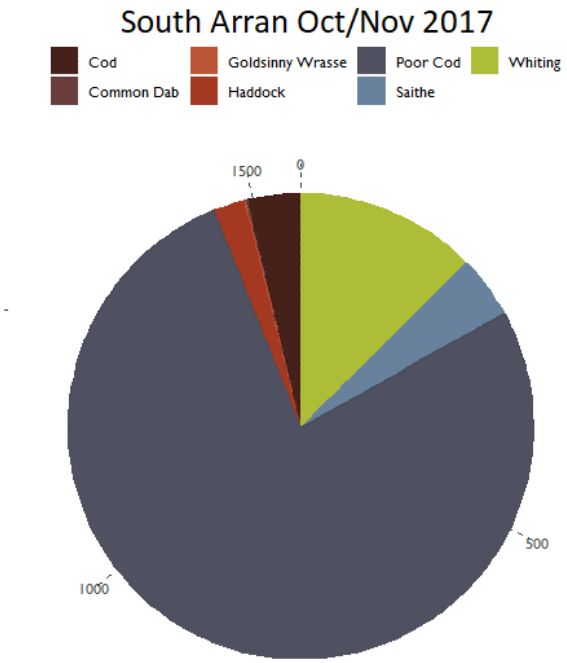

Figure 37: South Arran juvenile fish catch, October-November 2017.

5.2.2 2018

Four surveys took place in 2018, building on the work carried out in 2017, - two around the South Arran MPA and two in the Wester Ross MPA (Loch Ewe). The fish samples and video footage from these surveys are, at the time of writing, under analysis.

5.2.2.1 South Arran

Sites surveyed around the South Arran MPA are shown in the map below (Figure 38). The two surveys took place from 15-20 July, and 02-07 September 2018 on board RV *Actinia*. Fish traps were set and recovered each day, sampling a total of 30 locations.

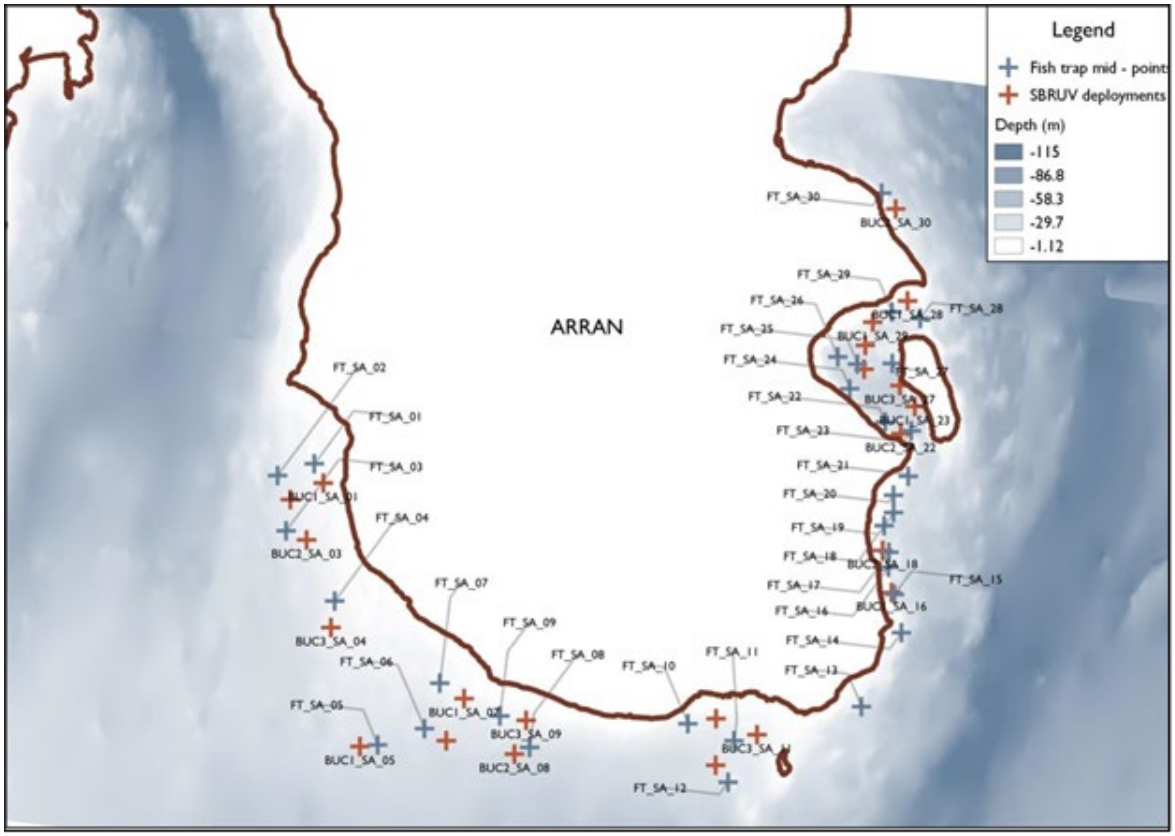

Figure 38: Map showing positions of both fish traps and baited underwater cameras around South Arran, 2018. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right (2020). All rights reserved. Ordnance Survey Licence number 100024655

Trap samples from the earlier survey contained mostly whiting and poor cod (Figure 39), although numbers of cod were higher compared to later in the year. Haddock were rarely found, with the exception of 1-2 individuals captured around whiting bay, to the south of Lamlash. Whiting and cod were caught in their highest densities along most of the eastern side of the MPA, in particular around the no take zone within Lamlash Bay. Catch rates were generally low south of the island. The SBRUV frames recorded a total of 31 hours and 16 minutes' worth of footage during the trip.

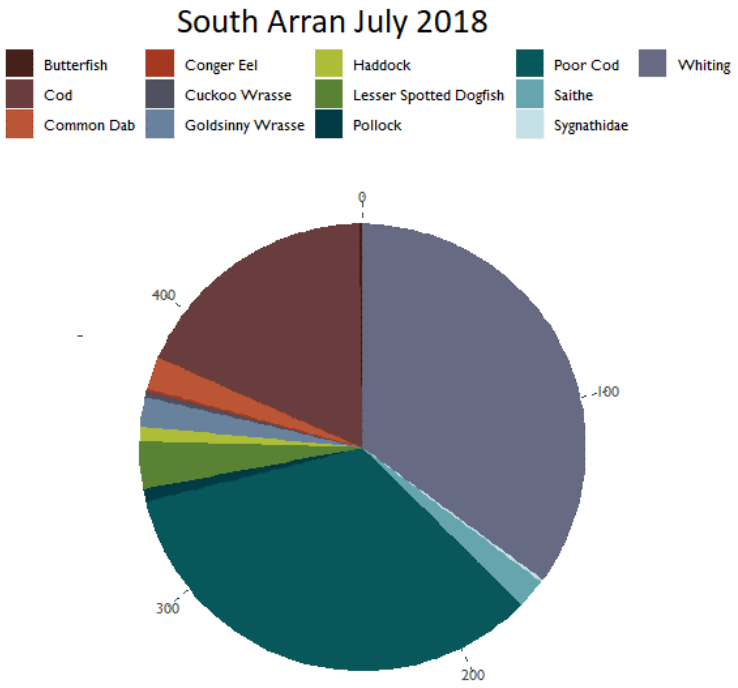

Figure 39: South Arran juvenile fish catch, July 2018.

Later on in the year, absolute numbers of fish retained were similar; however, whiting now dominated in terms of both frequency and percentage composition of species within the traps (Figure 40). In contrast to the earlier survey, cod were absent from both the south east of the MPA and within Lamlash Bay. The few individuals that were caught mostly appeared in traps set along Whiting Bay. Poor cod made up a smaller proportion of the total catch and appeared to be slightly more common further around the southern coast of the island, whereas densities were much reduced around Whiting Bay. Haddock were again largely absent from the traps, although were slightly more common within Lamlash Bay in the second survey. In total, 36 hours and 29 minutes' worth of video was captured by the stereo camera systems.

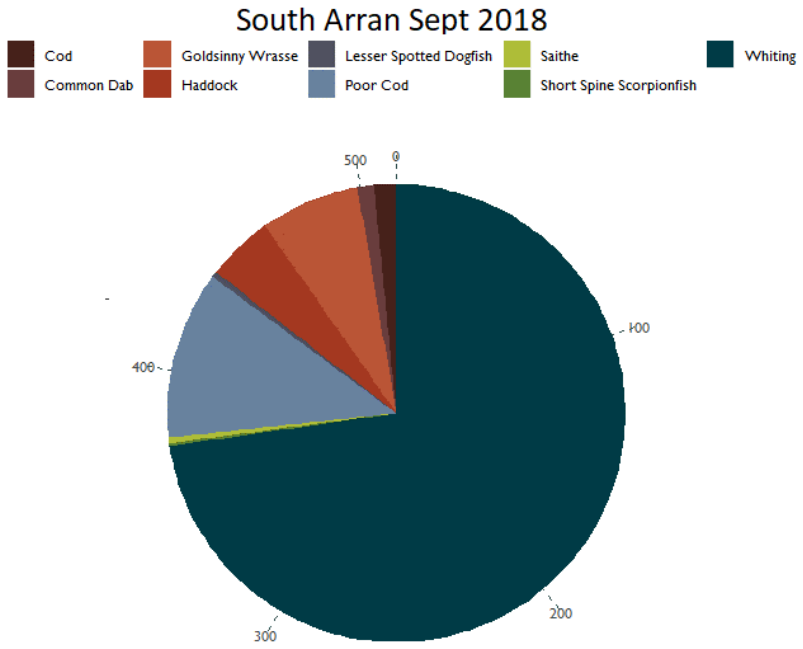

Figure 40: South Arran juvenile fish catch, September 2018.

5.2.2.2 Loch Ewe, Wester Ross

Loch Ewe was surveyed for juvenile fish twice during 2018 (22-27 July with a repeat visit between 17-23 September). Figure 41 shows the stations surveyed during both trips. Traps (Figure 42) and baited cameras (Figure 43) were deployed from MV *Glen Tarff,* working out of Aultbea. The fish traps were set and recovered each day (a total of 28 sites) and the baited underwater cameras recorded a total of 60 hours 36 minutes of video across 27 sites (approximately 1.5- 2.5hours per site).

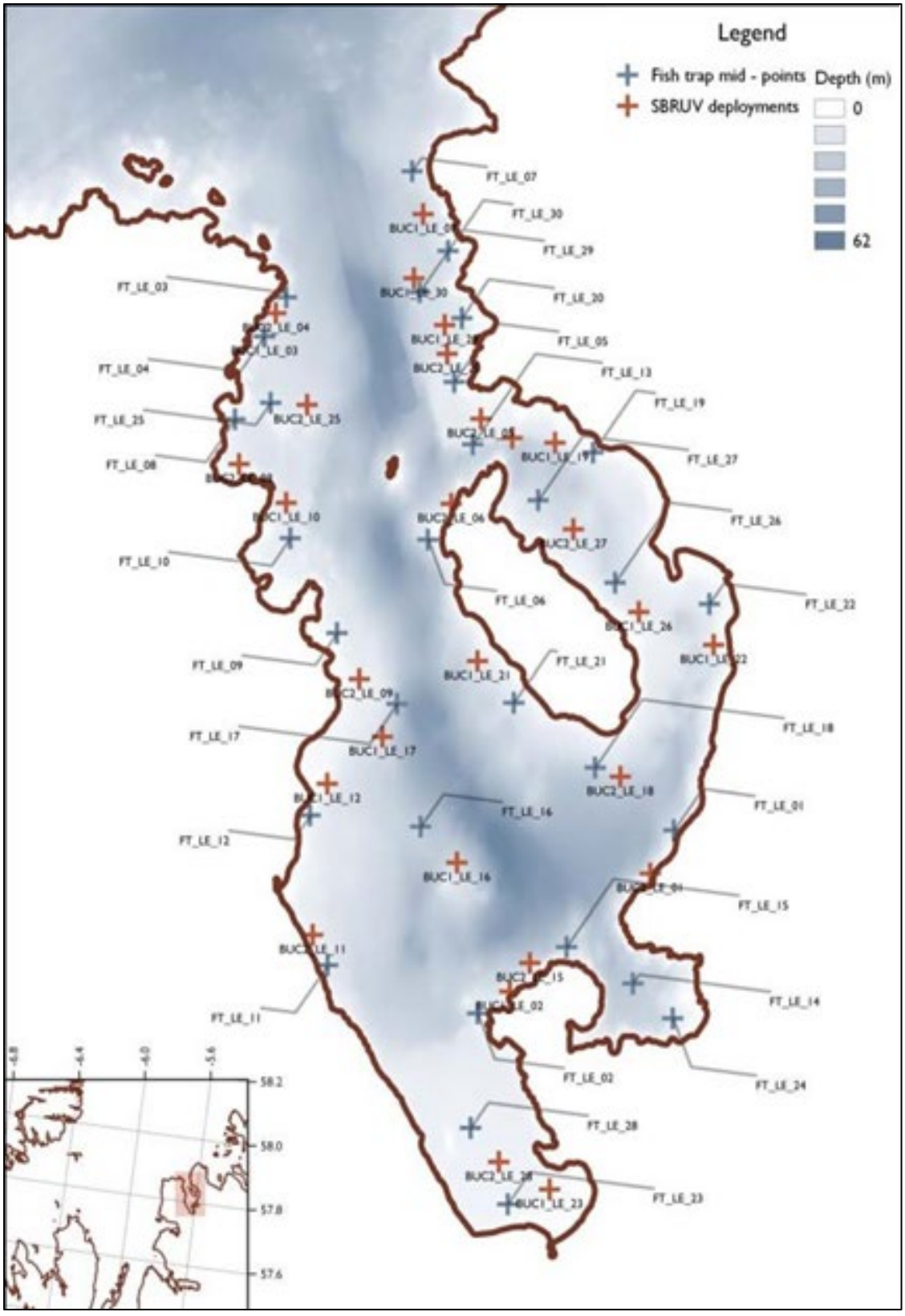

Figure 41: Map showing positions of fish traps and baited underwater camera sampling locations around Loch Ewe, Wester Ross, 2018. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right (2020). All rights reserved. Ordnance Survey Licence number 100024655

Figure 42: Fish traps ready to deploy.

Figure 43: Stereo Baited Remote Underwater Video Camera (SBRUV) frame.

5.2.3 2019

A local vessel (MFV *Walrus*) was chartered to carry-out two juvenile fish surveys in Loch Ewe, within the Wester Ross MPA (during July and September 2019).

Baited fish traps were set on the seabed at 30 locations within Loch Ewe (Figure 44). All juvenile fish found in the traps were frozen and taken back to the laboratory to be processed at a later date. SBRUVs were deployed in 30 different locations within the loch, and a minimum of 1.5 hours of footage was recorded per station.

Figure 44: Baited fish trap and SBRUV locations within Loch Ewe, 2019. Reproduced by permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right (2020). All rights reserved. Ordnance Survey Licence number 100024655

In total 12 species of fish were recorded during both surveys, and whiting and poor cod were by far the most numerous (Table 2). In July 2019, 236 fish were caught in the baited traps over the course of a week (Figure 45), about half of which were whiting (56%), and a quarter were poor cod (24%).

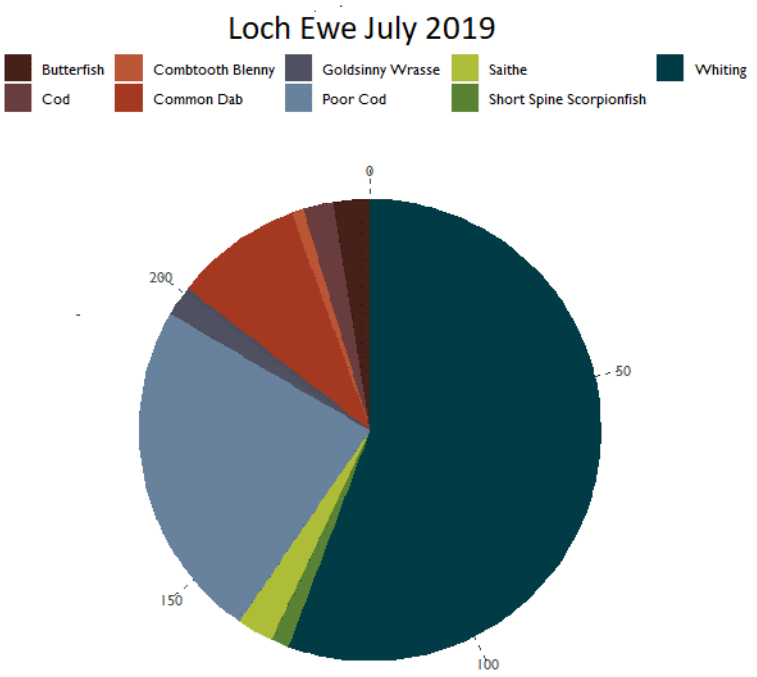

Figure 45: Loch Ewe juvenile fish catch, July 2019.

During the second survey in September a total of 1239 individual fish were caught. This surge in numbers was due to a 20-fold increase in poor cod, which accounted for 87% of the catch (Figure 46). Saithe and Atlantic cod made up less than 3% of the fish caught during both surveys, and no juvenile haddock were found in the traps. Other juvenile fishes captured in the traps in small numbers (<3% catch) included pollack, bull-rout (sea scorpion), butterfish, blennies, common dab, turbot, a freshwater eel, and goldsinny wrasse. Two dogfish were also recorded.

Table 2

Total fish caught in baited traps in Loch Ewe during the 2019 surveys.

Species	Abundance July	Abundance September
Poor cod	56	1077
Whiting	131	118
Saithe	6	27
Common dab	21	7
Sea scorpion	3	5
Atlantic cod	5	2
Turbot	0	1
Pollack	0	1
Goldsinny wrasse	5	1
Freshwater eel	1	0
Combtooth blennies	2	0
Butterfish	6	0
Total	236	1239

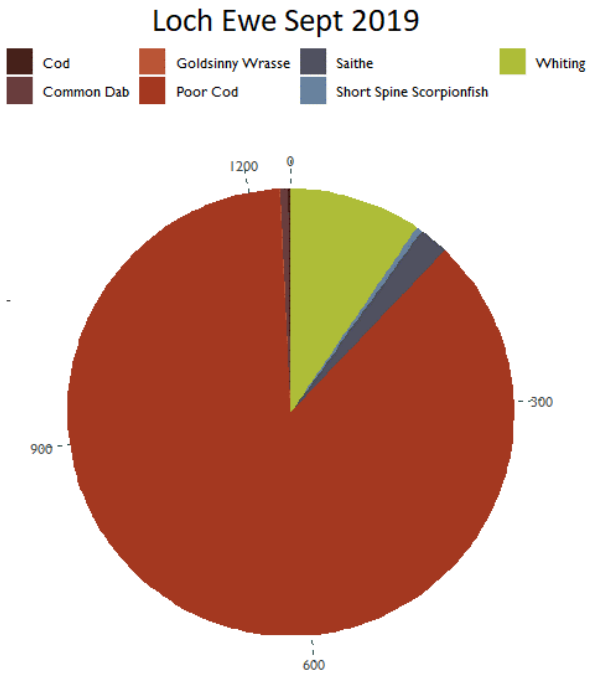

Figure 46: Loch Ewe juvenile fish catch, September 2019.

The SBRUVs filmed a total of 54 hours 55 minutes and 50 hours 28 minutes of high-definition footage in July and September, respectively. The team were pleased to see two flapper skate visiting the baited cameras (Figure 47). These skate were once common on the west coast of Scotland but have declined dramatically during the second half of the 20th century, and the species is now very rare or locally extinct across most of its natural range. The underwater video footage is currently being analysed.

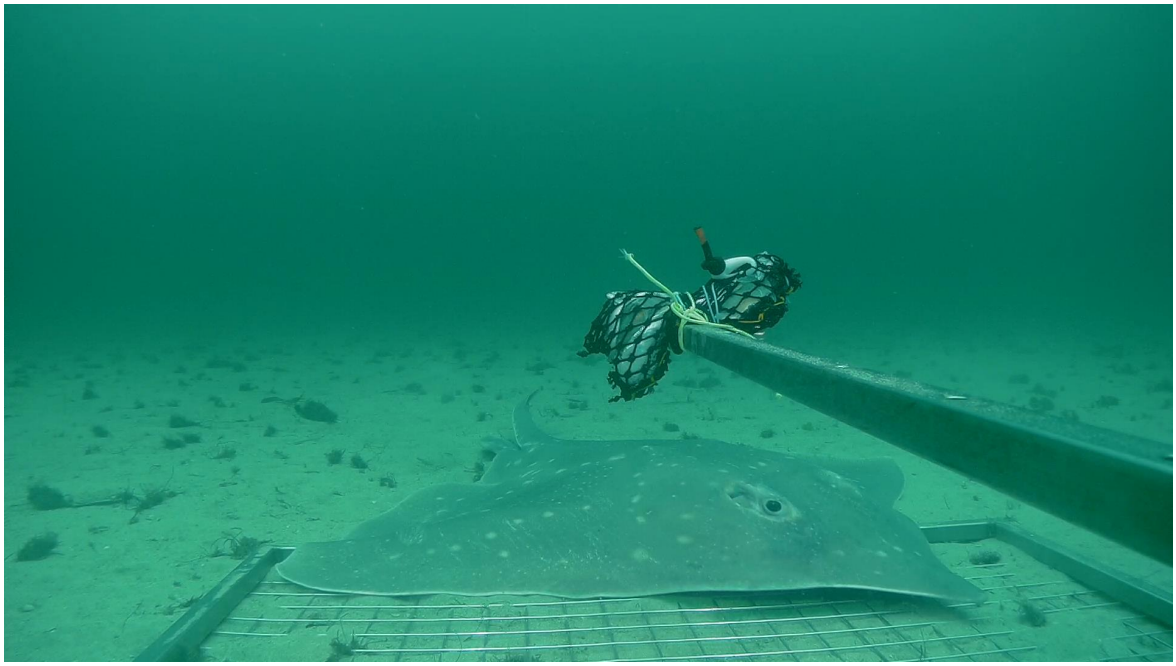

Figure 47: Flapper skate (*Dipturus intermedius*) visiting baited underwater video camera in Loch Ewe.

6 Movement ecology of the flapper skate

The flapper skate research supported by the EMFF project is led by James Thorburn, a post-doctoral fellow at the Scottish Oceans Institute, University of St Andrews in collaboration with NatureScot and the Scottish Government.

Flapper skate (*Dipturus intermedius*, a sub species of common skate) were once readily found around the coast of Britain but their population has reduced greatly, to such an extent that they were the first marine species to be declared locally extinct in some parts of the UK (Brander 1981)[14]. However, the area from Loch Sunart to the Sound of Jura is still home to a good number of flapper skate, and was designated as an MPA in 2014 for their protection. This study tracks skate movement (with acoustic tags) to learn how they use different habitats within the MPA, and to discern whether the area is an important skate breeding ground. Flapper skate are the largest species of skate in the world. They grow and mature very slowly and can measure over three metres long and weigh upwards of 100 kg. The long time it takes for the skate to reach maturity makes this species very vulnerable, and commercial fishing and landing of flapper skate was made illegal in Scotland in 2009 to protect them from further decline.

6.1 Seagoing skate tagging surveys

In order to monitor the long-term movement of skate in the MPA (see Figure 48), individuals are tagged with acoustic transmitters that transmit a unique identification code at a set time interval (approximately three minutes) for up to ten years. The data is then logged by acoustic receivers that have been moored on the seabed. The tagged skate need to be within approximately 500 m of these receivers for data to be recorded. The receivers are then recovered for servicing and to collect the data. Acoustic receiver units were deployed in ten locations within the MPA at depths ranging from 80 to 200 m. This acoustic data will allow scientists to track the behaviour of skate in relation to different habitats within the MPA over a long time period, helping identify changes in movement as skate grow. The study site, location of acoustic receivers and locations of previous tagging events are also shown in Figure 48.

[14] Brander, K. Disappearance of common skate *Raia batis* from Irish Sea. *Nature* **290**, 48-49 (1981). https://doi.org/10.1038/290048a0

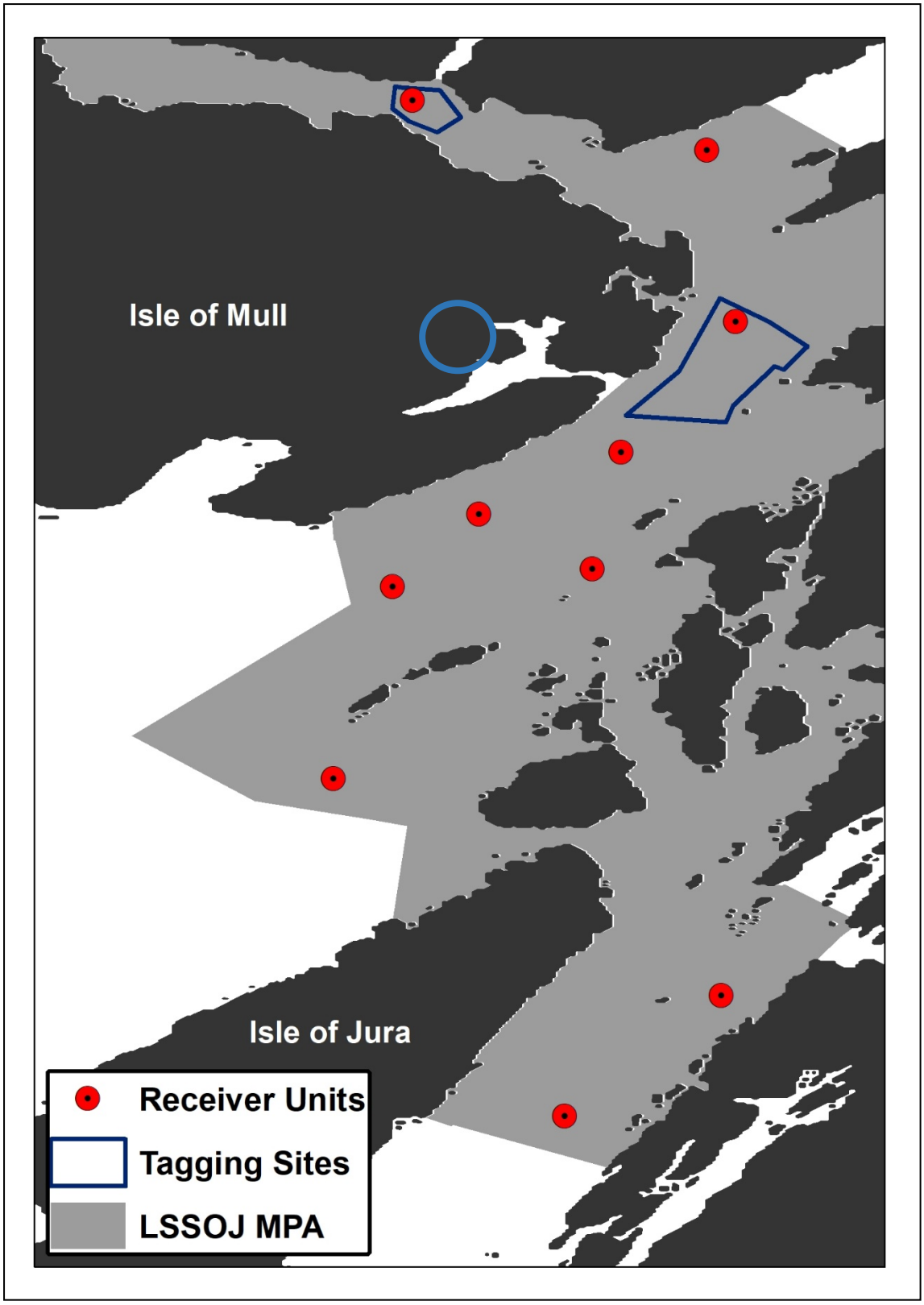

Figure 48: Map of the study site. Grey shaded area shows the current extent of the Loch Sunart to the Sound of Jura MPA, the red points show the location and the area covered by acoustic receivers and the blue polygons show where the tagging has already occurred. Chart image courtesy James Thorburn.

This setup of acoustic transmitters and receivers is capable of gathering data on skate locations within the MPA for up to ten years and will contribute to long-term monitoring of the species. This work is happening alongside other research that uses photo-identification to document the distribution and abundance of individual flapper skate around the Scottish coastline (e.g. Skatespotter[15]).

6.1.1 2018 Field work - Loch Sunart to Sound of Jura MPA

In July 2018, a charter vessel (*MV. Bluefin*) helped scientists catch and tag ten skate within the MPA using single lines with barbless hooks. Once on deck the skate were measured and had their weight recorded (Figure 49). The heaviest skate was an impressive 95 kg and the smallest was about 31 kg. Tags were then fitted to each animal, after which they were released.

Figure 49: Skate being measured ©James Thorburn.

Most of the tagged skate were males, however, the ratio of males and females in the area changes over the course of a year due to events in their life cycle, such as

[15] https://skatespotter.sams.ac.uk/

mating and laying eggs. In an effort to tag more females, further tagging trips were undertaken in 2019.

The acoustic receivers (n=10, Figure 50) were successfully deployed between 09 and 11 July 2018 from survey vessel (*MV. Shjandur*). The moorings are not visible from the surface, but are secured to the sea floor and float approximately 10 m off the seabed. They can be recovered based on an acoustic release system that allows them to float to the surface. All the equipment, including ballast, is recovered, and the data retrieved for analysis. This takes place approximately every six months.

Figure 50: Downloading data from the acoustic receiver. Photo credit: Andy Holbrow, Atlantic Diving Services Ltd.

6.1.2 2019 Field work– Loch Sunart to Sound of Jura MPA

A total of 22 skate were tagged between April and November 2019, this comprised of 13 females and nine males ranging from 20 to 95 kg. Skate were tagged in the Firth of Lorn and the Sound of Mull from the angling charter vessel (*MV. Bluefin*).
The acoustic receivers were retrieved and redeployed twice during 2019 (in February and September) in order to download data. In order to retrieve the units from the seabed the charter vessels (*Shjandur* and *Lady Nicola*) remotely triggered the acoustic receivers to float to the surface. Once the units surfaced, they were hauled aboard the vessel and serviced (the battery changed and data downloaded) before redeployment.

7 Conclusions: the engagement process and scientific considerations

This was an ambitious and complex project, ranging over three distinct programmes of work, that aimed to deliver multiple aims. The size and draught of vessels (as well as their speed etc.) has bearing on operational range and depths (and the accessibility of some nearshore/shallow habitats) and it has been the case that fishing vessels are not often used in survey activity. The project demonstrated that environmental monitoring work, including drop-down video sampling, can be undertaken from fishing vessels.

The EMFF-funding opportunity led to the successful completion of eight DDV surveys - collecting a significant quantity of new information and filling in gaps in existing sampling coverage that would not otherwise have happened. In addition, the funding facilitated survey elements of a number of related projects, seeking to expand our knowledge of biodiversity within MPAs.

The project provided an opportunity for members of the wider fishing industry to engage in nature conservation and to assist in evidence gathering within MPAs. It was hoped that the knowledge of fishers in respect of their local areas would also provide benefits to the project. Despite the stakeholder engagement work undertaken throughout the project, there were low levels of interest from fishing vessels. Complexities of the public procurement process was thought to play a role in this, although assistance was offered to interested parties. However, there are likely to have been other factors including the timing (conflicting economic interests if during good fishing periods) and the duration of the trips (they may have been too short to be viable initially so were extended from 5 to 10-day opportunities in year two). Despite fully competitive and open tender processes the uptake and capacity building aspirations of the work were, therefore, not fully realised.

The delivery of full seabed habitat monitoring needs platforms capable of combining multiple sampling methods across multiple features (e.g. diving, infaunal sampling, shallow water habitats etc.) and whilst potentially practicable, fishing vessels were found to have difficulties in this regard. The main project focussed on drop-down video sampling for logistical reasons and resources were not directed to complementary methods that might have generated a more complete picture of benthic habitat status.

The aim of developing a robust and simple underwater camera system was partially achieved. Initial problems with the camera equipment were largely overcome with more time in the field and greater familiarity of the vessel crew with the system. However, technical issues which required developer expertise were ongoing throughout the project. Survey crew were able to gain experience to get the best results in terms of sampling methodology, such as landing the camera, when conditions allowed, to get in-focus still images. It appears that the development of a ‘plug and play’ system, and the lack of dedicated engineering support found on a research vessel, resulted in trade-offs in both footage quality and system downtime.

The positional accuracy of the GPS feeds was found to have some issues post-survey. Additional time to fully work through data analysis of a trial dataset would have been beneficial and may have helped to identify solutions to e.g. the use of multiple positional data ‘feeds’. The framework of using one set of crew to develop and carry out surveys, and different contractors to undertake analysis has also been questioned in terms of efficacy.

This project ultimately brought together several partners, including those responsible for the biodiversity of Scotland’s seas (NatureScot and Scottish Government), with the assistance of contracted project managers. Communication between parties via the project steering group was successful and has provided a framework for the future evidence gathering within Scotland’s seas.

While the project did not fully realise some of its aspirational aims, it has demonstrated that platforms such as fishing vessels can be used for marine environmental surveys, while gathering data which will be used to inform on the status of MPAs and extent of PMFs in Scottish waters.

8 Acknowledgements

We would like to thank the European Maritime and Fisheries Fund (EMFF) for supporting these projects. Thanks also to all the owners, skippers and crews of the following vessels for their engagement and efforts to make the projects successful.

- MFV *Lady Nicola*
- MFV Walrus
- RV *Actinia*
- MV *Bluefin*
- MV *Shjandur*
- MV *Glen Tarff*

9 Glossary

DAC - Data Archive Centre

DASSH - The Archive for Marine Species and Habitats Data

DDV - Drop-down video

EMFF - European Maritime and Fisheries Fund

GeMS - Geodatabase of Marine features in Scotland

GPS - Global Positioning System

JNCC - Joint Nature Conservation Committee

MCA - Maritime and Coastguard Agency

MEDIN - Marine Environmental Data and Information Network

MPA - Marine protected area

NAFC - North Atlantic Fisheries College

NGO - Non-governmental Organisation

PF - Protected feature

PMF - Priority marine feature

RIFG - Regional Inshore Fisheries Group

RYA - Royal Yachting Association

SAC - Special area of conservation

SBRUV - Stereo Baited Remote Underwater Video Camera

SNH - Scottish Natural Heritage