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Research Report No. 1155

Monitoring for the possible spread of *Didemnum vexillum* into the subtidal environment of Loch Creran

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RESEARCH REPORT

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Monitoring for the possible spread of *Didemnum vexillum* into the subtidal environment of Loch Creran

For further information on this report please contact:

Lisa Kamphausen
Scottish Natural Heritage
Great Glen House
Leachkin Road
INVERNESS
IV3 8NW
Telephone: 01463 725000
E-mail: lisa.kamphausen@nature.scot

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RESEARCH REPORT

Summary

Monitoring for the possible spread of *Didemnum vexillum* into the subtidal environment of Loch Creran

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Keywords

serpulid reef; flame shell; horse mussel; *Didemnum vexillum*; carpet sea squirt; monitoring; SAC; MPA

Background

The Loch Creran SAC was established to afford protection for the marine feature reefs, which includes the biogenic sub-features serpulid reefs and horse mussel beds, as well as the bedrock reefs of the loch. Loch Creran is also designated as a Marine Protected Area (MPA), conferred to protect the flame shell beds and geodiversity features.

The invasive colonial sea squirt *Didemnum vexillum* was first recorded on an oyster farm in Loch Creran in 2016. In view of its possible spread into the subtidal environment, the current study established a diving programme to monitor such spread, with particular emphasis on colonisation of the protected features, serpulid reefs, horse mussel beds and flame shell beds.

Main findings

- Didemnid sea squirts were found growing on serpulid reefs and flame shell bed byssal turf, but the species *Didemnum vexillum* was not recorded subtidally in the loch throughout the monitoring period (7th May 2017 to 28th January 2019).

- It is concluded that *D. vexillum* is not currently exerting a significant impact on the serpulid reef, horse mussel bed or flame shell bed features of the loch.

- The presence of the invasive alga, *Sargassum muticum*, was recorded in the loch for the first time.

For further information on this project contact:
Lisa Kamphausen, Scottish Natural Heritage, Great Glen House, Leachkin Road, Inverness, IV3 8NW.
Tel: 01463 725000 or lisa.kamphausen@nature.scot
For further information on the SNH Research & Technical Support Programme contact:
Research Coordinator, Scottish Natural Heritage, Great Glen House, Leachkin Road, Inverness, IV3 8NW.
Tel: 01463 725000 or research@nature.scot

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Acknowledgements

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1. INTRODUCTION

Loch Creran lies 12 km to the north of Oban on the west coast of Scotland (Figure 1). It was designated a Special Area of Conservation (SAC) under the EC Habitats Directive (92/43 EEC) in 2005 in order to protect its qualifying feature, reefs. The SAC extends to the mouth of the loch (Figure 1) and includes the subtidal area to MLWS. The reefs feature comprises rocky and biogenic reefs, the latter including serpulid reefs (mass aggregations of the serpulid worm, *Serpula vermicularis*) and beds of the horse mussel, *Modiolus modiolus*. The loch harbours the greatest known development of the rare *S. vermicularis* reef habitat in the world (Moore *et al*., 1998). In 2014 Loch Creran was also designated as a Marine Protected Area (MPA) under the Marine (Scotland) Act 2010, with the same geographical coverage as the SAC. The MPA protected features include beds of the flame shell, *Limaria hians*, and the geodiversity feature, Quaternary of Scotland.

The invasive colonial sea squirt *Didemnum vexillum* was first recorded in Scotland in Largs Yacht Haven in 2009 (Beveridge *et al*., 2011). Its common name, the carpet sea squirt, alludes to its propensity to form extensive sheets on marine surfaces, overgrowing the native biota such as mussels, and man-made structures such as aquaculture gear. The potential ecological and economic impacts of this species are considered to be significant (Beveridge *et al*., 2011).

Didemnum vexillum was first recorded in Loch Creran by the Scottish Association for Marine Science on the bags of an oyster farm at Rubha Mór in 2016 (Turrell *et al*., 2018) (Figure 2). A subsequent survey in the same year found it growing on 40 out of 40,000 bags at the Rubha Mór oyster farm, but it was not found at five other foreshore sites around the loch (Turrell *et al*., 2018).

Although there have been no subtidal records of *Didemnum vexillum* in the loch, such an extension of its range has the potential to adversely impact the protected features of the loch. Consequently, the aim of the current study was to monitor the establishment and spread of the species in the subtidal environment of the loch, with particular emphasis on colonisation of the serpulid reef, flame shell bed and horse mussel bed habitats. This study accompanied an assessment of the current condition of these designated features, the results of which are reported elsewhere (Moore *et al*., 2020).

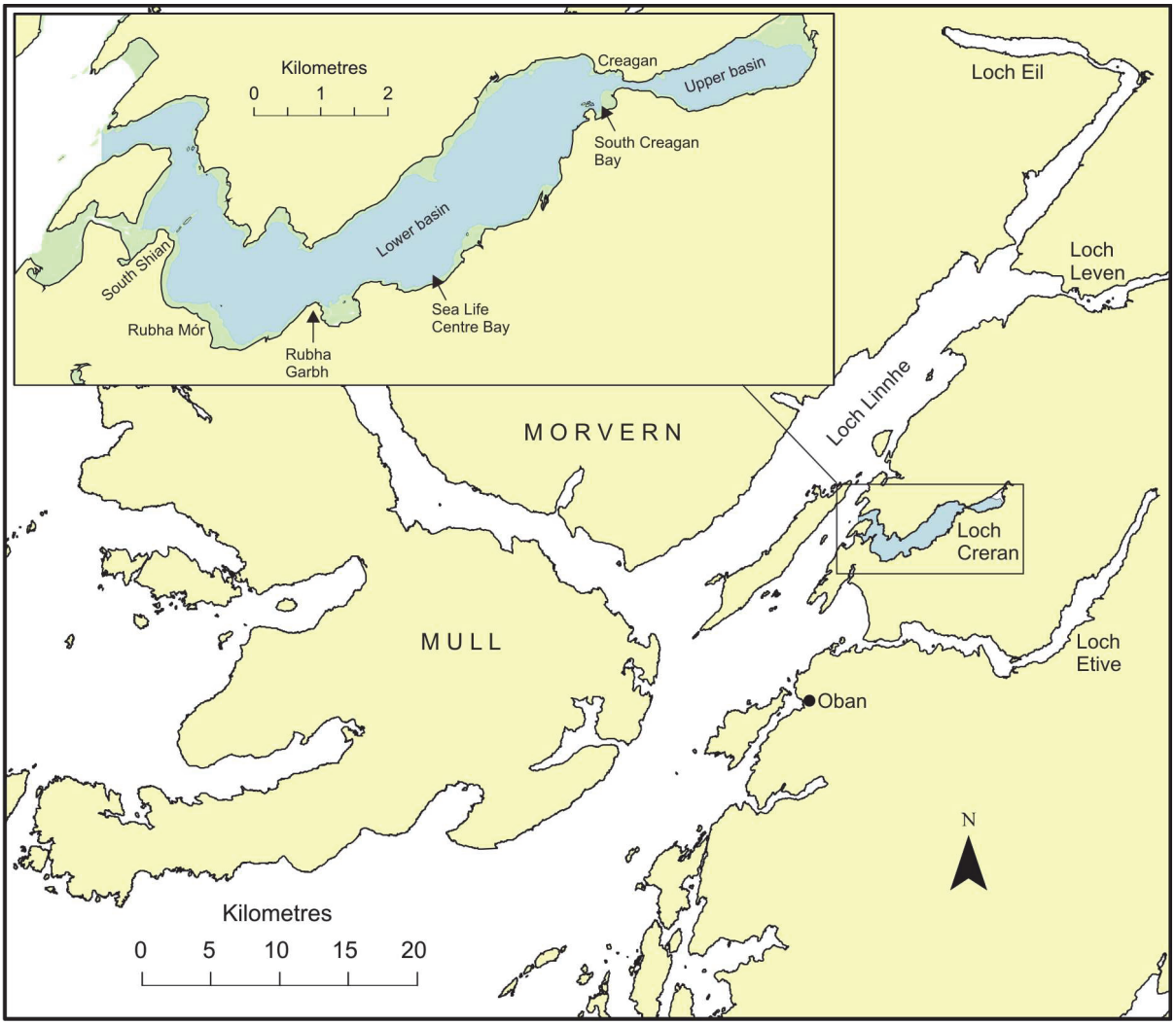

Figure 1. Location of Loch Creran on the west coast of Scotland, with inset showing detail of the loch. Loch Creran SAC and MPA in blue.

2. METHODS

The approach taken to monitoring *Didemnum vexillum* involved a combination of repeated surveys of the habitat along fixed, relocatable transects, and of artificial structures, such as pontoons and moorings. In addition, more extensive coverage of the loch was achieved through assessment of the presence of *D. vexillum* as part of the condition survey of the SAC and MPA protected features of the loch.

2.1 Relocatable transects

Relocatable seabed monitoring transects were established at 10 serpulid reef sites and two flame shell bed sites and were examined three times per year at 3 - 4 month intervals for two years between May 2017 and December 2018 (Table 1). The location of the sites is shown in Figure 2 and full site details provided in Table 1.1 (Annex 1). The sites represented for the most part relatively rich serpulid reef or flame shell bed grounds (Table 2) and provided reasonable geographical coverage in those parts of the loch where rich grounds are situated, while providing a slightly higher concentration of sites in the vicinity of the recorded intertidal presence of *Didemnum vexillum*.

Table 1. Timetable for relocatable transect and artificial substrate surveys.

Survey	Survey type	
	Relocatable transects	**Artificial substrates**
May 2017	7-9/05/2017	
August 2017	06/08/2017	7-9/08/2017
December 2017	11-12/12/2017	
April 2018	17-18/04/2018	
August 2018	24-27/08/2018	20-22/08/2018
December 2018	10-11/12/2018	

Table 2. Summary of details of relocatable transects.

Site	Habitat	Depth below chart datum start (m)	Depth below chart datum end (m)	% cover reef material or flame shell turf	Transect belt width (m)
DR1	serpulid reef	5.5	5.4	5	4
DR2	serpulid reef	7.7	6.8	10	2
DR3	serpulid reef	2.5	2.7	10	2
DR4	serpulid reef	7.7	8.1	10-15	2
DR5	serpulid reef	7.7	7.1	15-20	2
DR6	serpulid reef	6.7	5.6	15-20	2
DR7	serpulid reef	6.5	8.5	10	2
DR8	serpulid reef	6.9	5.8	30-40	2
DR9	serpulid reef	7.8	6.0	10	2
DR10	serpulid reef	6.5	6.4	15	2
DR11	flame shell bed	12.1	13.1	100	2
DR12	flame shell bed	10.8	10.4	85	2

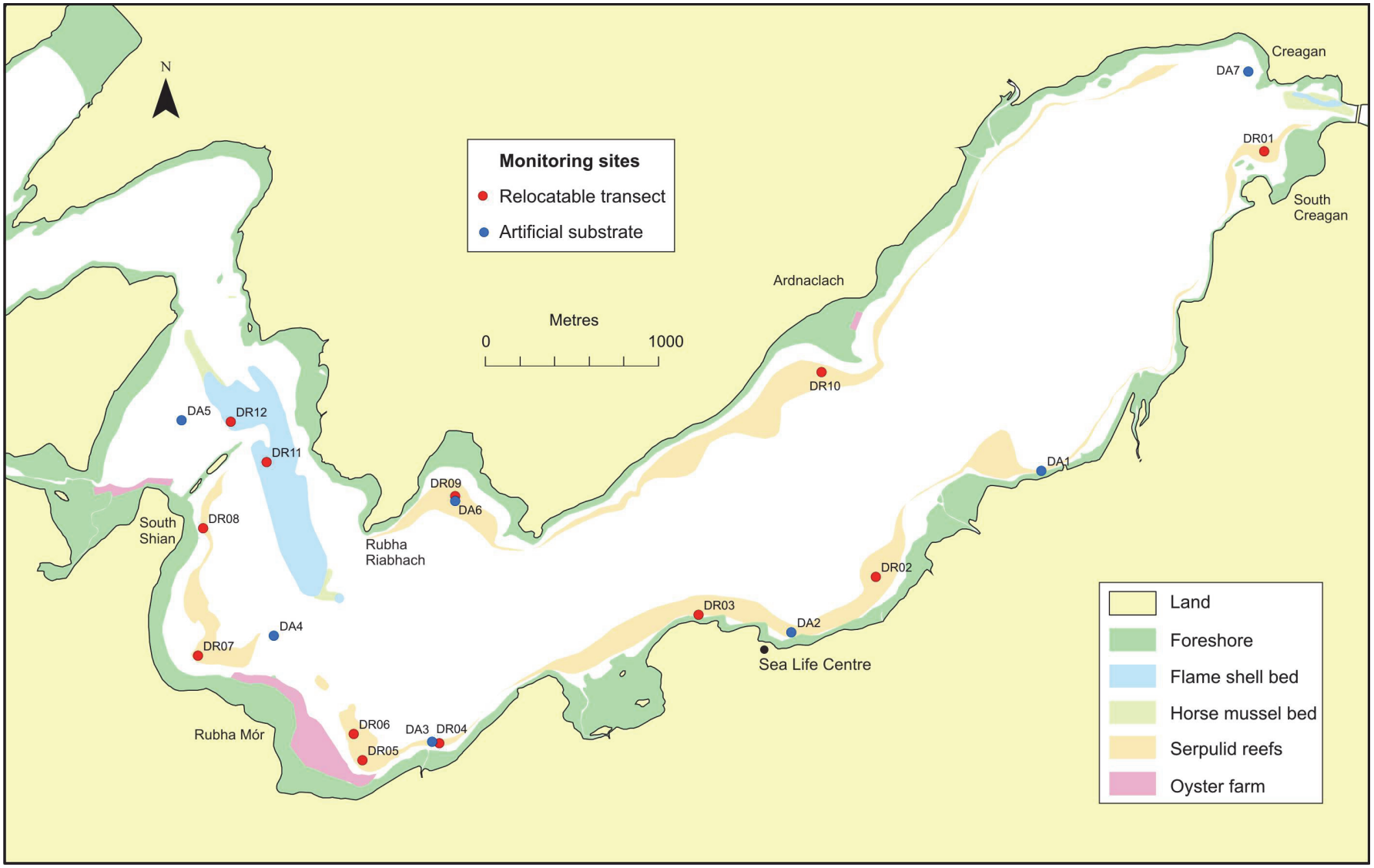

Figure 2. Distribution of relocatable transect and artificial substrate monitoring sites in relation to protected features (from Moore et al., 2020).

At each site a relocatable marker consisting of a 2 cm diameter blue polyethylene tube was driven into the seabed at both ends of a 25 m ground line, marked at 1 m intervals. The bearing of the transect and the depths at both ends were recorded. For some transects dog-legs were introduced to maximise passage through dense serpulid reef habitat, in which case additional markers were employed. A belt 1 m wide (extended to 2 m at one substrate-poor site) along both sides of the transect line was examined by diver for *Didemnum vexillum* and the following data recorded within each 1 x 1 m box where suspected *D. vexillum* was present:

- estimate of cover (in cm^2) of *D. vexillum*
- % cover by *D. vexillum* of available substrate (reef or flame shell turf) within 1 m^2 square
- % reef or flame shell turf cover within 1 m^2 square

Video footage of the transect band was collected by means of a helmet-mounted HD GoPro camera or through the use of a hand-held HD video camera operated by a second diver. In the event of the suspected presence of *Didemnum vexillum*, the material was collected for analysis on the surface vessel or if necessary in the laboratory. On the basis of the results the source of any material still suspected to be possibly *D. vexillum* was to be revisited with the collection of detailed *in situ* HD video and stills images using an SLR camera. Prior to diving operations samples and photographs of *Didemnum vexillum* were obtained from the Rubha Mór oyster farm to aid briefing of survey divers in the visual characteristics of the species (Figure 3).

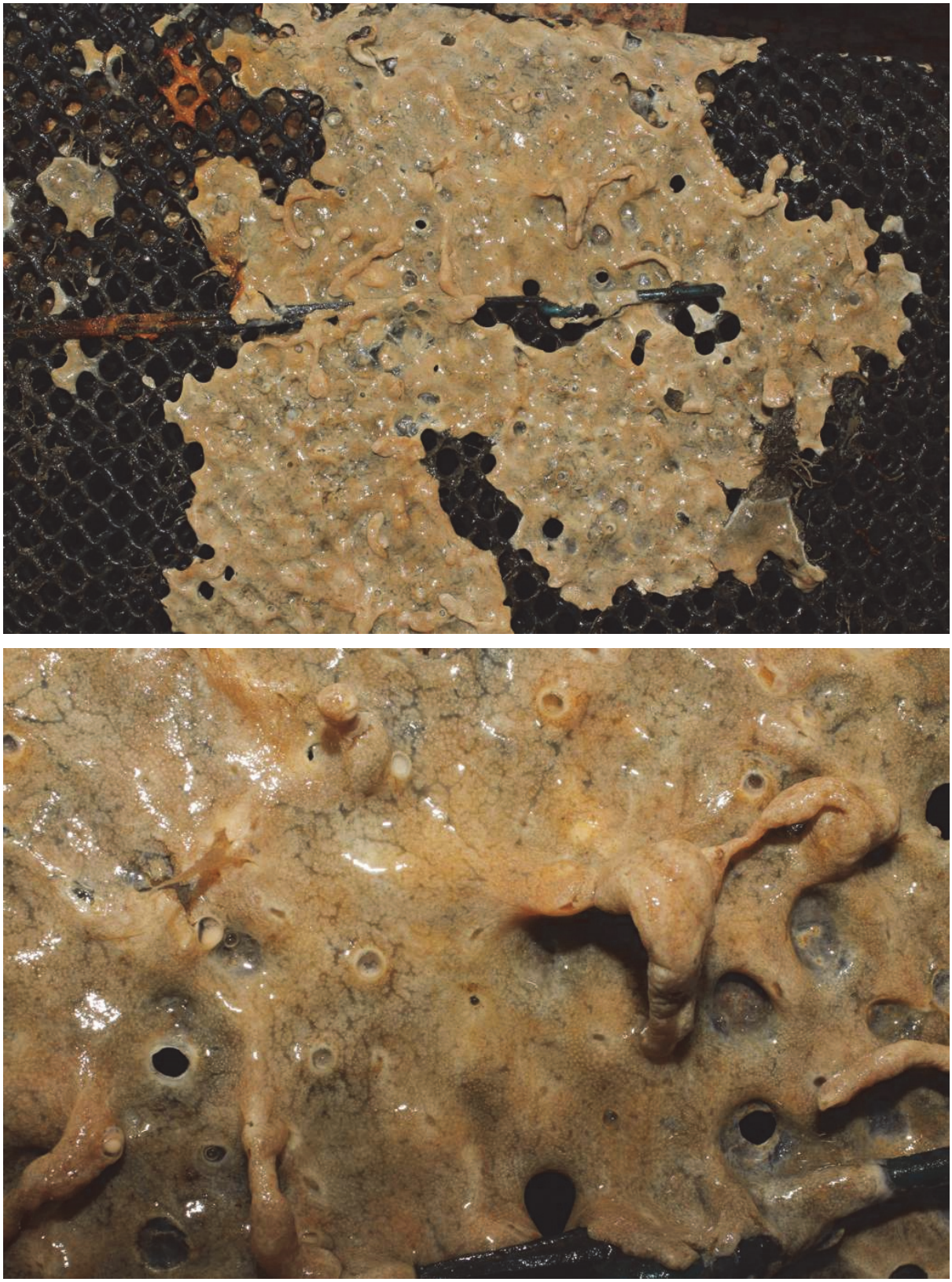

Figure 3. Didemnum vexillum, Rubha Mór oyster farm, 13th April 2017.

2.2 Artificial substrates

Seven artificial substrate sites were selected, representing reasonable geographical coverage of the lower basin of the loch and including several sites in close proximity to the Rubha Mór oyster farm. The locations are shown in Figure 2, with surface photographs of the structures in Figure 4. The site details are summarised in Table 3 and provided in full in Table 1.3 (Annex 1).

Table 3. Summary of details of the artificial substrate monitoring sites.

Site	Site description	Maximum depth below chart datum (m)
DA01	Creran Marine pontoon, Barcaldine	1.2
DA02	Fishing raft, Sea Life Centre Bay	8.0
DA03	Large yacht mooring, c.400 m east of oyster trestles	15.6
DA04	Ship mooring (Rose of Lorne), 330 m from position of intertidal *Didemnum vexillum* record	12.9
DA05	Outer of tern nesting rafts, South Shian	14.7
DA06	Yacht mooring, Rubha Garbh Bay, north coast	6.2
DA07	Creagan Inn moorings (3), Creagan	13.2

The sites were inspected annually by diver (Table 1) with examination including floating structures as well as associated moorings. The survey was recorded on video using a helmet-mounted HD GoPro camera. The protocol involved recording the extent and location of any suspected *Didemnum vexillum* colonies, with collection of material for analysis on the surface vessel or if necessary in the laboratory. As with the relocatable transects, further *in situ* video and stills imagery was to follow the identification of material still considered to be possibly *D. vexillum*.

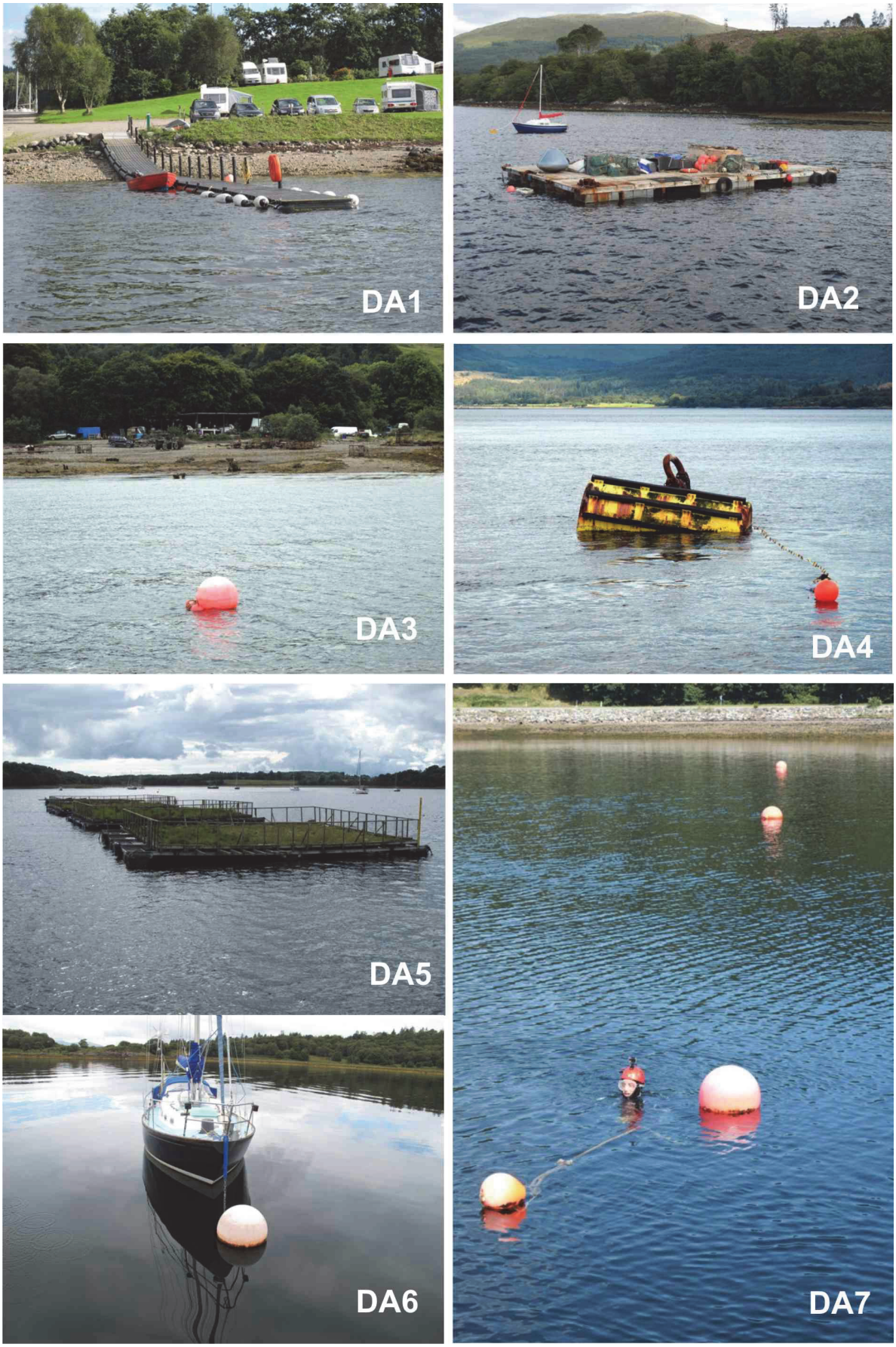

Figure 4. Photographs of artificial substrate monitoring sites.

2.3 Protected features condition surveys

2.3.1 Paired serpulid reef condition transects

The presence of *Didemnum vexillum* was recorded by diver along 30 transects distributed within serpulid reef habitat in the lower basin of the loch over the period 13/06/2017 to 28/01/2019. Most of the work was spread over two years to provide a temporal component to the *D. vexillum* work. At 15 sites *D. vexillum* presence (and serpulid reef condition) was recorded along two parallel 20 m long transects 10 m apart (termed 'paired transects'). The diver swam along a bearing for 20 m using a metre rule to aid distance determination, recording measurements within a band approximately 4 m wide. At the end of the transect the diver turned right and swam along a bearing at 90° to the initial bearing for a distance of 10 m. This was followed by the start of the second 20 m long transect which followed a reciprocal bearing to that of the first transect. To simplify navigation all transects ran either north then south, or west then east, depending upon which option better followed the depth contours in the area.

The total area surveyed at each site was approximately 160 m^2. The diver towed a surface buoy furnished with a GPS data logger storing dGPS signals at 3 s intervals. To avoid inaccuracy due to layback, the diver pulled the buoy into an overhead position and recorded the time at the start and end of each transect, as well as the depth. *Didemnum vexillum* presence triggered recording of the following data:

- position (through recording time and subsequent correlation with GPS tracking data)
- estimate of cover by *D. vexillum* (cm^2) (for single colonies)
- % cover by *D. vexillum* of serpulid reef substrate within 1 m^2 (for single colonies)
- % serpulid reef cover within 1 m^2 (for single colonies)
- % cover by *D. vexillum* of serpulid reef substrate within defined area (for scattered colonies)
- % serpulid reef cover within same defined area (for scattered colonies)

The diver carried a helmet-mounted HD GoPro camera, to be also used for stills photography of putative *D. vexillum*, with material collected for vessel-based or laboratory-based identification.

The location of sites is shown in Figure 5, with further details provided in Moore *et al.* (2020).

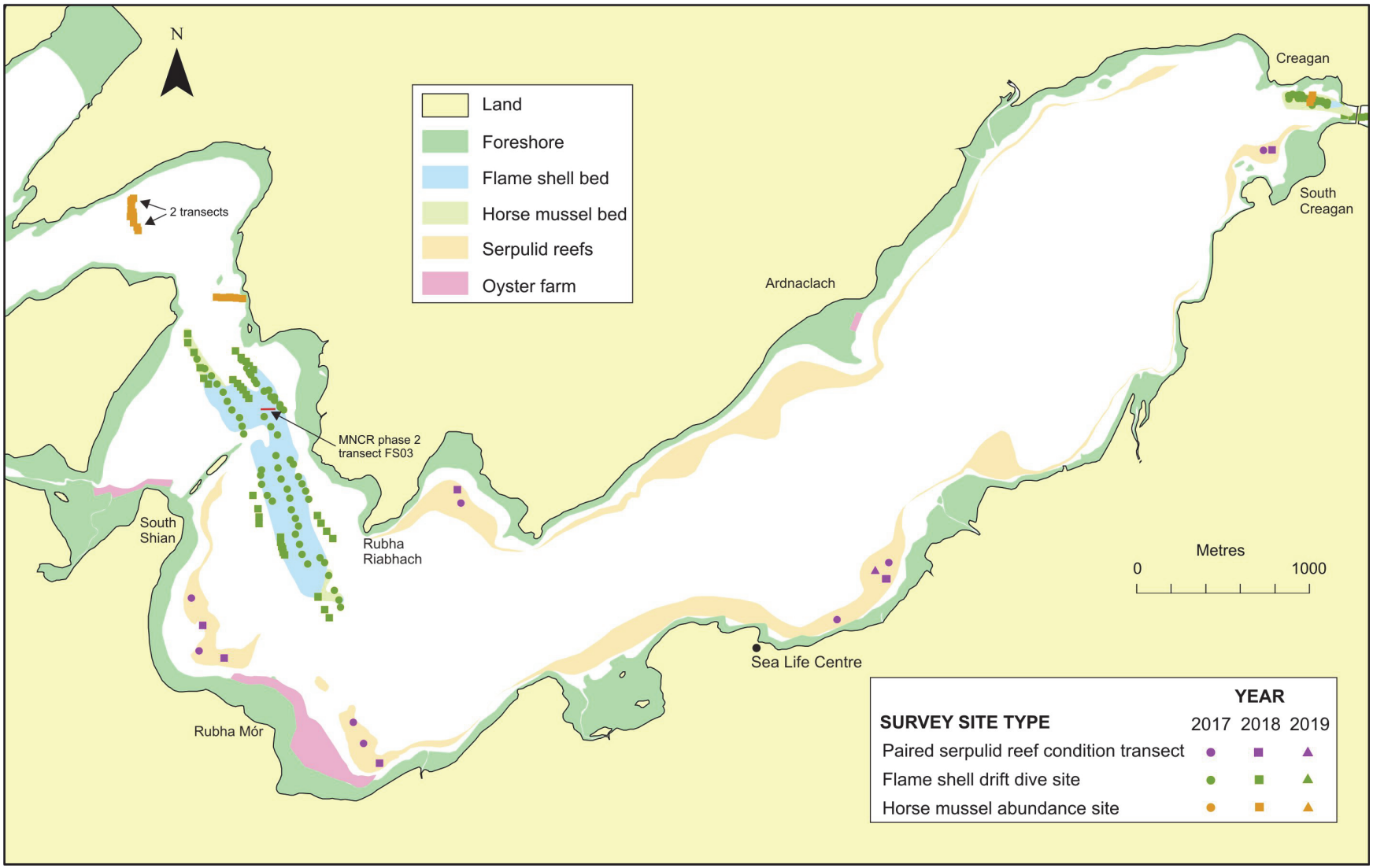

Figure 5. Distribution of protected features condition survey sites in the lower basin also assessed for Didemnum vexillum presence.

2.3.2 Zigzag serpulid reef condition transects

Reef condition assessment required a modified approach in the upper basin of Loch Creran, where reef density has historically been low and largely confined to an intermittent, narrow, peripheral band (Moore *et al*., 2006). Six sites were surveyed in August 2018, representing all the locations where either medium (50 - 500 cm^2 plan area) or large (>500 cm^2 plan area) reefs were recorded in 2005 (Moore *et al*., 2006). To maximise survey coverage of the reef habitat, at each site a diver zigzagged between the start and nominal end points (the latter aided by surface communication) employing a compass bearing indicating the overall direction of travel. The diver covered a specified depth range, which was slightly wider than the range over which reefs had been previously recorded in the location. Location fixes were provided by a towed dGPS logger which was pulled vertical and the time taken at the start and end of each swim. The diver surveyed an area within the range of visibility (c.3 m) either side of the direction of movement. In addition to recording measures of serpulid reef condition, the presence of *Didemnum vexillum* was also assessed, recording the same data as for the paired transects on finding suspected material (section 2.3.1) and collecting a sample for subsequent identification. The diver carried a helmet-mounted HD GoPro camera, which will also used for stills photography of putative *D. vexillum*, with material collected for vessel-based or laboratory-based identification.

The location of sites is shown in Figure 6, with further details provided in Moore *et al.* (2020).

2.3.3 Flame shell drift dive sites

The presence of *Didemnum vexillum*, as well as measures of the condition of the flame shell habitat, was examined along 23 diver transects in the vicinity of South Shian and Creagan Narrows during the period August 2017 - January 2019. Divers descended at selected coordinates and drifted or swam along a prescribed bearing for a prescribed distance, aided by mounting the compass on a 1 metre rule. Distances covered were mostly between 100 - 400 m. Spot records were taken at stations at approximately equal distance intervals along the transect (with a maximum of 11). Divers wore a head-mounted GoPro HD video camera, which will also to be used for stills photography of putative *D. vexillum*, with material collected for vessel-based or laboratory-based identification.

Parameters recorded for *Didemnum vexillum* monitoring purposes at each station included the following:

- Depth (m)
- Bearing of the towed surface marker buoy (SMB)
- Time (hh:mm:ss)
- % cover by *D. vexillum* of flame shell bed turf and hard substrates within 1 m^2 (for single colonies)
- % cover by flame shell turf and hard substrates within 1 m^2 (for single colonies)
- % cover by *D. vexillum* of flame shell bed turf and hard substrates within defined area (for scattered colonies)
- % cover by flame shell turf and hard substrates within same defined area (for scattered colonies)
- Substrate description
- Notes on biota and any other comments

The diver location was recorded by means of a surface GPS logger unit attached to the SMB. In view of the stronger currents encountered over flame shell beds, layback was calculated from the depth, as well as the SMB line length and bearing. Station positions are shown in Figures 5 and 6, with further site details provided in Moore *et al*. (2020).

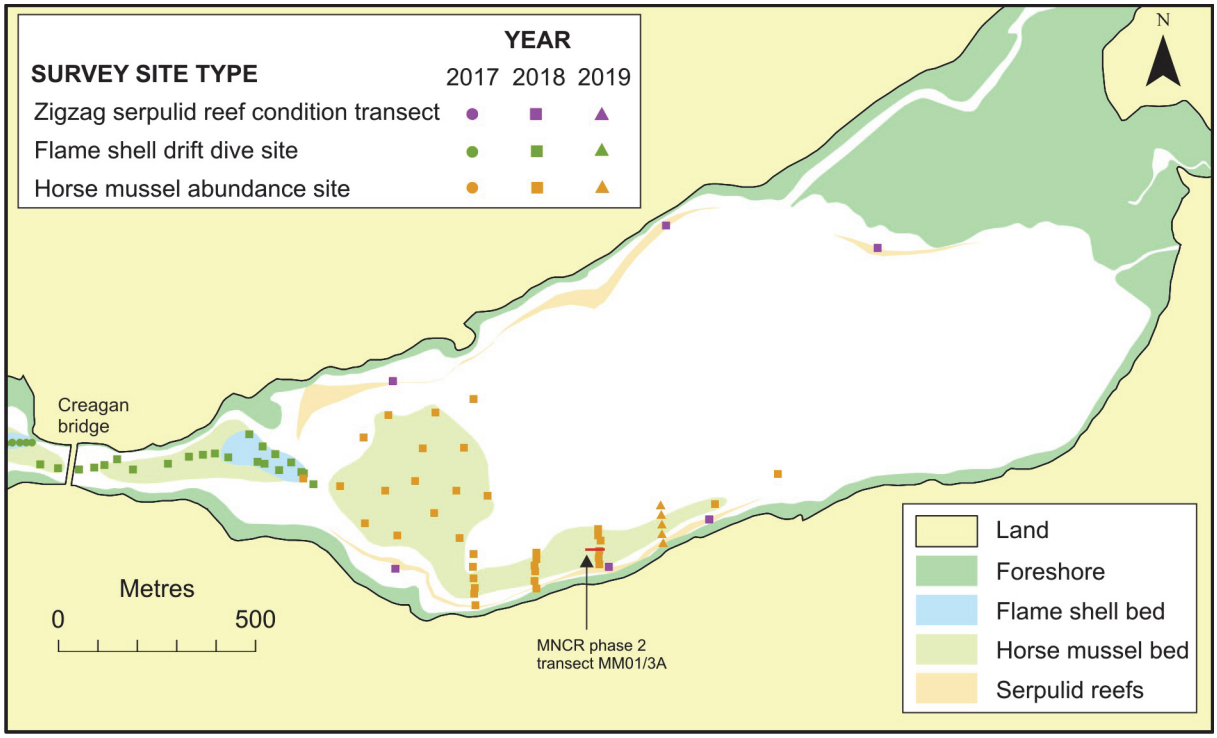

Figure 6. Distribution of protected features condition survey sites in the upper basin also assessed for Didemnum vexillum presence.

2.3.4 Horse mussel abundance sites

The presence of *Didemnum vexillum* was assessed during surveys of horse mussel abundance along four depth transects in the upper basin and four transects in the lower basin of the loch in August 2018. For each transect stations were occupied at approximately 20 m intervals along a compass bearing. Distance measurement was generally aided by use of a metre rule, although along two transects where more detailed assessment of horse mussel bed density were made, a ground line was laid calibrated in 20 m sections. The diver towed a surface buoy furnished with a GPS data logger, which was pulled overhead for position fixing. At each station where suspected *D. vexillum* was present, the same parameters were recorded as in section 2.3.1, except that instead of cover estimates relating to serpulid reef substrate, they were given in terms of horse mussel and other hard substrates. Divers wore a head-mounted GoPro HD video camera, which could also be used for stills photography of putative *D. vexillum*, with material collected for vessel-based or laboratory-based identification.

In addition to the use of transects, horse mussel abundance and distribution in the upper basin of the loch were examined by means of short dives at 16 sites in August 2018. At each site a shot line was dropped at the chosen position and a diver assessed *Modiolus* density along a short 3 - 5 minute swim eastwards, while also looking out for the presence of *Didemnum vexillum*. The protocol for recording *D. vexillum* was the same as that outlined in section 2.3.4. Start and end points of the dive were fixed by means of a towed GPS logger pulled overhead.

The positions of all stations along transects and midpoints of upper basin swims are shown in Figures 5 and 6, with further site details provided in Moore *et al*. (2020).

2.3.5 MNCR phase 2 surveys

Two MNCR phase 2 surveys (Hiscock, 1996) were carried out by diver in 2017. On 7th August 2017 a survey of the flame shell bed habitat off South Shian was undertaken within a 25 m long x 4 m wide transect band at site FS03. On 9th August 2017 an area of horse mussel bed habitat in the upper basin of the loch was surveyed (site ML01/3A). The transect band ran east-west for 50 m and was delimited in the north-south direction by the 12 and 15 m depth contours. At both sites, as part of recording the SACFOR abundance (Hiscock, 1996) of the epibiota, the presence and SACFOR abundance of *Didemnum vexillum* was assessed. Comprehensive video and still imagery were collected at both sites, including coverage of the ascidian fauna. Samples of all biota which could not be confidently identified *in situ* were returned to the laboratory for detailed examination.

The position of sites FS03 and MM01/3A are shown in Figure 5 and Figure 6 respectively. Further site details are given in Moore *et al*. (2020).

3. RESULTS

No *Didemnum vexillum* was recorded subtidally throughout the period of the monitoring programme (7th May 2017 to 28th January 2019). Colonial ascidians belonging to the *D. vexillum* family, Didemnidae, were observed at several of the survey sites. Tables 1.2 and 1.3 (Annex 1) list the didemnid material returned to the laboratory for microscopic examination and DNA sequencing, although additional material that was clearly not assignable to *D. vexillum* based on examination on the surface vessel, was not logged.

Most of the collected material were *Diplosoma* spp., which were found growing on serpulid reefs and the flame shell bed byssal turf (Figure 7). Species belonging to this genus can be difficult to distinguish anatomically and the loch may contain three examples of the genus: *Diplosoma listerianum* (e.g. Mair *et al*., 2000; Moore *et al*., 2006), *Diplosoma* cf. *spongiforme* (Black *et al*., 2000) and *Diplosoma* sp.1 (Bowen *et al*., 2018). DNA from four August 2017 samples of didemnid material (from sites DA1, DA2, DA3 and DA4) were subjected to molecular analysis by Marine Scotland. Three (DA1, DA2, DA4) produced PCR products that exhibited identical sequences to *Diplosoma listerianum* on the GenBank database.

Figure 7. Diplosoma sp. (probably Diplosoma listerianum) on flame shell bed at MNCR site FS03.

One example of a congener of *Didemnum vexillum* was recorded on a tern raft at site DA5. Microscopic examination revealed larvae exhibiting the characteristics of *D. maculosum* (see Figure 8).

At the same site the invasive brown alga *Sargassum muticum* (wireweed) was recorded on 22nd August 2018 (Figure 9). Several attached specimens up to around 1 m in length were observed from the surface vessel at the north-eastern corner of the northernmost tern raft. No subsequent examination of the extent of colonisation was undertaken.

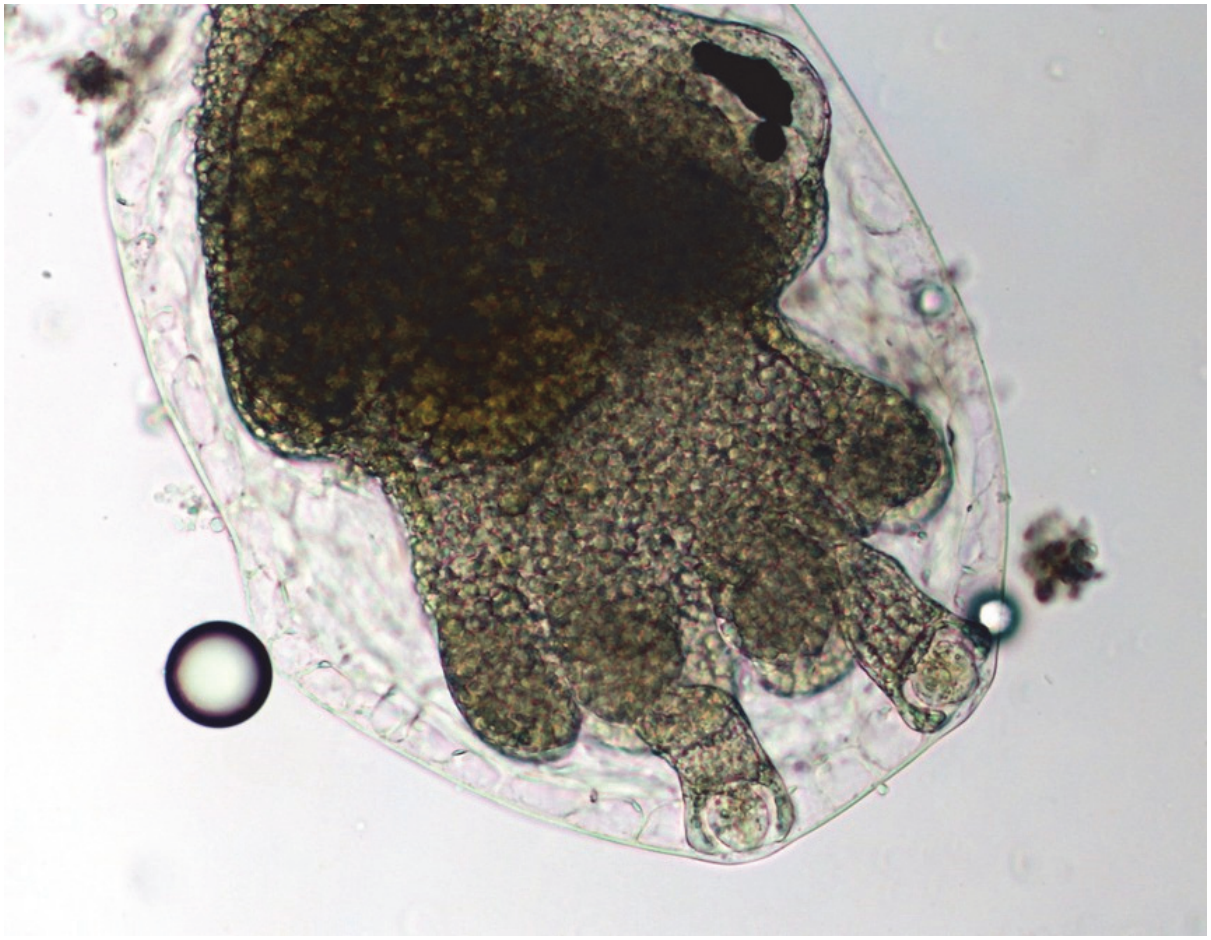

Figure 8. Didemnum maculosum larva from site DA5, showing two adhesive organs (bottom right) and four pairs of ectodermal ampullae (the upper four of which are clearly discernible). D. vexillum exhibits three adhesive organs and six pairs of ectodermal papillae.

Figure 9. Sargassum muticum from site DA5. 30 cm rule for scale.

4. DISCUSSION

The majority of divers involved in the monitoring programme were experienced field marine biologists and some of them had already gained experience of working with *Didemnum vexillum* through the programme of monitoring and eradication of the species in Holyhead Marina (Holt & Cordingley, 2011). Given the experience of the monitoring team and the extensive coverage of the loch through the incorporation of the SAC and MPA condition surveys within the *D. vexillum* monitoring programme, it is considered probable that *D. vexillum* has not currently succeeded in colonisation of the subtidal environment of the loch to any significant extent. It can certainly be said that it is not currently exerting any significant adverse impact on the biogenic reefs (serpulid reef and horse mussel bed habitats) and flame shell beds that are protected features within the loch.

Sargassum muticum was first recorded in Scotland in 2004 in Loch Ryan (Saunders, 2004). Since then it has spread up the west coast of Scotland (Harries *et al*., 2007; Trendall *et al*., 2010; Burrows *et al*., 2017, with scattered records extending northwards to Orkney. *Sargassum muticum* has been recently found on the south coast of Mull (Burrows *et al*., 2017) but it is believed that the current sighting in Loch Creran represents the first record of attached plants within the Loch Linnhe system of sea lochs.

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ANNEX 1: MONITORING SITE DETAILS

Table 1.1 Details of relocatable transect sites.

Site	Substrate	Latitude start	Longitude start	Latitude end	Longitude end	Depth below chart datum start (m)	Depth below chart datum end (m)	Bearing (°T)	% cover reef material/flame shell turf	Transect belt width (m)
DR01	serpulid reef	56.545300	-5.299550	56.545294	-5.299149	5.5	5.4	92	5	4
DR02	serpulid reef	56.522433	-5.334350	56.522269	-5.334617	7.7	6.8	222	10	2
DR03	serpulid reef	56.520250	-5.350783	56.520275	-5.351163	2.5	2.7	267	10	2
DR04	serpulid reef	56.513083	-5.374650	56.513056	-5.374251	7.7	8.1	107	10-15	2
DR05	serpulid reef	56.512083	-5.382067	56.512245	-5.382341	7.7	7.1	317	15-20	2
DR06	serpulid reef	56.513333	-5.383050	56.513273	-5.383424	6.7	5.6	257	15-20	2
DR07	serpulid reef	56.518050	-5.397733	56.517829	-5.397747	6.5	8.5	197	10	2
DR08	serpulid reef	56.523917	-5.397783	56.523709	-5.397688	6.9	5.8	177	30-40	2
DR09	serpulid reef	56.525883	-5.374267	56.525729	-5.374518	7.8	6.0	237	10	2
DR10	serpulid reef	56.533050	-5.340233	56.532992	-5.340598	6.5	6.4	243	15	2
DR11	flame shell turf	56.527350	-5.392017	56.527544	-5.392371	12.1	13.1	332	100	2
DR12	flame shell turf	56.529400	-5.395517	56.529080	-5.395288	10.8	10.4	147	85	2

Table 1.2 Relocatable transect monitoring data.

Survey	Transect	Date	Surveyor	Video filenames	Samples
May 2017	DR01	08/05/2017	Dan Harries	00003.mts	
May 2017	DR02	08/05/2017	Rob Cook	00004.mts	
May 2017	DR03	08/05/2017	Alastair Lyndon	00007.mts	
May 2017	DR04	08/05/2017	Dan Harries	00013.mts	
May 2017	DR05	07/05/2017	Dan Harries	GOPR2730mp4, GP012730.mp4	
May 2017	DR06	07/05/2017	Rob Cook	GOPR0354.mp4	
May 2017	DR07	07/05/2017	Dan Harries	GOPR2735.mp4	
May 2017	DR08	09/05/2017	Dan Harries	00002.mts	
May 2017	DR09	08/05/2017	Rob Cook	00015.mts	
May 2017	DR10	08/05/2017	Rob Cook	00017.mts	
May 2017	DR11	07/05/2017	Rob Cook	GOPR2731.mp4	
May 2017	DR12	07/05/2017	Alastair Lyndon	GOPR0355.mp4	
Aug 2017	DR01	06/08/2017	Graham Saunders	GOPR0392.mp4, GP010392.mp4	
Aug 2017	DR02	06/08/2017	Kieran Tulbure	GOPR0391.mp4, GP010391.mp4	*Diplosoma* sp.
Aug 2017	DR03	06/08/2017	Dan Harries	GOPR0390.mp4, GP010390.mp4	
Aug 2017	DR04	06/08/2017	Rob Cook	GOPR1436.mp4, GP011436.mp4	
Aug 2017	DR05	06/08/2017	Graham Saunders	GOPR1435.mp4, GP011435.mp4	
Aug 2017	DR06	06/08/2017	Kieran Tulbure	GOPR1434.mp4, GP011434.mp4	
Aug 2017	DR07	06/08/2017	Dan Harries	GOPR0018.mp4, GP010018.mp4	
Aug 2017	DR08	06/08/2017	Graham Saunders	GOPR0016.mp4, GP010016.mp4	
Aug 2017	DR09	06/08/2017	Dan Harries	GOPR2794.mp4, GP012794.mp4	
Aug 2017	DR10	06/08/2017	Rob Cook	GOPR2793.mp4	
Aug 2017	DR11	06/08/2017	Rob Cook	GOPR0017.mp4, GP010017.mp4	
Aug 2017	DR12	06/08/2017	Kieran Tulbure	GOPR2795.mp4, GP012795.mp4	*Diplosoma* sp.

Table 1.2 continued.

Survey	Transect	Date	Surveyor	Video filenames	Samples
Dec 2017	DR02	12/12/2017	Kieran Tulbure	GOPR2854.MP4, GP012854.MP4	
Dec 2017	DR03	12/12/2017	Jo Beaton	GOPR2833.MP4, GP012833.MP4	
Dec 2017	DR04	12/12/2017	Graham Saunders	GOPR2834.MP4, GP012834.MP4	
Dec 2017	DR05	11/12/2017	Graham Saunders	GOPR2831.MP4, GP012831.MP4	
Dec 2017	DR06	11/12/2017	Jo Beaton	GOPR2830.MP4, GP012830.MP4	
Dec 2017	DR07	11/12/2017	Kieran Tulbure	GOPR1444.MP4	
Dec 2017	DR08	11/12/2017	Dan Harries	GOPR1443.MP4, GP011443.MP4	
Dec 2017	DR09	11/12/2017	Kieran Tulbure	GOPR2840.MP4, GP012840.MP4	
Dec 2017	DR10	11/12/2017	Dan Harries	GOPR2815.MP4, GP012815.MP4	
Dec 2017	DR11	11/12/2017	Graham Saunders		
Dec 2017	DR11	12/12/2017	Dan Harries	GOPR1445.MP4, GP011445.MP4	
Dec 2017	DR12	11/12/2017	Jo Beaton	GOPR2825.MP4, GP012825.MP4	
Apr 2018	DR01	18/04/2018	Lisa Kamphausen	GOPR2843.MP4, GP012843.MP4, GP022843.MP4	
Apr 2018	DR02	17/04/2018	Dan Harries		
Apr 2018	DR03	17/04/2018	Graham Saunders	GOPR0402.MP4, GOPR0403.MP4	
Apr 2018	DR04	18/04/2018	Dan Harries	GOPR2844.MP4, GP012844.MP4, GP022844.MP4	
Apr 2018	DR05	18/04/2018	Lewis Press	GOPR1480.MP4	
Apr 2018	DR06	18/04/2018	Graham Saunders	GOPR1481.MP4	
Apr 2018	DR07	18/04/2018	Mairi Fenton	GOPR0404.MP4, GP010404.MP4	
Apr 2018	DR08	18/04/2018	Lisa Kamphausen	GOPR0405.MP4, GP010405.MP4	
Apr 2018	DR09	17/04/2018	Lewis Press, Mairi Fenton	GOPR0400.MP4, GOPR0401.MP4, GP010401.MP4	
Apr 2018	DR10	17/04/2018	Graham Saunders	GOPR2838.MP4, GOPR2839.MP4, GOPR2840.MP4, GP012840.MP4	
Apr 2018	DR11	17/04/2018	Dan Harries	GOPR2841.MP4, GOPR2842.MP4, GP012842.MP4, GP022842.MP4	
Apr 2018	DR12	18/04/2018	Dan Harries	GOPR0406.MP4, GP010406.MP4, GP020406.MP4	

Table 1.2 continued.

Survey	Transect	Date	Surveyor	Video filenames	Samples
Aug 2018	DR01	24/08/2018	Dan Harries	00019.mts, 00020.mts	
Aug 2018	DR02	25/08/2018	Dan Harries	00023.mts, 00024.mts	
Aug 2018	DR03	27/08/2018	Dan Harries	00030.mts	
Aug 2018	DR04	27/08/2018	Dan Harries	00035mts, 00036.mts	
Aug 2018	DR05	27/08/2018	Dan Harries	00033.mts 00034.mts	
Aug 2018	DR06	27/08/2018	Dan Harries	00031.mts 00032.mts	
Aug 2018	DR07	26/08/2018	Dan Harries	00027.mts 00029.mts	
Aug 2018	DR08	22/08/2018	Dan Harries	00017.mts	
Aug 2018	DR09	26/08/2018	Dan Harries	00025.mts, 00026.mts	
Aug 2018	DR10	24/08/2018	Dan Harries	00021.mts, 00022.mts	
Aug 2018	DR11	26/08/2018	Graham Saunders	GOPR1541.mp4, GP011541.mp4	
Aug 2018	DR12	26/08/2018	Alastair Lyndon	GOPR0444.mp4, GP010444.mp4	
Dec 2018	DR01	10/12/2018	Kieran Tulbure	GOPR2950.MP4, GOPR2951.MP4, GP012951.MP4	
Dec 2018	DR02	10/12/2018	Ben James	GOPR2942.MP4, GOPR2943.MP4, GP012943.MP4	
Dec 2018	DR03	10/12/2018	Mairi Fenton	GOPR0014.MP4, GOPR0015.MP4, GP010015.MP4	
Dec 2018	DR04	11/12/2018	Ben James	GOPR2944.MP4, GOPR2945.MP4, GP012945.MP4	
Dec 2018	DR05	11/12/2018	Mairi Fenton	GOPR2946.MP4, GOPR2947.MP4, GP012947.MP4	
Dec 2018	DR06	11/12/2018	Graham Saunders	GOPR2954.MP4, GOPR2956.MP4, GP012956.MP4	
Dec 2018	DR07	11/12/2018	Lewis Press	GOPR2957.MP4, GOPR2958.MP4, GP012958.MP4	
Dec 2018	DR08	10/12/2018	Graham Saunders	GOPR0461.MP4, GOPR0462.MP4, GP010462.MP4	
Dec 2018	DR09	10/12/2018	Lewis Press	GOPR0463.MP4, GOPR0464.MP4, GP010464.MP4	
Dec 2018	DR10	10/12/2018	Graham Saunders	GOPR2952.MP4, GOPR2953.MP4, GP012953.MP4	
Dec 2018	DR11	10/12/2018	Dan Harries	GOPR0458.MP4, GOPR0459.MP4	
Dec 2018	DR12	10/12/2018	Kieran Tulbure	GOPR0016.MP4, GOPR0017.MP4, GP010017.MP4	

*Table 1.3 Details of artificial substrate sites with monitoring data. *indicates confirmation of identification by DNA sequencing.*

Site	Site description	Date	Latitude	Longitude	Time start UT	Time end UT	Minimum depth below chart datum (m)	Maximum depth below chart datum (m)	Surveyor	Video files	Samples
DA1	Creran Marine pontoon, Barcaldine	07/08/2017	56.528262	-5.319143	08:28	09:00	-2.8	1.2	Dan Harries	GOPR0019.mp4, GP010019.mp4	**Diplosoma listerianum*
DA2	Fishing raft, Sea Life Centre	07/08/2017	56.519583	-5.342317	09:39	10:17	-1.9	7.1	Graham Saunders	GOPR0020.mp4, GOPR0021.mp4, GP010020.mp4	**Diplosoma listerianum*
DA3	Large yacht mooring, c.400 m east of oyster trestles	07/08/2017	56.513125	-5.375537	16:02	16:15	-3.0	15.6	Dan Harries	GOPR2798.mp4	
DA4	Ship mooring (Rose of Lorne), 330 m from position of intertidal *Didemnum vexillum* record	07/08/2017	56.518358	-5.390760	15:33	15:42	-2.7	8.3	Rob Cook	GOPR2797.mp4	**Diplosoma listerianum*
DA5	Outer of tern nesting rafts, South Shian	07/08/2017	56.529967	-5.399100	14:18	15:14	-2.0	14.7	Kieran Tulbure	GOPR0022.mp4, GP010022.mp4, GP020022.mp4, GP030022.mp4	
DA6	Yacht mooring, Rubha Garbh Bay, north coast	08/08/2017	56.525770	-5.374174	09:44	09:56	-2.4	6.2	Kieran Tulbure	GOPR2801.mp4	
DA7	Creagan Inn moorings (3), Creagan	09/08/2017	56.549400	-5.301017	10:43	11:21	-1.8	13.2	Kieran Tulbure	GOPR2805.mp4, GP012805.mp4, GP022805.mp4, GP032805.mp4	

Table 1.3 continued

Site	Site description	Date	Latitude	Longitude	Time start UT	Time end UT	Minimum depth below chart datum (m)	Maximum depth below chart datum (m)	Surveyor	Video files	Samples
DA1	Creran Marine pontoon, Barcaldine	21/08/2018	56.528262	-5.319143	14:37	14:47	-3.0	0.0	Jo Beaton	GOPR0421.MP4, GOPR0422.MP4	
DA2	Fishing raft, Sea Life Centre	20/08/2018	56.519583	-5.342317	08:46	09:00	-1.8	8.0	Graham Saunders	GOPR1517.mp4, GOPR1519.mp4	*Diplosoma* sp.
DA3	Large yacht mooring, c.400 m east of oyster trestles	20/08/2018	56.513125	-5.375537	10:27	11:02	-2.2	14.8	Lewis Press, Jo Beaton	GOPR1520.mp4, GOPR1521.mp4, GP011521.MP4, GP021521.MP4	*Diplosoma* sp.
DA4	Ship mooring (Rose of Lorne), 330 m from position of intertidal *Didemnum vexillum* record	22/08/2018	56.518358	-5.390760	12:42	13:14	-2.1	12.9	Lewis Press, Jo Beaton	GOPR1530.MP4, GOPR1531.MP4, GP011531.MP4, GP021531.MP4	
DA5	Outer of tern nesting rafts, South Shian	22/08/2018	56.529967	-5.399100	10:52	11:55	-1.7	14.6	Graham Saunders	GOPR2892.MP4, GOPR2893.MP4, GP012893.MP4, GP022893.MP4	*Didemnum maculosum*
DA6	Yacht mooring, Rubha Garbh Bay, north coast	20/08/2018	56.525770	-5.374174	14:28	14:46	-2.9	6.1	Lewis Press, Jo Beaton	GOPR0419.MP4, GOPR0420.MP4, GP010420.MP4	
DA7	Creagan Inn moorings (3), Creagan	21/08/2018	56.549400	-5.301017	08:37	08:58	-1.9	13.2	Graham Saunders	GOPR2886.MP4, GP012886.MP4	

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Great Glen House, Leachkin Road, Inverness, IV3 8NW
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