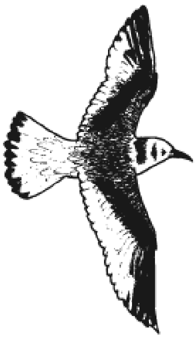
SOTEAG

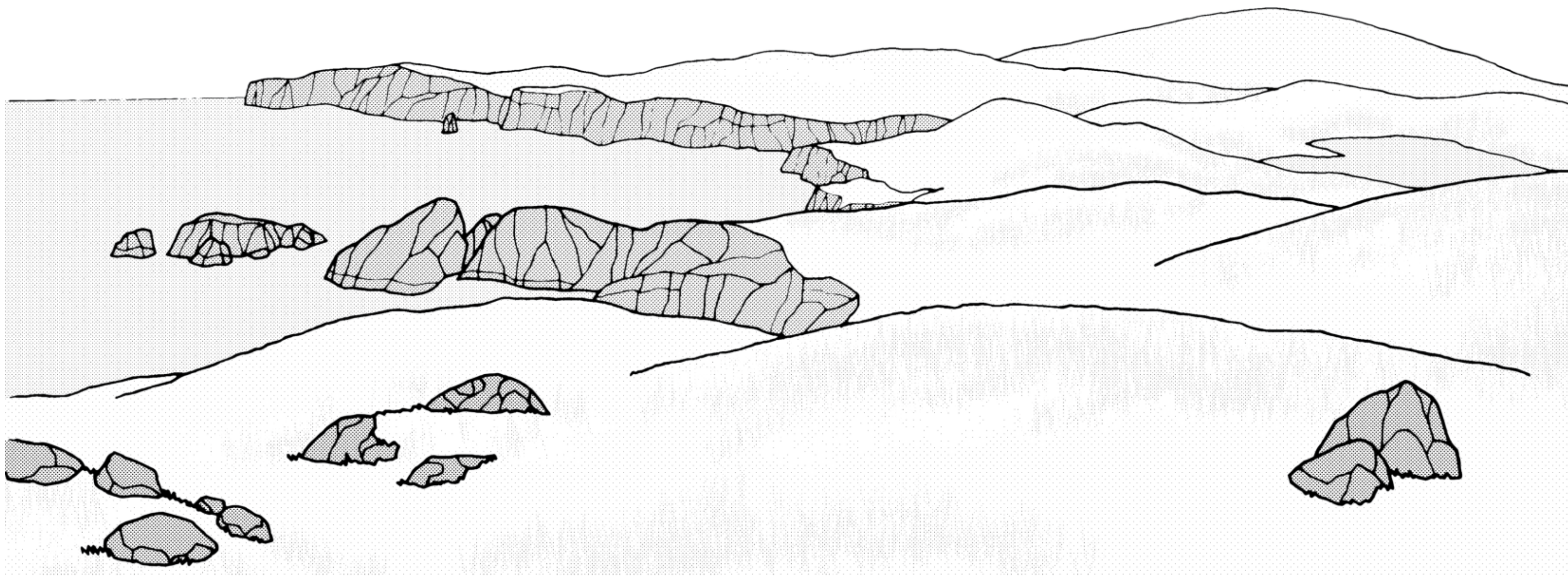
Survey of the rocky shores in Sullom Voe 2019



A report to the Shetland Oil Terminal Environmental Advisory Group

by

Aquatic Survey and Monitoring Ltd



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Survey of the rocky shores in the region of Sullom Voe, Shetland, August 2019

A report for SOTEAG

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Data access

Summary

Biological monitoring of rocky shore communities in Sullom Voe has been carried out annually since 1976. Annual reports to SOTEAG have described the changes from year to year and assessed the effects of the terminal operation. This report summarises the work carried out in August 2019 – the 42nd survey since the programme's inception.

The 2019 survey was carried out with a methodology and strategy adopted in 1993. Earlier data is still directly comparable for analyses. The fifteen original transects in Sullom Voe and the ten reference transects outside the Voe were re-surveyed, and the abundances of all conspicuous species (algae, lichens and invertebrates) were recorded at five stations along each transect. A photographic record of each site was made.

Comparisons of recorded abundances, field notes and photographs from the 2019 survey with those from the 2018 survey and previous surveys have been carried out.

Rocky shore communities at the twenty-five sites in 2019 were generally very like 2018. The most notable features are listed below:

- Abundance of the barnacle *Semibalanus balanoides* reduced at both Sullom Voe sites and reference sites, but well within the normal range of fluctuations. Over winter survival was high.
- Limpet, *Patella vulgata*, densities in Sullom Voe were very similar to 2018, but abundances at Reference sites showed a slight increase.
- Abundances of edible winkles *Littorina littorea* increased, particularly at the boulder sites; while flat winkles *Littorina obtusata* / *fabalis* reduced.
- Populations of dogwhelks reduced slightly overall but continued to increase between the Sullom Voe terminal jetties and are back to abundances similar to pre-TBT[1] levels. No dogwhelks were found at the Vidlin Ness site after a promising start last year.
- Epiphytic bryozoa on fucoids were more abundant, particularly the *Alcyonidium* species.
- There was a reduced abundance of *Corallina* overall, but within the previous range. Records of another branching coralline *Ellisolandia elongata* were made from two sites and are possibly the most northerly records for this species.
- Records of *Osmundea pinnatifida* and *O. hybrida* have much reduced in recent years and fell again in 2019, but the reduction is likely natural.
- Abundance of knotted wrack *Ascophyllum nodosum* was generally stable, but a reduction at a site between the jetties suggests that a boulder moving operation in 2016 caused continued instability.
- There were notable fluctuations in the abundances of other fucoid algae (including *Pelvetia canaliculata*, *Fucus spiralis*, *Fucus vesiculosus* and *Fucus serratus*), with reductions at many of the reference sites and some Sullom Voe sites. However, they were still within the previous ranges.
- Numbers of records of the low shore alga *Himanthalia elongata* has decreased slightly in recent years.
- Abundance of green algae remained relatively low.
- Notable changes in rocky shore communities at the Voxter Ness site, over the course of the monitoring programme, are summarised.

Three small oil spills were reported in the period between July 2018 and August 2019, but they are unlikely to have caused any notable ecological impacts and no signs of them were seen.

With the exception of the impacts on knotted wrack at the South of Jetty 2 transect, there were no observed impacts on rocky shore communities from terminal activities.

[1] Tributyltin.

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1 Introduction

The potential environmental impacts of operations at the Sullom Voe oil terminal were recognised when construction of the complex began in 1975. A monitoring programme was devised by the Shetland Oil Terminal Environmental Advisory Group (SOTEAG). The rocky shore element of this monitoring programme began in 1976 and, apart from a break of two years (1982-83), the rocky shores in Sullom Voe have been surveyed annually. It is thought to be the longest running continuous programme of rocky shores surveys anywhere in the world. The programme was designed to assess gross changes in the plant and animal populations and the survey sites are centred on the oil terminal.

The survey methodology has been modified over this 42-year period, with various changes to the suite of sites and stations, but the species abundance data are comparable throughout.

This report describes the results of the survey in August 2019, highlighting changes that have occurred since the survey in August 2018 and discusses any notable longer-term fluctuations or trends.

Note: An associated programme of surveys of dogwhelk populations at rocky shore sites around Sullom Voe and Yell Sound is carried out every two or three years and was carried out during the August 2018 survey (Moore, Anderson & Mercer, 2018). Appendix 2 lists the dogwhelk survey years.

2 Methods

2.1 Methodological changes during the monitoring programme

Between 1976 and 1981 'full' surveys were carried out in all stations at between 23 and 43 sites, with field surveyors recording onto blank recording forms – i.e. with no reference to previous results. Between 1984 and 1992, following a review of the programme (Hiscock 1983), the methodology was changed and the survey at each site took the form of a rapid visual assessment of the shore to identify gross changes. This involved: comparing, in the field, abundances of species along the fixed transects with records from the most recent full survey, viewing longer sections of the shores from the sea or by walking, and comparing photographs taken from defined viewpoints with those taken in previous years.

In 1993, following suggestions from the SOTEAG monitoring committee, the methodology was modified to allow a more detailed and objective analysis of the data. The number of survey sites in Sullom Voe was reduced to fifteen and five reference sites were established outside the Voe in Yell Sound. Full surveys, rather than rapid visual assessment surveys, were carried out at just five stations along each transect, representing the main zones. This methodology has been used annually since 1993, but in 2017 five additional reference sites were established in Yell Sound (see Section 2.2.1).

The various changes in sites, transect stations surveyed, survey month and survey personnel that have occurred over the 42 years of the SOTEAG rocky shore monitoring programme are summarised in Appendix 2.

Moore (2013) provides a more detailed summary of the rocky shore transect monitoring programme (1976 to 2012), including a description of the methodologies, the methodological changes that had occurred over the course of the programme to 2012, the database and the limitations of the data.

2.2 Field survey, August 2019

Fieldwork was carried out by Jon Moore and Francis Bunker between the 30th July and 7th August 2019, with assistance from Cait Moore and Kristofer Wilson on some days. Table 1 details the sites and the transect stations surveyed, and Figure 1 shows the location of the sites. All surveys were carried out within three hours of low water.

2.2.1 Site and station location

Fifteen sites are located within, or at the entrance to, Sullom Voe to enable monitoring of the effects of oil terminal activities. A further ten sites are distributed around Yell Sound, Lunna and Vidlin Voe to act as Reference sites for the natural changes that occur in rocky shore populations. Five of those reference sites have been within the monitoring programme since 1993, but five were added during the 2017 survey, following a review of the programme that highlighted the unbalanced survey design. The additional sites (green dots in Figure 1) were chosen to improve the balance of the survey design (i.e. increased proportion of reference sites to Sullom Voe sites) and to better represent the environmental character and variability of the Sullom Voe sites. The site selection and establishment procedures are described in the 2017 annual report (Moore and Bunker 2017).

Access to sites was either by car and foot, or by boat as appropriate. A workboat was supplied by EnQuest. A hand-held GPS receiver and site location sheets, containing maps, colour photographs and written notes in laminated plastic, were used to aid relocation.

The site numbering system is based on the wave exposure of the shore. The first number (ranging from 1 to 6) is based on the Ballantine scale (Ballantine, 1961), which uses the biological communities on the shore to estimate the wave exposure (where 1 = extremely exposed, 5 = extremely sheltered, 6 = boulder / cobble shores). The second number is a consecutive number at that exposure.

Table 1 Rocky shore transect sites surveyed in July / August 2019, with the stations surveyed on each transect.

No.	Site name	Stations surveyed	Survey date	OS Grid Ref.
Sullom Voe sites				
1-1	W. of Mioness	15, 18, 21, 24, 27	31/07/2019	HU 41828 79071
2-3	Roe Clett	8, 11, 14, 17, 20	03/08/2019	HU 39437 78127
3-3	Noust of Burraland	1, 3, 5, 7, 10	02/08/2019	HU 37201 75186
3-4	Gluss Island East	6, 9, 11, 13, 15	02/08/2019	HU 37711 77551
3-5	S. of Swarta Taing	4, 7, 10, 12, 15	03/08/2019	HU 40160 77901
4-1	Grunn Taing	3, 5, 7, 9, 11	01/08/2019	HU 37942 78992
4-3	The Kames	5, 7, 9, 12, 15	04/08/2019	HU 38437 76459
4-6	Voxter Ness	5, 8, 10, 12, 14	05/08/2019	HU 36084 70089
5-1	S. of Skaw Taing	9, 12, 15, 18, 20	04/08/2019	HU 39621 78236
5-2	Jetty 3	5, 7, 9, 11, 13	06/08/2019	HU 38594 75578
5-5	Mavis Grind	3, 5, 7, 9, 12	05/08/2019	HU 34054 68462
6-1	Fugla Ayre	3, 5, 7, 9, 11	02/08/2019	HU 37342 74182
6-2	S. of Jetty 2	3, 6, 9, 11, 13	06/08/2019	HU 39163 75089
6-12	Scatsta Ness (cleared)	2, 4, 6, 7, 8	07/08/2019	HU 38874 73544
6-13	Scatsta Ness (uncleared)	4, 5, 8, 10, 12	07/08/2019	HU 38976 73524
	Orka Voe bund		31/07/2019	
Reference sites				
2-9	Riven Noust	13, 17, 19, 22, 24	03/08/2019	HU 50774 73063
3-8	Vidlin Ness	5, 7, 9, 10, 12	04/08/2019	HU 47998 66267
3-12	Burgo Taing	3, 6, 9, 11, 13	06/08/2019	HU 37381 89088
6-11	Kirkabister	4, 6, 8, 10, 12	04/08/2019	HU 48460 66257
6-14	N. Burra Voe	4, 6, 8, 10, 12	06/08/2019	HU 37220 89378
New reference sites				
3-10	Ola's Ness	4, 7, 9, 11, 13	01/08/2019	HU 35332 83092
4-7	West Sandwick	1, 2, 3, 4, 5	01/08/2019	HU 44583 86955
5-8	West Lunna Pund South	1, 2, 3, 4, 5	05/08/2019	HU 47829 69044
6-3	Croo Taing	7, 9, 11, 12, 14	31/07/2019	HU 43282 78645
6-15	West Lunna Pund North	1, 2, 3, 4, 5	05/08/2019	HU 47926 69094

The sites are termed ‘transect sites’: defined as a line of fixed stations, distributed at height intervals from supralittoral (lichen zone) to extreme low water. A fixed datum (pat of concrete, paint mark or other durable and conspicuous feature) marks the top of each transect. The line of the transect is defined by a bearing and by reference to conspicuous marks (permanent rock features and distant landmarks) shown in the photographs on the individual site location sheet. A tape may be laid down the shore from the fixed datum marker at the top of the transect, to provide a visible reference.

Originally, at the programme’s inception, the fixed stations were located at equal intervals of 20cm vertical height (i.e. 1 tenth of the tidal range) from the fixed datum, with Station 1 at the top. Stations were originally established and relocated using a cross staff level (Baker and Crothers, 1987) with 20cm leg. The number of stations on a transect varies between sites, from 10 (sites with no lichen zone) to 29 (W. of Mioness; wave exposed site with extensive lichen zone). However, as explained in Section 2.2.1, only five stations per transect are monitored annually in the current programme. [Note: for the reference transects established in 2017, only five fixed stations were established, without any attempt to measure 20cm intervals].

The five stations currently monitored on each transect were selected to represent the five major shore zones of upper shore (Station A), upper middle shore (Station B), middle shore (Station C), lower middle shore (Station D) and lower shore (Station E) as defined by their relative height above chart datum and their assemblages of plants and animals. At two sites (Mavis Grind and Voxter Ness), it has become routine to attempt an additional station in the sublittoral fringe (Station F). However, tides and time did not allow for this in 2019. The stations surveyed are listed in Table 1.

Since 1993, precise relocation of the monitored stations is made mainly with annotated close-up photographs; except on gradually sloping boulder / shingle shores where measured distances are used. The photographs and other relocation information are provided in the ‘site location sheets’ for each site.

2.2.2 *In situ* species recording

Comprehensive surveys by the two surveyors, one surveying animals the other surveying algae and lichens, were made of all conspicuous species at each station. The categorical (semi-quantitative) abundance score for each species was noted and recorded from a 3-metre horizontal strip (1.5 m each side from the relocated station mark). The width of the strip varies depending on the slope of the substrata, aiming to represent the 10 cm height band lying below the relocated station mark. On vertical rock surfaces the band is therefore 10 cm high; but a broader band, to a maximum of 30 cm, is surveyed on gradually sloping areas. Precise relocation can be difficult over the full 3 m length but can be improved with the aid of a 3 m length of leaded line laid horizontally by eye along the top of the station. Records were written into a standard pro-forma on waterproof paper, with checklists of species for animals and plants. Categorical abundance scores are assigned from a series of abundance scales, described in Baker and Crothers (1987) (see Appendix 1), which have been used since the inception of the programme in 1976. The surveyors carry a copy of these abundance scales to refer to during the survey. Thus, in each station, species of algae, lichen and some colonial animals are each assigned a categorical abundance score based on percentage cover, while species of mobile and other non-colonial animals are each assigned a categorical abundance score based on numbers of individuals per unit area.

Protocol and rationale for estimating categorical abundance scores: Estimation of abundance for each species found is by eye and is necessarily rapid. Most species have a very patchy distribution across the long narrow (3m x 10cm) strip, many are cryptic and require some searching and many are not easy to identify rapidly and *in-situ*. Abundance estimation, averaged across the whole strip, therefore requires some mental collation of species occurrences as the surveyor works back and forth through it. Methodical use of the species checklists and occasional use of small quadrats (e.g. 10cm x 10cm) aid the process, but accurate quantitative measurement of abundance is not achievable for most species in the available time and is not recorded. Assignment to the less precise categorical abundance scores is quicker and achievable, though errors and inconsistencies in estimates may still occur. Survey time at each station depends on species richness and habitat complexity, so the time required to survey a dense algal turf habitat on the low shore takes a lot more time than upper shore bedrock covered in a few encrusting lichens. To relocate and survey a site (five stations) takes approximately 1 hour (not including travel time between sites).

Any points of interest on the shores or relating to the populations observed were also noted on the recording form.

2.2.3 Photography

Photographs were taken of each transect from different viewpoints and angles, usually the same as on the site location sheet, and close-ups of selected stations. The equipment used was an Olympus TG5 digital compact camera. Digital images (high resolution jpgs) were recorded and copies are filed with SOTEAG and ASML.

2.3 Data analysis

The data from the survey were entered into a Microsoft Access database, with a bespoke data entry module, which holds the data from previous surveys. Each record comprises the species name and taxonomic code (based on Howson & Picton, 1997), station number, site number, year and recorded abundance scores. The abundance scores are recorded as the numerical equivalent of the categories, e.g. 4 = Common (see Appendix 1).

All taxonomic nomenclature used in the database and this report has been revised and updated according to the World Register of Marine Species (www.marinespecies.org).

Tabulated printouts from the database and simple graphical presentations (graphs in Section 3.1) were used to compare the 2019 species abundances with previous years. In addition, the field notes and the photographs were compared with those from previous years and any notable changes described.

Because each abundance value is based on a semi-quantitative category, summing or averaging the numbers can give misleading results. However, a method has been devised to calculate mean abundances from these values by replacing the abundance scores with the midpoint value on the appropriate scale (Table 2). Thus, a score of ‘Common’ for barnacles, corresponding to 10 to 99 per 0.01 m^2, was converted to a value of 50 per 0.01 m^2. These values were then converted to natural logs. Absence at a station was valued as a population density an order of magnitude less than the minimum density defined in the scale. For each species, average log-transformed abundance was calculated, then anti-logged (exponential) to provide a single time series. As most species show a strong zonation pattern that restricts their vertical range, the abundances were then multiplied by a factor calculated from the maximum number of stations at which the species was ever recorded, to give typical average abundance values from within their range.

Whilst it should be appreciated that this methodology will introduce some errors into the data, the transformation of the densities will reduce the scale of this inaccuracy by taking better account of shifts at both ends of the abundance scale. The mean abundance graphs are a useful means of presenting trends that have been identified by a detailed scrutiny of the data. For some groups of taxa, including epiphytic bryozoa on fucoid algae and red algal turf species, the abundance data can also be summed and graphed to look for any trends across those whole groups. The methodologies for calculating and presenting mean abundances have been improved since the 2015 survey report. The calculations are applied as queries to the raw long-term monitoring data held in the Access database and the modifications have made it easier to identify trends and notable changes.

Table 2 Median values used in calculations for each abundance category

		Abundance category						
Scale	**Units**	**R**	**O**	**F**	**C**	**A**	**S**	**Ex**
1	No./0.01m2	0.005	0.5	5	50	200	400	600
2	No./0.01m2	0.005	0.05	0.5	5	55	200	350
3	No./0.1m2	0.05	0.25	0.75	2.5	7.5	15	30
4	No./0.1m2	0.05	0.5	2.5	7.5	15	35	60
5	No./1m2	0.25	0.5	2.5	7.5	25	75	130
6	% cover	0.1	1	2.5	12	35	65	90
7	No./0.01m2	0.005	0.05	0.5	25	60	-	-
8	No./0.01m2	0.005	0.05	0.5	50	150	-	-
9	% cover	0.1	1	2.5	12	25	-	-
10	% cover	0.1	0.5	2.5	10	35	65	90
11	% cover	0.2	1	2.5	17	45	75	95

In addition to the graphs of average abundance plotted from the above analysis, lines showing changes in the number of stations from which the species was recorded have also been plotted. Values for the latter are given on a second y-axis (on the right of the graph). The maximum number of monitoring stations is 75 (15 sites x 5 stations). The maximum number of reference stations is 25 (5 sites x 5 stations). The maximum number of new stations is 25 (5 sites x 5 stations). Data from the new reference sites have been included on graphs for selected species where they show interesting trends in recent years. The number of years given along the x-axis of the graphs varies between species, depending on their known (and reliable) inclusion in the survey. For example, epiphytic bryozoa (e.g. *Alcyonidium hirsutum*) were not surveyed before 1993. Also, the earliest year used is 1980, because Mavis Grind was only established in 1980 and the Scatsta Ness sites were only established in 1979.

2.4 Data archive

The master data are held in two *Microsoft Access* database files, one for species abundance data (currently 108,815 records) and one for the photograph catalogue (currently 7,987 photos), that are updated after each survey. ASML send copies to SOTEAG after completion of the annual report. In 2015 both databases were restructured to make them fully compliant with metadata standards developed by the Marine Environmental Data and Information Network (MEDIN). SOTEAG have sent a full copy of the database, up to 2016, to the Archive for Marine Species and Habitats Data (DASSH) (www.dassh.ac.uk). The photographs are all in high resolution digital format (jpg and tiff) (including scans of the slides and prints from the earlier surveys). Complete sets are held by ASML and SOTEAG.

Note: species records are held in the database under the name to which they were identified (or the currently accepted name in the World Register of Marine Species). However, for the purposes of long term analysis, which often requires species data to be aggregated upwards to a more reliably identified taxon, a field in the species dictionary provides the taxon for these aggregations.

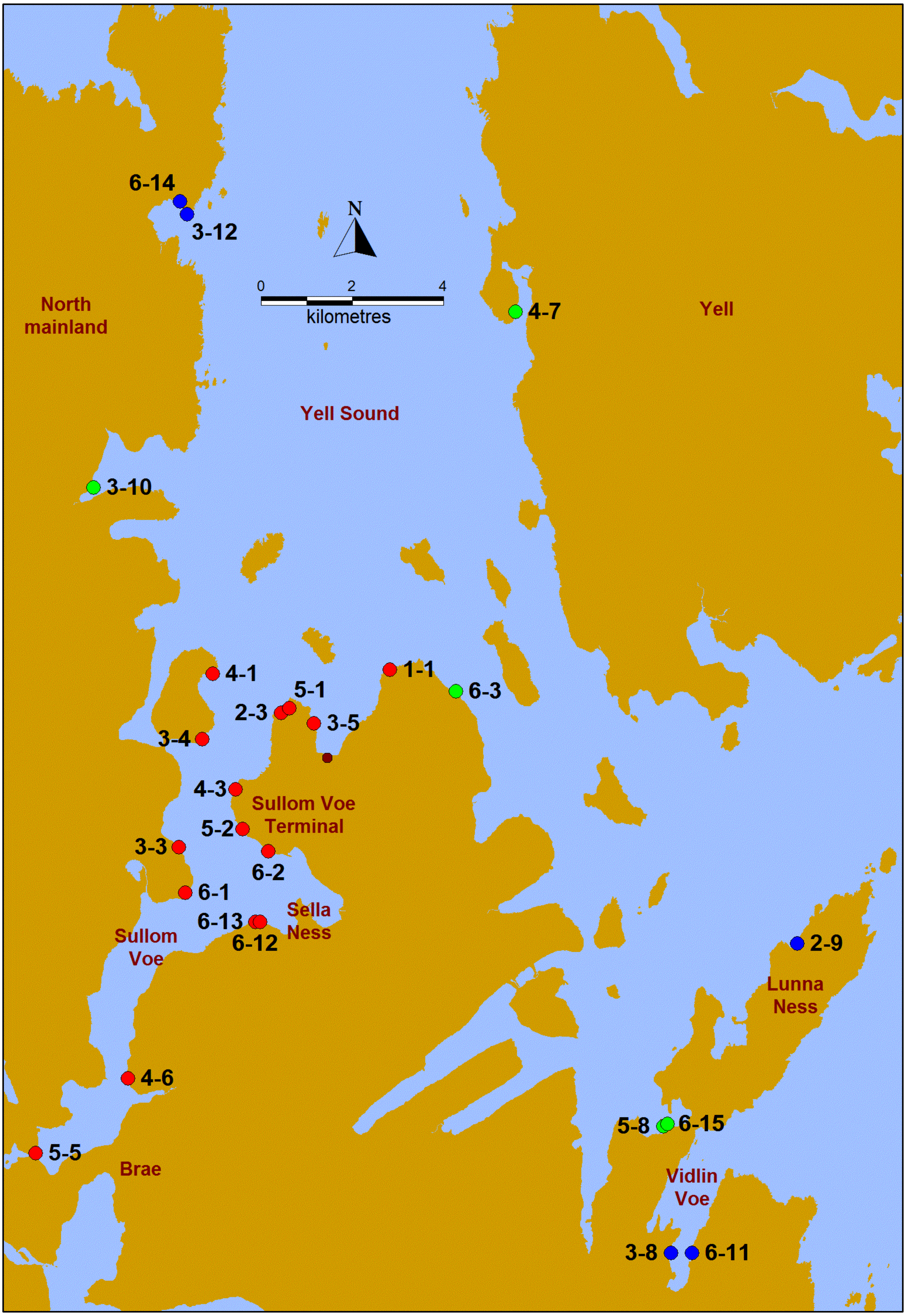


Figure 1 Location of rocky shore transect sites. Surveys of rocky shores in the region of Sullom Voe, Shetland, August 2019. ● Sullom Voe sites, ● old Reference sites (established 1993), ● new Reference sites (established 2017).

Table 3 Changes in categorical abundance of selected species between 2018 and 2019 at monitoring stations in Sullom Voe (left) and at Reference stations (right) (including stations at the 5 new reference sites). Values are the percentage number of stations at which there was a change in abundance shown in the top row of the table. Example: Osmundea hybrida reduced in abundance by three categories at 5% of Sullom Voe stations.

		Abundance changes in Sullom Voe stations									Abundance changes in Reference stations										
Entity	**EntityName**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
ZM10780	Osmundea hybrida	0	5	10	5	80	0	0	0	0	0	0	0	25	8	67	0	0	0	0	0
ZR06680.42	Fucus (spiralis/guiryi)	0	7	7	2	66	12	0	0	5	0	0	5	27	18	41	9	0	0	0	0
W008170	Nucella lapillus	4	4	14	6	48	12	8	2	2	0	6	9	9	13	47	9	6	0	0	0
ZR06760	Fucus vesiculosus	6	2	4	4	55	19	11	0	0	0	3	7	13	30	40	7	0	0	0	0
ZM10800	Osmundea pinnatifida	0	4	16	8	68	4	0	0	0	0	0	0	0	33	67	0	0	0	0	0
ZS03380	Cladophora	0	4	13	17	51	4	9	0	2	0	0	0	25	22	38	9	6	0	0	0
ZM00830	Porphyra	0	6	2	14	66	4	4	2	2	0	0	9	22	9	48	9	4	0	0	0
ZM04010	Corallina	0	3	10	7	66	10	3	0	0	0	0	7	7	43	29	0	14	0	0	0
R001080	Semibalanus balanoides	0	0	6	38	47	8	2	0	0	0	0	0	5	31	55	10	0	0	0	0
ZR06740	Fucus serratus	8	0	0	22	56	8	6	0	0	0	0	0	5	40	40	10	5	0	0	0
ZM02660	Dumontia contorta	0	3	3	7	66	14	7	0	0	0	0	13	13	7	60	7	0	0	0	0
ZR06810	Pelvetia canaliculata	0	0	14	14	59	10	3	0	0	0	0	0	12	47	24	6	6	6	0	0
ZM06110	Chondrus crispus	0	3	12	18	44	21	3	0	0	0	4	9	9	4	48	13	13	0	0	0
ZS02400	Ulva (flat)	0	3	19	6	67	6	0	0	0	0	0	0	9	9	61	17	4	0	0	0
ZS02110	Ulva (tubular)	2	2	10	8	58	15	5	0	0	0	0	5	11	16	58	0	11	0	0	0
ZM07570	Ceramiaceae (fine filamentous)	0	0	8	13	63	13	5	0	0	0	0	5	14	14	52	10	5	0	0	0
ZR02490	Elachista fucicola	3	0	13	15	41	18	8	3	0	0	0	0	8	32	48	8	4	0	0	0
ZM07510	Lomentaria articulata	0	0	0	5	79	0	16	0	0	0	0	0	38	15	23	15	8	0	0	0
W002580	Littorina saxatilis (eco. neglecta)	0	3	6	10	70	6	3	0	1	0	0	3	11	5	61	16	5	0	0	0
R000210.9	Cirripedia (dead)	0	0	8	20	55	15	2	0	0	0	0	2	5	7	71	7	5	2	0	0
W002600	Littorina saxatilis	0	4	11	7	58	9	7	1	3	0	0	4	13	11	50	7	13	2	0	0
P023550	Spirorbinae	3	6	0	3	71	6	3	3	3	0	0	4	4	4	79	4	4	0	0	0
W002550	Littorina obtusata	2	4	11	11	33	11	22	4	2	0	3	3	11	25	36	11	8	3	0	0
W001340	Patella vulgata	0	0	3	27	48	14	5	3	0	0	3	3	0	15	58	18	5	0	0	0
ZM06050	Mastocarpus stellatus	0	0	7	5	80	5	5	0	0	0	0	4	9	9	57	9	9	4	0	0
ZM03840.3	Corallinaceae (encrusting)	2	2	7	20	48	11	9	2	0	0	0	0	7	17	50	17	7	0	3	0
W002500	Littorina littorea	4	5	9	15	36	20	7	4	0	0	0	4	4	18	36	11	21	7	0	0
W016500	Mytilus edulis	0	0	6	8	57	15	15	0	0	0	0	0	7	7	59	21	7	0	0	0
W001300.1	Patella (juvenile, <10mm)	2	2	9	7	57	5	16	0	2	0	0	0	8	4	50	17	13	8	0	0
ZM03760	Hildenbrandia	0	0	5	12	30	32	19	1	0	0	0	0	2	22	27	20	27	2	0	0
R000210.1	Cirripedia (spat)	0	0	6	13	39	16	23	3	0	0	0	2	0	5	48	21	14	7	2	0
ZY00035	Verrucaria	0	0	1	9	35	24	20	8	3	0	2	2	4	14	36	26	10	4	0	2

3 Results

3.1 Fluctuations in abundance of selected species

Table 3 provides a summary of the abundance changes that occurred between August 2018 and August 2019 for the most frequently recorded taxa. The majority of these changes continued to reflect natural variability from year to year, but there were notable changes in some species and at some sites.

The following sections describe the results for selected characterising species and others that have shown notable changes. The mean abundance graphs have been prepared using the methodology described in Section 2.3, for Sullom Voe sites and Reference sites.

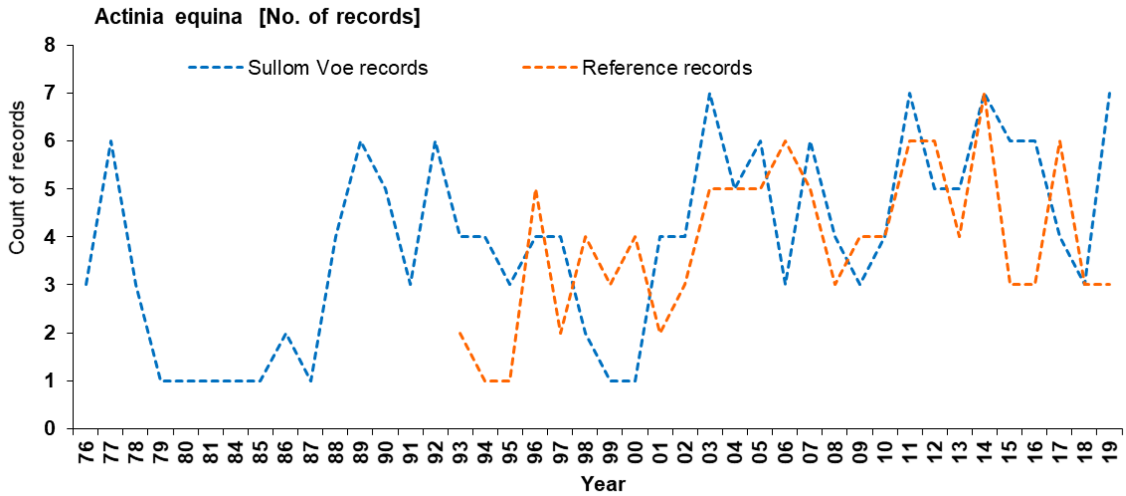
Other tables of data have been prepared from the species abundance data, with colour coding (conditional formatting features in Excel) to highlight patterns in those abundances between years, sites and species.

Appendix 1 provides the abundance scales used for each species. The fixed monitored stations, representing the five shore zones, are referred to in the text and some tables as follows: upper shore (A), upper middle shore (B), middle shore (C), lower middle shore (D), lower shore (E) and sublittoral fringe (F).

Note: for readers with the electronic version of this report, the species names in the section headings below contain hyperlinks to relevant pages on their biology on the MarLIN website.

3.1.1 Actinia equina

Beadlet anemones are frequent on some of the monitoring sites, typically in crevices or under boulders. On warm dry days they pull back into the crevices where they are less easily visible. The abundance scales are not well designed for recording them in the small areas defined for the stations, so the numbers of records are a better measure for describing temporal change. The graph below shows very large fluctuations, at least some of which will be due to a greater or lesser effort to search for them by the surveyors (particularly in the period from 1979 to 1987). However, the apparent trend of increase since the methodology changed in 1993 is interesting.

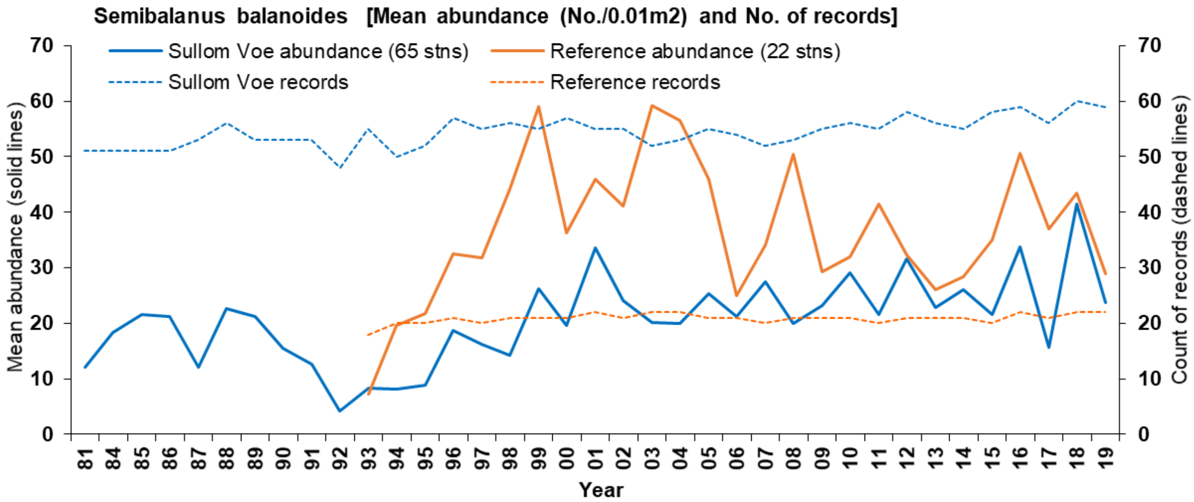


3.1.2 Semibalanus balanoides

Semibalanus balanoides at W. of Mioness (left) and Riven Noust (right), including adults, spat and empty cases (likely eaten by dogwhelks)

Average densities of barnacles *Semibalanus balanoides* were lower than 2018, at both Sullom Voe and Reference sites, but were well within the normal range of fluctuations (see graph below). The reduced densities were recorded across the full range of sites (see table below), with no trends related to the terminal, to wave exposure or any other factor. There was a wide age range of barnacles present, suggesting good survival over the last winter, which in turn might suggest reduced space for early settlement and therefore reduced recruitment of young adults.

Densities of barnacle spat had fallen in recent years, after a peak in 2014, but were moderately higher in the 2019 survey. However, interpretation of these data is not straightforward as they only represent the later settlement of these barnacles, i.e. near the end of their season.

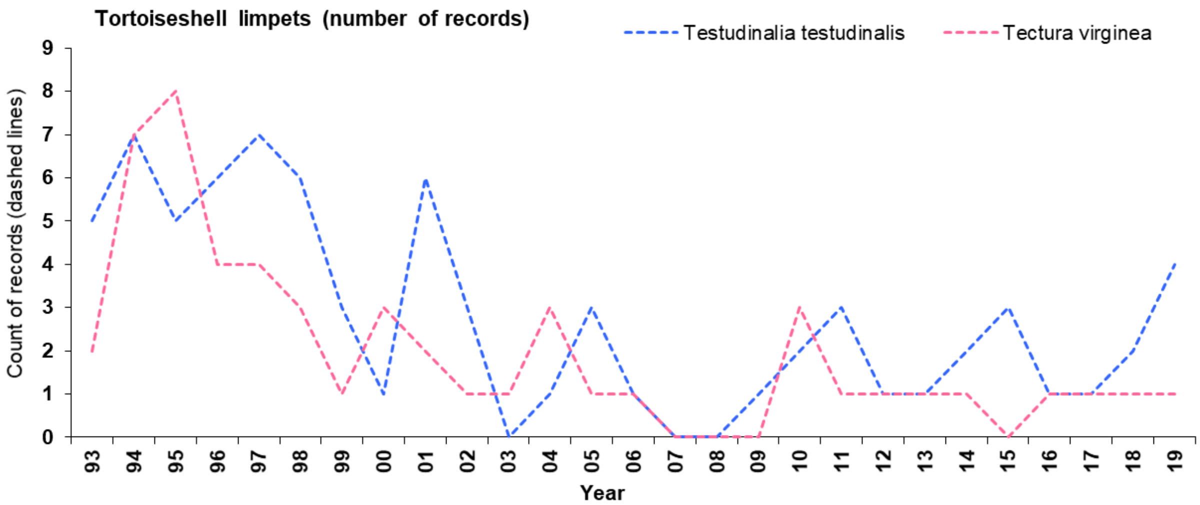


Semibalanus balanoides (sum of abundance scores from five stations, by site and year)

		81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Sullom Voe	West of Mioness	12	12	13	14	14	10	16	15	18	11	13	13	15	18	15	14	15	15	15	16	14	14	11	13	12	15	13	15	15	19	17	15	15	16	16	17	16
	Roe Clett	16	16	16	16	18	21	16	15	15	13	14	13	14	18	18	18	19	18	15	13	14	16	16	15	16	16	18	19	18	21	18	13	18	17	16	19	16
	Noust of Burraland	16	16	17	16	16	28	20	21	21	14	20	18	16	16	18	19	22	22	21	19	19	21	20	15	18	20	20	19	21	20	20	19	18	20	17	20	18
	Gluss Island East	17	17	17	17	17	17	18	17	20	14	16	14	19	21	21	20	23	20	21	21	21	23	23	21	21	21	20	23	22	21	23	21	23	24	19	22	21
	South of Swarta Taing	15	15	15	15	15	13	16	16	15	11	14	16	13	17	15	16	17	15	16	13	15	15	17	14	15	12	14	14	15	18	15	16	15	16	15	17	15
	Grunn Taing	16	16	17	16	17	16	17	15	15	13	14	16	16	18	17	18	19	19	18	20	20	20	20	17	18	17	19	19	19	19	19	18	19	20	19	19	19
	The Kames	11	12	12	12	14	15	15	11	11	10	13	13	15	14	12	13	15	14	13	14	13	16	15	13	14	14	12	12	14	14	14	15	14	15	13	15	14
	Voxter Ness	12	14	15	13	14	19	15	17	17	13	15	16	13	16	15	15	16	17	21	19	18	20	21	19	21	17	19	21	21	21	20	20	21	19	18	19	19
	South of Skaw Taing	11	11	11	11	10	14	9	11	10	7	10	8	10	11	9	9	11	7	12	11	10	10	7	8	8	9	8	13	9	8	7	11	9	12	7	9	8
	Jetty 3	12	15	15	16	14	15	15	14	11	8	10	10	11	16	14	13	15	14	19	17	16	16	17	14	19	15	17	15	17	17	14	15	17	17	14	17	16
	Mavis Grind (Stream 3)	13	13	13	18	10	10	10	10	10	10	12	10	10	10	10	11	10	11	13	13	10	10	15	15	14	14	14	12	13	14	13	16	13	16	13	15	15
	Fugla Ayre	6	12	12	12	6	13	17	9	9	7	8	9	10	11	11	9	14	14	16	15	15	10	11	13	10	8	14	17	14	15	13	15	15	14	11	19	14
	South of Jetty 2	9	10	9	11	8	15	14	11	8	4	7	7	6	12	12	12	15	14	18	15	15	13	15	14	17	14	13	16	13	16	14	13	14	15	12	16	14
	Scatsta Ness (cleared)	13	13	14	14	12	9	14	12	12	9	12	9	8	13	15	14	15	13	15	14	9	11	14	15	15	15	15	14	9	16	16	16	13	18	13	18	14
	Scatsta Ness (uncleared)	7	8	10	7	7	16	11	10	8	3	6	4	7	13	11	10	12	12	13	10	8	9	13	14	12	10	12	14	10	12	11	13	10	12	10	15	12
Reference	Riven Noust											16	17	22	21	20	21	23	20	20	19	21	21	21	20	21	22	18	21	21	21	19	16	19	22	20	19	19
	Vidlin Ness											17	18	18	19	21	24	23	24	26	24	24	23	25	22	25	24	23	22	23	22	19	24	22	24	22	25	22
	Burgo Taing											11	15	18	17	17	20	19	20	19	18	18	21	19	20	18	19	19	17	15	18	19	17	19	19	18	18	18
	Kirkabister											10	14	11	16	11	13	12	12	17	15	18	19	15	11	13	15	12	13	14	13	14	15	11	17	14	16	15
	North Burra Voe											8	11	11	12	14	14	16	13	13	13	15	13	14	11	10	13	13	13	10	13	12	12	13	14	12	13	12
New refere.	Ola's Ness																																			19	21	20
	West Sandwick																																			17	19	19
	West Lunna Pund South																																			14	15	12
	West Lunna Pund North																																			13	15	13
	Croo Taing																																			15	16	14

3.1.3 Testudinalia testudinalis and Tectura virginea

Occasional specimens of these small limpets are found in shaded microhabitats of some lower shore stations, although their populations are mostly subtidal. There were a few more in 2019 than recent years, although there were more records in the 1990s (see graph and photographs below).



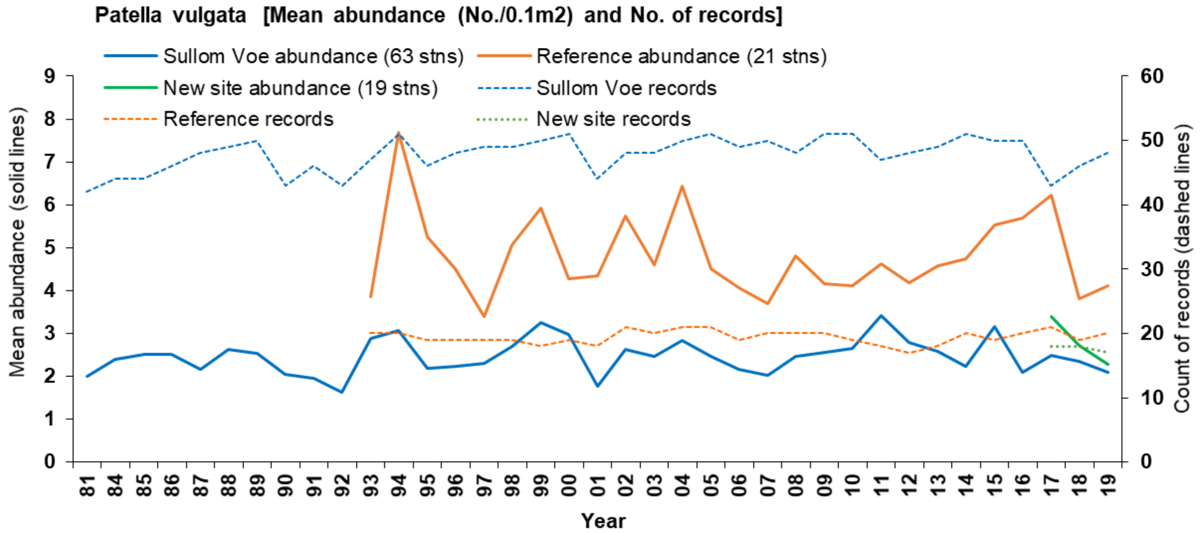
Testudinalia testudinalis at Kirkabister and Tectura virginea at Mavis Grind.

3.1.4 Patella vulgata

Following the notable decline in densities of adult limpets at all of the reference sites in 2018 (including most of the new reference sites), the 2019 data suggest a modest increase at those sites (see graph below). There were also modest increases in juvenile limpets.

Populations at the Sullom Voe sites continued to show a typical range of fluctuations, with average densities of adults and juveniles remaining fairly stable. Decreased abundances were recorded at four stations on the Jetty 3 transect (see table below), but these were still within the range recorded previously, while abundances on the Jetty 2 transect had increased.

Patella vulgata, adult and juveniles, amongst barnacles at Mavis Grind.



Patella vulgata 5-2 Jetty 3

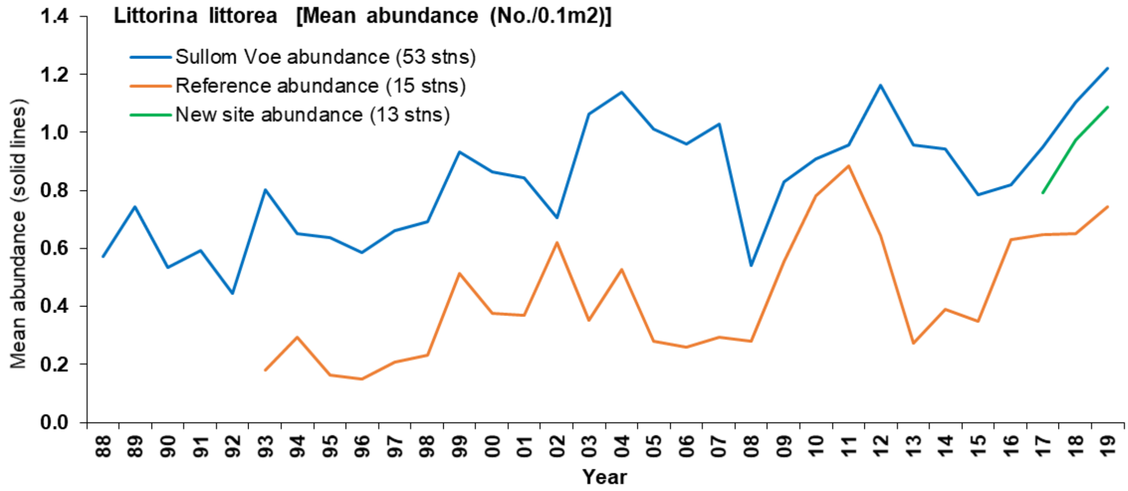
	81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
US	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UMS	0	0	4	0	0	2	2	3	3	3	3	3	3	3	4	3	4	4	4	4	4	3	3	4	3	4	3	4	4	4	4	4	4	3	3	4	3
MS	2	3	2	2	4	4	3	3	2	3	4	5	4	3	3	5	4	4	4	3	4	3	4	4	4	3	5	4	5	5	4	4	4	4	4	4	3
LMS	0	0	3	0	3	1	1	0	0	1	1	0	2	0	2	2	3	2	0	3	4	2	3	2	2	0	2	3	4	2	2	2	2	3	0	3	2
LS	3	3	3	4	3	3	3	3	3	2	0	4	2	2	1	2	2	0	1	0	2	0	3	2	3	2	2	3	4	3	4	3	4	4	4	4	3

Patella vulgata 6-2 South of Jetty 2

	81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
US	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UMS	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2	2	0	2	0	3	2	2	0	0	3	0	0	0	0	2	3
MS	0	0	0	0	4	1	1	0	0	1	2	1	0	3	3	2	2	3	1	3	4	3	4	3	2	2	3	3	3	4	4	2	2	0	0	0	3
LMS	0	4	0	3	1	2	2	0	0	0	0	3	2	3	2	3	4	1	0	0	4	3	3	2	3	3	3	3	3	3	4	4	2	4	3	2	3
LS	0	0	0	0	0	2	0	2	0	0	0	2	3	2	0	2	3	2	0	3	4	3	2	2	2	2	0	3	2	2	0	3	2	4	4	2	4

3.1.5 Littorina littorea

Edible winkles (see photo below) are most abundant at the relatively sheltered sites, particularly on the boulder shores. A trend of increasing abundance of these snails has been apparent for many years and is likely linked to the increase in fucoid algae. Recent increases in average densities are shown in the graph below, which includes data from the new reference stations (green line). Detailed inspection of the site data shows that the 2019 increases did not occur at all sites and that the largest increases were mostly at the boulder sites.



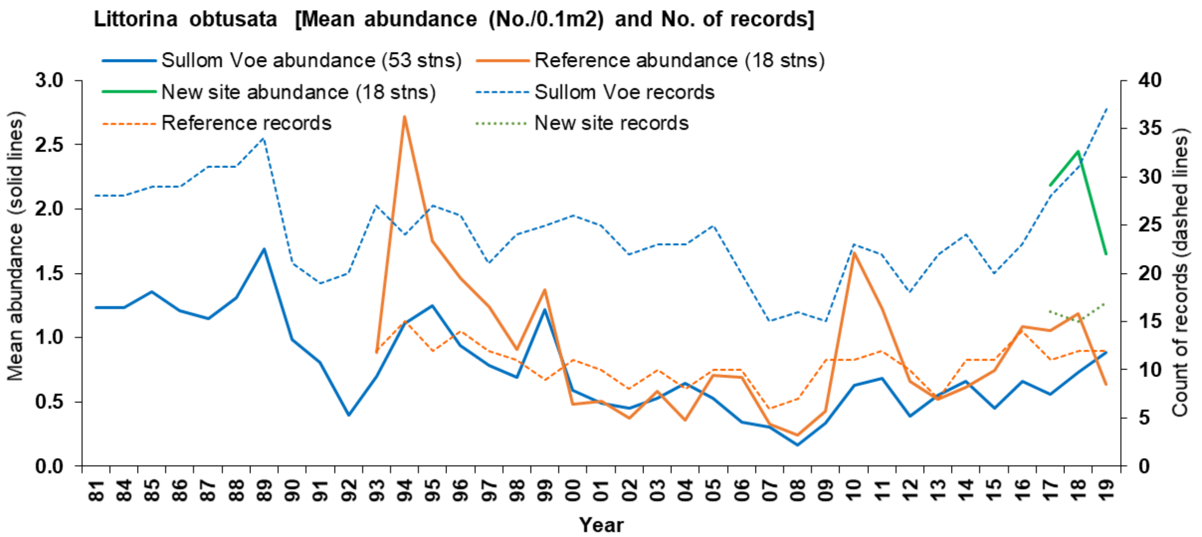
Littorina littorea (sum of abundance scores from five stations, by site and year)

		81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Sullom Voe	West of Mioness	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roe Clett	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	2	0	2	0	2	0	2	2
	Noust of Burraland	2	2	2	2	2	2	3	1	1	0	2	3	0	0	12	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	2	2	2	0	13	5
	Gluss Island East	0	0	0	0	0	0	4	0	0	0	3	5	4	5	5	4	3	5	5	0	2	6	5	7	7	7	4	7	7	6	6	5	3	2	6	10	8
	South of Swarta Taing	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	3	0	4	0	2	0	0	2	3	2
	Grunn Taing	0	0	0	0	0	0	0	0	0	4	2	2	4	2	0	6	4	5	2	2	5	6	4	6	8	1	2	4	7	8	0	6	2	4	7	8	6
	The Kames	1	1	1	1	1	2	2	2	2	0	2	0	2	3	4	0	6	0	3	0	8	3	6	2	7	2	4	3	5	3	3	2	3	2	3	7	4
	Voxter Ness	9	9	9	9	9	11	11	13	13	10	17	11	7	9	9	11	11	16	12	10	12	13	18	13	13	11	9	10	2	10	10	8	6	9	13	14	11
	South of Skaw Taing	3	3	3	3	4	5	13	4	5	5	5	9	6	4	5	6	4	4	5	4	6	7	6	9	5	4	5	8	5	8	6	5	7	6	8	4	6
	Jetty 3	2	2	2	7	6	9	7	6	7	9	11	11	12	12	8	12	13	7	11	14	12	16	11	13	13	11	11	14	14	11	14	11	15	16	13	12	16
	Mavis Grind (Stream 3)	8	8	8	9	9	5	5	5	6	7	9	9	2	6	5	7	11	14	11	8	17	13	10	12	11	11	13	5	8	4	2	3	6	2	6	13	9
	Fugla Ayre	2	2	6	2	4	7	9	8	8	2	7	5	2	0	2	0	4	3	7	5	7	5	3	0	0	0	3	3	3	3	7	2	0	0	0	3	5
	South of Jetty 2	5	5	5	5	7	8	6	6	5	7	7	14	11	13	14	14	17	16	15	12	18	15	18	13	15	8	20	18	17	19	23	21	14	11	19	12	14
	Scatsta Ness (cleared)	11	11	11	13	11	15	13	14	14	15	14	11	16	14	16	14	16	15	18	13	18	17	13	17	16	11	16	16	18	21	16	16	19	22	18	15	19
	Scatsta Ness (uncleared)	10	10	10	10	11	8	15	11	11	7	12	9	12	8	12	11	14	16	12	13	8	14	14	14	14	14	16	15	19	19	19	19	18	17	15	18	17
Reference	Riven Noust											0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Vidlin Ness											7	0	0	0	2	0	0	2	0	0	0	0	2	2	0	0	2	6	7	2	0	2	7	5	7	6	8
	Burgo Taing											0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	2
	Kirkabister											6	10	9	7	7	10	10	10	11	15	12	16	11	8	11	11	15	18	19	18	14	14	7	14	14	12	13
	North Burra Voe											0	6	2	3	5	2	8	3	6	6	3	6	2	3	5	4	4	3	2	2	0	3	3	5	7	8	12
New refere.	Ola's Ness																																			0	0	1
	West Sandwick																																			0	0	3
	West Lunna Pund South																																			6	10	13
	West Lunna Pund North																																			13	13	11
	Croo Taing																																			7	7	4

Littorina littorea (left). Littorina fabalis on Fucus serratus (right)

3.1.6 [Littorina obtusata](#) / L. fabalis

The upward trend in average densities of flat winkles, described in the 2018 report, came to an abrupt halt in 2019. The graph below shows that there was a notable decrease across the reference sites and the new sites, but a continued increase in Sullom Voe. However, those average values mask a lot of fluctuations and there were increases and decreases in all areas. The most notable changes were at Voxter Ness, where no flat winkles were found, despite an apparent increase in fucoid algae, and at Croo Taing where numbers had decreased sharply in the upper and mid shore stations. However, neither of those reductions are particularly unusual for those sites (see example table of abundances for Voxter Ness below).



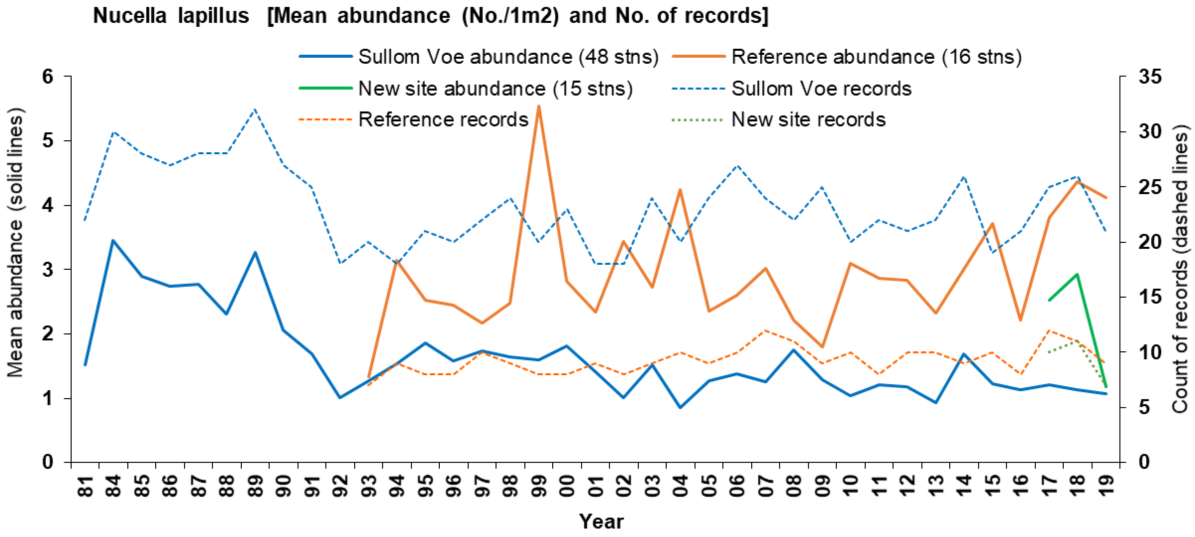
Littorina obtusata 4-6 Voxter Ness

	81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
MS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	3	0
LMS	3	3	3	3	3	3	3	0	0	0	0	0	0	0	2	0	0	1	0	2	2	0	0	0	0	0	0	0	0	2	4	2	0	3	2	3	0
LS	2	2	2	2	2	2	3	0	0	0	2	0	2	0	0	0	0	2	0	0	0	3	3	2	0	0	0	0	0	2	2	2	0	0	2	2	0

3.1.7 [Nucella lapillus](#)

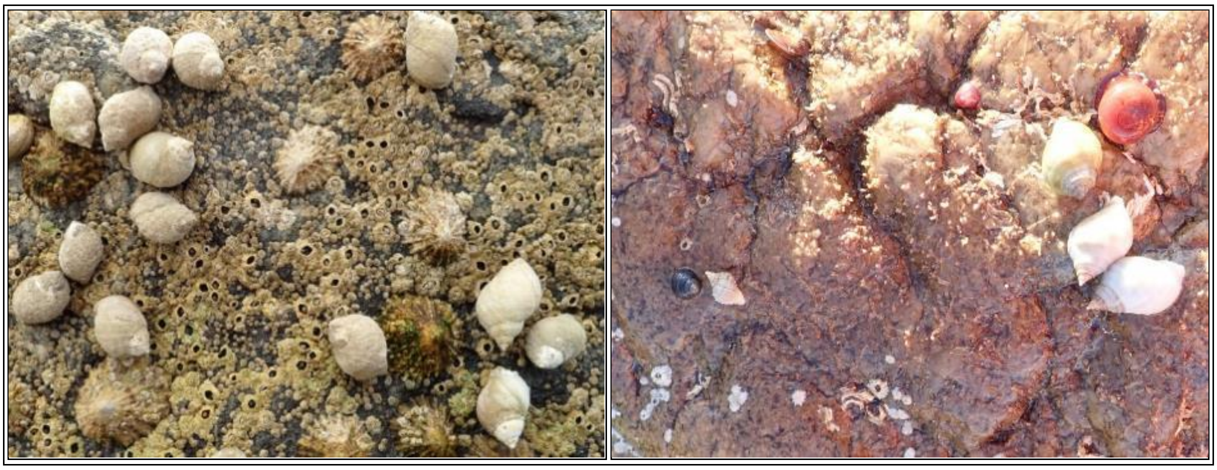
A gradual recovery of dogwhelk populations, following their decline at sites impacted by TBT antifouling paints, has been described in recent years from sites close to the oil terminal. However, their average abundance across the Sullom Voe sites still appears to be lower than it was in the 1980s.

There was an overall reduction in 2019, some of the largest being at the new reference sites (see graph below), but with no obvious relationships to environmental factors.



Nucella lapillus (sum of abundance scores from five stations, by site and year)

		76	77	78	79	80	81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Sullom Voe	West of Mioness	8	14	12	8	7	7	12	13	8	7	14	9	14	14	9	15	11	11	14	11	13	8	11	8	10	13	10	7	10	8	9	13	11	12	10	10	12	15	10	10	12	11
	Roe Clett	9	15	5	0	5	7	7	7	9	12	9	15	5	7	2	7	0	2	7	4	7	8	9	3	3	10	3	6	6	11	9	8	8	10	9	10	9	8	5	4	4	4
	Noust of Burraland	11	8	11	3	14	9	9	9	10	9	4	13	10	10	8	8	11	8	11	7	10	13	11	10	12	3	6	5	3	3	3	6	7	9	7	9	8	6	7	8	2	2
	Gluss Island East	9	11	8	7	8	6	8	6	9	12	10	15	12	13	9	15	9	17	5	11	10	9	9	7	8	8	3	6	3	5	9	10	0	3	3	2	2	3	3	4	6	6
	South of Swarta Taing	9	4	6	4	6	9	9	9	7	7	13	12	11	7	3	4	11	12	11	10	10	0	9	8	7	6	3	10	6	2	3	6	3	5	3	2	10	8	3	11	5	2
	Grunn Taing	10	13	19	13	10	14	15	16	16	15	9	15	15	13	17	9	18	17	16	13	14	14	13	15	6	11	5	13	13	14	14	11	14	13	12	11	11	9	11	9	6	10
	The Kames	9	8	10	5	3	6	6	5	5	8	9	6	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	3	3	3	3	4	8	4	6	5	4	5	6	4
	Voxter Ness	9	5	4	6	4	10	10	10	10	11	10	6	3	3	5	6	5	10	10	8	12	9	13	5	5	4	5	8	9	11	11	7	7	0	5	3	7	0	3	4	2	0
	South of Skaw Taing	9	5	8	4	4	7	13	8	9	12	6	10	10	10	6	6	8	5	2	8	5	10	2	3	3	13	12	12	10	7	13	8	8	10	6	5	10	3	8	4	8	5
	Jetty 3	7	6	4	0	0	0	2	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	6	4
	Mavis Grind (Stream 3)					0	0	3	3	0	0	6	6	6	6	3	0	0	2	3	6	1	3	5	7	4	7	5	5	5	4	2	0	0	0	0	0	2	3	2	2	2	0
	Fugla Ayre	2	2	2	0	0	1	2	1	1	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	South of Jetty 2	2	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	4	7
	Scatsta Ness (cleared)				4	5	0	15	15	14	9	10	10	7	5	2	1	3	4	2	9	6	7	8	8	6	7	10	6	11	8	8	7	2	5	8	9	2	12	10	17	14	13
	Scatsta Ness (uncleared)				4	0	0	3	0	0	3	4	3	3	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	8	3	3	4	6	4	3	4	11	0	5	3	4	3
Reference	Riven Noust		11														13	16	12	16	13	15	15	16	16	18	17	19	15	11	15	11	8	16	11	12	13	18	14	14	13	20	19
	Vidlin Ness		5	7	9	8											0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0
	Burgo Taing																8	17	18	14	14	14	19	17	14	15	14	15	10	12	13	14	12	13	9	15	11	15	14	13	15	11	15
	Kirkabister		6	6	0	2											0	0	0	0	1	0	0	0	0	0	0	3	4	9	5	3	2	0	3	6	4	3	4	0	5	5	4
	North Burra Voe																4	5	4	4	7	7	9	3	5	5	6	7	6	6	10	10	10	11	10	6	9	2	9	6	11	8	4
New refere.	Ola's Ness		7																																						3	0	2
	West Sandwick																																								8	13	8
	West Lunna Pund South																																								15	10	8
	West Lunna Pund North																																								2	5	0
	Croo Taing	13	2																																						8	12	6



Dogwhelks: Adults feeding on barnacles (left). Juveniles under boulder on Jetty 3 transect.

However, there were increased abundances at the S. of Jetty 2 transect, which resulted in the highest abundances ever recorded from that site, including records from before the introduction of TBT (see table of abundance records below). Numerous juveniles were present under boulders on the lower and middle shore.

Nucella lapillus 6-2 South of Jetty 2

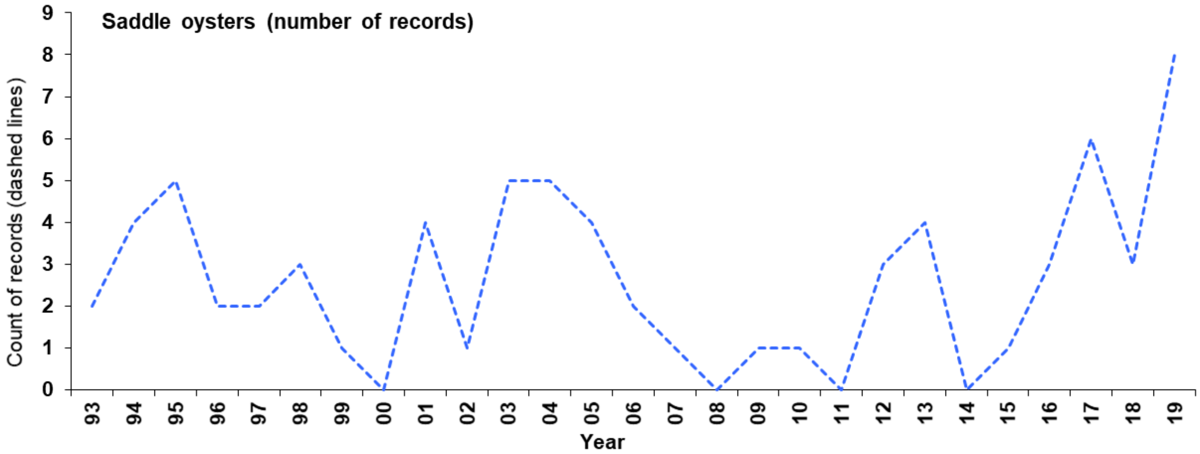
	76	77	78	79	80	81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
MS	2	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
LMS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	4	3
LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2

No dogwhelks were found at Vidlin Ness in 2019. This site has been characterised by a notable lack of dogwhelks since the early 1990s (see Moore and Bunker 2017 for more details and discussion). A few individuals were recorded in 2017 and 2018, and it was thought they might signal the start of a recovery.

For more information on dogwhelk populations see the associated report from SOTEAG's dogwhelk monitoring programme, which was last repeated in 2018 (Moore, Anderson & Mercer, 2018).

3.1.8 Anomiidae

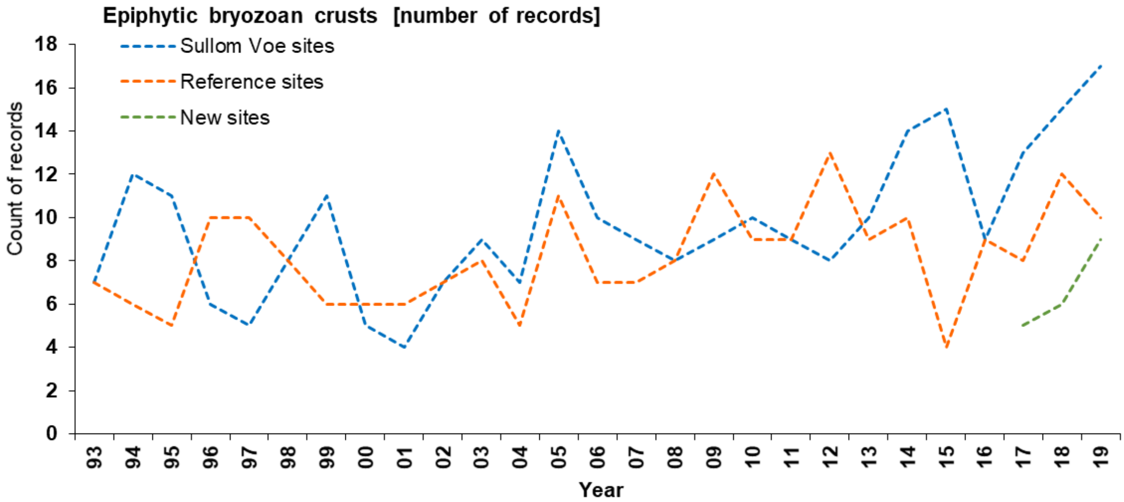
Saddle oysters (see photo below) are found under boulders and other shaded habitats of the lower shore at some sites. They are fairly cryptic, so fluctuations in the data cannot be relied upon. However, the recent rise in numbers of records (see graph below), due to additions from the new reference sites, suggests that there are now enough to make it worthwhile focussing more attention on them in future reports.



Saddle oysters (Anomiidae) amongst hydroids and algae at Roe Clett; and Alcyonidium hirsutum on low shore fucoids at Fugla Ayre.

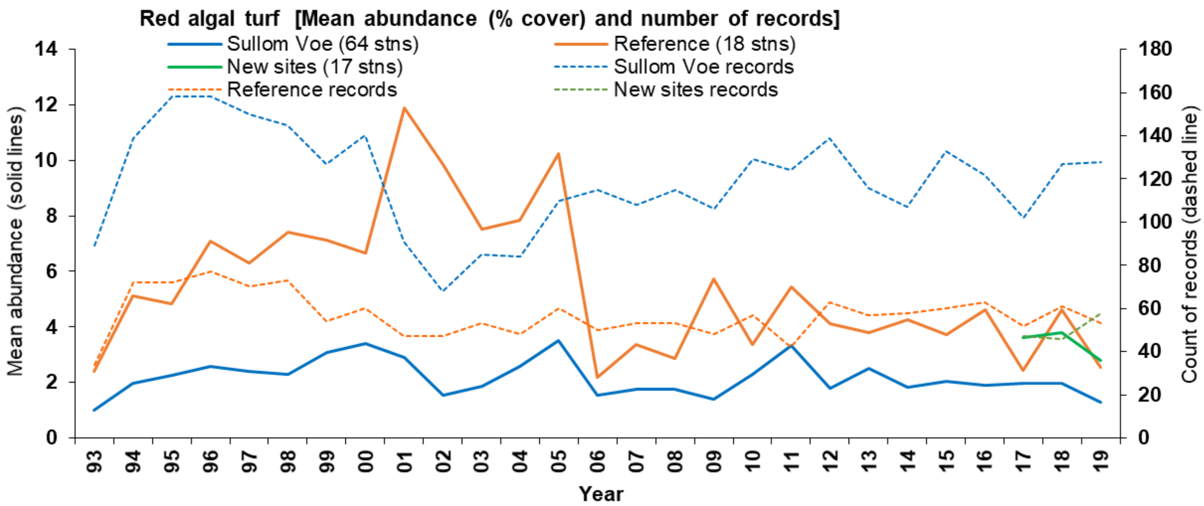
3.1.9 *Flustrellidra hispida* & *Alcyonidium* spp.

Epiphytic bryozoa, growing on serrated wrack and other lower shore algae (see photos below), were more frequently recorded in 2019 at Sullom Voe sites than usual and there was also an increase at the new reference sites, but not at the other reference sites. Interestingly, many of the increases were from the Alcyonidium species (*A. hirsutum* (see photo above) and *A. gelatinosum*) rather than *Flustrellidra hispida* which is usually more abundant. There were no trends in relation to the terminal and the changes are considered to be natural fluctuations.



3.1.10 Red algal turf

A large number of foliose and filamentous red algal taxa have been recorded from the monitoring sites. The most abundant include *Mastocarpus stellatus* (False Irish moss), *Chondrus crispus* (Irish moss/Carrageen), *Vertebrata lanosa* (associated with the knotted wrack *Ascophyllum nodosum*), *Corallina* spp., *Osmundea pinnatifida*, *Lomentaria articulata*, *Polysiphonia* spp., other fine filamentous Ceramiaceae (aggregated because they often require microscopic identification) and *Dumontia contorta*. Individually, many of these red algal taxa can fluctuate considerably from year to year (see table below graph), but the average cover of red algal turf has remained fairly stable for many years (see graph below).

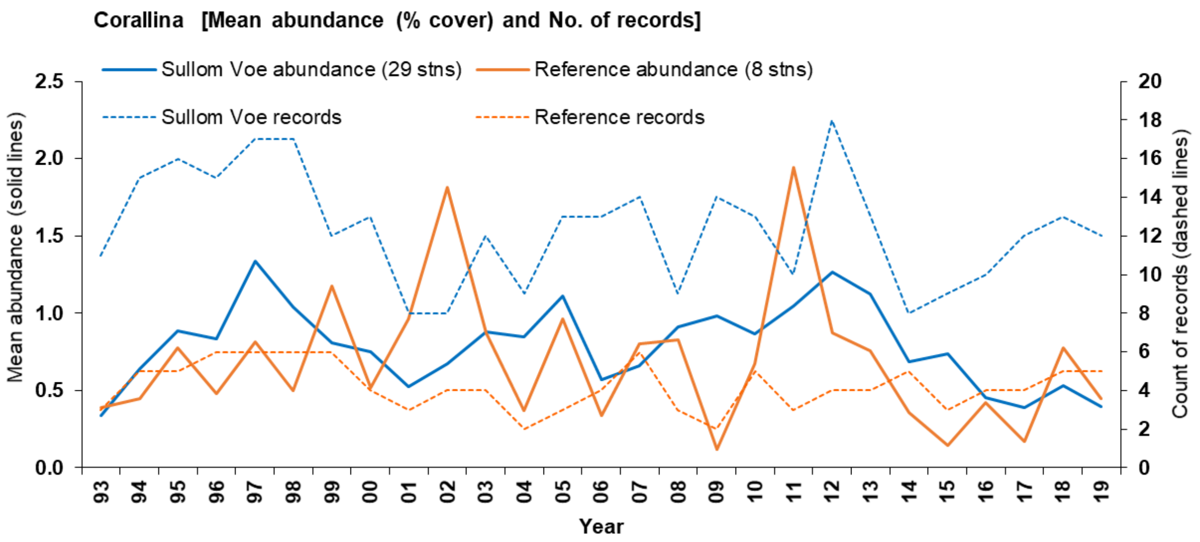


Selected red algal turf taxa, sum of abundance scores by year (summed across all Sullom Voe sites)	81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Dumontia contorta	30	30	30	30	29	23	25	13	15	14	16	13	25	24	15	18	19	19	31	3	11	9	15	7	4	3	1	7	2	6	7	5	20	11	13	8	9
Corallina	44	44	44	44	59	55	44	37	35	31	21	33	39	39	45	43	34	33	24	27	38	31	41	29	33	30	36	32	35	44	37	25	27	25	24	30	24
Mastocarpus stellatus	41	41	41	44	43	50	54	46	43	44	37	54	44	50	48	50	53	56	36	24	33	34	55	46	40	48	42	58	65	54	50	41	50	52	23	33	31
Chondrus crispus	0	0	0	0	5	7	8	4	7	4	3	23	28	30	28	24	21	22	16	14	23	12	16	18	14	27	21	21	14	21	22	28	18	18	35	37	29
Lomentaria articulata	9	9	9	9	19	11	18	11	11	13	9	17	14	14	15	18	18	18	19	13	15	12	19	18	14	13	11	18	20	20	18	19	14	8	14	7	12
Ceramiaceae (fine filame	45	41	45	45	51	50	43	25	29	18	14	30	28	46	49	49	36	45	26	15	21	39	42	25	22	34	28	28	24	35	26	22	25	21	17	21	19
Plumaria plumosa	0	0	0	0	0	0	1	0	0	0	0	2	2	8	6	7	5	3	0	3	0	6	0	3	6	5	2	7	6	6	4	4	10	11	4	6	8
Membranoptera alata	0	0	0	0	0	0	0	1	0	1	3	10	10	9	8	9	11	8	5	6	9	6	11	6	8	9	1	7	13	16	10	9	15	10	6	8	7
Osmundea hybrida	31	30	29	31	34	29	31	19	17	17	13	14	20	20	16	19	12	25	7	19	20	27	3	24	18	9	0	6	0	7	9	9	6	7	5	8	0
Osmundea pinnatifida	33	33	31	33	37	30	33	28	26	24	17	33	28	29	30	32	26	19	30	13	14	9	19	17	20	21	24	20	33	28	21	24	23	22	19	27	15
Polysiphonia	25	25	25	25	25	19	17	13	15	10	23	30	30	24	20	35	19	20	13	13	17	11	33	8	16	8	5	3	20	2	4	4	4	20	6	8	15
Vertebrata lanosa													16	18	17	9	20	17	21	19	17	26	13	17	22	19	9	20	35	16	29	19	27	23	21	23	20

Mastocarpus stellatus and *Chondrus crispus* are both widespread and common, particularly on the lower shore, but they are sometimes difficult to distinguish. However, reliably identified plants of both species were present and in good condition at both Sullom Voe and Reference sites.

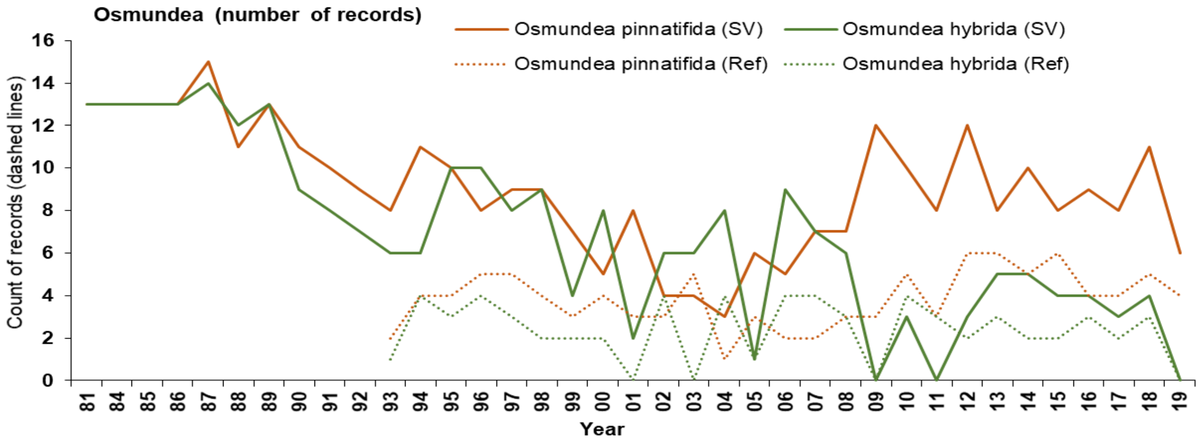
Mastocarpus stellatus at Riven Noust (left). Chondrus crispus (right).

Corallina records primarily comprise *C. officinalis* (the common species at this latitude), but various other erect branching coralline algae have also been recorded and their records have been aggregated as *Corallina* for analysis purposes because they could easily be confused with it in a mixed turf. They include *C. caespitosa* (a southern species, fairly recently identified as present in the UK), *Ellisolandia elongata* (see photo below) which was recorded for the first time in 2019 (diminutive forms at Roe Clett and S. of Skaw Taing) and *Jania* (probably *J. rubens*) which was recorded once in 1997. Their average abundance has decreased in recent years (see graph below), though notable fluctuations have also occurred. The records of *C. caespitosa* and *E. elongata* require further work to confirm them, as they are possibly the most northern records for these species.

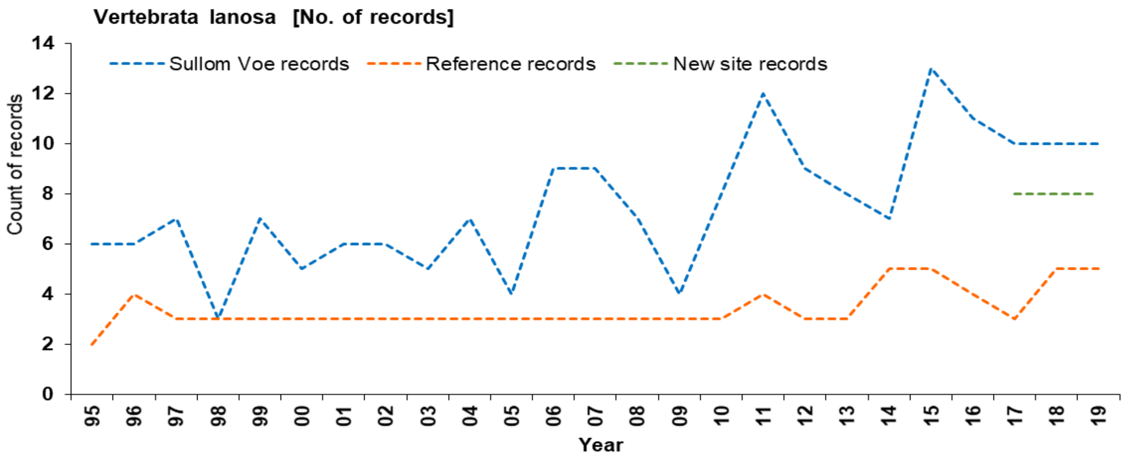


Ellisolandia elongata and Osmundea pinnatifida (amongst Himanthalia buttons), at Roe Clett.

Records of *Osmundea pinnatifida* (see photo above) and *O. hybrida* appear to have considerably declined within Sullom Voe since the early years of the programme (see graph below), and *O. hybrida* has been uncommon or absent from the data for a number of years. 2019 was another bad year for these species. The reason for the decline is unknown, but reductions at Reference sites as well as Sullom Voe sites suggests that they are not related to terminal operations.



Vertebrata lanosa (previously known as *Polysiphonia lanosa*) has an almost exclusive association with knotted wrack *Ascophyllum nodosum* (see photos below), but it was not distinguished from other *Polysiphonia* species in these SOTEAG surveys until 1995. The graph below suggests there has been a trend of increase over the last decade, which will have some relationship with the abundance of its host (see next section), but the presence and abundance of the epiphyte is also affected by other environmental factors.



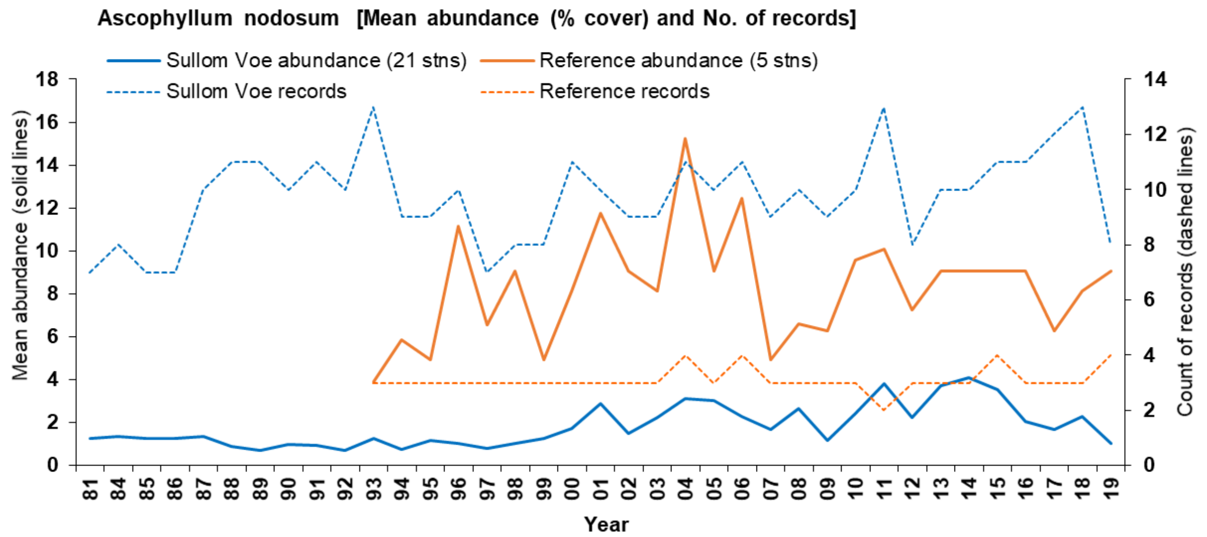
3.1.11 *Ascophyllum nodosum*

The knotted wrack (see photos below) is only found in abundance at sites with very sheltered conditions. It suffered from various damaging activities associated with the terminal at the sites in Sullom Voe during the 1970s (see Moore and Howson 2015, for more details) but populations recovered considerably and were likely back to pre-impact levels at all sites by 2013. Further disturbance on the S. of Jetty 2 transect occurred in 2016 with the removal of some boulders (see Moore and Mercer 2016), and the site appears to show continued instability with no *A. nodosum* recorded from the monitoring stations and very little visible in the photographs. Abundances at the reference sites were stable.

Ascophyllum nodosum (max of abundance scores from five stations, by year at selected sites)

		76	77	78	79	80	81	84	85	86	87	88	89	90	91	92
SV	Mavis Grind (Stream 3)					0	4	4	4	4	4	3	3	4	4	4
SV	South of Jetty 2	5	3	0	0	0	0	0	0	0	0	1	2	1	1	0
SV	Scatsta Ness (cleared)				5	3	4	4	4	4	3	3	2	3	4	3
SV	Scatsta Ness				6	6	5	5	5	5	5	5	5	5	4	4
R	North Burra Voe															
New	West Lunna Pund South															
New	West Lunna Pund North															
New	Croo Taing	6	5													

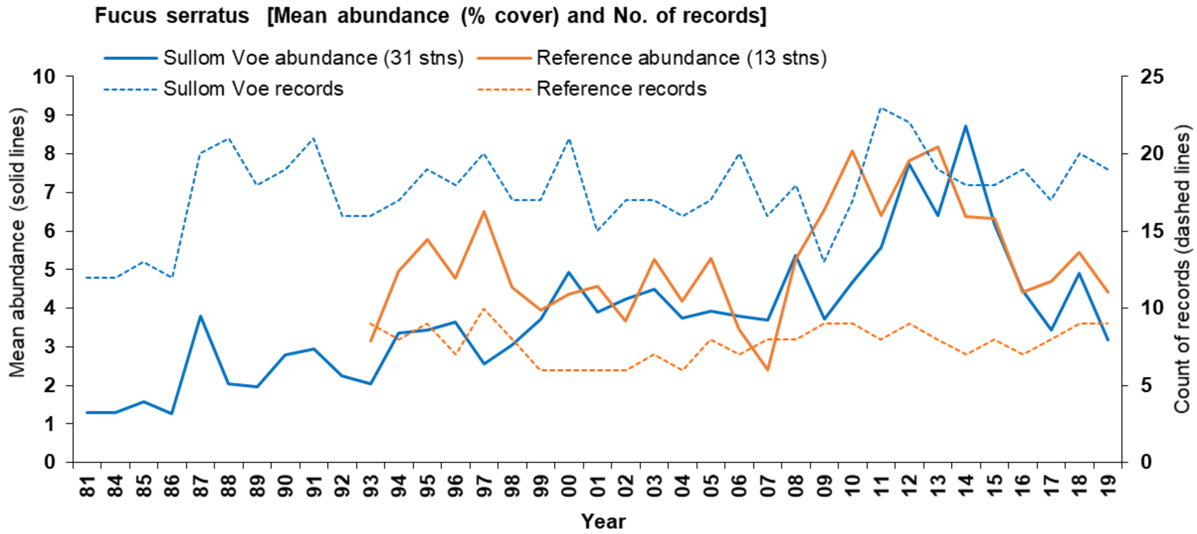
		93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
SV	Mavis Grind (Stream 3)	6	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	4	6	5	4	4	4	3
SV	South of Jetty 2	2	0	0	0	0	0	0	2	4	4	4	4	4	2	2	4	1	4	4	4	5	5	4	3	2	4	0
SV	Scatsta Ness (cleared)	2	2	4	4	3	4	4	4	5	4	4	5	5	4	4	5	4	5	5	4	5	5	5	5	4	4	4
SV	Scatsta Ness	4	4	5	4	3	4	4	5	5	5	5	5	4	5	5	5	4	4	5	4	5	5	6	4	4	4	5
R	North Burra Voe	5	5	5	6	6	6	5	6	7	6	6	6	6	6	5	7	6	7	6	5	6	6	6	6	6	6	6
New	West Lunna Pund South																									5	5	5
New	West Lunna Pund North																									6	7	6
New	Croo Taing																									6	6	6



Ascophyllum nodosum, with some Fucus vesiculosus and Vertebrata lanosa, at Scatsta Ness (left). Close-up of dense epiphytic growth of V. lanosa on A. nodosum at N. Burra Voe (right).

3.1.12 *Fucus serratus*

Average abundance of serrated wrack (see photo below) on lower shores fell again across Sullom Voe sites and Reference sites in 2019, but was still higher than it was before the mid 1990s. There were notable fluctuations, down and up, at a few stations, particularly S. of Jetty 2, where bladder wrack *Fucus vesiculosus* was more abundant in the lower station.



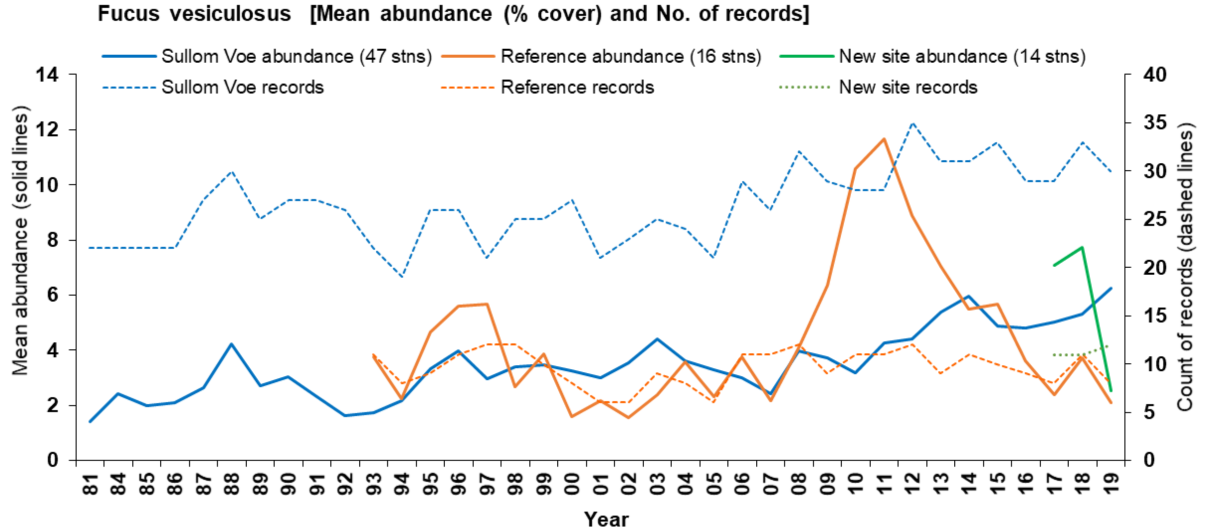
Fucus serratus (sum of abundance scores from five stations, by site and year)

		81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Sullom Voe	West of Mioness	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roe Clett	0	0	0	0	4	3	4	5	5	0	1	2	2	2	2	2	3	2	0	4	4	3	6	2	1	4	3	3	3	2	2	0	4	4	4	8	5
	Noust of Burraland	2	2	2	2	4	4	5	4	4	4	2	4	4	4	4	5	4	4	5	4	6	6	5	6	5	6	6	7	6	6	6	6	6	5	6	6	6
	Gluss Island East	0	0	0	0	0	1	0	0	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0	1	2	3	0	4	3	0	3	3
	South of Swarta Taing	5	5	5	5	6	3	4	2	2	4	4	4	7	4	4	5	4	4	4	6	7	5	4	5	9	4	5	9	6	5	10	6	5	6	4	5	5
	Grunn Taing	9	9	9	9	10	9	8	6	6	4	5	6	5	5	5	5	6	5	4	4	6	5	6	7	5	6	6	7	5	6	6	6	5	4	5	7	6
	The Kames	0	0	0	0	6	0	0	7	5	6	7	7	6	5	5	4	5	6	6	6	6	7	6	7	6	7	6	7	7	6	7	6	6	5	6	7	7
	Voxter Ness	1	1	1	1	1	2	1	1	1	1	0	0	2	0	0	0	0	1	2	0	3	0	0	3	0	1	0	0	3	0	0	5	0	0	1	0	3
	South of Skaw Taing	6	6	6	6	7	6	8	9	9	9	10	8	10	6	9	9	11	7	10	6	7	7	6	9	7	11	7	7	11	12	13	12	11	10	10	14	10
	Jetty 3	6	6	13	5	6	11	11	9	8	5	2	7	8	7	8	10	7	11	4	9	8	11	9	8	7	6	6	9	11	10	10	10	10	11	8	9	7
	Mavis Grind (Stream 3)	0	0	0	0	5	3	3	1	1	3	4	4	2	2	2	4	3	4	4	4	4	5	4	4	4	5	4	5	4	4	4	4	5	4	4	2	4
	Fugla Ayre	4	4	3	4	3	4	3	5	4	5	6	5	5	5	4	4	4	8	5	6	10	3	7	4	0	5	5	1	6	10	10	10	6	9	4	6	4
	South of Jetty 2	3	3	3	3	3	4	4	3	5	1	3	4	4	11	10	4	7	12	9	11	8	4	5	6	7	10	10	10	10	12	5	9	8	5	5	8	3
	Scatsta Ness (cleared)	1	1	1	1	6	4	0	7	9	9	9	8	9	9	4	5	9	8	6	6	5	8	5	6	9	10	6	6	9	14	6	11	11	7	10	8	8
	Scatsta Ness (uncleared)	0	0	0	0	7	8	5	10	10	8	4	5	6	10	8	8	9	11	9	8	4	8	8	7	8	8	4	9	8	8	8	9	6	6	4	3	2
Reference	Riven Noust											5	6	5	5	6	6	4	4	4	4	4	4	7	6	5	7	7	8	9	7	9	8	6	7	6	7	5
	Vidlin Ness											6	6	10	8	14	7	7	7	6	7	9	6	6	5	5	6	5	9	10	6	6	6	10	7	8	9	7
	Burgo Taing											3	4	5	4	3	4	4	5	5	5	4	5	7	4	3	4	5	5	0	5	5	5	6	4	5	5	4
	Kirkabister											13	13	11	11	12	12	8	10	12	11	12	11	12	8	8	13	12	16	12	12	11	12	6	11	10	10	13
	North Burra Voe											4	5	6	4	4	4	5	4	4	3	5	4	4	4	5	4	8	4	3	10	8	6	6	4	4	5	4
New refere.	Ola's Ness																																			4	3	4
	West Sandwick																																			6	4	3
	West Lunna Pund South																																			4	6	5
	West Lunna Pund North																																			5	6	5
	Croo Taing																																			5	7	6

Fucus serratus at The Kames (left). Fucus vesiculosus at South of Jetty 2.

3.1.13 *Fucus vesiculosus*

There was another modest rise in the average abundance of bladder wrack at Sullom Voe sites, but a decrease at the reference sites, including a surprisingly large decrease at the new reference sites (see graph below). The tables below show that the largest reduction occurred at Kirkabister, but that the abundances recorded there are within the range previously recorded.



Fucus vesiculosus (sum of abundance scores from five stations, by site and year)

		76	77	78	79	80	81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Sullom Voe	West of Mioness	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roe Clett	0	0	1	0	0	0	0	0	0	0	3	0	1	1	0	0	0	1	1	0	0	0	4	4	3	0	0	0	1	0	3	0	2	4	3	2	0	3	8	7	5	3
	Noust of Burraland	2	1	0	4	3	3	3	3	3	3	9	5	4	4	4	4	1	7	7	5	3	1	5	0	3	3	7	4	4	7	5	4	5	4	4	4	6	6	4	5	9	7
	Gluss Island East	0	0	1	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	3	3	0	0	0	3	6	1	3	3	2	1	2	2	0	4	5	6	10	9	9
	South of Swarta Taing	1	0	3	2	3	1	5	5	3	2	3	2	2	2	1	0	1	3	0	0	1	2	3	4	5	4	4	0	5	0	4	2	1	2	5	2	4	3	3	7	6	9
	Grunn Taing	6	10	7	12	7	1	1	1	1	6	12	3	10	9	4	5	4	3	2	0	3	3	3	0	3	7	9	4	9	9	8	8	2	2	4	1	5	5	4	7	8	7
	The Kames	2	0	1	1	4	0	0	0	0	2	0	0	0	0	0	1	1	1	2	3	4	3	2	0	0	1	3	0	4	3	7	7	5	4	8	7	4	3	3	4	3	4
	Voxter Ness	4	4	1	0	1	7	7	9	7	7	9	7	6	5	4	1	0	3	2	5	6	6	6	6	8	8	7	8	7	6	6	7	6	9	11	9	10	11	8	8	7	9
	South of Skaw Taing	3	4	3	3	3	2	2	2	2	5	2	5	5	5	5	6	5	5	13	6	5	5	4	5	4	5	6	5	6	6	11	11	11	8	8	10	9	9	10	6	8	8
	Jetty 3	5	9	6	0	0	1	5	6	6	16	17	16	15	11	9	16	14	17	15	14	16	17	12	13	15	13	10	15	13	11	11	15	19	17	15	18	15	15	13	13	14	13
	Mavis Grind (Stream 3)					6	13	13	13	13	10	12	11	8	8	9	0	8	10	9	9	7	8	8	4	5	9	3	5	8	7	8	6	3	7	5	7	8	9	7	7	7	7
	Fugla Ayre	10	13	13	11	9	7	7	5	8	5	9	6	10	9	10	9	7	7	13	5	11	9	12	14	13	13	7	4	1	4	4	3	0	7	9	15	15	10	10	9	11	10
	South of Jetty 2	7	8	0	2	8	7	11	7	14	11	9	10	9	8	5	7	10	17	16	15	17	15	13	12	13	16	16	14	10	9	15	15	17	17	14	15	16	13	13	12	13	17
	Scatsta Ness (cleared)				8	4	21	24	21	21	22	18	16	19	19	16	16	12	15	17	19	16	16	16	15	15	16	15	17	18	15	19	17	18	17	17	21	21	19	19	14	19	16
	Scatsta Ness (uncleared)				12	5	4	5	5	4	6	14	15	14	10	11	12	14	15	16	15	15	17	12	13	13	16	15	13	14	13	14	16	15	16	14	16	15	14	16	14	12	13
Reference	Riven Noust		0														0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Vidlin Ness		8	7	4	4											10	5	11	13	13	9	9	1	3	3	7	3	0	2	4	8	10	19	15	16	11	14	14	9	8	11	8
	Burgo Taing																6	6	9	9	10	10	6	6	5	4	6	13	5	11	8	9	9	14	9	9	9	8	9	5	4	8	6
	Kirkabister		14	15	14	12											15	12	14	13	14	13	17	12	14	13	13	16	15	11	11	14	17	18	21	19	17	17	12	17	14	16	10
	North Burra Voe																7	6	5	8	9	6	7	6	4	3	8	4	8	14	10	9	8	5	5	9	9	6	6	6	4	7	6
New refere.	Ola's Ness		5																																						9	9	7
	West Sandwick																																								12	11	8
	West Lunna Pund South																																								4	6	5
	West Lunna Pund North																																								13	14	11
	Croo Taing	7	6																																						6	4	3

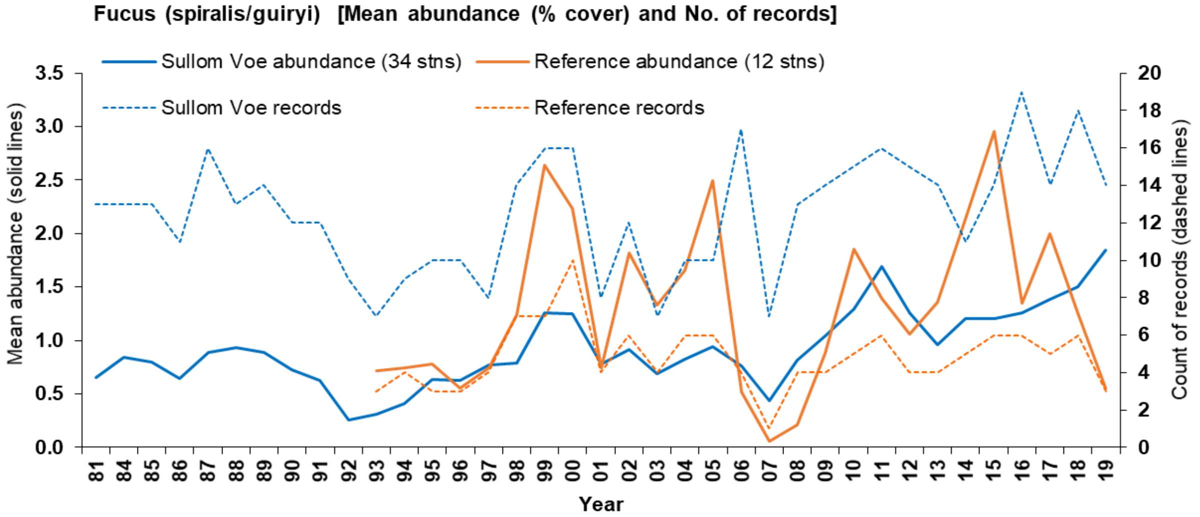
Fucus vesiculosus 6-11 Kirkabister

	76	77	78	79	80	81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
US	0	2	2	0	0	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UMS	0	2	2	3	2	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	4	2	2	0	3	1	5	3	4	4	3	0	0	0	1	0	0	0	4	2	0	3	1	5	3	0	0
MS	0	5	5	5	5	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	5	6	6	6	6	6	7	5	5	5	7	7	7	6	4	4	6	7	6	6	7	7	6	7	6	7	6
LMS	0	5	4	5	5	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	5	4	5	4	5	4	5	4	5	4	3	5	5	4	4	5	6	7	6	6	6	7	5	5	5	6	4
LS	0	0	2	1	0	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	1	0	0	1	0	2	0	0	0	0	0	4	3	1	2	5	5	4	5	5	4	0	0	0	0	3	0

3.1.14 *Fucus spiralis*

Similar to bladder wrack, the 2019 data show a further increase in average abundance of spiral wrack (see photo below) at the Sullom Voe sites, but a notable reduction at the reference sites (see graph below). The table below shows that reductions occurred at many sites, including some of those in Sullom Voe. The largest decrease was at Scatsta Ness (cleared) where spiral wrack was not found in the upper two stations. The photographs show that a band of this fucoid was present but fell between the two stations. Fluctuations at some other sites may be due to confusion with poorly developed bladder wrack (at the upper edge of its vertical range on the shore). However, the widespread reduction is compelling, but no explanation is known.

Note: specimens showing features similar to the recently described *Fucus guiryi* were sent to Ester Serrão, University of Algarve, for DNA analysis. The results found that they were all *Fucus spiralis*.



Fucus (spiralis/guiryi) (sum of abundance scores from five stations, by site and year)

		81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Sullom Voe	West of Mioness	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roe Clett	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	4
	Noust of Burraland	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	1	0	1	0	0	1	0	0	0
	Gluss Island East	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	6	5	3	2	0	1	3	1	1	3	3	5	4	5	5
	South of Swarta Taing	1	1	1	0	2	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	1	2	1	0	2	2	4	0
	Grunn Taing	2	3	2	2	2	3	4	2	2	1	1	4	3	0	3	3	4	4	0	3	0	3	9	5	0	1	3	1	2	3	3	4	5	6	3	3	5
	The Kames	1	1	1	1	4	2	1	1	0	0	0	0	0	0	0	1	3	4	0	2	0	3	3	1	0	1	4	1	2	1	1	0	1	3	3	3	3
	Voxter Ness	4	4	4	4	4	3	3	1	1	0	0	0	1	2	2	4	4	5	4	3	0	6	0	6	7	7	7	8	10	5	4	4	8	7	8	8	10
	South of Skaw Taing	1	1	1	1	1	1	1	0	1	0	0	0	1	2	4	0	3	3	2	0	0	3	0	0	0	1	1	1	0	0	1	0	2	2	3	2	4
	Jetty 3	13	14	13	8	13	6	6	6	5	2	0	5	9	6	5	5	6	7	5	10	7	6	5	4	3	5	8	8	6	6	4	6	5	6	4	4	5
	Mavis Grind (Stream 3)	4	4	4	4	4	9	9	8	7	4	4	2	4	3	2	2	2	3	4	0	3	3	3	1	2	5	4	4	7	4	4	5	5	5	4	5	4
	Fugla Ayre	2	2	2	2	2	3	1	3	3	2	3	2	3	2	4	4	4	7	4	3	4	0	0	1	0	1	4	0	5	4	5	5	4	3	4	4	4
	South of Jetty 2	0	0	0	0	3	0	3	1	2	2	2	0	3	4	6	8	6	5	4	4	4	4	3	2	0	4	5	6	5	6	4	5	3	3	3	5	5
	Scatsta Ness (cleared)	0	0	0	0	0	5	6	5	4	4	6	6	4	8	4	7	8	4	4	7	5	4	4	5	5	6	5	10	9	8	4	3	4	7	6	6	0
	Scatsta Ness (uncleared)	3	5	5	5	4	4	3	4	4	2	1	2	3	3	0	1	7	6	2	7	4	4	4	3	3	1	1	4	4	4	4	4	5	3	4	6	3
Reference	Riven Noust											0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Vidlin Ness											4	4	5	5	4	6	8	8	6	10	8	10	7	3	2	5	7	13	9	6	6	8	9	7	6	6	5
	Burgo Taing											0	0	0	0	0	2	4	6	0	4	0	0	4	1	0	0	0	0	1	0	0	2	4	3	4	3	1
	Kirkabister											4	4	4	3	4	6	8	5	0	0	8	5	5	4	0	1	4	5	6	5	5	6	5	4	5	4	3
	North Burra Voe											2	3	1	1	3	4	6	7	7	7	0	6	7	2	0	1	1	1	2	3	4	4	5	5	4	4	0
New refere.	Ola's Ness																																			8	9	8
	West Sandwick																																			0	7	5
	West Lunna Pund South																																			4	3	0
	West Lunna Pund North																																			4	6	4
	Croo Taing																																			6	6	5

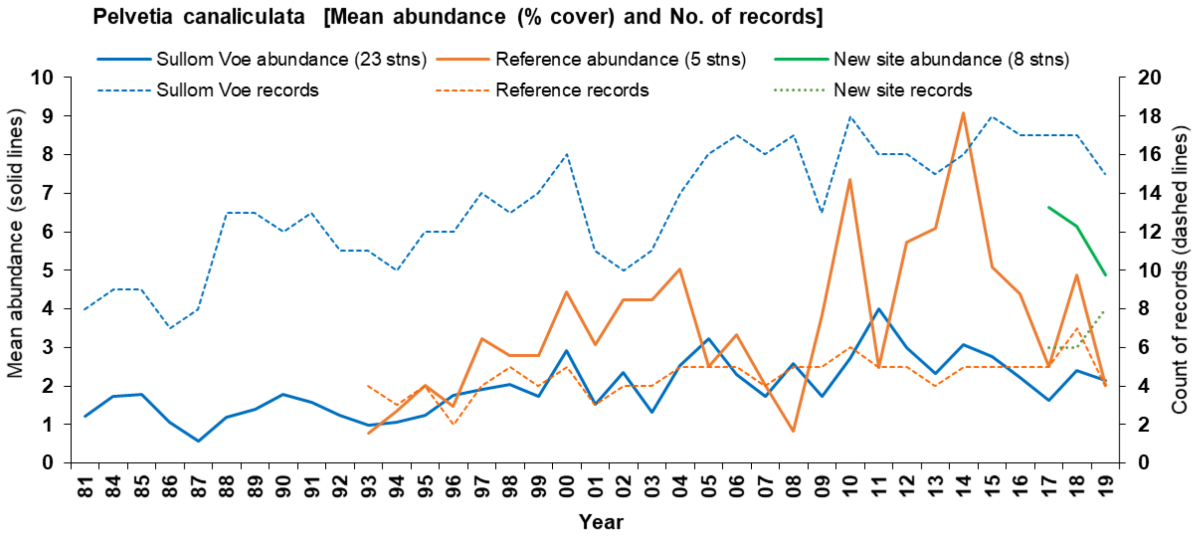
Fucus (spiralis/guiryi) 6-12 Scatsta Ness (cleared)

	81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
US	0	0	0	0	0	0	0	0	0	0	1	2	0	1	0	0	0	0	0	3	0	0	0	0	0	1	0	4	3	4	0	3	1	3	2	3	0
UMS	0	0	0	0	0	5	2	5	4	4	5	4	4	6	4	4	5	4	4	4	5	4	4	5	5	5	5	5	6	4	4	0	3	4	4	3	0
MS	0	0	0	0	0	0	4	0	0	0	0	0	0	1	0	3	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0


Fucus spiralis at Voxter Ness (left). Pelvetia canaliculata at Gluss island East (right).

3.1.15 Pelvetia canaliculata

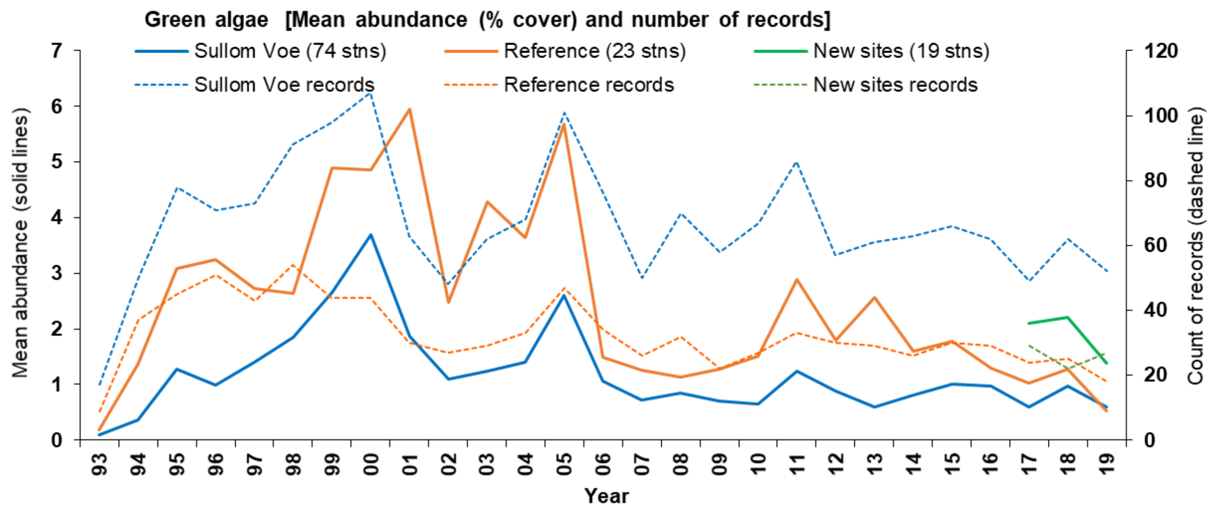
Channelled wrack (see photo above) typically forms a distinct narrow band along the upper shore of sheltered and moderately sheltered rocky shore sites. They are usually very stable, but notable fluctuations can occur. As with some of the other fucoids, average abundance in 2019 was lower than 2018, at Sullom Voe sites and Reference sites (see graph below), but within the range of previous fluctuations.



Pelvetia canaliculata (sum of abundance scores from five stations, by site and year)																																						
		81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Sullom Voe	West of Mioness	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roe Clett	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2	1	0	1	1	1	1	1	0	2	1	2	2	2	2
	Noust of Burraland	0	3	3	0	1	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
	Gluss Island East	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	0	0	1	0	0	0	3	3	3	3	3	0	2	2	0	0	0	1	4	1	3	3
	South of Swarta Taing	1	1	1	1	1	1	4	3	3	0	4	4	4	4	4	4	4	4	4	5	5	5	5	5	4	5	4	5	5	5	5	4	4	5	6	5	5
	Grunn Taing	4	4	5	4	4	6	7	5	5	7	6	5	2	4	7	7	6	8	6	0	3	6	7	3	4	4	4	4	4	5	5	7	6	7	4	6	6
	The Kames	0	0	0	0	0	0	2	1	2	0	0	1	1	2	1	2	2	5	2	3	1	6	6	5	2	3	1	1	2	3	4	1	2	4	3	6	5
	Voxter Ness	7	7	6	6	4	5	4	6	6	5	3	5	5	5	5	5	5	6	6	5	3	5	5	5	4	4	5	5	6	5	4	5	5	4	4	3	2
	South of Skaw Taing	0	0	0	0	0	2	2	2	4	4	4	2	2	4	4	4	4	5	3	5	3	4	4	4	3	4	2	4	4	4	4	4	4	4	4	4	5
	Jetty 3	4	5	5	5	5	5	5	7	7	6	3	4	5	5	5	5	6	5	4	5	6	6	5	7	5	9	5	7	5	6	6	6	5	4	6	9	5
	Mavis Grind (Stream 3)	8	8	8	5	2	8	7	8	7	4	5	4	5	5	5	7	5	7	4	7	5	0	7	5	6	8	6	5	9	7	6	8	9	7	4	7	4
	Fugla Ayre	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	South of Jetty 2	0	0	0	0	0	0	2	0	0	2	1	0	3	4	2	3	2	3	4	4	3	3	5	4	3	2	3	7	6	5	7	5	1	1	3	1	4
	Scatsta Ness (cleared)	0	0	0	0	0	0	0	0	0	0	0	0	2	0	4	2	3	2	0	3	3	6	3	4	5	4	4	4	4	4	3	4	6	3	3	3	4
	Scatsta Ness (uncleared)	2	4	4	2	3	4	2	7	3	3	3	3	3	4	2	3	4	4	3	4	4	7	4	4	4	3	3	5	7	5	3	5	5	4	3	5	2
Reference	Riven Noust											0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Vidlin Ness											1	2	2	0	3	3	3	4	4	4	4	4	3	3	3	3	4	4	4	4	4	4	4	4	4	6	4
	Burgo Taing											3	2	3	2	4	2	3	3	3	3	3	4	3	4	4	2	3	4	3	3	4	4	4	2	3	5	3
	Kirkabister											0	0	0	0	1	1	0	1	0	3	0	3	3	3	2	2	3	3	2	3	1	3	1	3	1	1	0
	North Burra Voe											4	4	6	5	4	7	7	7	4	4	7	5	6	5	2	2	6	7	4	7	5	7	5	6	5	5	4
New refere.	Ola's Ness																																			2	4	2
	West Sandwick																																			5	4	5
	West Lunna Pund South																																			6	7	6
	West Lunna Pund North																																			9	7	8
	Croo Taing																																			2	3	4

3.1.16 Green algae

Green algae, comprising *Ulva* (tubular and flat forms), *Cladophora*, *Codium* and various other taxa, were again present in relatively low abundance, compared to some previous years (see graph and table below). The maximum abundance of *Ulva* (tubular), typically the most common green algal taxa recorded in these surveys, was Common; and that was only in 3 stations.



Ulva (tubular) (max of abundance scores from five stations, by site and year)

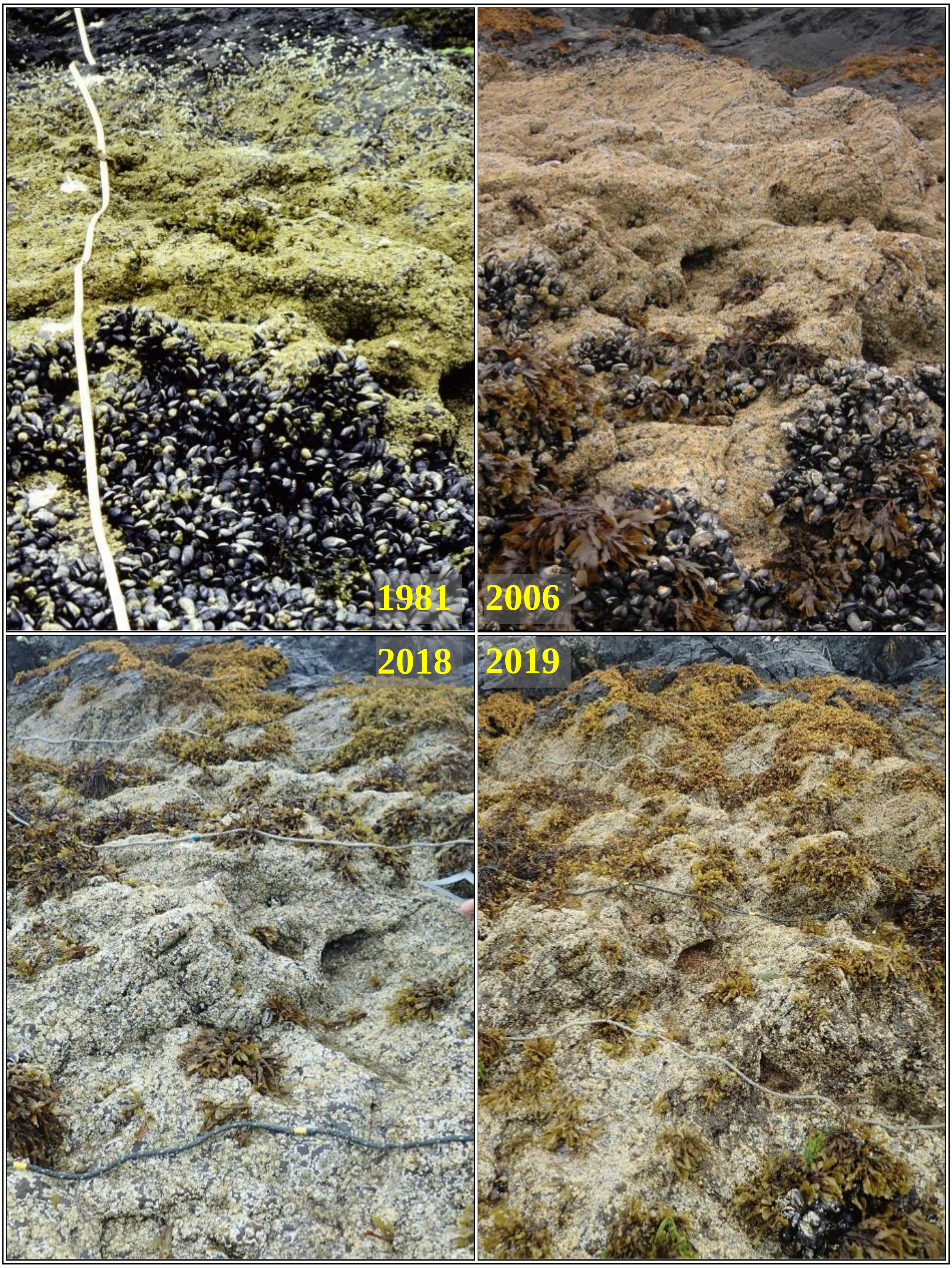
		81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Sullom Voe	West of Mioness	2	0	0	2	2	2	2	3	3	0	2	1	1	3	3	3	2	0	2	2	3	3	3	1	2	3	3	3	2	4	1	3	2	3	2	2	2
	Roe Clett	0	0	0	0	0	0	1	0	1	3	2	3	4	2	2	2	2	5	6	4	4	0	4	3	3	4	4	5	3	4	3	0	4	4	4	5	3
	Noust of Burraland	4	4	4	4	4	1	4	4	4	4	0	2	3	4	3	3	3	4	4	3	0	3	3	2	2	3	3	3	0	4	4	4	2	2	2	3	2
	Gluss Island East	1	1	1	1	2	3	1	1	1	4	1	2	0	0	2	2	3	2	3	0	3	3	4	4	2	2	2	4	3	2	1	3	4	3	2	3	3
	South of Swarta Taing	3	3	3	3	2	3	3	4	4	3	3	4	4	4	4	3	3	4	5	4	4	4	4	4	3	4	3	4	2	3	3	4	3	4	4	3	4
	Grunn Taing	2	2	3	2	3	4	3	2	2	0	2	2	4	5	4	3	4	3	5	4	4	3	3	2	2	1	1	3	4	3	2	4	4	3	2	3	2
	The Kames	0	0	0	0	0	0	0	1	3	2	0	2	3	4	4	3	3	3	4	4	3	3	3	2	2	4	4	3	4	4	0	2	3	4	3	2	0
	Voxter Ness	3	3	2	0	0	3	3	0	0	0	0	0	0	0	0	3	0	2	3	0	0	0	3	1	0	0	1	1	1	1	1	1	0	0	3	2	2
	South of Skaw Taing	1	1	1	1	2	0	2	0	2	0	0	1	2	2	1	2	3	7	3	3	2	3	3	1	3	2	2	3	3	1	2	1	3	3	2	4	1
	Jetty 3	4	5	4	5	3	1	1	2	2	0	1	3	0	2	1	3	3	2	4	0	3	0	3	1	2	1	2	0	0	1	1	1	0	0	0	1	0
	Mavis Grind (Stream 3)	2	1	2	2	2	0	0	0	0	0	0	0	2	2	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	3	4	2	2	3	1
	Fugla Ayre	4	6	6	5	2	4	3	1	1	3	2	2	4	3	5	3	5	5	4	3	3	4	4	5	6	4	5	0	5	5	4	4	4	4	4	5	4
	South of Jetty 2	0	0	4	3	0	0	0	0	0	0	0	0	0	0	4	0	1	2	0	3	3	0	3	0	2	3	3	0	0	0	0	0	0	0	2	1	2
	Scatsta Ness (cleared)	2	2	2	2	2	0	0	0	0	0	0	0	1	0	0	1	0	1	2	0	2	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	(uncleared)	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	2	0	2	0	0	0	3	1	0	0	0	1	0	0	0	0	0	0	0	0	0
Reference	Riven Noust											2	3	3	2	3	2	3	3	0	2	4	3	3	2	2	2	3	0	2	3	2	1	0	0	2	2	2
	Vidlin Ness											2	4	3	4	4	4	5	3	4	5	4	5	4	3	3	4	4	2	4	4	5	5	4	4	4	4	3
	Burgo Taing											0	2	2	3	3	3	3	3	4	4	3	3	4	3	3	2	3	4	4	4	3	4	3	3	3	3	2
	Kirkabister											0	3	2	4	4	3	3	5	3	3	4	3	3	1	3	2	3	0	2	1	3	0	0	0	0	0	0
	North Burra Voe											0	1	2	2	2	1	0	1	4	0	0	0	3	1	2	1	1	1	2	2	2	1	4	2	2	0	0
New refere.	Ola's Ness																																			3	3	3
	West Sandwick																																			3	4	4
	West Lunna Pund South																																			1	2	2
	West Lunna Pund North																																			1	0	2
	Croo Taing																																			4	5	3

Note: Specimens of *Cladophora* were collected this year by Francis Bunker and identified by Anne Bunker (who has particular interest and experience in green algae identification). Four species were confirmed: *C. rupestris* (already known to be present and identifiable in the field), *C. sericea*, *C. albida* and *C. prolifera*. The latter is of some interest as it is a southern species, infrequently recorded in the UK, with no known records this far north.

3.2 Site-specific descriptions

3.2.1 Voxter Ness

The Voxter Ness transect has seen some larger changes in its community dominants than most sites. For the first 3 decades of the monitoring programme the lower shore and shallow subtidal was dominated by mussels (see example photos below from 1991 and 2006). The middle and upper shore zones were dominated by barnacles and limpets with relatively small amounts of fucoid algae. Then, from approximately 2012, the mussel cover gradually reduced and was very sparse by 2015. Barnacles and limpets still dominated the middle and upper shore but increasing amounts of fucoid algae have been recorded (see example photos below from 2018 and 2019).



Voxter Ness: View up shore from bottom of transect. Top: with mussel dominated lower shore (up to approx. 2011). Bottom: with increasing algal cover in recent years.

The table below shows fluctuations in maximum abundance recorded for selected taxa, and highlights a number of notable changes, including the reductions in mussels *Mytilus edulis*, edible winkles

Littorina littorea, rough winkles *Littorina saxatilis*, and dogwhelks *Nucella lapillus*, and the more modest and more variable increases in some of the fucoid algae.

Voxter Ness, selected taxa, maximum abundance recorded from 5 stations, by year																																					
	81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
Cirripedia (spat)	4	4	2	4	4	0	4	4	3	0	2	0	0	2	4	5	3	2	6	2	2	2	2	5	4	5	3	7	0	4	0	6	4	5	4	4	4
Cirripedia (dead)	3	4	4	3	3	3	3	4	4	3	4	3	4	4	4	4	3	4	4	4	4	3	4	4	5	4	4	4	4	4	4	4	4	4	4	3	4
Semibalanus balanoides	5	5	6	6	6	7	7	5	5	4	4	5	4	5	5	5	6	6	7	6	5	6	7	6	6	5	6	7	6	6	6	6	6	5	5	5	5
Patella vulgata	5	5	5	5	5	6	7	6	6	6	7	7	5	7	6	6	5	7	6	7	7	7	6	6	6	7	7	7	7	6	5	6	7	6	7	6	6
Steromphala cineraria	0	0	0	0	0	0	3	1	1	0	0	2	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	4	0	0	3	4	2
Littorina littorea	5	5	5	5	5	5	6	6	6	6	7	6	7	6	5	6	6	6	6	6	6	7	6	5	4	4	4	4	2	4	3	5	3	4	4	4	4
Littorina obtusata	3	3	3	3	3	3	3	0	0	0	2	0	2	0	2	2	0	2	0	2	2	3	3	2	0	2	0	0	0	2	4	2	0	3	2	3	0
Littorina saxatilis (v neglecta)	4	4	4	4	4	4	4	4	4	4	6	6	6	4	4	4	4	3	4	4	4	3	4	3	3	4	3	4	4	4	4	4	4	4	3	3	2
Littorina saxatilis	6	6	6	6	6	6	6	6	6	4	4	5	4	5	2	5	4	4	3	3	2	2	3	2	2	1	2	2	2	2	2	3	3	2	3	2	0
Nucella lapillus	5	5	5	5	6	5	4	3	3	3	2	4	5	5	5	5	5	5	5	5	4	3	5	4	5	5	5	4	0	5	3	4	0	3	4	2	0
Mytilus edulis	6	6	6	6	6	6	4	6	6	6	7	7	7	6	7	6	6	6	6	5	6	6	5	5	4	5	4	5	5	3	4	4	4	4	3	4	2
Fucus (spiralis/guiryi)	3	3	3	3	3	3	2	1	1	0	0	0	1	2	2	3	4	3	4	3	0	3	0	4	4	4	4	4	6	5	4	4	4	4	4	4	5
Fucus serratus	1	1	1	1	1	2	1	1	1	1	0	0	2	0	0	0	0	1	2	0	3	0	0	2	0	1	0	0	2	0	0	5	0	0	1	0	2
Fucus vesiculosus	3	3	5	3	3	4	3	3	2	2	1	0	2	2	3	3	3	3	4	4	4	4	4	4	3	4	3	3	5	4	4	5	6	4	4	4	5
Pelvetia canaliculata	6	6	5	5	3	4	4	5	5	5	3	5	5	5	5	5	5	6	6	5	3	5	5	5	4	4	5	5	6	5	4	5	5	4	4	3	2

The changes at this site are thought to be natural or, at least, not related to the terminal or any other human activity. It will be interesting to follow what happens to these communities.

3.2.2 Orka Voe bund

The bund, created when Orka Voe was filled in during the construction of the terminal in the late 1970s, is visited during the annual survey for a brief assessment of the condition of the rocky shore communities present. Attention is paid to the area of disturbance caused by the installation of the Magnus EOR pipeline in 2004/2005.

There were no notable changes in habitat or communities along the bund or at the EOR pipeline crossing compared to recent years.

Orka Voe bund: EOR pipeline crossing (left). View along bund from the west (right).

3.2.3 Additional reference sites

The five additional reference sites were relocated and surveyed successfully. Site specific changes will be considered in future reports when there is more data to analyse.

4 Discussion

4.1 Changes in rocky shore communities

There were few notable changes in rocky shore communities around Sullom Voe between 2018 and 2019. All but one of the fluctuations described in the results sections are considered to be natural and mostly within typical levels for those shores and the survey methodology. See the next section for details of the one exception.

Fucoid abundances fluctuated considerably between 2018 and 2019 at many sites. Some of the largest changes were reductions at some reference sites, but there were also notable reductions at some Sullom Voe sites. A feature of this programme's methodology is the relatively narrow horizontal bands (3m wide by 10cm high) that define the recording stations. When recording the abundance (based on percentage cover) of large fucoid algae that can flop in and out of that band, then it is inevitable that some of the recorded variability will be greater than real population change. Interpreting such changes against the national long-term trend of increasing fucoid cover is difficult but it highlights the value of having a large number of sites, including reference sites, to buffer the larger than real variability. It also highlights the importance of the quality control procedures, which will be reemphasised in future surveys. More emphasis will also be given to representative photographs of the fucoid cover in each zone.

4.2 Effects of terminal operations and oil spills

During the period 1st August 2018 to 31st August 2019 there were three small pollution incidents reported within Sullom Voe (Simon Skinner, pers. comm.):

- 1st Feb 2019 Small spill of engine oil from a tug at Sella Ness, causing a light sheen
- 16 March 2019 Leak of hydraulic oil from a winch control box on Jetty 3, causing a sheen that was broken up by wave action.
- 15 April 2019 Small spill of marine diesel from a fishing boat at Sella Ness, causing a sheen that was broken up by wave action.

None of these spills is likely to have caused any notable ecological impacts.

On the South of Jetty 2 transect (site 6.2), where there were notable effects from the movement of large boulders in 2016 (see Moore and Bunker 2017), there are signs of continuing instability of the substrata resulting in reduced abundance of knotted wrack (see section 3.1.11). The communities appeared to be otherwise unaffected.

Terminal activities during the past 12 months appear to have had no obvious impacts upon the rocky shore communities of Sullom Voe.

4.3 Additional Reference sites

The recommended (Jenkins 2015) increase to the suite of Reference sites was implemented in 2017. The ten Reference sites will provide improved statistical comparisons with changes at the Sullom Voe sites. It will take a few years of surveys before the new sites provide sufficient data to become well integrated into the data analyses. Meanwhile, comparisons between data from 2018 and 2019 show levels of fluctuations that are typical for the monitoring sites in the SOTEAG rocky shore programme.

5 References

Baker, J.M. and Crothers, J.H. (1987) Intertidal rock. In: Baker, J.M. and Wolff, W.J. (eds.) *Biological Surveys of Estuaries and Coasts*. Estuarine and Brackish Water Sciences Association handbook. Cambridge University Press. 157-197.

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Moore, J. and Mercer, T. (2016). *Survey of the rocky shores in the region of Sullom Voe, Shetland, July 2016*. A report to SOTEAG from Aquatic Survey & Monitoring Ltd., Cosheston, Pembrokeshire. 31 pp + iv.

Appendix 1 Abundance scales used for intertidal organisms

Adapted slightly from Baker & Crothers 1987 (page 170).

1. Live barnacles (record adults, spat, cyprids separately); *Melarhaphe neritoides; Littorina saxatilis (ecotype neglecta)* 7 Ex 500 or more per 0.01 m^2, 5+ per cm^2 6 S 300-499 per 0.01 m^2, 3-4 cm^2 5 A 100-299 per 0.01 m^2, 1-2 per cm^2 4 C 10-99 per 0.01 m^2 3 F 1-9 per 0.01 m^2 2 O 1-99 per m^2 1 R Less than 1 per m^2	**7. *Spirobranchus* sp.** 5 A 50 or more tubes per 0.01 m^2 4 C 1-49 tubes per 0.01 m^2 3 F 1-9 tubes per 0.1 m^2 2 O 1-9 tubes per m^2 1 R Less than 1 tube per m^2
2. *Perforatus perforatus – not applicable in Shetland*	**8. Spirorbinae** 5 A 5 or more per cm^2 on appropriate substrata; more than 100 per 0.01 m^2 generally 4 C Patches of 5 or more per cm^2; 1-100 per 0.01 m^2 generally 3 F Widely scattered small groups; 1-9 per 0.1 m^2 generally 2 O Widely scattered small groups; less than 1 per 0.1 m^2 generally 1 R Less than 1 per m^2
3. *Patella* spp. 10 mm+, *Littorina littorea* (juv. & adults), *Littorina obtusata/fabalis* (adults), *Nucella lapillus* (juv., <3 mm). 7 Ex 20 or more per 0.1 m^2 6 S 10-19 per 0.1 m^2 5 A 5-9 per 0.1 m^2 4 C 1-4 per 0.1 m^2 3 F 5-9 per m^2 2 O 1-4 per m^2 1 R Less than 1 per m^2	**9. Sponges, hydroids, Bryozoa** 5 A Present on 20% or more of suitable surfaces. 4 C Present on 5-19% of suitable surfaces 3 F Scattered patches; <5% cover 2 O Small patch or single sprig in 0.1 m^2 1 R Less than 1 patch over strip; 1 small patch or sprig per 0.1 m^2
4. *Littorina 'saxatilis', Patella* <10 mm, *Anurida maritima, Hyale nilssoni* and other amphipods, *Littorina obtusata/fabalis* juv. 7 Ex 50 or more per 0.1 m^2 6 S 20-49 per 0.1 m^2 5 A 10-19 per 0.1 m^2 4 C 5-9 per 0.1 m^2 3 F 1-4 per 0.1 m^2 2 O 1-9 per m^2 1 R Less than 1 per m^2	**10. Flowering plants, lichens, encrusting coralline algae** 7 Ex More than 80% cover 6 S 50-79% cover 5 A 20-49% cover 4 C 1-19% cover 3 F Large scattered patches 2 O Widely scattered patches all small 1 R Only 1 or 2 patches
5. *Nucella lapillus* (>3 mm), *Gibbula* sp., *Actinia equina, Idotea granulosa, Carcinus* (juv. & recent settlement), *Ligia oceanica* 7 Ex 10 or more per 0.1 m^2 6 S 5-9 per 0.1 m^2 5 A 1-4 per 0.1 m^2 4 C 5-9 per m^2, sometimes more 3 F 1-4 per m^2, locally sometimes more 2 O Less than 1per m^2, locally sometimes more 1 R Always less than 1 per m^2	**11. Algae (non-encrusting)** 7 Ex More than 90% cover 6 S 60-89% cover 7 5 A 30-59% cover 4 C 5-29% cover 3 F Less than 5% cover, zone still apparent 2 O Scattered plants, zone indistinct 1 R Only 1 or 2 plants
6. *Mytilus edulis, Dendrodoa grossularia* 7 Ex 80% or more cover 6 S 50-79% cover 5 A 20-49% cover 4 C 5-19% cover 3 F Small patches, 5%, 10+ small individuals per 0.1 m^2, 1 or more large per 0.1 m^2 2 O 1-9 small per 0.1 m^2 1-9 large per m^2; no patches except small in crevices 1 R Less than 1 per m^2	**Other animal species**: record as percentage cover or approximate numbers within 0.01, 0.1 or 1 m^2

Appendix 2 Chronology of personnel changes and methodology during SOTEAG rocky shore monitoring programme

Contractors: Oil Pollution Research Unit (OPRU), Field Studies Council Research Centre (FSCRC), Cordah Ltd., BMT Cordah Ltd., Aquatic Survey & Monitoring Ltd. (ASML)

Survey staff: Annette Little (AL), Tony Thomas (AT), Ben James (BJ), Christine Howson (CH), David Emerson (DE), David Levell (DL), Francis Bunker (FB), Frank Fortune (FF), Harry Goudge (HG), Heather Howcroft (HH), John Addy (JA), Jenny Baker (JB), John Crothers (JC), John Hartley (JH), Jon Moore (JM), Keith Hiscock (KH), Kingsley Iball (KI), Lou Luddington (LL), Peter Taylor (PT), Sue Hiscock (nee. Hainsworth) (SH), Tom Mercer (TM).

Sites: No. of sites within Sullom Voe and adjacent part of Yell Sound + No. of reference sites (*dogwhelks* refers to the associated monitoring of dogwhelks; see Moore *et al.* 2018)

Year	Contractor	Survey staff	Sites	Stns	Methods (see Moore 2013 for explanation)	Month
1976	OPRU	JB, KH, SH, DL, JA, JH	30 + 4	All	Full survey	May
1977	OPRU	JB, SH, KH, JC, DE, AT	34 + 9	All	Full survey	May
1978	OPRU	KH, JC, AT, AL	18 + 2	All	Full survey	May
1979	OPRU	KH, AT, DE, HH	21 + 2	All	Full survey	May
1980	OPRU	KH, JC, DE, AT	25 + 2	All	Full survey	May
1981	OPRU	KH, DE, AT, KI	25 + 2	All	Full survey	May/June
1982	Not surveyed					
1983	Not surveyed					
1984	OPRU	KH	25	All	Rapid survey	August
1985	OPRU	KH	25	All	Rapid survey	August
1986	OPRU	KH	25	All	Rapid survey	August
1987	OPRU	CH	23	All	Rapid survey	August
1988	FSCRC (OPRU)	CH, AL	23	All	Rapid survey, reestablishment of 6 transects	August
1989	FSCRC (OPRU)	AL, TM	23	All	Rapid survey, reestablishment of 2 transects	August
1990	FSCRC (OPRU)	JM, PT	23	All	Rapid survey	August
1991	FSCRC (OPRU)	JM, PT	23	All	Rapid survey (+ dogwhelks)	August
1992	FSCRC (OPRU)	PT, JM	23	All	Rapid survey	July/Aug
1993	FSCRC (OPRU)	JM, PT	15 + 5	5	Full survey (+ dogwhelks)	August
1994	FSCRC (OPRU)	JM, AL	15 + 5	5	Full survey	August
1995	FSCRC (OPRU)	JM, AL	15 + 5	5	Full survey (+ dogwhelks)	August
1996	OPRU	JM, AL	15 + 5	5	Full survey	August
1997	OPRU	JM, AL	15 + 5	5	Full survey (+ dogwhelks)	August
1998	Cordah	JM, BJ	15 + 5	5	Full survey	August
1999	Cordah	BJ, JM	15 + 5	5	Full survey (+ dogwhelks)	July/Aug
2000	Cordah	JM, BJ	15 + 5	5	Full survey	August
2001	BMT Cordah	FF, JM	15 + 5	5	Full survey (+ dogwhelks)	July/Aug
2002	BMT Cordah	FF, JM	15 + 5	5	Full survey	July
2003	BMT Cordah	FF, JM	15 + 5	5	Full survey	July/Aug
2004	BMT Cordah	JM, FF	15 + 5	5	Full survey (+ dogwhelks)	July/Aug
2005	BMT Cordah	JM, FF	15 + 5	5	Full survey	July
2006	ASML	JM, CH	15 + 5	5	Full survey	August
2007	ASML	JM, LL	15 + 5	5	Full survey (+ dogwhelks)	July/Aug
2008	ASML	JM, CH	15 + 5	5	Full survey	August
2009	ASML	JM, CH	15 + 5	5	Full survey (+ dogwhelks)	August
2010	ASML	JM, CH	15 + 5	5	Full survey	July/Aug
2011	ASML	JM, HG	15 + 5	5	Full survey (+ dogwhelks)	August
2012	ASML	JM, CH	15 + 5	5	Full survey	July
2013	ASML	JM, CH	15 + 5	5	Full survey (+ dogwhelks)	July
2014	ASML	JM, CH	15 + 5	5	Full survey	July/Aug
2015	ASML	JM, CH	15 + 5	5	Full survey (+ dogwhelks)	July
2016	ASML	JM, TM	15 + 5	5	Full survey	July
2017	ASML	JM, FB	15 + 10	5	Full survey	July
2018	ASML	JM, TM	15 + 10	5	Full survey (+ dogwhelks)	August
2019	ASML	JM, FB	15 + 10	5	Full survey	August