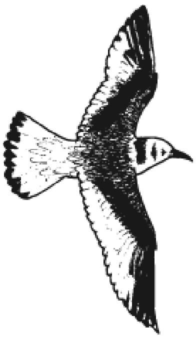
SOTEAG

Survey of the rocky shores

in Sullom Voe



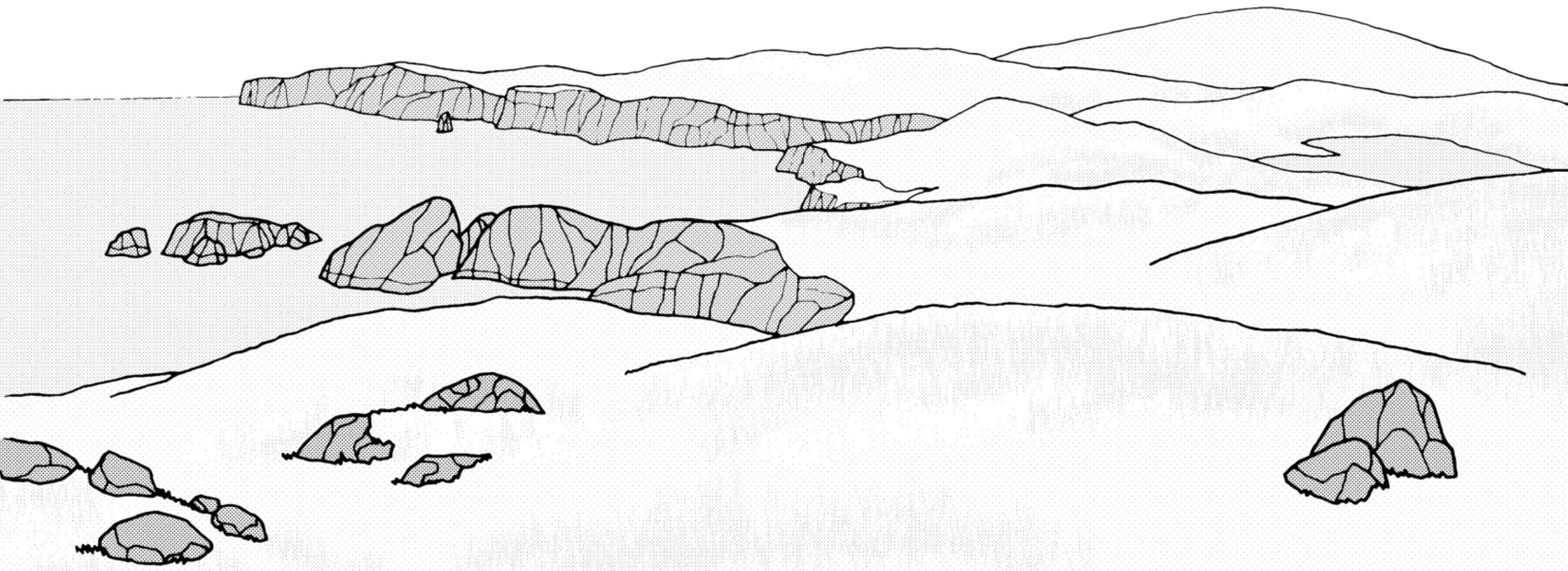
2022

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 2022

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 2022 – the 45th survey since the programme's inception.

The 2022 survey was carried out with a methodology and strategy adopted in 1993. Earlier data is still directly comparable for analyses. Fifteen transects in Sullom Voe and 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 2022 survey with those from the 2021 survey and previous surveys have been carried out.

Rocky shore communities at the twenty-five sites in 2022 were generally similar to those surveyed in 2021. The most noteworthy features of interest are listed below:

- Similar average abundances of many community dominants in Sullom Voe and the Reference sites, compared to 2021, including the barnacle *Semibalanus balanoides*, the limpet *Patella vulgata*, serrated wrack *Fucus serratus*, and the egg wrack *Ascophyllum nodosum*, albeit with fluctuations in abundance at individual sites.
- A large increase in records and abundance of numerous red algal turf species, particularly *Chondrus crispus*. Increases in abundance of *Dumontia contorta*, *Corallina*, *Membranoptera alata*, *Osmundea hybrida* and *Polysiphonia* were also recorded.
- Some evidence of increased disturbance from wave action at Sullom Voe boulder sites, suggested by comparison of photos and reduced numbers of grey topshells *Steromphala cineraria*, but not supported by data on fucoid cover.
- 2022 was a good year for the hydroid *Dynamena pumilla*, which was present in higher abundance than usual at several sites.
- A decrease in average abundance of the small winkle *Littorina saxatilis* (ecotype *neglecta*) in Sullom Voe and the reference sites, following the increase in 2021.
- A further increase in average abundance of dogwhelks *Nucella lapillus* in Sullom Voe, particularly at The Kames, but a decrease at the reference sites. The populations of dogwhelks in Sullom Voe have recovered, following the impacts of TBT contamination in the 1980s.
- Increases in numbers of records and abundance of the epiphytic bryozoa *Flustrellidra hispida*, *Alcyonidium hirsutum* and *Electra pilosa*, possibly due to increases in abundance of large mature serrated wrack *Fucus serratus* at some sites.
- An increase in the average percentage cover of encrusting coralline algae. However, it is considered likely that this may be due more to inconsistent recording than real changes.
- An increase in the average abundance of both spiral wrack *Fucus spiralis* and bladder wrack *F. vesiculosus*, with a particularly large increase at one of the new reference sites.
- Increased abundance of green algae, including the three main species: Ulva (tubular), Ulva (flat) and Cladophora.

One very small oil pollution event was reported in the period between July 20120 and August 2022 but is not expected to have caused any notable ecological effects. No signs of pollution impact were seen.

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

Contents

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 43-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 July / August 2022, highlighting changes that have occurred since the survey in August 2021 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 in 2021 during the same period of fieldwork as the rocky shore transect surveys (Moore et al. 2022). 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 43 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 2022

Fieldwork was carried out by Jon Moore and Tom Mercer between the 27^{th} July and 4^{th} August 2022. 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 August 2022, 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	29/07/2022	HU 41828 79071
2-3	Roe Clett	8, 11, 14, 17, 20	30/07/2022	HU 39437 78127
3-3	Noust of Burraland	1, 3, 5, 7, 10	03/08/2022	HU 37201 75186
3-4	Gluss Island East	6, 9, 11, 13, 15	27/07/2022	HU 37711 77551
3-5	S. of Swarta Taing	4, 7, 10, 12, 15	29/07/2022	HU 40160 77901
4-1	Grunn Taing	3, 5, 7, 9, 11	27/07/2022	HU 37942 78992
4-3	The Kames	5, 7, 9, 12, 15	31/07/2022	HU 38437 76459
4-6	Voxter Ness	5, 8, 10, 12, 14	01/08/2022	HU 36084 70089
5-1	S. of Skaw Taing	9, 12, 15, 18, 20	30/07/2022	HU 39621 78236
5-2	Jetty 3	5, 7, 9, 11, 13	31/07/2022	HU 38594 75578
5-5	Mavis Grind	3, 5, 7, 9, 12	01/08/2022	HU 34054 68462
6-1	Fugla Ayre	3, 5, 7, 9	03/08/2022	HU 37342 74182
6-2	S. of Jetty 2	3, 6, 9, 11, 13	31/07/2022	HU 39163 75089
6-12	Scatsta Ness (cleared)	2, 4, 6, 7, 8	02/08/2022	HU 38874 73544
6-13	Scatsta Ness (uncleared)	4, 5, 8, 10, 12	02/08/2022	HU 38976 73524
Reference sites				
2-9	Riven Noust	13, 17, 19, 22, 24	29/07/2022	HU 50774 73063
3-8	Vidlin Ness	5, 7, 9, 10, 12	01/08/2022	HU 47998 66267
3-12	Burgo Taing	3, 6, 9, 11, 13	04/08/2022	HU 37381 89088
6-11	Kirkabister	4, 6, 8, 10, 12	01/08/2022	HU 48460 66257
6-14	N. Burra Voe	4, 6, 8, 10, 12	04/08/2022	HU 37220 89378
New reference sites				
3-10	Ola's Ness	4, 7, 9, 11, 13	31/07/2022	HU 35332 83092
4-7	West Sandwick	1, 2, 3, 4, 5	28/07/2022	HU 44583 86955
5-8	West Lunna Pund South	1, 2, 3, 4, 5	30/07/2022	HU 47829 69044
6-3	Croo Taing	7, 9, 11, 12, 14	28/07/2022	HU 43282 78645
6-15	West Lunna Pund North	1, 2, 3, 4, 5	30/07/2022	HU 47926 69094

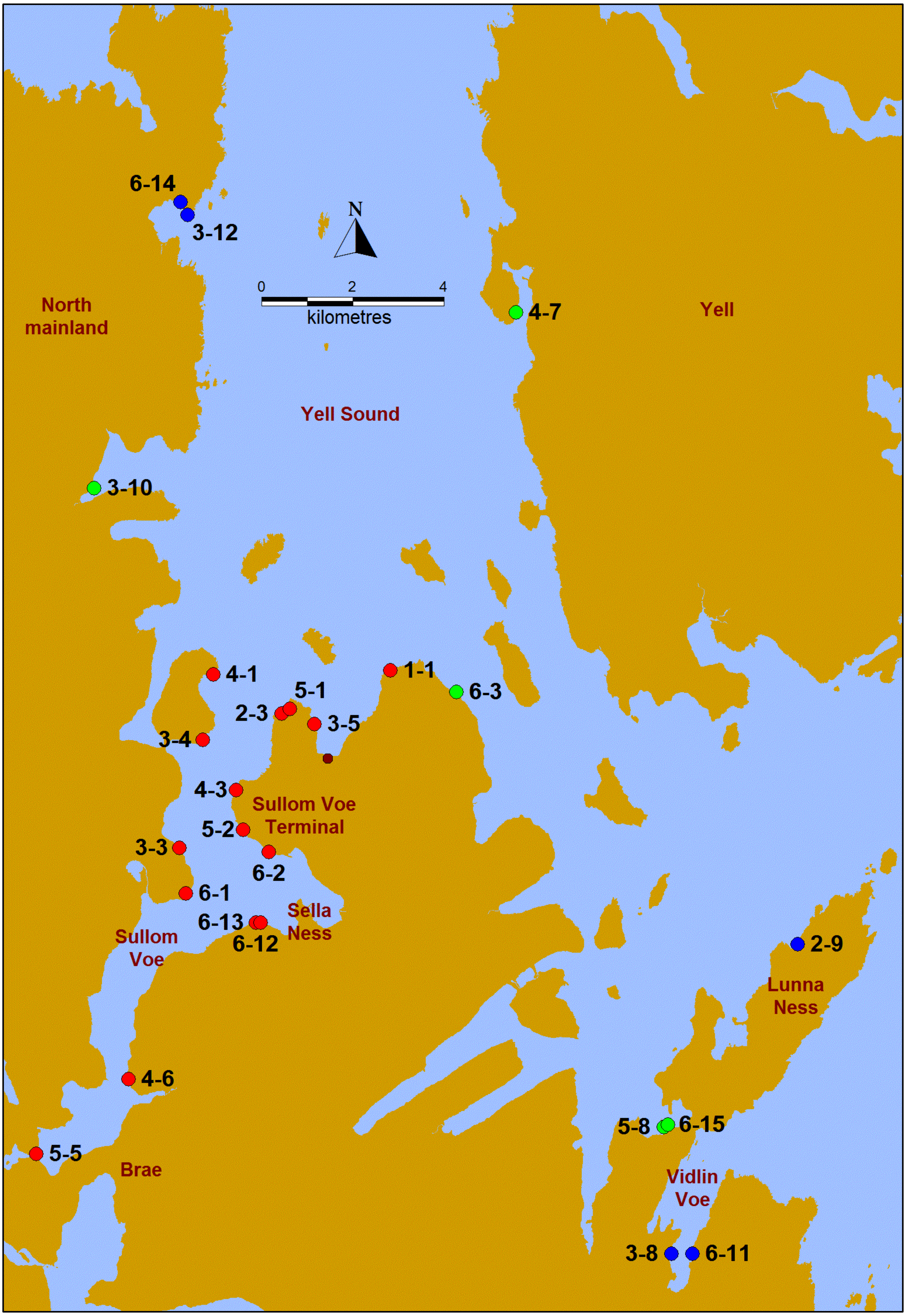


Figure 1 Location of rocky shore transect sites. Surveys of rocky shores in the region of Sullom Voe, Shetland, July / August 2022. ● Sullom Voe sites, ● old Reference sites (established 1993), ● new Reference sites (established 2017).

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 2022. The stations surveyed are listed in Table 1.

On a few occasions time and tide constraints have resulted in an incomplete survey of a lower shore station (i.e. water covering the station). This happened at Fugla Ayre in 2022. On one occasion, in 2020, a relocation error resulted in a whole transect (site 6.13) being surveyed in the wrong place. The missing data are tagged and explained in the metadata associated with the full dataset. Analyses carried out for the 2020 report excluded all data from site 6.13, but analyses for this report on the 2022 survey has included them. As most of the data analyses are based on averages of the existing data, the effects of missing data are limited, but notes are applied where they can have an effect on the results.

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. All plants and animals (except drift material) found within the defined area of the station at the time of the survey are recorded, even if their attachment is outside that area. This mainly affects recording of the large fucoids that may have their holdfasts outside the station, and the epiphytes that grow on them.

It is therefore important that the abundance of large fucoids and their epiphytes is recorded first, before they are pulled back to study the understorey.

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 is a lot greater than for 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.

2.2.4 Site and station relocation information

New markers, notes and imagery, to improve the ease of site and station relocation were made during the 2020 and 2021 surveys. Details are given in the reports from those survey. Additional photos and notes for relocation purposes were taken in 2022. The relocation information is being collated for each site and copies of the new site location sheets will be provided to SOTEAG in due course.

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. 1 = Rare and 4 = Common (see Appendix 1).

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

Tabulated exports from the database and simple graphical presentations (graphs in Section 3.1) were used to compare the 2022 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. This factor only affects the scale on the y-axis, not the shape of the lines.

An inevitable feature of the graphs is that the average abundance for a species will tend to be higher in one dataset than the other, i.e. in Sullom Voe or in the Reference sites. This may reflect a real difference in species distribution between those areas but may simply reflect a difference between the selected sites. Showing such differences is not the primary purpose of the graphs, which is to illustrate the temporal changes.

Whilst it should be appreciated that the methodology described above will introduce some errors into the data, the log 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 temporal changes 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 (see Appendix 1)

		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	0.05	0.1	0.5	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 Sullom Voe 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). The number of Sullom Voe records is therefore derived from three times as many stations as the Reference stations, which inevitably means that those lines are positioned higher up the y-axis. As for the average abundance data, showing such differences is not the primary purpose of the graphs, which is to illustrate the temporal changes.

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.

Tables of summed abundance data are used to present selected results for multiple sites or species. Colour shading (using conditional formatting from Excel) is used to highlight changes in those abundances between years, sites and species. Here, the numerical abundance categories have been summed, which can give misleading results – e.g. a value of 4 could be the sum of 4 records of Rare or a single record of Common. However, the potential for wrong interpretation is limited by the typical distribution patterns that each species has at each site.

2.4 Data archive

The master data are held in two *Microsoft Access* database files, one for species abundance data (currently 117,860 records) and one for the photograph catalogue (currently 9,254 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 copy of the databases, and an update each year, 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: records are held in the database at the taxonomic level to which they were identified. 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.

3 Results

3.1 Fluctuations in frequency and abundance of selected species

Table 3 provides a summary of abundance changes that occurred between August 2021 and July / August 2022 for 32 of the most characteristic taxa of these Shetland rocky shore communities.

Table 4 provides a summary of changes in numbers of records (from the 15 Sullom Voe sites only) over the last 28 years, for 66 of the most frequently recorded taxa. [Note: Comparable data for Reference sites are not shown as there were too few sites and stations to provide good representation over that period].

Between them, those tables show that fluctuations in the frequency and abundance of most taxa occur every year and that some of them are substantial. Analyses and interpretation over the course of the programme have indicated that the majority of those fluctuations reflect natural variability, but there have been notable changes in some years, sites and species. The following sections describe the results for selected characterising species and others that have shown notable changes in the last year.

Table 3 Changes in categorical abundance of selected species between 2021 and 2022 at stations in Sullom Voe (left) and at Reference stations (right) (including the 5 new Reference sites). Values are the percentage number of stations, in each of the two groups, at which there was a change in abundance of one or more categories shown in the top row of the table. Example: Spirorbinae reduced in abundance by two categories at 6% of Sullom Voe stations. Coloured data bars (using conditional formatting from Excel and scaled to a max of 40) have been added to highlight changes.

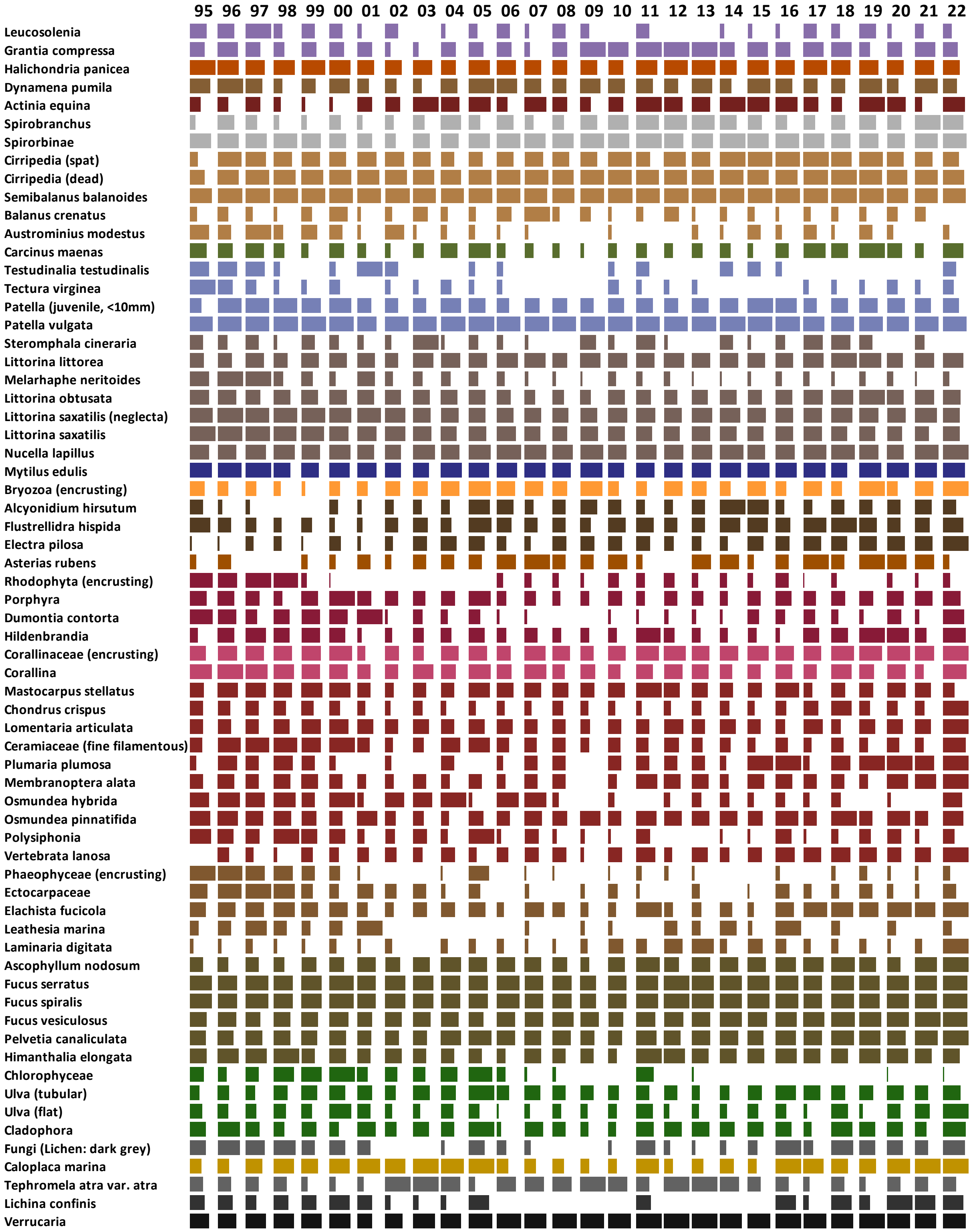
Abundance changes in Sullom Voe stations

	-4	-3	-2	-1		1	2	3	4	5
Littorina saxatilis (neglecta)		2	14	18	61	5	2			
Patella (juvenile, <10mm)		2	7	9	51	19	7	5		
Cirripedia (dead)			7	22	56	12	3			
Littorina obtusata	2	4	11	11	51	8	8	6		
Littorina littorea	2	2	4	9	58	15	9		2	
Spirorbinae			6	10	68	6	3	6		
Nucella lapillus	2	6	4	12	44	6	16	8		2
Patella vulgata		2	3	14	67	11	3			
Mastocarpus stellatus		2	5	2	80	9	2			
Mytilus edulis			8	6	71	10	6			
Cirripedia (spat)	2	6	5	11	54	11	6	3		2
Pelvetia canaliculata			3	3	57	30	3	3		
Semibalanus balanoides			3	12	52	23	8	2		
Fucus vesiculosus			6	12	52	17	12		2	
Fucus spiralis			2	10	63	15	10			
Porphyra			7	9	61	13	6	2	2	
Osmundea hybrida				5	67	5	24			
Fucus serratus			3	11	58	17	8		3	
Littorina saxatilis			7	12	53	8	8	8	3	
Lomentaria articulata			5		74		16	5		
Ceramiaceae (fine filamentous)			3		69	5	23			
Cladophora			4	9	47	23	17			
Corallina			3	3	45	17	21	10		
Ulva (tubular)			2	5	66	16	11		2	
Elachista fucicola		2		7	51	22	10	7		
Ulva (flat)				3	74	9	14			
Osmundea pinnatifida				4	73	8	15			
Verrucaria			3	7	41	31	14	5		
Hildenbrandia				4	32	29	27	5	3	
Dumontia contorta	3				47	23	23	3		
Chondrus crispus			3		35	32	27	3		
Corallinaceae (encrusting)				4	33	29	25	6	2	

Abundance changes in Reference stations

	-4	-3	-2	-1		1	2	3	4	5
Littorina saxatilis (neglecta)		3	10	15	68	5				
Patella (juvenile, <10mm)	7	7	15	15	41	7	7			
Cirripedia (dead)			12	20	59	5	5			
Littorina obtusata		11	5		68	8	8			
Littorina littorea		10	10	13	52	13	3			
Spirorbinae	4	4		8	72	8		4		
Nucella lapillus		6	15	15	48	6	9			
Patella vulgata			10	18	38	25	10			
Mastocarpus stellatus		4	9		74			13		
Mytilus edulis			7	7	59	7	14	7		
Cirripedia (spat)			5	10	55	14	12	5		
Pelvetia canaliculata			11	6	56	17	11			
Semibalanus balanoides				12	56	26	5	2		
Fucus vesiculosus		3	6	6	39	24	15	6		
Fucus spiralis				9	57	17	9	4	4	
Porphyra				8	52	20	8	12		
Osmundea hybrida					83		17			
Fucus serratus			14		45	18	9	9	5	
Littorina saxatilis		2	9	6	45	6	21	11		
Lomentaria articulata				21	36	14	21	7		
Ceramiaceae (fine filamentous)			8		54	17	17		4	
Cladophora			3	8	33	39	17			
Corallina			7	7	57	7	14	7		
Ulva (tubular)			2	2	33	37	26			
Elachista fucicola			13	3	32	10	35	6		
Ulva (flat)				3	41	17	31	3	3	
Osmundea pinnatifida					40	30	20	10		
Verrucaria			2	8	32	24	20	10	2	2
Hildenbrandia			8	2	27	33	22	4	4	
Dumontia contorta			5		29	19	29	10	10	
Chondrus crispus				4	26	30	22	19		
Corallinaceae (encrusting)				3	12	36	27	6	15	

Table 4 Proportional changes in numbers of records of most frequently recorded taxa from sites in Sullom Voe (15 sites, 75 stations), 1995 to 2022. Length of coloured bars are calculated from the number of records in that year divided by the maximum number recorded in any year. Abundances recorded as Rare are not included. Colours indicate different taxa and taxonomic groups.



Graphs of mean abundance in this section have been prepared using a bespoke methodology described in Section 2.3. Interpreting these graphs is not straightforward because the source data for each line is calculated from a different number of stations, which complicates direct comparison between the lines. Thus, the main purpose of the graphs is to study the pattern of temporal changes on each line and between the lines, rather than the difference in their vertical position on the y-axis. The tables of summed abundances are also unconventional and have the potential to mis-represent some of the more detailed distribution patterns. However, the graphs and tables provide effective and concise means to summarise the main temporal changes. See Section 2.3 for more details.

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 Sponges *Leucosolenia* & *Halichondria panicea*

The calcareous sponge *Leucosolenia* (see photo below) is confined to damp dark microhabitats on the lower shore, particularly under stable boulders and amongst dense red algal turfs. It is therefore typically inconspicuous and present in low abundance, so number of records are influenced by the surveyor's attention to detail. It was recorded from eight stations in 2022, which is more than usual but within the level of variability.

The breadcrumb sponge *Halichondria panicea* (see photo below) is more conspicuous, but still confined to fairly damp dark microhabitats. It was recorded from 21 stations and in relatively higher abundances than usual in 2022. This pattern of modest increase is evident in both Sullom Voe and the reference sites. However, it is notable that there have been no records at Scatsta Ness (cleared) since 2017, where *H. panicea* used to be more frequent.

Halichondria panicea (sum of abundance scores from five stations, by site and year)

	Site name	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	20	21	22
Sullom Voe	W.of Mioness	0	1	2	2	0	0	1	2	0	0	0	0	2	1	0	0	2	0	2	0	0	2	2	2	0	2	2	2	3	3
	Roe Clett	3	2	2	2	2	2	2	3	3	3	2	1	1	2	2	2	0	3	3	2	2	0	2	3	2	2	2	2	2	2
	Noust of Burraland	4	3	2	2	2	2	2	2	3	3	2	3	3	3	3	4	3	4	4	4	3	4	3	3	3	3	4	3	3	3
	Gluss Island East	0	3	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	2	1
	S.of Swarta Taing	2	4	4	4	3	3	5	4	4	4	3	4	4	4	3	4	4	5	4	4	4	4	4	4	4	4	4	3	4	4
	Grunn Taing	3	4	3	2	3	2	4	3	3	3	3	3	3	3	4	4	4	4	5	4	4	4	4	3	4	4	4	5	4	4
	The Kames	3	3	3	2	2	3	3	3	4	3	2	3	3	3	4	3	3	4	4	3	3	3	4	4	3	4	3	4	3	3
	Voxter Ness	0	2	2	0	0	0	2	0	0	0	0	0	2	2	2	0	2	0	1	2	0	0	0	0	0	0	0	0	0	0
	S.of Skaw Taing	3	4	4	7	6	6	7	5	5	4	4	4	4	4	4	5	4	5	5	7	7	5	4	4	4	8	4	4	4	5
	Jetty 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	0	0	0	0	0	0
	Mavis Grind	1	2	2	2	2	3	2	3	2	2	3	2	2	3	1	2	2	3	2	2	2	2	2	2	3	2	2	2	0	2
	Fugla Ayre	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
	S.of Jetty 2	0	0	2	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
	Scatsta Ness (cleared)	3	2	6	3	2	5	5	6	2	3	5	1	2	2	1	0	0	0	4	4	4	2	4	2	5	0	0		0	0
	Scatsta Ness (uncleared)	0	0	0	0	0	0	0	0	0	0	0	2	3	1	2	0	0	0	0	0	3	0	0	0	2	0	0	0	2	0
Reference	Riven Noust	2	4	6	5	5	6	3	6	4	5	4	3	3	5	4	4	5	5	4	4	5	4	4	5	4	4	5	5	4	5
	Vidlin Ness	0	2	2	2	2	2	2	3	3	2	1	1	2	2	3	3	2	2	2	0	2	2	2	2	1	0	2	2	2	3
	Burgo Taing	2	0	3	3	4	2	3	2	3	3	3	3	5	3	2	5	5	3	1	3	3	2	2	3	3	3	3	3	0	2
	Kirkabister	0	1	0	0	0	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
	North Burra Voe	5	6	7	6	5	7	6	7	6	6	6	6	6	7	6	4	6	8	3	7	7	7	6	6	6	8	5	4	4	5
New refere.	Ola's Ness																									0	2	2	2	2	4
	West Sandwick																									0	0	2	0	0	0
	West Lunna Pund South																									0	2	4	2	2	4
	West Lunna Pund North																									2	1	2	2	1	2
	Croo Taing																									0	2	3	0	4	3

White tubes of *Leucosolenia* at North Burra Voe (*left*) and green cushions of *Halichondria panicea* at South of Skaw Taing (*right*). Note: the purple cushion is another sponge *Haliclona*.

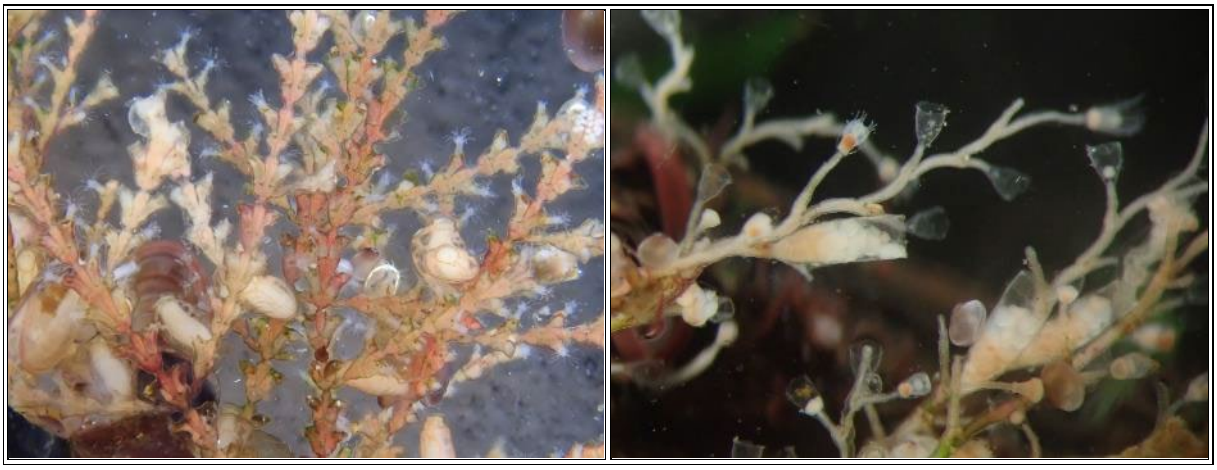
3.1.2 Hydroids *Dynamena pumila* & others

A variety of hydroids, usually attached to algae, are recorded from the transect sites; primarily on the lower shore though *Dynamena pumila* (see photo below) is sometimes around the base of fucoid algae on the mid shore. *D. pumila* is fairly consistently recorded from certain Sullom Voe sites (including Grunn Taing and The Kames) and reference sites (including Vidlin Ness and North Burra Voe) where large mature fucoid algae are often present. 2022 was a good year for this hydroid, particularly at Vidlin Ness and Croo Taing, where it was present in three stations at both sites.

Dynamena pumila (sum of abundance scores from five stations, by site and year)

	Site name	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	20	21	22
Sullom Voe	W.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
Sullom Voe	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	0	0	0	2	2	2	0
Sullom Voe	Noust of Burraland	1	1	2	1	0	1	0	0	0	0	1	2	2	2	2	2	2	2	2	0	2	0	2	0	2	1	2	0	2	0
Sullom Voe	Gluss Island East	0	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
Sullom Voe	S.of Swarta Taing	2	3	2	3	2	2	3	2	2	2	1	2	2	3	2	2	2	2	2	2	3	2	2	2	2	3	2	2	2	3
Sullom Voe	Grunn Taing	3	3	2	2	2	2	3	2	0	2	3	2	2	3	3	2	2	2	3	2	4	3	2	2	3	3	2	3	3	3
Sullom Voe	The Kames	4	3	2	2	2	1	2	0	2	2	3	3	3	2	3	2	3	3	3	2	3	2	3	3	2	3	3	3	3	3
Sullom Voe	Voxter Ness	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
Sullom Voe	S.of Skaw Taing	6	5	3	5	3	2	4	4	2	4	2	3	3	3	3	2	4	3	2	3	4	3	5	5	3	2	2	0	3	4
Sullom Voe	Jetty 3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	2	0	0	0	0	2	2
Sullom Voe	Mavis Grind	0	2	0	5	0	1	1	2	2	0	0	0	2	0	2	0	2	0	0	0	2	0	0	0	0	0	0	1	2	0
Sullom Voe	Fugla Ayre	3	2	0	2	2	0	2	2	3	0	1	0	2	2	0	0	0	0	2	2	2	0	3	0	0	2	0	0	0	0
Sullom Voe	S.of Jetty 2	0	0	2	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
Sullom Voe	Scatsta Ness (cleared)	0	2	2	0	0	0	1	3	0	0	0	0	0	2	0	0	0	3	1	0	0	0	0	0	0	0	0		0	1
Sullom Voe	Scatsta Ness (uncleared)	0	2	0	2	2	0	0	2	0	0	0	2	4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Reference	Riven Noust	0	2	2	2	0	0	0	2	1	2	1	2	2	2	2	2	4	2	2	3	3	3	3	3	0	2	2	2	3	2
Reference	Vidlin Ness	3	6	4	4	3	2	2	4	4	4	2	2	3	3	3	2	3	2	3	5	3	4	2	2	3	2	2	2	2	7
Reference	Burgo Taing	3	9	2	5	2	2	2	0	2	0	0	0	3	2	2	0	3	0	0	2	0	0	3	2	2	0	2	2	2	2
Reference	Kirkabister	2	5	3	4	0	2	0	2	1	2	0	2	0	3	0	0	3	0	0	0	0	0	0	0	2	1	3	0	0	0
Reference	North Burra Voe	4	6	4	5	4	3	2	0	4	2	1	4	5	3	2	5	0	4	2	4	3	1	5	4	4	3	1	2	2	3
New refere.	Ola's Ness																									1	0	0	0	0	2
New refere.	West Sandwick																									2	0	2	0	2	2
New refere.	West Lunna Pund South																									3	0	2	5	0	2
New refere.	West Lunna Pund North																									0	0	1	0	1	0
New refere.	Croo Taing																									8	5	6	7	8	9

Hydroids from the family Campanulariidae, which include *Laomedea flexuosa* (see photo below) are inconspicuous and difficult to identify in-situ but are frequently present amongst lower shore algal turfs. They were recorded from more stations in 2022 than any previous year and were particularly abundant at Vidlin Ness. They are less often recorded from the Sullom Voe sites.



Dynamena pumila (*left*) and *Laomedea flexuosa* (*right*) from the lower shore station at Grunn Taing. The specimens shown have feeding polyps (with tentacles) and reproductive gonothecae (flask shaped).

3.1.3 *Spirobranchus* (keel worm)

Keel worms *Spirobranchus* (see photo below) were present in relatively high abundance on the Scatsta Ness and Jetty 2 sites in 2021, following the notable settlement in 2020. That abundance was maintained at Jetty 2 in 2022, but it declined at Scatsta.

Spirobranchus on lower shore cobble at Jetty 2 (*left*); and a solitary *Chthamalus stellatus*, surrounded by *S. balanoides* spat and adults, at West of Mioness (*right*).

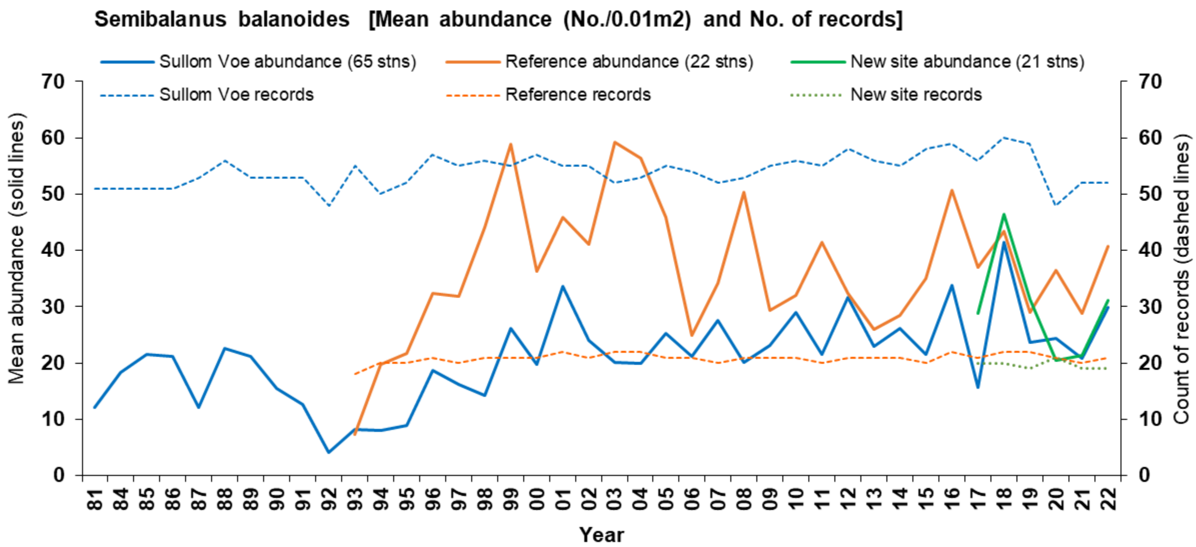
3.1.4 *Chthamalus stellatus* (barnacles)

Small numbers (mostly just solitary individuals) of the southern species of barnacle *Chthamalus stellatus* (see photo above) persist at a few wave exposed sites (including West of Mioness, Riven Noust and Burgo Taing). There were more records (5) in 2022 than any previous year, including a first record for Vidlin Ness.

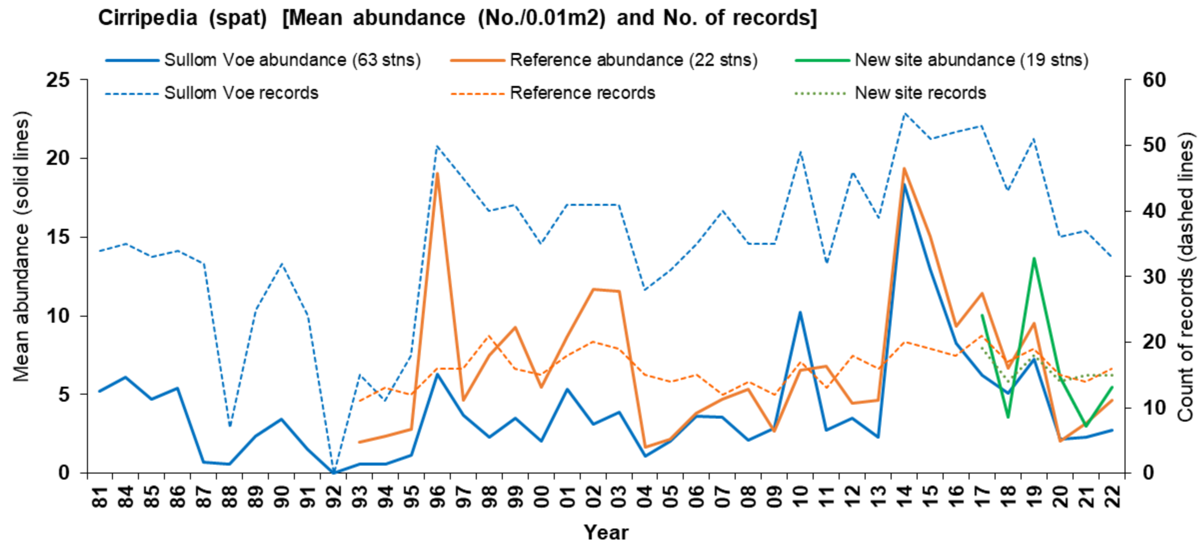
3.1.5 ***Semibalanus balanoides*** **(barnacle)**

Old adult *Semibalanus balanoides* (note dark coloured pitting, from the lichen *Pyrenocollema halodytes* (*left*); and Abundant *Semibalanus balanoides* with Super abundant barnacle spat at Ola's Ness *(right)*.

Average densities of adult barnacles *Semibalanus balanoides* did not change much between 2021 and 2022 and were well within the normal range of fluctuations at both Sullom Voe and Reference sites (see graph below).



Densities of barnacle spat were also similar to 2021 but remaining relatively low compared to some years. Spat were particularly uncommon at the boulder sites, where the habitat is less suitable for barnacles and they often compete for space with algae; with no records at any of the stations on the Kirkabister transect. However, densities at one of the new reference sites, Ola's Ness (see photo above), were relatively high, illustrating the spatial patchiness of settlement



3.1.6 [*Balanus crenatus*] (barnacles)

This barnacle is common in many rocky subtidal habitats but only extends up into the lower parts of the intertidal. It is often recorded in low abundance in lower shore stations but was only found at two sites in 2022.

Balanus crenatus (sum of abundance scores from five stations, by site and year)

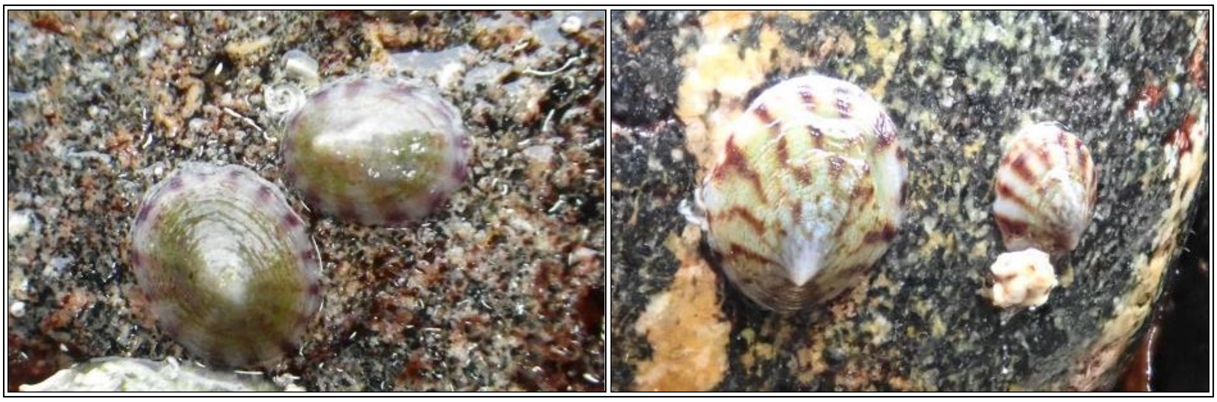
	Site name	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
Sullom Voe	W.of Mioness	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Roe Clett	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
	Noust of Burraland	0	0	0	0	0	0	0	0	0	0	0	0	0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

3.1.7 Tectura virginea & [Testudinalia testudinalis] (tortoiseshell limpets)

In Shetland both of these species are confined to damp rock on the lower shore (see photos below) and they are more abundant subtidally. Within UK, *T. virginea* has a more southerly distribution than *T. testudinalis* and it is expected that climate change will result in the former becoming more abundant as the latter gets pushed north. This effect is not yet evident in this rocky shore data. The numbers of records of both have been relatively higher in recent years but were higher in the mid '90s.

Tortoiseshell limpets, count of records by year (summed across all sites)

Year	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	20	21	22
Testudinalia testudinalis	5	7	5	6	7	6	3	1	6	3	0	1	3	1	0	0	1	2	3	1	1	2	3	1	1	2	4	2	3	3
Tectura virginea	2	7	8	4	4	3	1	3	2	1	1	3	1	1	0	0	0	3	1	1	1	1	0	1	1	1	1	6	1	4

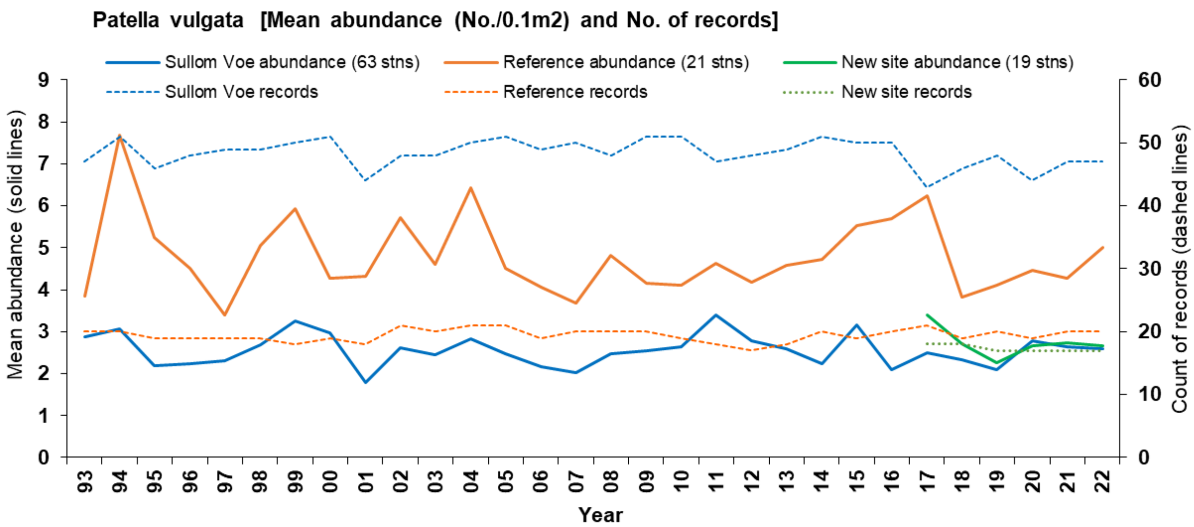


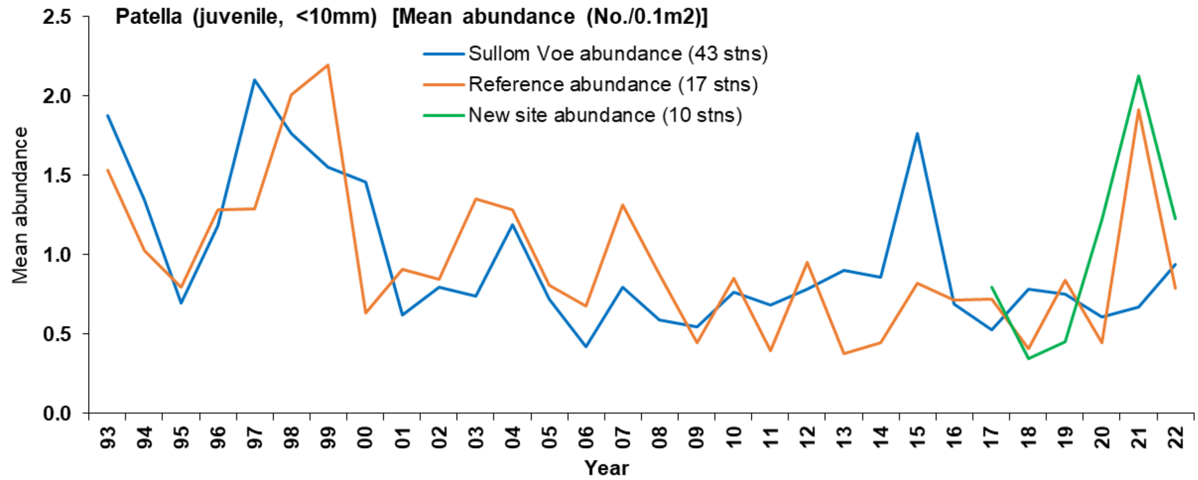
Tectura virginea (*left*); and *Testudinalia testudinalis* (*right*) on lower shore rock at Mavis Grind (2013) and Kirkabister (2019) respectively.

3.1.8 *Patella vulgata* (limpet)

Patella vulgata, adults at Burgo Taing (*left*) and an adult and juveniles at Roe Clett (*right*).

Abundances of adult limpets showed little change, compared to 2021, at any of the monitoring sites, in Sullom Voe or the Reference transects (see graph below). However, there was a large decrease in numbers of juvenile limpets at some Reference sites (see lower graph) following the notable recruitment seen in 2020 at Vidlin Ness, Kirkabister and the West Lunn Pund sites. Densities at Ola's Ness remained fairly high.





3.1.9 *Steromphala cineraria* (grey topshell)

Grey topshells (see photo below) are frequently recorded in lower shore stations at the relatively sheltered sites, particularly in microhabitats that don't dry out, under boulders and dense *Fucus serratus* canopy, where they feed on microalgae and organic detritus. The 2021 report suggested that they may be useful indicators of habitat stability, and this has been further assessed here. The lower shore at Scatsta Ness (cleared) and Kirkabister are often characterised by numerous grey topshells (see table below); however, in 2022, none were found at the former while particularly large numbers were recorded from the latter. Observations made during the survey suggested that the lower shore at the former appeared disturbed while the fucoid canopy at the latter was still well developed. Signs of disturbance were also noted at South of Jetty 2. This is discussed further in Section 4.

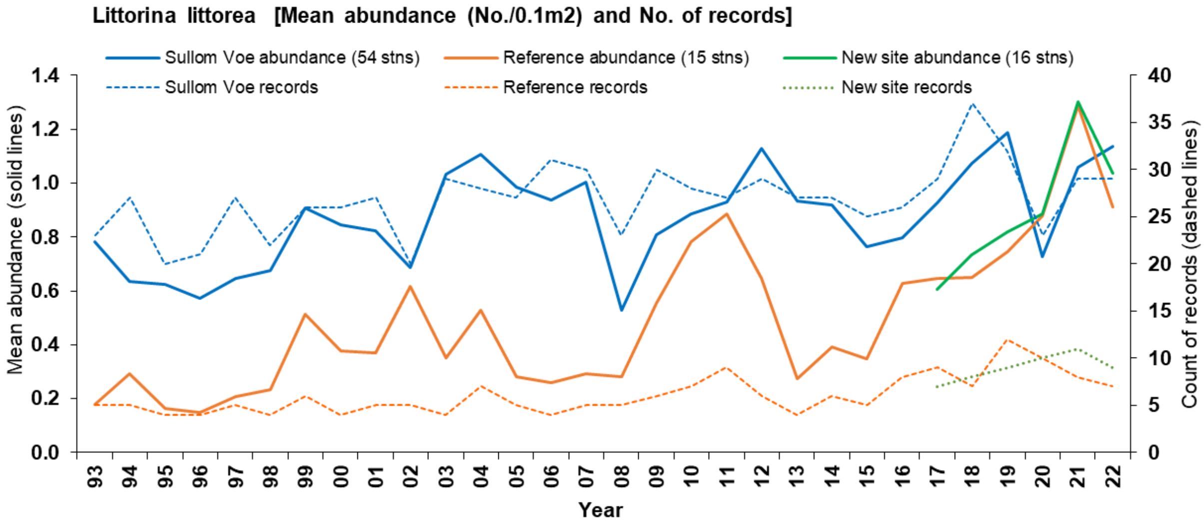
Steromphala cineraria (sum of abundance scores from five stations, by site and year)

Site name	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	20	21	22
Voxter Ness	0	2	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	4	0	0	5	6	2	0	0	0
S.of Skaw Taing	0	0	0	0	3	0	2	0	0	0	0	0	0	0	0	0	4	0	0	0	0	3	0	0	0	2	2	0	0	0
Mavis Grind	0	0	2	0	0	0	4	0	0	0	3	0	0	0	0	0	0	0	2	0	0	0	0	3	2	0	0	0	0	0
S.of Jetty 2	0	0	2	0	0	0	0	0	0	2	4	0	3	0	0	0	2	0	3	0	0	0	0	0	0	2	0	0	5	0
Scatsta Ness (cleared)	3	4	7	9	9	2	5	5	4	2	5	4	6	4	3	0	5	5	3	4	0	5	2	4	6	8	7		5	0
Kirkabister	6	6	6	9	9	6	2	5	3	3	2	4	4	5	9	8	4	4	0	2	0	4	0	5	6	0	3	6	5	9
West Lunna Pund South																									2	3	4	3	2	2
West Lunna Pund North																									0	2	3	2	3	4
Croo Taing																									4	0	4	2	2	0


Steromphala cineraria on serrated wrack at Kirkabister (*left*) and large numbers of *Littorina littorea* near Skaw Taing (*right*).

3.1.10 *Littorina littorea* (edible winkle)

Edible winkles (see photo above) 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 has been linked to increases in fucoids. The graph below shows a continued increase in overall abundance in Sullom Voe since 2020, but a notable reduction at the reference sites. However, fairly large fluctuations in the recorded abundances of this mobile species are not unusual.

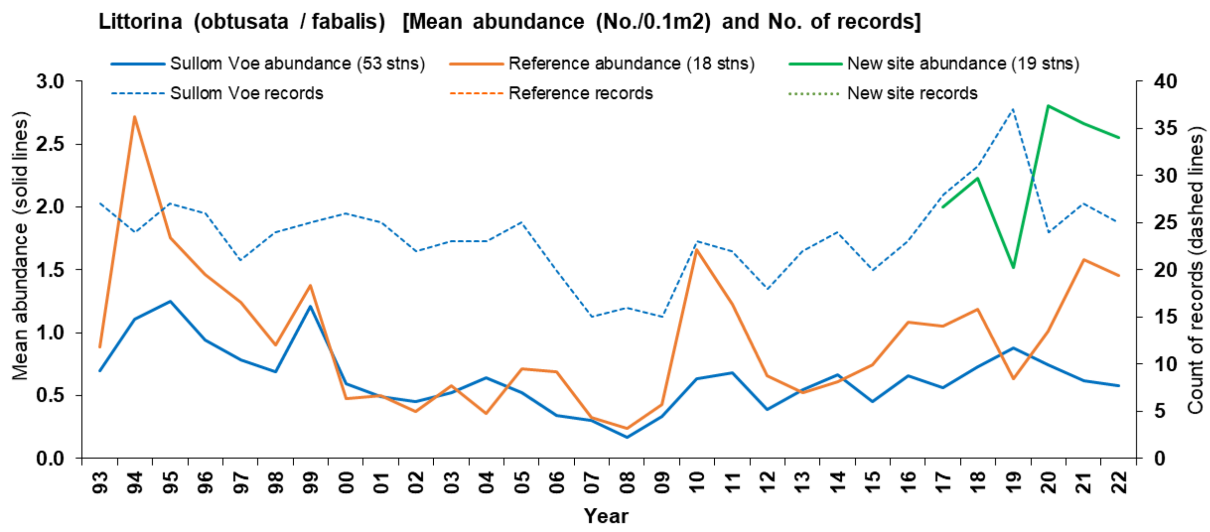


Littorina obtusata (showing two of their colour variations) at North Burra Voe and Burgo Taing.

3.1.11 *Littorina* (*obtusata* / *fabalis*) (flat winkles)

Littorina obtusata (see photos above) is mainly found on the fucoid algae that they prefer to feed upon, particularly *Fucus vesiculosus* and *Ascophyllum nodosum* on the mid shore. *L. fabalis* is mainly found on *Fucus serratus* on the lower shore where it feeds upon a variety of other epiphytes. However, there is much overlap in their habitats and distinguishing the two species is often unreliable (without dissection), so recording is routinely aggregated to *Littorina* (*obtusata* / *fabalis*).

A trend of increasing abundance has been apparent for many years and is likely due to the trend of increasing fucoid algae that has been discussed in previous reports. Notable large fluctuations, at some sites but occasionally overall sites, have been seen in the data (see graph and table below). There was an overall increase at the reference sites in 2021 and those levels were maintained in 2022; but there were both increases and decreases at Sullom Voe sites with no obvious pattern.

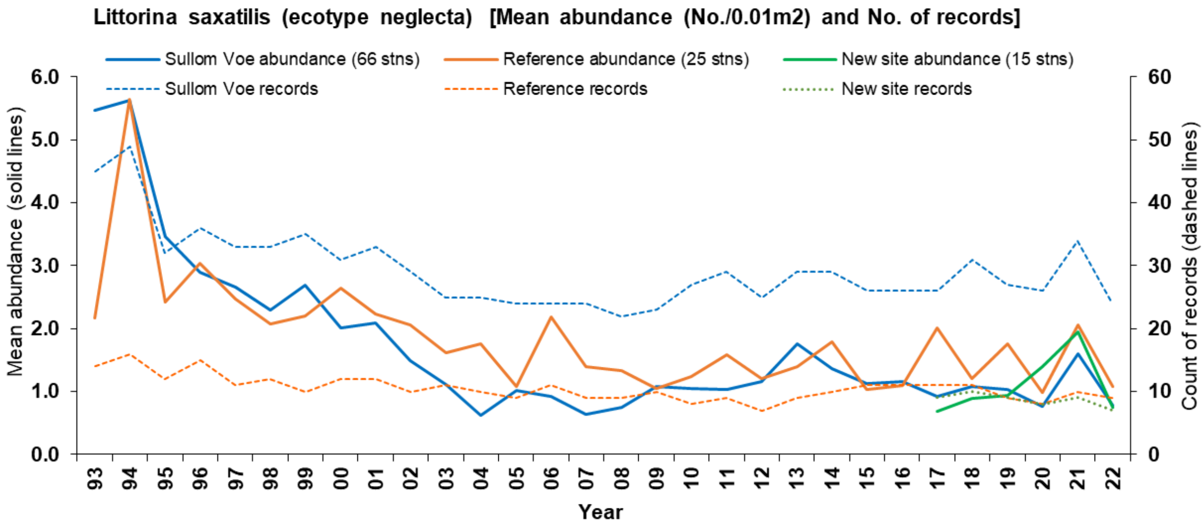


Littorina (obtusata / fabalis) (sum of abundance scores from five stations, by site and year)

	Site name	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	20	21	22
Sullom Voe	W.of Mioness	1	3	0	2	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	1	0	2	0
	Roe Clett	0	3	0	0	3	0	0	0	0	0	0	0	3	2	0	0	0	0	2	0	0	0	0	0	2	0	4	3	3	2
	Noust of Burraland	2	0	2	2	0	2	1	0	2	0	4	0	0	4	0	0	0	0	0	0	4	0	0	0	2	4	2	3	0	0
	Gluss Island East	0	4	2	0	0	0	0	0	1	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4	2	5	5	4
	S.of Swarta Taing	0	2	9	0	2	2	0	2	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	5	6	6	7	6	4
	Grunn Taing	4	6	3	2	0	2	4	5	2	2	2	0	5	5	4	2	0	0	1	2	2	4	0	0	4	4	7	3	7	5
	The Kames	3	3	0	2	0	4	6	2	2	2	0	6	0	5	0	2	0	2	2	0	0	3	3	4	0	0	6	0	0	0
	Voxter Ness	2	0	2	0	2	2	0	3	0	2	2	3	3	2	0	2	0	0	0	4	6	4	0	5	4	8	0	4	0	3
	S.of Skaw Taing	8	10	10	10	8	8	9	5	4	4	2	5	7	9	6	5	5	6	7	4	4	11	7	7	5	12	8	9	8	9
	Jetty 3	13	14	18	14	7	9	13	10	10	13	13	11	14	7	4	4	8	14	10	8	12	9	11	10	10	11	13	13	7	8
	Mavis Grind	13	11	11	12	12	11	11	8	8	4	6	5	6	2	6	3	4	6	5	3	4	4	6	6	7	6	11	3	7	8
	Fugla Ayre	7	4	6	7	3	4	9	5	9	6	5	2	2	0	0	0	3	2	2	3	8	4	0	8	7	6	6	9	6	3
	S.of Jetty 2	8	10	16	18	15	13	20	13	9	11	16	14	13	3	2	8	11	16	16	7	14	14	8	7	7	14	17	15	12	13
	Scatsta Ness (cleared)	20	19	23	20	20	20	22	19	18	13	15	18	16	15	14	12	13	21	20	18	15	20	21	25	21	18	20		14	14
	Scatsta Ness (uncleared)	11	17	13	14	14	10	16	15	12	14	14	18	11	8	11	5	9	14	17	13	9	13	12	11	10	13	15	13	14	11
Reference	Riven Noust	2	6	2	4	3	3	0	3	2	2	2	0	2	0	0	0	4	0	2	2	4	5	2	3	0	3	2	0	3	2
	Vidlin Ness	11	18	14	12	16	6	2	4	3	0	2	2	5	4	3	2	2	22	15	9	11	9	13	10	15	14	10	14	16	14
	Burgo Taing	3	6	6	8	3	0	8	3	2	2	5	7	3	5	2	0	7	2	2	3	0	0	0	2	0	0	1	0	7	9
	Kirkabister	15	20	14	14	15	16	17	12	13	10	13	8	15	15	8	10	11	12	19	10	8	11	12	18	15	16	12	13	14	14
	North Burra Voe	11	14	14	14	9	14	11	10	11	10	10	7	9	10	7	8	6	11	4	9	3	10	10	14	11	11	11	8	9	9
New refere.	Ola's Ness																									9	8	10	11	9	8
	West Sandwick																									7	9	8	8	12	12
	West Lunna Pund South																									17	13	14	14	14	11
	West Lunna Pund North																									17	16	18	20	17	15
	Croo Taing																									12	17	10	17	16	16

3.1.12 *Littorina saxatilis* (ecotype *neglecta*) (a small winkle)

Small globular shaped rough winkles found amongst barnacles and particularly inside the empty cases of dead barnacles (see photo below) are common on many of the wave exposed and moderately exposed monitoring sites. Following the increased mean abundance in 2021 that was described in the last report, abundances in 2022 were much lower, at almost all sites (see graph below).

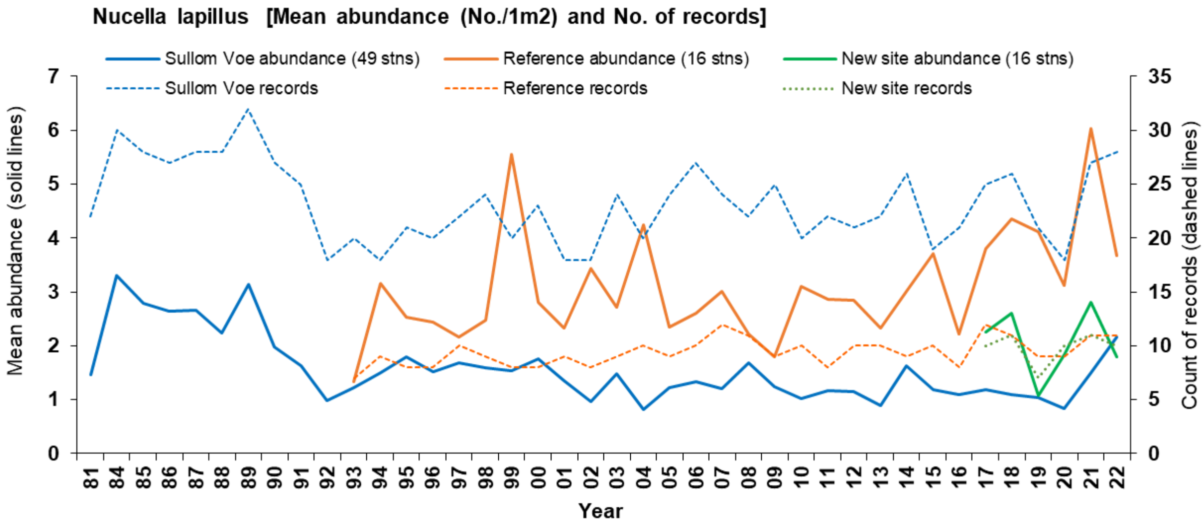


Littorina saxatilis ecotype *neglecta* in and amongst barnacles at Riven Noust (*left*). Adult and juvenile *Nucella lapillus* (*right*).

3.1.13 *Nucella lapillus* (dogwhelk)

In the late 1980s and early 1990s dogwhelk populations in Sullom Voe, particularly around the oil terminal, suffered a decline caused by contamination from TBT antifouling paints. A gradual recovery has been described in recent years and dogwhelks eventually returned to sites closest to the terminal - first to The Kames in 2006 and then to the jetty sites in 2018. Their average abundance across the Sullom Voe sites remained lower than it was in the 1980s but there was an increase in 2022, as shown in the graph below, particularly at The Kames. Decreases were seen at the Reference sites, but large numbers of dogwhelks were still present in their typical habitats, except at Vidlin Ness where their continued absence is unusual.

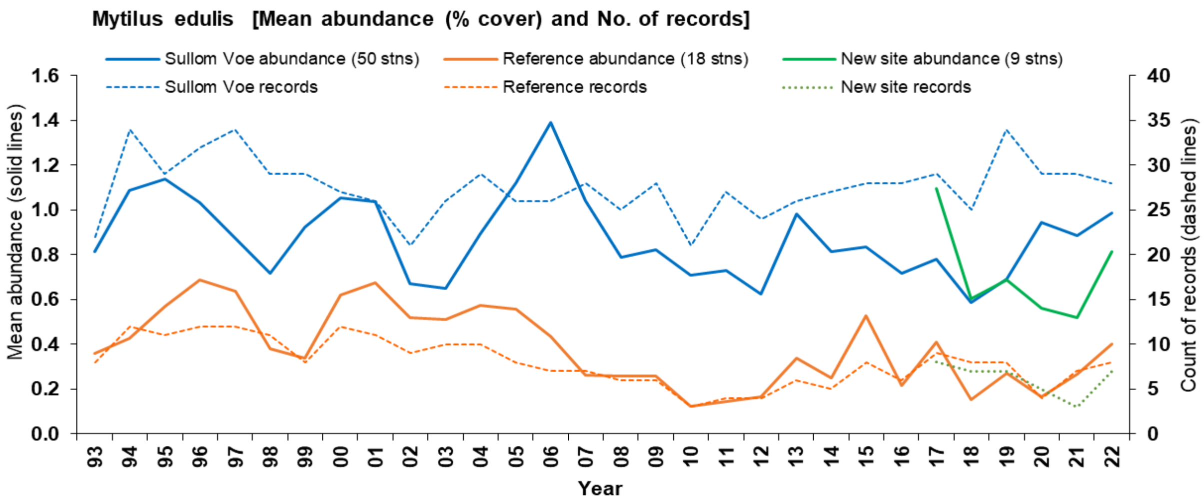
For more information on dogwhelk populations see the associated report from SOTEAG's dogwhelk monitoring programme (Moore et al. 2022). The next dogwhelk survey is planned for 2024.



3.1.14 [Mytilus edulis]() (mussels)

Juvenile *Mytilus edulis* at West of Mioness in 2005 (*right*); and adults at Mavis Grind (*left*).

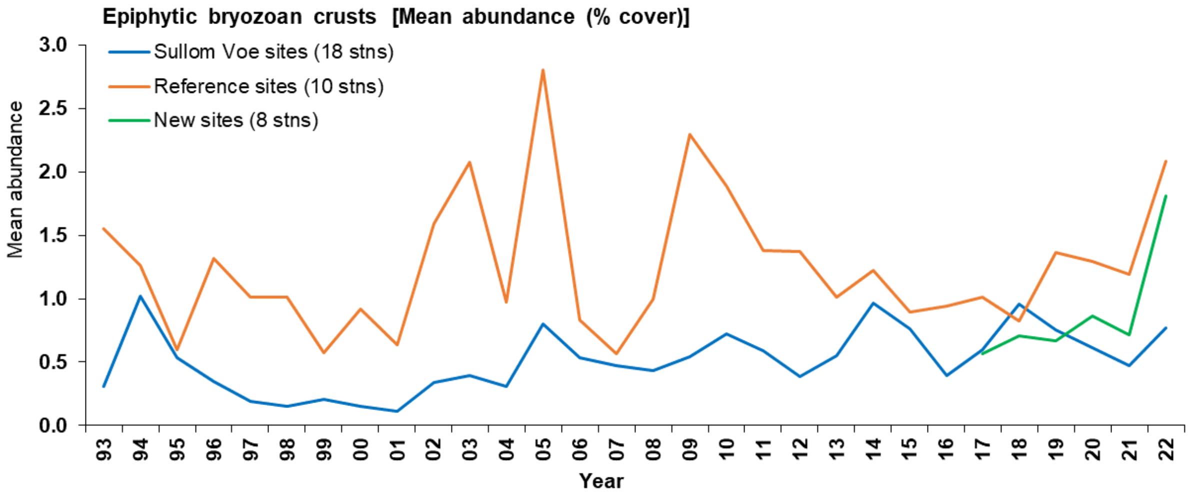
Juvenile mussels commonly occur at most sites and sometimes cover significant areas of rock surfaces at some of the more wave exposed sites (see photo above, from 2005). In contrast, growth and survival to adult mussels is much less common and there are relatively few, mostly wave sheltered, sites where clumps of adults are found. The ecological functions of the two life stages are likely different but the recording protocol has never distinguished between them, although it would be straightforward to do so. The graph below shows that 2005 and 2006 were particularly good years for mussels and it is apparent from the detailed records that this was primarily due to high cover of juveniles at sites like West of Mioness. The graph also shows increases in overall mussel cover in 2020 and 2022, but the further inspection shows that this is partly due to increases in adults at sites like Kirkabister.



3.1.15 Epiphytic bryozoa

Variety of epiphytic bryozoa on lower shore, including *Flustrellidra hispida*, *Alcyonidium hirsutum* and *Electra pilosa* (*left*); and close-up of *Alcyonidium polyoum* to show characteristic clusters of pink embryos (*right*); both on *Fucus serratus* at Kirkbister.

A few species of encrusting bryozoa (see photo above) colonise the stipes and blades of lower shore algae, particularly on mature thalli of *Fucus serratus* at moderately exposed sites. *Flustrellidra hispida* and *Alcyonidium hirsutum* are usually the most abundant and both showed notable increases in both numbers of records and overall abundance in 2022 (see graph and table below). Two other *Alcyonidium* species, *A. gelatinosum* and *A. polyoum*, are generally found less frequently at the monitoring sites and records are often best aggregated (as *Alcyonidium* (*gelatinosum* / *polyoum*)) because they are difficult to distinguish unless they are in a particular reproductive state. Embryos were visible in specimens from Kirkabister in 2022 (see photo above), so identification to *A. polyoum* was confirmed. *Electra pilosa* was recorded from more stations than any previous survey.



Epiphytic bryozoa

Year	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	20	21	22
Flustrellidra hispida	11	14	12	12	11	11	9	6	7	9	11	7	15	10	12	10	10	13	12	11	11	14	12	12	16	20	16	12	16	19
Alcyonidium hirsutum	3	4	4	4	4	5	8	5	3	5	6	5	10	7	4	6	9	5	4	7	6	8	5	6	7	7	9	8	9	15
Alcyonidium (gelat./poly.)	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	nr	2	1	2	3	2	2	2	0	3	6	11	8	5	6
Electra pilosa	7	8	2	4	6	7	7	6	7	7	12	10	11	7	5	11	9	10	9	6	7	7	12	12	12	9	18	14	15	19

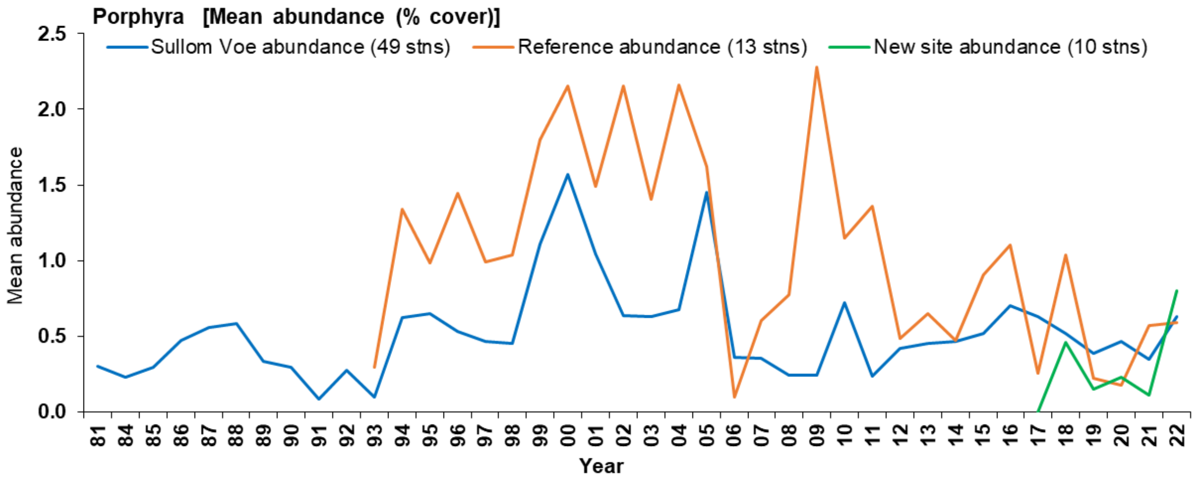
3.1.16 Sea urchins and starfish

Psammechinus miliaris at Mavis Grind (*left*); *Echinus esculentus* at Kirkabister (*middle*); *Henricia* at Scatsta Ness (*right*).

Three species of echinoderms are included here for general interest. The green sea urchin *Psammechinus miliaris*, the edible sea urchin *Echinus esculentus* and the bloody henry star fish *Henricia* (see photos above) are occasionally recorded from lower shore stations, though all three are primarily subtidal species. *P. miliaris* is most frequently recorded at Mavis Grind where they are fairly common in the sublittoral fringe. The others have been recorded from various sites. All three were recorded in 2022 and *Henricia* was recorded from four sites.

3.1.17 *Porphyra* (a red alga)

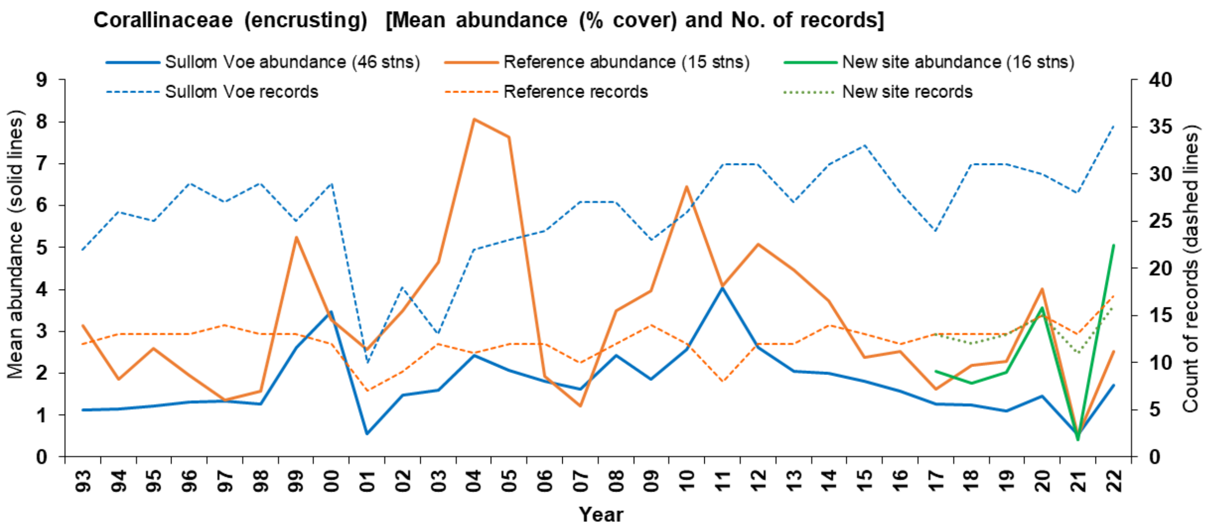
This fast-growing opportunistic species sometimes smothers areas of rocky shores (see photo below) where it likely has effects on barnacles and other fauna. High cover can occur at many sites and stations but that has been largely confined to two or three moderately exposed sites in recent years, particularly South of Swarta Taing.



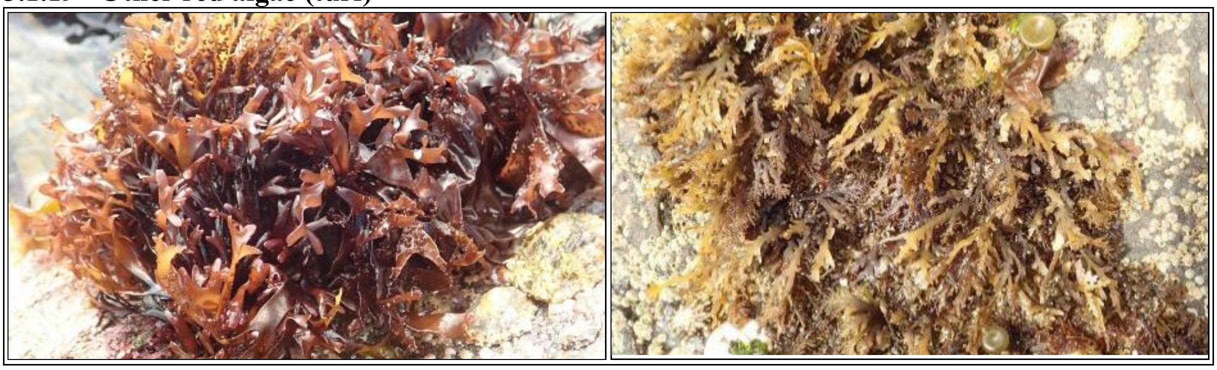
Porphyra on mid shore (*left*) and encrusting coralline algae on the low shore (*right*); both at South of Swarta Taing.

3.1.18 Encrusting coralline algae

Encrusting corallines are common on lower shore rock (see photo above) and in other places on the shore which are permanently wet. As relatively slow growing species their recorded abundances fluctuate much more than expected. Consistency of recording is difficult to achieve as the crusts are often temporarily hidden beneath other fauna and flora and their appearance can range from striking pink to very pale and drab and inconspicuous. The records are also likely influenced by changes in surveyor, and this is likely the reason for the notable reduction in overall abundance in 2021 followed by a similarly sized increase in 2022. However, it is also notable that these crusts were recorded from more stations in 2022 than in any previous survey.



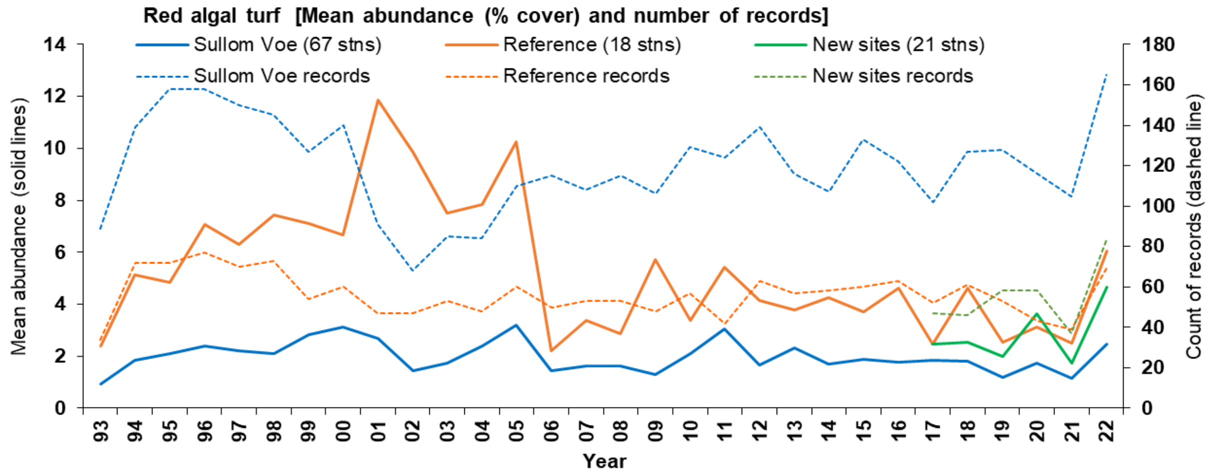
3.1.19 Other red algae (turf)



Mastocarpus stellatus (*left*) and *Osmundea pinnatifida* (*right*) at Burgo Taing.

Numerous species of foliose and filamentous red algae grow as a low turf in damp and shaded habitats on the shore, with increasing species richness towards the lower shore. The table below lists the most frequently recorded species. Aggregated data across all species provides an overview of changes in these turfs (see graph below) and shows that there was a large increase in both numbers of records and overall abundance in 2022. Most of that increase was from six species: *Dumontia contorta*, *Corallina*, *Chondrus crispus*, *Membranoptera alata*, *Osmundea hybrida* and *Polysiphonia*. Four of those, *D. contorta*, *M. alata*, *Gelidium* and *C. crispus* were recorded from more stations in 2022 than in any previous survey. Increases were recorded from both Sullom Voe and Reference sites. A high abundance of *Plumaria plumosa* in the lower station at Roe Clett was unusual.

The species with the most notable increase was *Chondrus crispus*, which was recorded from over 50% more stations in 2022 than in any previous survey. Overall abundance also increased considerably. Much of that was due to many new records of low abundance, but there were also many small increases in abundance (e.g. from Occasional to Frequent) at sites where it is routinely recorded. Inconsistency of identification between *C. crispus* and *Mastocarpus stellatus* has been noted in past reports, but that played no significant part in the 2022 increase. Numbers of records of *M. stellatus* decreased slightly but there was no notable change in overall abundance.

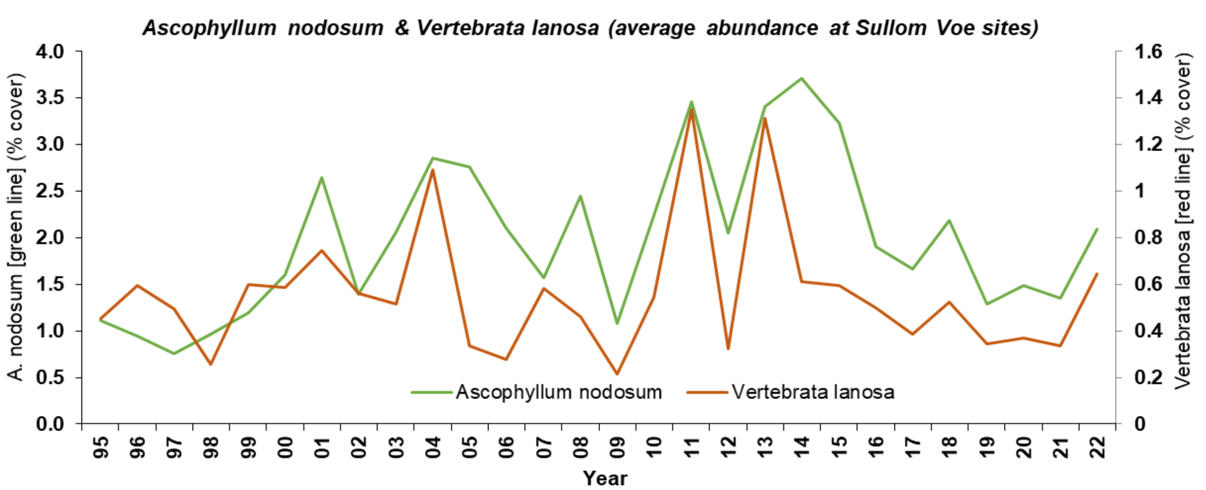


Selected red algal turf taxa, sum of abundance scores by year (summed across all sites)

	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	20	21	22
Gelidium	5	8	14	4	12	11	7	7	19	7	7	12	14	11	7	16	8	9	7	13	15	15	8	9	11	11	15	17	14	22
Dumontia contorta	17	18	31	31	17	23	26	30	37	9	23	18	24	9	12	5	1	11	4	14	10	8	22	14	19	24	15	25	9	57
Corallina	28	42	51	49	58	53	48	42	34	41	50	37	51	36	46	39	39	43	45	54	46	33	31	33	32	51	38	44	22	50
Mastocarpus stellatus	58	79	66	73	79	73	77	84	73	42	71	57	73	64	58	65	62	80	75	79	73	60	71	73	56	54	52	71	52	52
Chondrus crispus	5	34	40	43	36	38	30	35	22	23	26	28	35	26	14	33	23	24	17	24	28	40	30	29	41	68	54	46	27	94
Lomentaria articulata	13	25	24	19	25	29	23	26	27	22	18	21	28	26	23	21	20	33	29	36	27	31	25	19	28	24	21	33	19	34
Plumaria plumosa	0	4	4	8	6	7	5	3	0	6	0	9	0	4	6	5	2	9	6	8	4	4	18	15	5	13	10	9	6	15
Membranoptera alata	6	23	21	17	12	17	19	13	18	15	15	12	24	7	14	15	11	11	18	30	19	12	23	20	21	23	13	20	18	39
Osmundea hybrida	15	20	26	28	21	23	17	30	7	32	20	41	7	34	26	12	0	12	7	10	14	11	9	10	12	17	2	7	8	22
Osmundea pinnatifida	22	45	40	42	42	44	37	32	41	24	30	13	30	23	26	29	30	31	43	43	34	42	37	31	30	41	26	30	21	40
Polysiphonia	36	44	42	32	28	38	21	22	20	17	29	17	49	14	20	10	5	4	24	4	7	5	8	24	12	8	25	23	8	35

3.1.20 *Ascophyllum nodosum* (knotted wrack) and *Vertebrata lanosa* (a red alga)

Knotted wrack (also known as egg wrack) forms a thick canopy across the mid shore of some sheltered sites like Scatsta Ness, North Burra Voe and Croo Taing. Overall abundance has been relatively low in recent years (see graph below), but inspection of the data shows that is mainly due to fluctuations at a few boulder stations where the substrata can be particularly unstable. The apparent increase in overall abundance in 2022 may not be significant. Abundances at bedrock stations have been relatively stable, at both Sullom Voe and reference sites.

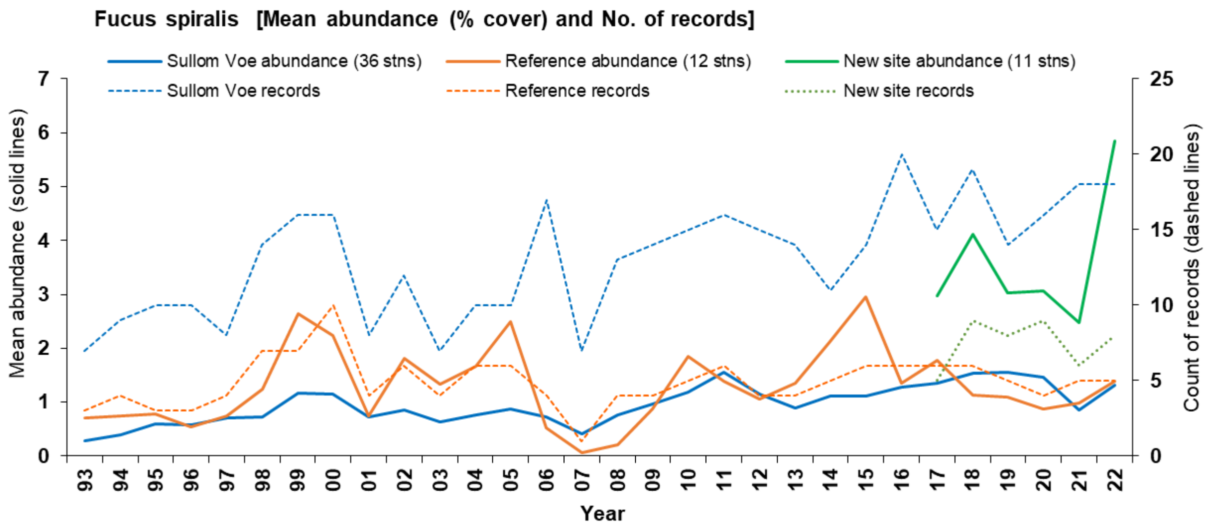


Vertebrata lanosa (see photo below) is a filamentous red alga that lives almost exclusively on egg wrack. Its fluctuations in recorded abundance have mostly followed the same pattern as its host.

Ascophyllum nodosum at West Lunna Pund (*left*) and *Vertebrata lanosa* at North Burra Voe (*right*).

3.1.21 *Fucus spiralis* (spiral wrack)

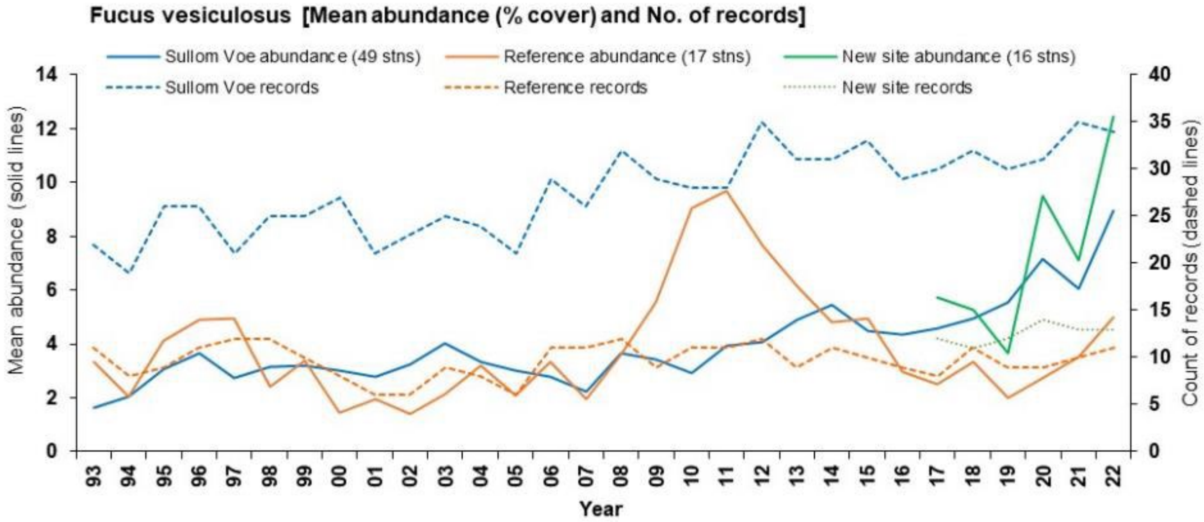
Spiral wrack (see photo below) grows in a narrow band on the upper mid shore and abundances can fluctuate considerably. Numbers of records and overall abundance have increased significantly at the Sullom Voe sites over the course of the monitoring programme. This trend was not apparent at the reference sites but there was a notable increase in abundance at the new reference sites in 2022 (see graph below). The latter was mainly due to a large increase in two stations at West Sandwick.



Fucus spiralis at Mavis Grind (*left*). *Fucus vesiculosus* at South of Jetty 2 (*right*).

3.1.22 *Fucus vesiculosus* (bladder wrack)

Bladder wrack (see photo above) is common on the midshore of all but the most wave exposed sites and is particularly abundant at wave sheltered boulder sites like South of Jetty 2, Scatsta Ness and Kirkabister. A trend of increasing abundance has been discussed in previous reports and appears to be continuing (see graph below). A particularly large increase in three stations at West Sandwick is also shown by the green line in the graph.

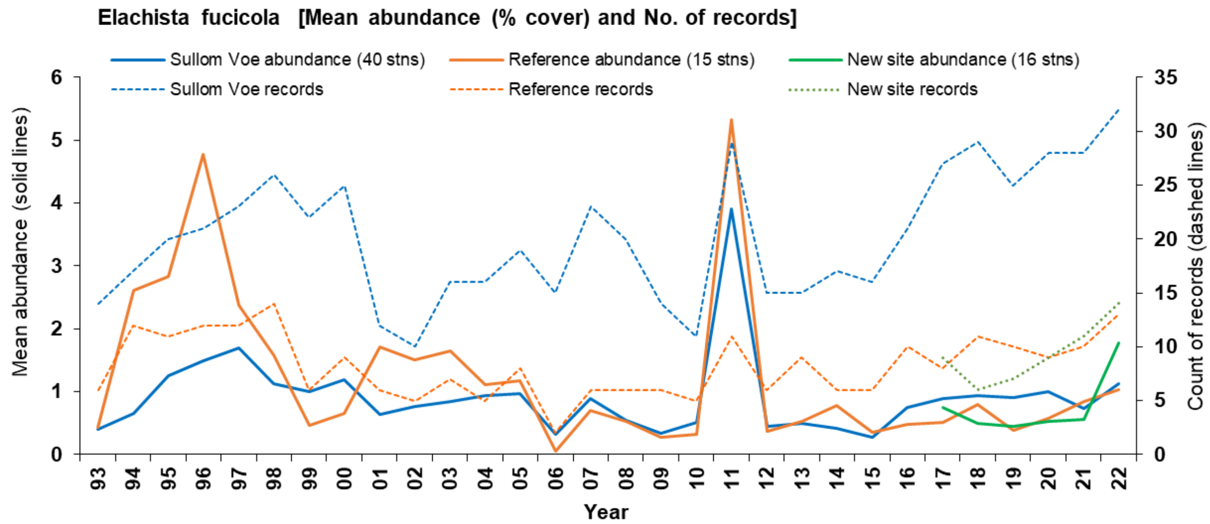


Fucus vesiculosus (sum of abundance scores from five stations, by site and year)

	Site name	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	20	21	22
Sullom Voe	Roe Clett	0	0	1	1	0	0	0	4	4	3	0	0	0	1	0	3	0	2	4	3	2	0	3	8	4	4	3	7	5	3
	Noust of Burraland	4	1	7	7	5	3	1	5	0	3	3	7	4	4	7	5	4	5	4	4	4	6	6	4	6	9	7	9	7	8
	Gluss Island East	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	9	8	10
	S.of Swarta Taing	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	9	10	10
	Grunn Taing	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	11	10	12
	The Kames	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	4	4	5	4	4
	Voxter Ness	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	8	11	9	11
	S.of Skaw Taing	6	5	5	13	6	5	5	4	5	4	5	6	5	6	6	11	11	11	8	8	10	9	9	9	8	8	8	8	10	11
	Jetty 3	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	14	14	13
	Mavis Grind	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	8	8	8
	Fugla Ayre	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	10	10	10
	S.of Jetty 2	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	17	14	19
	Scatsta Ness (cleared)	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		20	22
	Scatsta Ness (uncleared)	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	13	13	14
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	0	3
	Vidlin Ness	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	10	12	11	10
	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	7	7	10
	Kirkabister	15	12	14	13	14	13	17	12	14	13	13	16	15	11	11	14	17	18	21	19	17	17	12	16	16	16	10	11	13	13
	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	6	9	10
New refere.	Ola's Ness																									9	8	8	9	10	10
	West Sandwick																									12	11	11	13	12	17
	West Lunna Pund South																									7	6	6	9	5	6
	West Lunna Pund North																									13	14	11	14	15	15
	Croo Taing																									6	4	5	11	9	12

3.1.23 *Elachista fucicola* (a brown alga)

This filamentous brown alga (see photo below), which primarily grows on serrated wrack and bladder wrack, was recorded from more stations in 2022 than in any previous survey (see graph below). Its abundance also increased, although estimating percentage cover is likely inconsistent because of the multiple overlapping surfaces of its host. Comparison of abundance changes with those of the wracks suggests possible correlation at many sites but not at others.



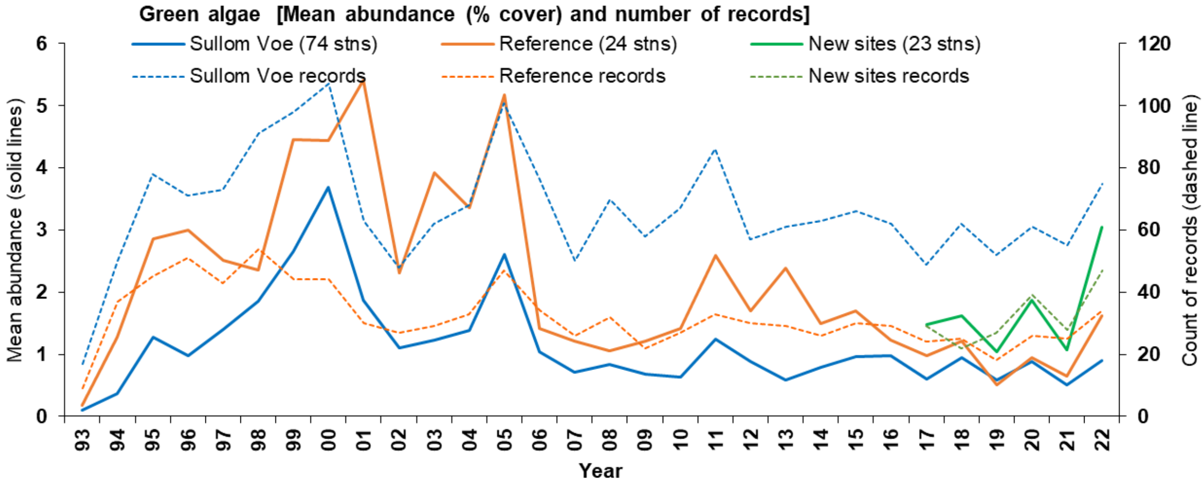
Elachista fucicola at Burgo Taing (*right*). *Ulva* (tubular and flat) at Fugla Ayre (*right*)

3.1.24 Green algae

Many green algae are ephemeral opportunists, so their abundance, as an aggregate group, can be an indicator of community stress and/or long periods of warm wet weather. The table and graph below shows that their abundance has been relatively low in recent years but increased in 2022, particularly at the new reference sites. Inspection of the data shows that increases were seen at most sites, both in Sullom Voe and reference sites, and for all three of the most frequently recorded taxa: *Ulva* (tubular), *Ulva* (flat) and *Cladophora rupestris* (see photos above and below).

Green algal turf taxa, sum of abundance scores by year (summed across Sullom Voe sites)

	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	20	21	22
Chlorophyceae	0	7	78	52	80	113	125	153	51	56	55	72	119	54	14	20	6	3	70	2	12	0	0	0	0	0	0	7	0	2
Ulva (tubular)	17	30	39	41	41	49	61	69	60	39	61	55	95	56	53	58	56	46	47	58	36	51	60	66	58	56	47	55	38	61
Ulva (flat)	4	20	21	18	20	21	18	37	23	12	12	22	18	4	6	20	18	18	30	10	12	19	20	16	9	26	9	21	20	32
Cladophora	5	28	39	50	40	33	36	26	49	29	40	33	65	23	36	37	22	40	38	54	53	47	48	39	27	49	37	39	33	52



Cladophora rupestris at Croo Taing (*left*). *Ovis aries* at The Kames (*right*).

3.1.25 Other species of interest

It is not unusual for sheep to be seen on shorelines in Shetland, but our sighting of three sheep at The Kames (see photo above) was the first time that we had seen them on one of the monitoring sites. Hansen et al. (2003) list a range of algae that are routinely eaten by sheep on North Ronaldsay, which include brown, red and green species. However, they found that there was a strong preference for *Palmaria palmata*, *Alaria esculenta* and *Laminaria* spp., either drift (i.e. unattached and deposited on the shore by tides and wave action) or fresh (only accessible during spring low tides). Fucoid algae were usually rejected unless there was nothing else because they do not meet the energy requirements of the sheep. This may explain why we have rarely noticed signs of sheep grazing on any of the monitoring sites.

3.2 Species richness

The number of taxa recorded from each site during each survey fluctuates considerably, as shown in the table below. The fluctuations are primarily of species that are relatively inconspicuous and present in low abundance, particularly those not listed on the proforma; and whether they are found and recorded is highly dependent on the recorder, the time spent recording and the survey conditions.

Despite those inconsistencies, studying the numbers of species recorded has occasionally been useful to assess the effects of site specific effects, e.g. physical disturbance at the jetty sites, sometimes with a focus on particular groups of taxa. It was studied this year to assess the effects of a perceived increase in disturbance from wave action on boulder shores in Sullom Voe, i.e. Fugla Ayre, the two Scatsta Ness sites and South of Jetty 2. However, species richness was well within the level of typical fluctuations at all four sites.

Number of recorded taxa, by site (excluding records with abundance=Rare)

	SiteName	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	20	21	22
Sullom Voe	West of Mioness	21	23	29	27	25	22	27	22	25	20	24	25	18	21	20	23	22	28	24	18	25	24	28	24	25	29	26	30	33
	Roe Clett	31	37	35	34	34	32	38	31	30	30	28	33	26	32	29	25	31	34	29	30	14	34	39	40	40	46	48	39	47
	Noust of Burraland	35	38	47	43	43	36	36	34	31	33	37	42	35	38	33	32	32	33	33	36	32	34	32	31	39	43	39	40	40
	Gluss Island East	42	21	21	28	30	28	31	23	19	20	26	34	26	23	19	19	20	32	23	25	25	23	29	33	30	39	37	31	37
	South of Swarta Taing	44	60	46	53	54	47	54	38	44	44	45	41	39	37	42	35	41	46	44	39	42	40	51	48	48	45	51	48	57
	Grunn Taing	47	46	43	50	48	42	42	30	33	36	38	42	36	35	34	38	36	45	40	43	38	47	48	35	39	48	54	39	53
	The Kames	27	39	44	45	42	40	39	33	28	32	35	43	33	32	34	31	33	42	35	35	31	39	40	36	38	38	38	35	44
	Voxter Ness	22	30	36	35	31	25	28	27	21	27	30	33	28	29	19	26	22	30	24	24	30	23	29	35	38	29	35	23	43
	South of Skaw Taing	42	48	52	53	50	50	50	43	40	46	50	51	38	46	36	35	32	49	47	45	40	41	47	50	49	52	53	48	53
	Jetty 3	34	25	32	29	29	28	26	23	24	24	26	33	22	26	24	26	24	34	23	23	24	27	31	33	33	38	37	35	33
	Mavis Grind (Stream 3)	38	41	49	41	33	41	38	35	30	38	37	34	33	34	30	27	28	38	31	33	34	36	42	43	44	43	46	35	49
	Fugla Ayre	27	22	30	27	21	19	28	21	24	24	15	22	17	12	16	21	16	31	29	25	21	19	21	15	24	28	15	29	31
	South of Jetty 2	22	37	29	28	27	23	27	21	21	25	25	31	22	24	26	25	27	32	23	23	25	19	29	29	34	36	32	35	35
	Scatsta Ness (cleared)	37	44	47	42	43	36	40	43	38	41	39	43	39	37	32	29	37	36	28	39	36	36	37	37	37	41		34	31
	Scatsta Ness (uncleared)	34	26	31	38	26	31	35	31	31	26	34	39	26	32	22	17	24	29	25	28	26	26	29	33	28	26	32	27	32
Reference	Riven Noust	49	43	46	48	34	34	41	38	34	36	44	44	32	39	39	42	34	39	39	44	40	40	41	36	47	43	42	34	48
	Vidlin Ness	35	42	36	45	38	38	41	34	31	37	34	38	28	31	32	23	29	44	38	30	28	28	33	38	37	42	36	40	46
	Burgo Taing	49	50	50	47	42	48	41	36	39	30	41	49	36	34	33	36	37	32	33	37	34	41	47	38	46	41	43	40	53
	Kirkabister	38	39	52	47	44	32	37	37	44	37	52	50	31	28	26	31	29	30	28	31	35	25	34	37	33	38	39	37	37
	North Burra Voe	42	51	51	52	46	43	44	46	44	37	34	47	36	42	34	35	41	40	45	38	37	39	44	44	47	36	43	41	47
New refere.	Ola's Ness																								37	35	41	41	31	48
	West Sandwick																								35	31	40	32	32	44
	West Lunna Pund South																								38	45	47	53	34	51
	Croo Taing																								46	35	49	53	49	52
	West Lunna Pund North																								43	45	46	46	35	47

4 Discussion

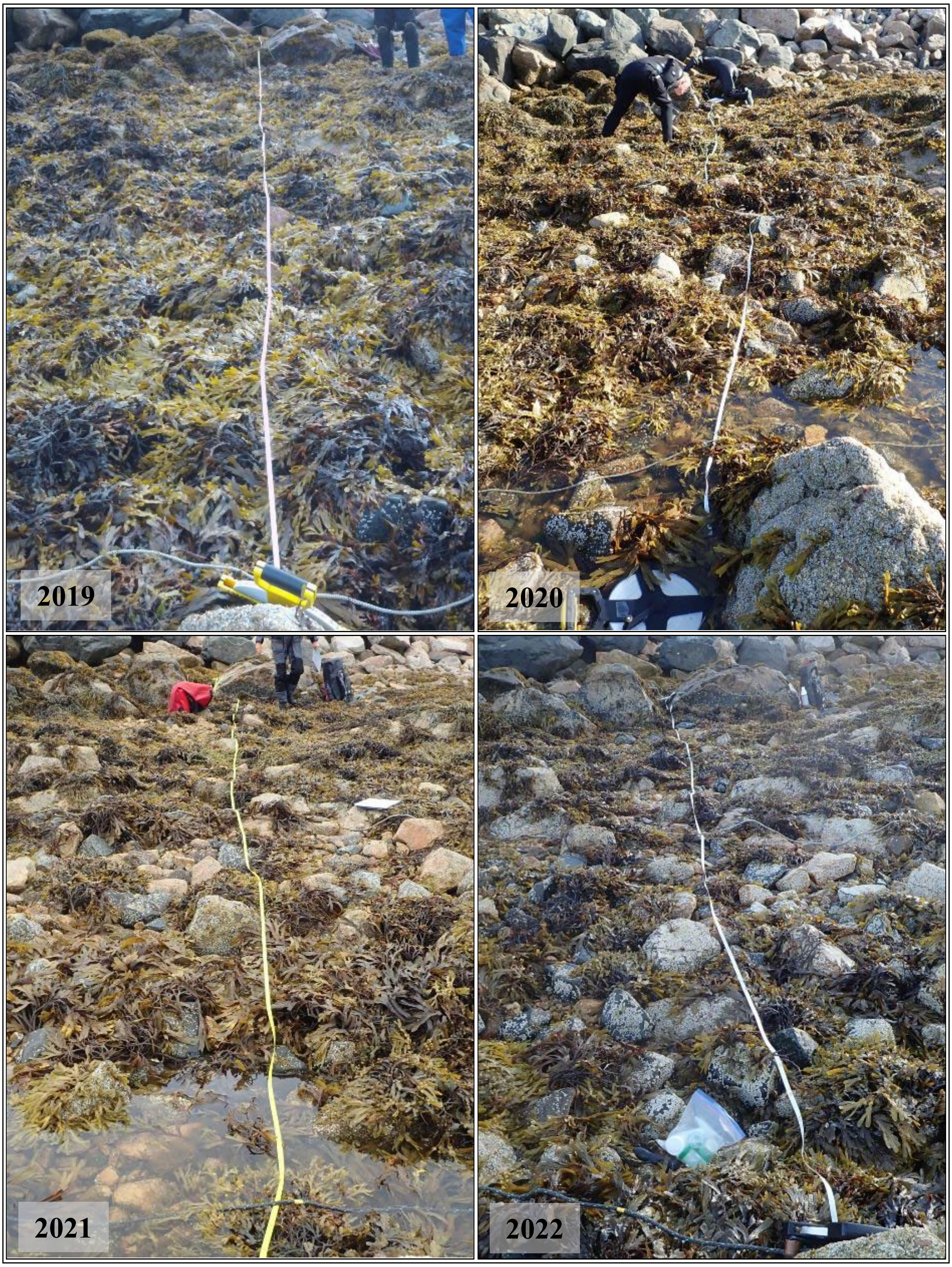
4.1 Changes in rocky shore communities

There were few notable changes in rocky shore communities around Sullom Voe between 2021 and 2022. All 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.

The most notable change in 2022 was the increase in records and abundance of numerous red algal turf species. Some of that increase was a typical level of fluctuation following a poor year in 2021, but for some species, like *Chondrus crispus*, the large increase in numbers of records was unusual. No explanation for the increase is known but it was unrelated to the terminal.

There was also a large increase in the recorded percentage cover of encrusting coralline algae, but that was a return to pre-2021 abundances. The difficulties of estimating abundance of algal crusts was discussed in the last report (Moore and Bunker 2022) and further quality assurance methods are being considered.

In Section 3.1.9 it was noted that signs of increased disturbance were apparent on the boulder shores of Scatsta Ness and South of Jetty 2 and that a lack of grey topshells may be indicative. Data on fucoid cover and species richness (Section 3.2) do not support this suggestion, but the photos shown below from South of Jetty 2 appear to show less fucoid cover across the mid shore and lower boulders. The photos from Scatsta Ness were inadequate for similar comparisons. Any possible trends should be considered further in future reports.



Photos to illustrate reduction in fucoid algae cover at South of Jetty 2 from 2019 to 2022.

4.2 Effects of terminal operations and oil spills

During the period 1st August 2021 to 31st August 2022 there was one small pollution incident reported within Sullom Voe (Sullom Voe Port Authority, pers. comm.). Surface sheen was reported in the vicinity of Jetty 3 on 23 December 2021, but the source was not apparent. The sheen was monitored with no other action. No notable ecological impacts from this pollution event have been reported.

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

4.3 Methodology

As discussed in Section 3.1.14, the recording protocol for *Mytilus edulis* has not distinguished between juvenile and adult mussels, although the ecological functions of the two life stages are likely different and interpretation of changes in their abundance may be confused. It is therefore proposed that future surveys will distinguish between the two life stages while allowing continued comparison with the aggregated data from previous years

5 References

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Appendix 1 Abundance scales used for intertidal organisms

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

R = Rare, O = Occasional, F = Frequent, C = Common, A = Abundant, S = Super abundant, E = Extremely abundant. The letters are converted to a numerical scale, from 1 = Rare to 7 = Extremely abundant, for database storage and for some numerical analyses (see methods sections).

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), *Steromphala* 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: Anne Bunker (AB), Annette Little (AL), Tony Thomas (AT), Ben James (BJ), Christine Howson (CH), Cait Moore (CM), 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), Kirsten Laurenson (KL), Kristofer Wilson (KW), 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.* 2022)

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

Year	Contractor	Survey staff	Sites	Stns	**Methods** (see Moore 2013 for explanation)	Month
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, KL	15 + 10	5	Full survey (5 additional Reference sites)	July
2018	ASML	JM, TM, CM, KL	15 + 10	5	Full survey (+ dogwhelks)	August
2019	ASML	JM, FB, CM, KW	15 + 10	5	Full survey	August
2020	ASML	JM, TM, CM	14 + 10	5	Full survey	August
2021	ASML	JM, AB	15 + 10	5	Full survey (+ dogwhelks)	August
2022	ASML	JM, TM	15 + 10	5	Full survey (+ dogwhelks)	July/Aug