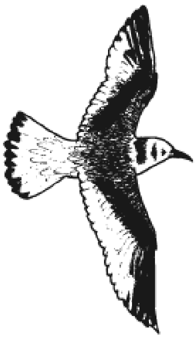
SOTEAG

Survey of the rocky shores in Sullom Voe

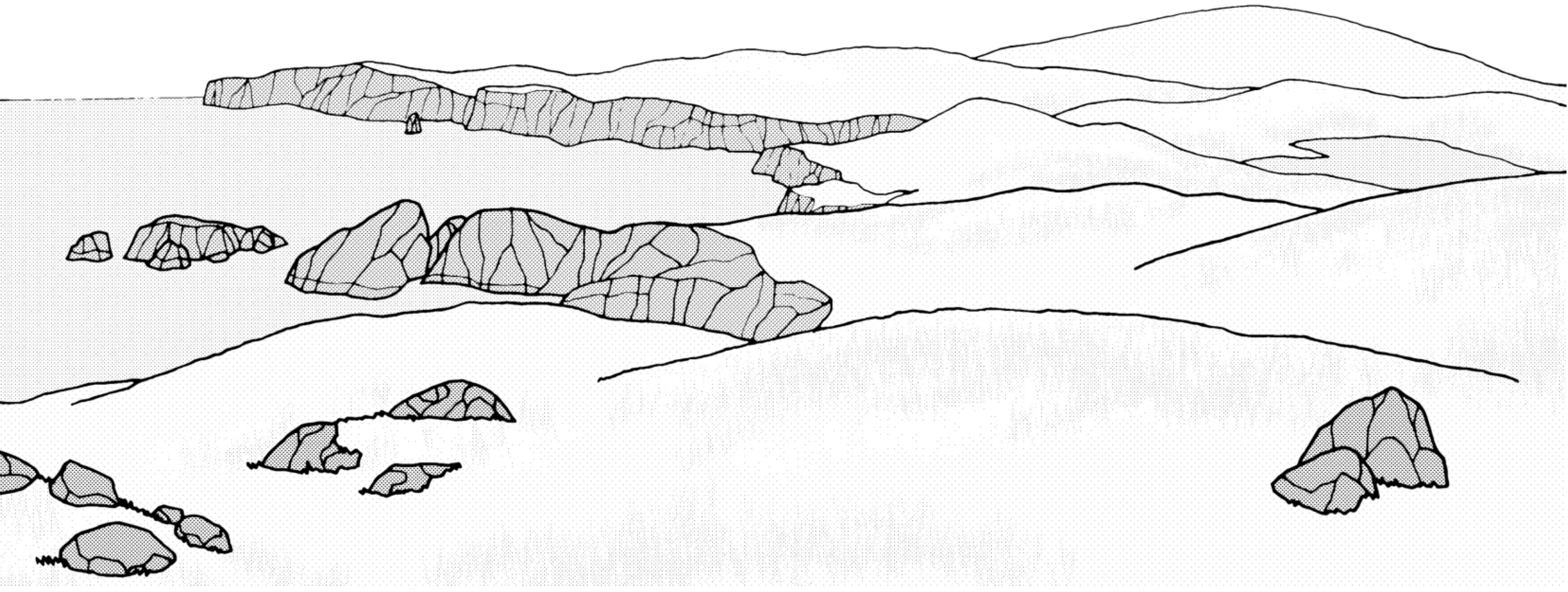


2016

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, July 2016

A report for SOTEAG

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Dr Mike Burrows and other members of the SOTEAG monitoring committee

Data access

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This report is dedicated to the memory of

Christine Howson

who died on 21st September 2016

Christine's involvement with the SOTEAG rocky shore programme began in 1987. She coordinated the fieldwork and reporting in that year and the next. She took part in another eight surveys between 2006 and 2015, when ASML had the monitoring contract and her expert skills and experience in algal identification and marine ecological recording provided considerable benefits to the rocky shore long-term monitoring data.

She also loved the Shetland Islands, its environment and its wildlife.

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 July 2016 – the 39th survey since the programme's inception.

The 2016 survey was carried out with a modified methodology and strategy used since 1993. Earlier data is still directly comparable for analyses. The fifteen original transects in Sullom Voe and the five reference transects outside the Voe were re-surveyed, and the abundance of conspicuous species was 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 2016 survey with those from the 2015 survey and previous surveys have been carried out.

Rocky shore communities at the twenty sites in 2016 were generally very like 2015. The most notable features are listed below:

- The average density of adult barnacles, *Semibalanus balanoides*, across all Sullom Voe sites in 2016 was the highest recorded since the programme began. There was also an increase at Reference sites.
- Densities of limpets, *Patella vulgata*, fell slightly at Sullom Voe sites, but remained relatively high compared to the early years of the programme. Densities increased at the Reference sites.
- Similarly, there were decreases in edible winkle, *Littorina littorea* populations in Sullom Voe sites, but increases at Reference sites.
- Dogwhelk populations continue to recover gradually at sites between and close to the terminal jetties.
- Serrated wrack cover decreased further at both Sullom Voe and Reference sites, due mainly to a contraction in its vertical range up the shore at some sites.
- A notable increase in recorded abundances of spiral wrack, *Fucus spiralis*, and a slight decrease in abundances of bladder wrack, *Fucus vesiculosus*, was found to be partly related to difficulties in identification of some upper mid shore plants. However, much of the increase in spiral wrack was shown to be real.
- A clear trend of increase in both abundance and numbers of records of channelled wrack, *Pelvetia canaliculata*, over the course of the monitoring programme has been noted. This increase, and that of other fucoid algae, may be related to climate change.
- Remediation of the shore between Jetty 1 and Jetty 2, to remove a temporary containment area, has resulted in physical disturbance to a transect site. Removal and movement of boulders from the mid and upper shore had had some impacts, including loss of knotted wrack, *Ascophyllum nodosum*, from one station. Recovery is likely to be slow, even if suitable stable substrata returns.

Most of the changes summarised above are considered to be due to natural fluctuations, with the exception of the impacts between Jetty 1 and Jetty 2.

There was one reported oil spill (a small quantity of light sheen) from a tanker at the terminal in the period between 1st August 2015 to 1st August 2016, with no observed impacts on the rocky shore communities.

Re-levelling to measure the intertidal heights of the fixed monitoring stations was successfully undertaken during the July 2016 survey, but it is recommended that this should be similarly repeated during the next survey to provide confirmation of the results.

Some other changes in analysis and presentation have been made, following a review of the programme in 2015. Some further recommendations for improvement are under consideration.

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 40-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 2016, highlighting changes that occurred since the survey in July 2015 and discussing any notable longer term fluctuations or trends. Some modifications to the methodological descriptions and results presentation have been incorporated since the 2015 survey report, based on recommendations in a recent review of the monitoring programme (Jenkins 2015).

Note: An associated programme of surveys of dogwhelk populations at rocky shore sites around Sullom Voe and Yell Sound is carried out approximately every two years, and was carried out during the July 2015 survey (Moore and Gubbins, 2015). Appendix 3 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 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 took the form of a rapid visual assessment of the shores 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 (1981, 1987 or 1988), 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 more detailed and objective analysis of the data. The number of survey sites in Sullom Voe was reduced and five reference sites were established outside the Voe. Full surveys, rather than rapid visual assessment surveys, were carried out at five stations along each transect, representing the main zones. The latter methodology has been used annually since 1993.

The various changes in sites and transect stations surveyed, survey month and survey personnel that have occurred over the 38 years of the SOTEAG rocky shore monitoring programme are summarised in Appendix 3.

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

2.2 Field survey, July 2016

Fieldwork was carried out by Jon Moore and Tom Mercer between the 19th and 26th July 2016. Table 1 details the sites and the transect stations surveyed, and Figures 1 and 2 show the location of the sites. 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 five sites are in Vidlin Voe and Burra Voe to act as Reference sites for the natural changes that occur in rocky shore populations. The Reference sites do not fully represent the range of environmental variability present across the Sullom Voe sites, so there are often notable differences in some species trends between the two groups of sites.

Access to sites was either by car and foot, or by boat as appropriate. A workboat was supplied by the BP Pollution Response Base. 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). The second number is a consecutive number at that exposure.

A fixed datum marker, usually a pat of concrete and/or a paint mark, 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 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.

Fixed recording stations have been established along the transects at all sites. The stations are located at equal intervals of 20cm vertical height from the fixed datum, with Station 1 at the top. The number of stations on a transect varies between sites (maximum 29), but only five are monitored annually in the current programme. Precise relocation of the monitored stations is mainly with annotated close-up photographs; except on gradually sloping boulder / shingle shores where tape distances are used.

Table 1 Rocky shore transect sites surveyed in Sullom Voe in July 2016, with the stations surveyed on each transect.

No.	Site name	Stations surveyed	Survey date
Monitoring sites			
1.1	W. of Mioness	15, 18, 21, 24, 27	20/07/2016
2.3	Roe Clett	8, 11, 14, 17, 20	22/07/2016
3.3	Noust of Burraland	1, 3, 5, 7, 10	21/07/2016
3.4	Gluss Island East	6, 9, 11, 13, 15	21/07/2016
3.5	S. of Swarta Taing	4, 7, 10, 12, 15	24/07/2016
4.1	Grunn Taing	3, 5, 7, 9, 11	21/07/2016
4.3	The Kames	5, 7, 9, 12, 15	20/07/2016
4.6	Voxter Ness	5, 8, 10, 12, 14	20/07/2016
5.1	S. of Skaw Taing	9, 12, 15, 18, 20	22/07/2016
5.2	Jetty 3	5, 7, 9, 11, 13	23/07/2016
5.5	Mavis Grind	3, 5, 7, 9, 12, 14	21/07/2016
6.1	Fugla Ayre	3, 5, 7, 9, 11	22/07/2016
6.2	S. of Jetty 2	3, 6, 9, 11, 13	23/07/2016
6.12	Scatsta Ness (cleared)	2, 4, 6, 7, 8	24/07/2016
6.13	Scatsta Ness (uncleared)	4, 5, 8, 10, 12	24/07/2016
	Orka Voe bund		24/07/2016
Reference sites			
2.9	Riven Noust	13, 17, 19, 22, 24	20/07/2016
3.8	Vidlin Ness	5, 7, 9, 10, 12	22/07/2016
3.12	Burgo Taing	3, 6, 9, 11, 13	23/07/2016
6.11	Kirkabister	4, 6, 8, 10, 12	22/07/2016
6.14	N. Burra Voe	4, 6, 8, 10, 12	23/07/2016

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). This was achieved at Mavis Grind in 2016, but tides and time did not allow for this at the Voxter Ness site. The stations surveyed are listed in Table 1.

2.2.2 Levelling shore height of stations

The transect stations were originally levelled with a cross-staff level from a fixed point at the top of each transect. When the survey programme changed in 1993 the relative tidal height of each station was calculated from pre-1993 survey data (knowing the lowest accessible station and the tidal height at the time of the survey). Graphical alignment of these heights was used to aid selection of the five stations on each transect for the current monitoring strategy. However, these height estimates had potential errors of many centimetres, due to multiple small errors in the use of the cross-staff level.

A recent review of the monitoring programme (Jenkins 2015) recommended that the tidal height of each station should be more clearly defined. A simple low-tech Water Level method was considered to be adequate and was applied during the 2016 survey.

The equipment consisted of a clear PVC tube filled with water (except for approx. 50 cm at each end), and a 1m wooden ruler. At each transect site, once the stations had been relocated (see Section 2.2.1), the tidal height of each station was levelled relative to sea level using the following procedure:

- Surveyor A holds wooden ruler vertically with the 0 cm mark on the rock judged to be at sea level (average level, taking account of waves). A length of tube at one end held against the ruler so that the height of the water in the tube could be read-off.
- Surveyor B holds a length of tube at the other end against the Station E marker and moves tube up/down until the water level in the tube is at the level of that station marker.
- Surveyor A reads-off the ruler height of the water in the tube. This height, the station number and the date and time are recorded.
- Surveyor B moves up the shore and holds the tube against the Station D marker.
- Surveyor A moves up the shore and holds wooden ruler vertically with the 0 cm mark on the Station E marker, just vacated by Surveyor B.
- Surveyor A reads-off the ruler height of the water in the tube. This height and the station number date are recorded.
- Surveyors move progressively up the shore, repeating for all stations. Data tabulated in Excel to calculate heights of each station relative to sea level at the time of each site survey.
- The tidal height of the sea in Sullom Voe at the date and time of the levelling is taken from *Neptune Tides* software, which uses Admiralty licensed data. These tidal heights were entered into the Excel table. Small adjustments were made for the reference sites, which are a significant distance from the Voe.
- Tidal heights of each station are calculated.

The results of the levelling (i.e. a table and graph of tidal heights for the 20 sites) are given in Appendix 2 and are discussed in Section 4.3.

2.2.3 *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 selected 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 Wolff (1987) (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.

2.2.4 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 a Ricoh WG-4 digital compact camera for most sites and a Sonim Ex-Handy 07 intrinsically safe mobile phone for the two Jetty sites. 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 computer spreadsheet (*Microsoft Excel*). They were then transferred to a more versatile database package (*Microsoft Access*) that holds the data from previous surveys, for further analysis. 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 2016 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, the numbers should not be summed or averaged. 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.

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

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.

In addition to the average abundance histograms plotted from the above analysis, the graphs also include line plots of the number of stations from which the species was recorded. The values 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).

2.4 Data archive

The master data are held in two *Microsoft Access* database files, one for species abundance data (currently 104,918 records) and one for the photograph catalogue (currently 7,271 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 2015, 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). The original hard copies of 35mm transparencies and prints from the earlier surveys were scanned in 2015. Complete sets are held by ASML and SOTEAG.

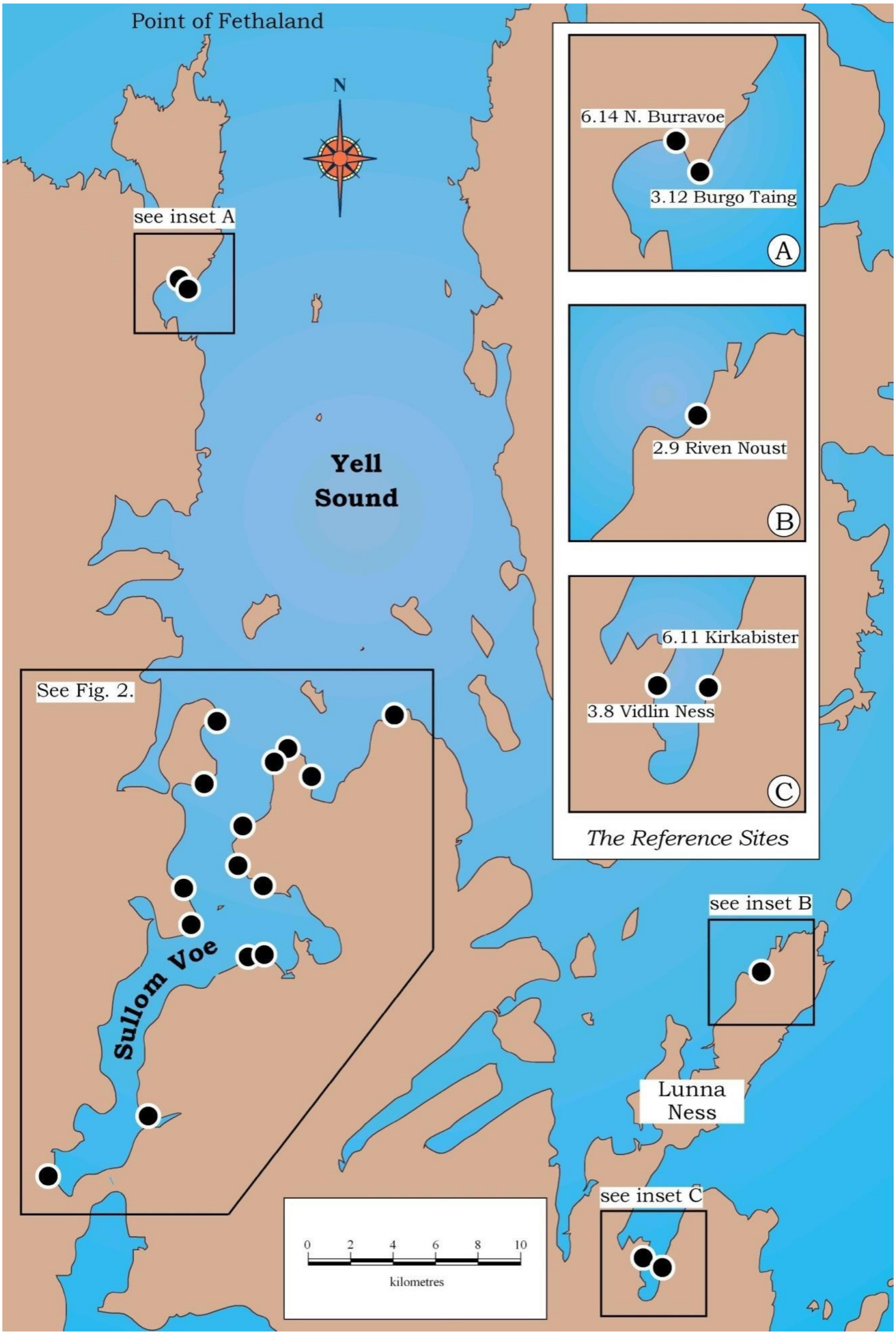


Figure 1 *Location of rocky shore transect monitoring and reference sites. Surveys of rocky shores in the region of Sullom Voe, Shetland, July 2016.*

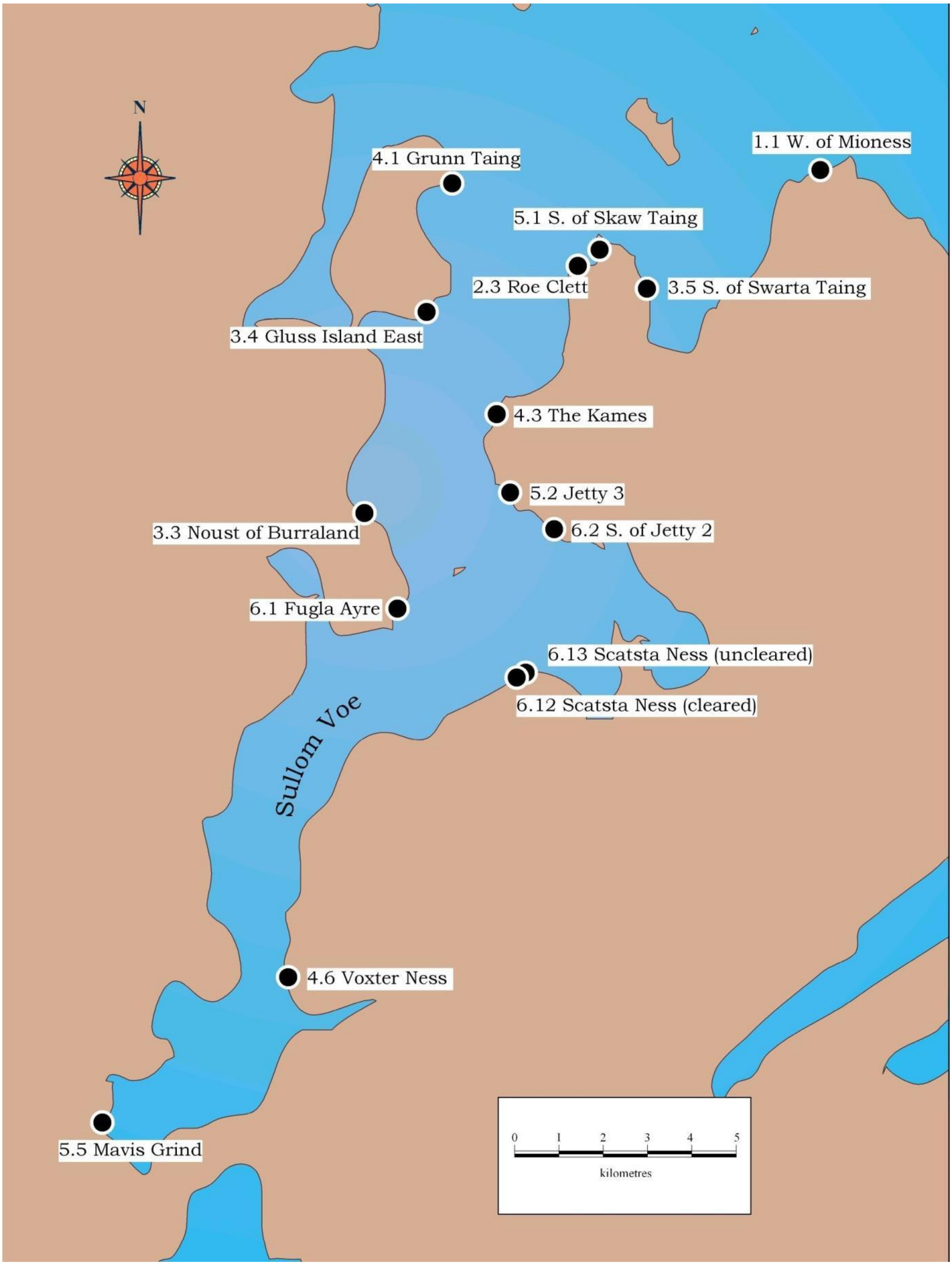


Figure 2 Location of rocky shore transect monitoring sites within Sullom Voe. Surveys of rocky shores in the region of Sullom Voe, Shetland, July 2016.

3 Results

3.1 Fluctuations in abundance of species

Table 3 provides a summary of the abundance changes that occurred between July 2015 and July 2016 for species recorded. The majority of these changes continued to reflect a low level of natural variability from year to year, but there were notable changes in some species and at some sites. Species emboldened are discussed later in this Section.

Table 3 Summary of the main changes in selected species presence/absence and abundance between 2015 and 2016 over all sites and stations (including reference sites). Values are the No. of stations out of 100 (20 sites x 5 stations). See category definitions at bottom of table. Species names in bold indicate those which are discussed in the sections below. Distribution is the known biogeographic distribution relative to Britain.

Taxa	Distribution	None	Gone	Down	Same	Up	New
Halichondria panicea	Ubiquitous	83	2	0	15	0	0
Clava	Ubiquitous	91	9	0	0	0	0
Dynamena pumila	Ubiquitous	87	2	0	11	0	0
Actinia equina	Ubiquitous	87	4	2	3	0	4
Spirorbinae	Ubiquitous	72	2	0	19	1	6
Cirripedia (spat)	Ubiquitous	23	7	11	47	5	7
Cirripedia (dead)	Ubiquitous	28	4	0	60	2	6
Chthamalus stellatus	Southern	96	1	0	2	0	1
Semibalanus balanoides	Northern	18	1	0	74	3	4
Austrominius modestus	Invasive	95	2	0	2	0	1
Amphipoda	Ubiquitous	72	7	2	6	1	12
Carcinus maenas	Ubiquitous	86	4	0	2	0	8
Anurida maritima	Ubiquitous	80	9	0	5	0	6
Patella (juvenile, <10mm)	Ubiquitous	54	9	4	28	0	5
Patella ulyssiponensis	Southern	98	2	0	0	0	0
Patella vulgata	Northern	26	4	9	54	2	5
Littorina littorea	Northern	58	8	4	15	3	12
Littorina obtusata	Ubiquitous	58	5	0	24	2	11
Littorina saxatilis (ecotype neglecta)	Southern	58	5	0	32	0	5
Littorina saxatilis	Northern	38	3	4	40	4	11
Nucella lapillus	Northern	64	7	1	21	0	7
Mytilus edulis	Ubiquitous	60	6	0	30	0	4
Flustrellidra hispida	Ubiquitous	84	4	0	8	0	4
Electra pilosa	Ubiquitous	83	5	0	7	0	5
Rhodophyta (encrusting)	Ubiquitous	70	5	0	6	2	17
Porphyra	Ubiquitous	75	5	1	11	3	5
Dumontia contorta	Ubiquitous	84	9	1	4	0	2
Hildenbrandia	Ubiquitous	49	29	2	13	0	7
Corallinaceae (encrusting)	Ubiquitous	49	11	3	31	1	5
Corallina	Ubiquitous	85	1	2	8	1	3
Mastocarpus stellatus	Northern	64	7	2	18	0	9
Chondrus crispus	Northern	77	7	0	7	0	9
Ceramium shuttleworthianum	Ubiquitous	79	6	0	8	0	7
Membranoptera alata	Ubiquitous	87	4	1	4	2	2
Osmundea pinnatifida	Southern	84	3	4	6	1	2
Polysiphonia	Ubiquitous	90	2	0	0	0	8
Vertebrata lanosa	Ubiquitous	80	5	1	12	0	2

Taxa	**Distribution**	**None**	**Gone**	**Down**	**Same**	**Up**	**New**
Phaeophyceae (encrusting)	Ubiquitous	86	0	0	0	0	14
Ectocarpaceae	Ubiquitous	86	2	0	2	0	10
Ralfsia	Ubiquitous	68	0	0	0	0	32
Elachista fucicola	Ubiquitous	63	6	1	15	0	15
Alaria esculenta	Northern	96	0	0	2	0	2
Fucaceae (sporelings)	Ubiquitous	87	0	0	0	0	13
Ascophyllum nodosum	Northern	84	2	2	11	0	1
Fucus serratus	Northern	71	3	4	18	1	3
Fucus spiralis	Northern	74	1	1	16	2	6
Fucus vesiculosus	Northern	56	6	3	31	3	1
Pelvetia canaliculata	Northern	75	3	1	16	3	2
Ulva (tubular)	Ubiquitous	55	8	3	25	2	7
Ulva (flat)	Ubiquitous	83	5	1	9	0	2
Cladophora	Ubiquitous	74	14	0	2	1	9
Cladophora rupestris	Ubiquitous	70	18	1	9	1	1
Verrucaria maura	Ubiquitous	12	9	10	54	6	9
Verrucaria mucosa	Ubiquitous	57	6	1	7	6	23

None = not recorded at the station in 2015 or 2016
Gone = recorded at the station in 2015, but not in 2016
Down = decreased abundance in 2016
Same = same or almost same (up or down by only one class) in 2015 and 2016
Up = increased abundance in 2016
New = recorded at station in 2016 but not in 2015

The following sections describe the results for selected species 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).

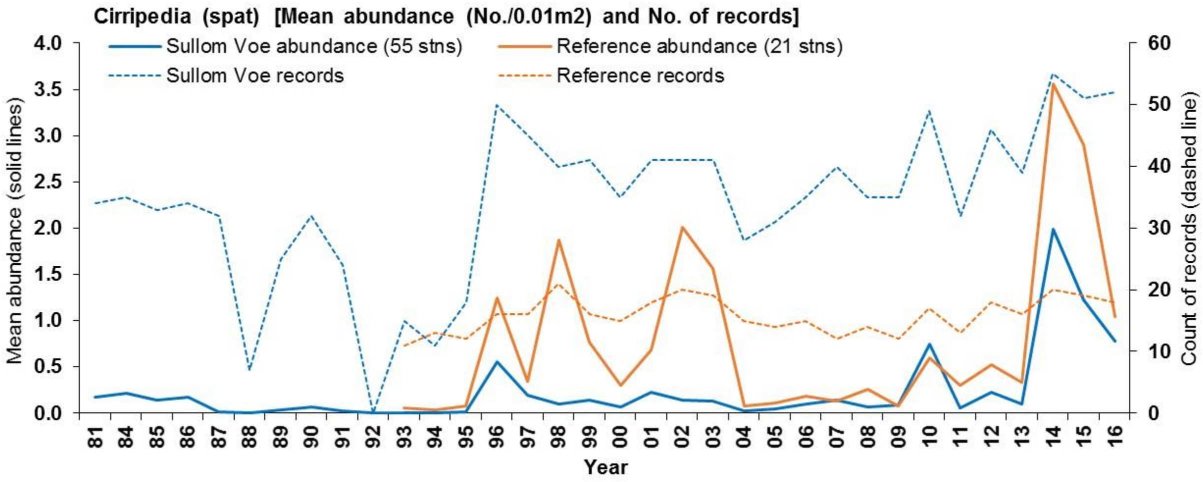
Note: for readers with the electronic version of this report, the species names in the section headings below contain hyperlinks to relevant pages on their biology on the MarLIN website.

3.1.1 Chthamalus stellatus

This southern species of barnacle has been recorded from a few of the more wave exposed sites since 2011. Small numbers were again found at three sites in 2016 – The Kames (4.3) and the reference sites Riven Noust (2.9) and Burgo Taing (3.12).

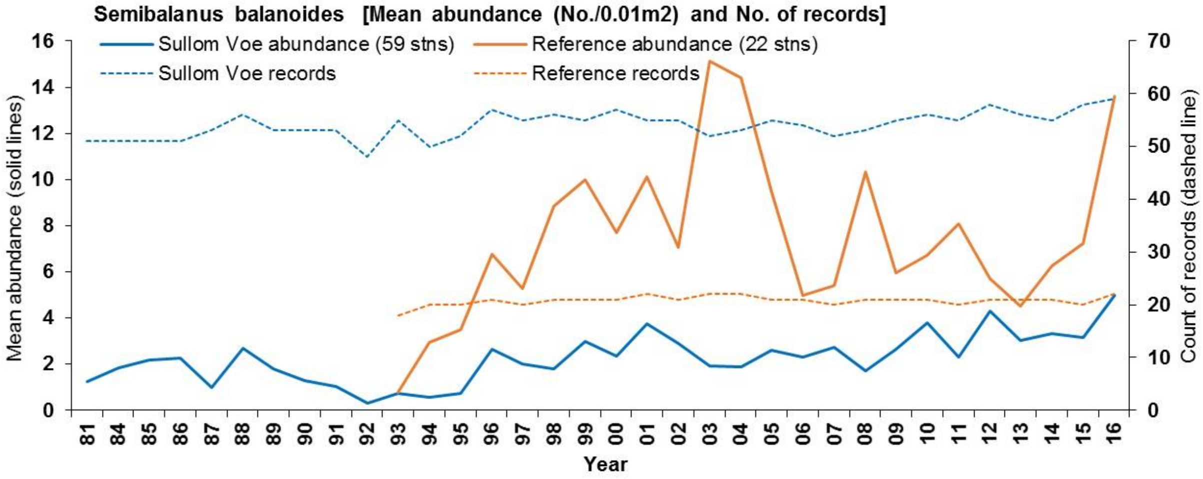
3.1.2 Semibalanus balanoides

Average densities of barnacle spat dropped in 2016 from their recent record highs. However, they were still relatively abundant compared to many previous years.

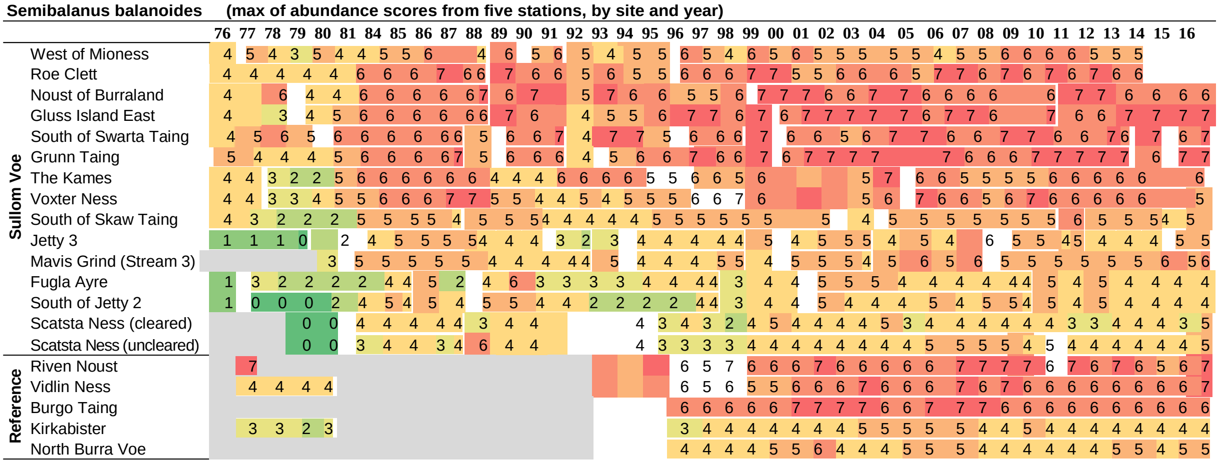


The average density of adult barnacles across all Sullom Voe sites in 2016 was the highest ever recorded, due to small increases at several sites and stations, particularly Scatsta Ness (cleared) and South of Skaw Taing. Average densities across the Reference sites have always been higher, just due to the characteristics of those sites, and a large increase was also seen in several of those stations, particularly at the two sites in Vidlin Voe (Kirkabister and Vidlin Ness).

The relatively lower densities recorded from 2013 to 2015 was due in part to the space taken by large old individuals that had survived since the previous year. This pattern was less apparent in 2016, allowing for higher densities of new adults.



The table below shows that the distribution of maximum abundances has not changed much in recent years. As noted above, the largest change was at Scatsta Ness (cleared), with a relatively high abundance recorded in the low shore station.

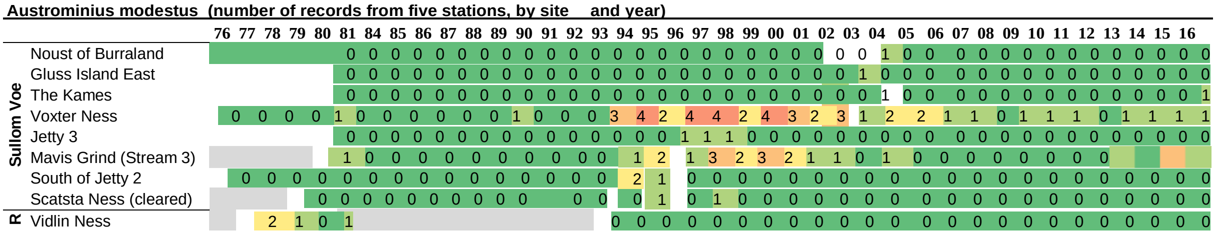


Semibalanus balanoides **(max of abundance scores from five stations, by site and year)**

		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
Sullom Voe	West of Mioness	4 5 4 3 5 4 4 5 5 6 4 6 5 6 5 4 5 5 6 5 4 6 5 6 5 5 5 5 5 4 5 5 6 6 6 6 5 5 5
	Roe Clett	4 4 4 4 4 6 6 6 7 6 6 7 6 6 5 6 5 5 6 6 6 7 7 5 5 6 6 6 5 7 7 6 7 6 7 6 7 6 6
	Noust of Burraland	4 6 4 4 6 6 6 6 6 7 6 7 5 7 6 6 5 5 6 7 7 7 6 6 7 7 6 6 6 6 6 7 7 6 6 6 6
	Gluss Island East	4 3 4 5 6 6 6 6 6 6 7 6 4 5 5 6 7 7 6 7 6 7 7 7 7 7 6 7 7 6 7 6 6 7 7 7 7
	South of Swarta Taing	4 5 6 5 6 6 6 6 6 6 5 6 6 7 4 7 7 5 6 6 6 7 6 6 5 6 7 7 6 6 7 7 6 6 7 6 7 6 7
	Grunn Taing	5 4 4 4 5 6 6 6 6 7 5 6 6 6 4 5 6 6 7 6 6 7 6 7 7 7 7 7 6 6 6 7 7 7 7 7 6 7 7
	The Kames	4 4 3 2 2 5 6 6 6 6 6 6 4 4 4 6 6 6 6 5 5 6 6 5 6 5 7 6 6 5 5 5 5 6 6 6 6 6 6
	Voxter Ness	4 4 3 3 4 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
	South of Skaw Taing	4 3 2 2 2 5 5 5 5 4 5 5 5 4 4 4 4 4 5 5 5 5 5 5 5 4 5 5 5 5 5 5 5 6 5 5 5 4 5
	Jetty 3	1 1 1 0 2 4 5 5 5 5 4 4 4 3 2 3 4 4 4 4 4 5 4 5 5 5 4 5 4 6 5 5 4 5 4 4 4 5 5
	Mavis Grind (Stream 3)	3 5 5 5 5 5 4 4 4 4 4 5 4 4 4 5 5 4 5 5 5 4 5 6 5 6 5 5 5 5 5 5 6 5 6
	Fugla Ayre	1 3 2 2 2 2 4 4 5 2 4 6 3 3 3 3 4 4 4 4 3 4 4 5 5 5 4 4 4 4 4 4 5 4 5 4 4 4 4
	South of Jetty 2	1 0 0 0 2 4 5 4 5 4 5 5 4 4 2 2 2 2 4 4 3 4 4 5 4 4 4 5 4 5 5 4 5 4 5 4 4 4 4
	Scatsta Ness (cleared)	0 0 4 4 4 4 4 3 4 4 4 3 4 3 2 4 5 4 4 4 4 5 3 4 4 4 4 4 4 3 3 4 4 4 3 5
	Scatsta Ness (uncleared)	0 0 3 4 4 3 4 6 4 4 4 3 3 3 3 4 4 4 4 4 4 4 4 5 5 5 5 4 5 4 4 4 4 4 4 5
Reference	Riven Noust	7 6 5 7 6 6 6 7 6 6 6 6 6 7 7 7 7 6 7 6 7 6 5 6 7
	Vidlin Ness	4 4 4 4 6 5 6 5 5 6 6 6 7 6 6 6 7 6 7 6 6 6 6 6 6 6 6 7
	Burgo Taing	6 6 6 6 6 7 7 7 7 6 6 7 7 7 6 6 6 6 6 6 6 6 6 6
	Kirkabister	3 3 2 3 3 4 4 4 4 4 4 4 5 5 5 5 5 4 4 5 4 4 4 4 4 4 4 4
	North Burra Voe	4 4 4 4 5 5 6 4 4 4 5 5 5 4 4 4 4 4 4 5 5 4 5 5

3.1.3 Austrominius modestus

Small populations of this immigrant barnacle persist in low densities (typically <10 per m^2 in upper shore zones) at some sites within the Voe.



Austrominius modestus (number of records from five stations, by site and year)

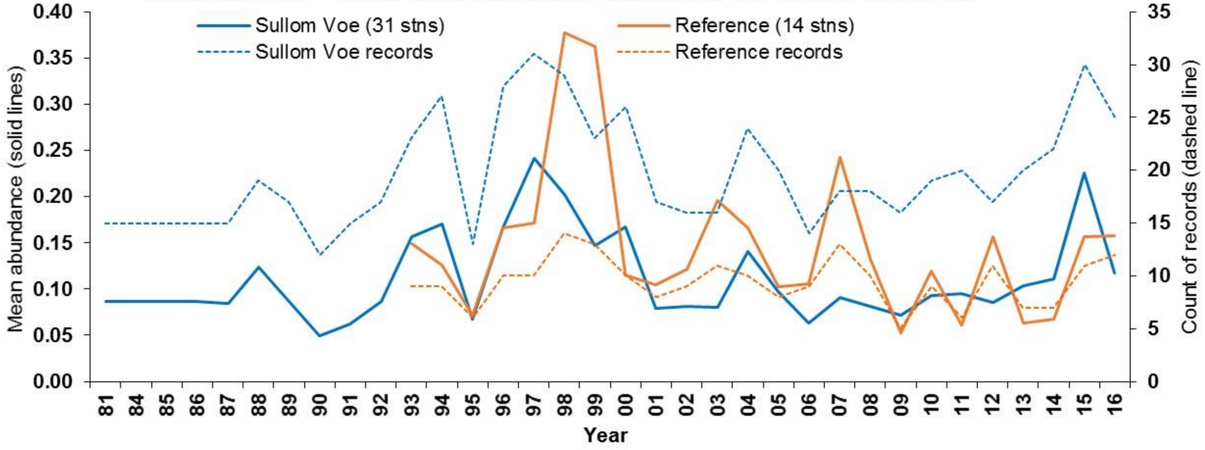
		76 77 78 79 80 81 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16
Sullom Voe	Noust of Burraland	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	Gluss Island East	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	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 1 0 0 0 0 0 0 0 0 0 0 0 0 0 1
	Voxter Ness	0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 3 4 2 4 4 2 4 3 2 3 1 2 2 1 1 0 1 1 1 0 1 1 1 1
	Jetty 3	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	Mavis Grind (Stream 3)	1 0 0 0 0 0 0 0 0 0 0 1 2 1 3 2 3 2 1 1 0 1 0 0 0 0 0 0 0 0
	South of Jetty 2	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	Scatsta Ness (cleared)	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
R	Vidlin Ness	2 1 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

3.1.4 Patella vulgata

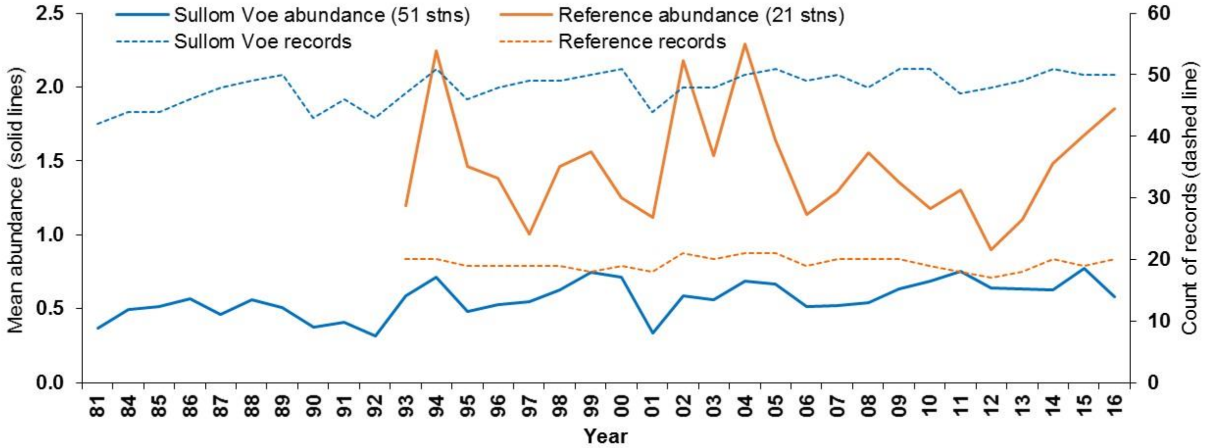
Average densities of adult limpets were slightly lower at sites in Sullom Voe in 2016, compared to recent years, despite the particularly large numbers of juveniles that were recorded at many of those sites in 2015. The reason for the poor recruitment to adult populations is not known, and scrutiny of photographs from stations with the largest reductions provide no clues. The lower mid shore station (D) at Roe Clett (2.3), where densities declined from Extremely abundant to Abundant, was characterised by a fairly dense sward of green and brown algae (*Ulva* (flat) and young *Fucus vesiculosus*) that also suggests reduced grazing pressure.

In contrast, there was a large increase in average densities of limpets at Reference sites, though the increases at individual stations were mostly small. The apparent difference with the Sullom Voe sites is not known, and there is no known link to the Terminal. It should be noted that limpet densities overall remain relatively high compared to those recorded during the early years of the programme (1980-1992).

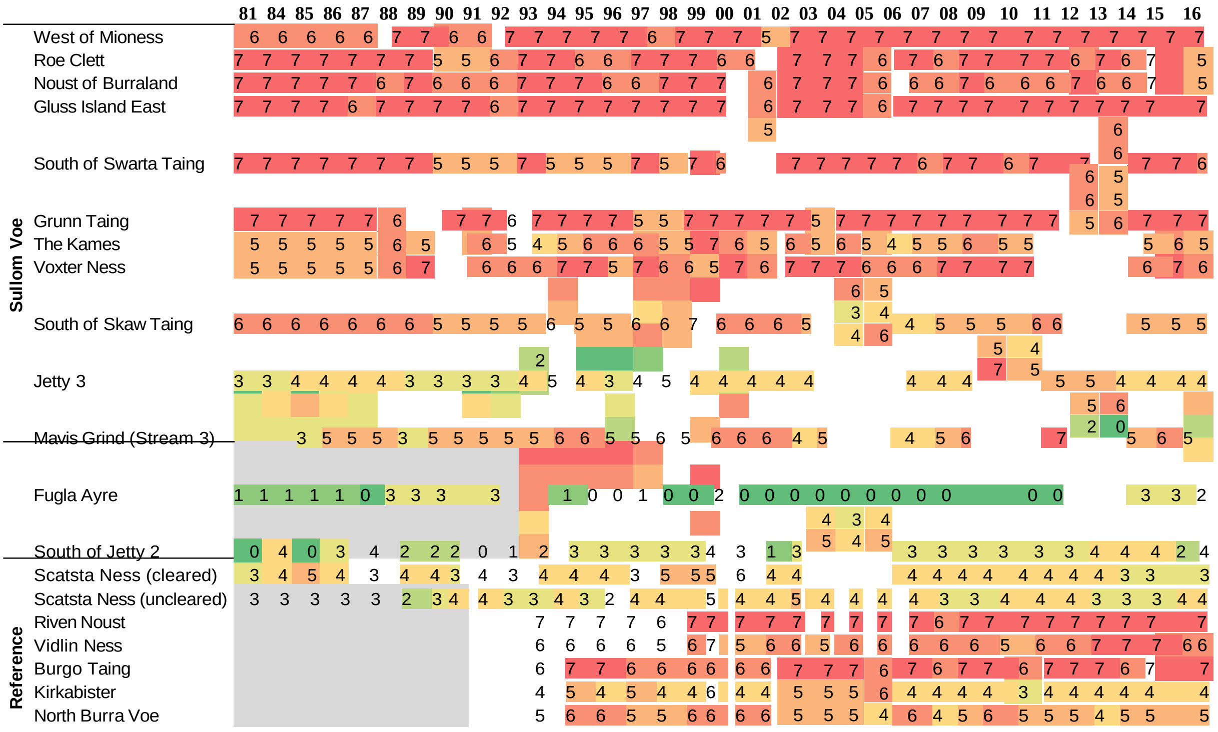
Patella (juvenile, <10mm) [Mean abundance (No./0.1m2) and number of records]



Patella vulgata [Mean abundance (No./0.1m2) and number of records]



Patella vulgata **(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
Sullom Voe	West of Mioness	6 6 6 6 6 7 7 6 6 7 7 7 7 7 6 7 7 7 5 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
	Roe Clett	7 7 7 7 7 7 7 5 5 6 7 7 6 6 7 7 7 6 6 7 7 7 6 7 6 7 7 7 7 6 7 6 7 5
	Noust of Burraland	7 7 7 7 7 6 7 6 6 6 7 7 7 6 6 7 7 7 6 7 7 7 6 6 6 7 6 6 6 7 6 6 7 5
	Gluss Island East	7 7 7 7 6 7 7 7 7 6 7 7 7 7 7 7 7 7 6 7 7 7 6 7 7 7 7 7 7 7 7 7 7 7
		5
		6
		6
	South of Swarta Taing	7 7 7 7 7 7 7 5 5 5 7 5 5 5 7 5 7 6 7 7 7 7 7 6 7 7 6 7 7 7 7 6
		6 5
		6 5
	Grunn Taing	7 7 7 7 7 6 7 7 6 7 7 7 7 5 5 7 7 7 7 7 5 7 7 7 7 7 7 7 7 7 5 6 7 7 7
	The Kames	5 5 5 5 5 6 5 6 5 4 5 6 6 6 5 5 7 6 5 6 5 6 5 4 5 5 6 5 5 5 6 5
	Voxter Ness	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 7 6
		6 5
		3 4
	South of Skaw Taing	6 6 6 6 6 6 6 5 5 5 5 6 5 5 6 6 7 6 6 6 5 4 5 5 5 6 6 5 5 5
		4 6
		5 4
		2 7 5
	Jetty 3	3 3 4 4 4 4 3 3 3 3 4 5 4 3 4 5 4 4 4 4 4 4 4 4 5 5 4 4 4 4
		5 6
		2 0
	Mavis Grind (Stream 3)	3 5 5 5 3 5 5 5 5 5 6 6 5 5 6 5 6 6 6 4 5 4 5 6 7 5 6 5
	Fugla Ayre	1 1 1 1 1 0 3 3 3 3 1 0 0 1 0 0 2 0 0 0 0 0 0 0 0 0 0 0 3 3 2
		4 3 4
		5 4 5
	South of Jetty 2	0 4 0 3 4 2 2 2 0 1 2 3 3 3 3 3 4 3 1 3 3 3 3 3 3 3 4 4 4 2 4
Reference	Scatsta Ness (cleared)	3 4 5 4 3 4 4 3 4 3 4 4 4 3 5 5 5 6 4 4 4 4 4 4 4 4 4 4 3 3 3
	Scatsta Ness (uncleared)	3 3 3 3 3 2 3 4 4 3 3 4 3 2 4 4 5 4 4 5 4 4 4 4 3 3 4 4 4 3 3 3 4 4
	Riven Noust	7 7 7 7 6 7 7 7 7 7 7 7 7 7 6 7 7 7 7 7 7 7 7 7
	Vidlin Ness	6 6 6 6 5 6 7 5 6 6 5 6 6 6 6 6 5 6 6 7 7 7 6 6
	Burgo Taing	6 7 7 6 6 6 6 6 6 7 7 7 6 7 6 7 7 6 7 7 7 6 7 7
	Kirkabister	4 5 4 5 4 4 6 4 4 5 5 5 6 4 4 4 4 3 4 4 4 4 4 4
	North Burra Voe	5 6 6 5 5 6 6 6 6 5 5 5 4 6 4 5 6 5 5 5 4 5 5 5

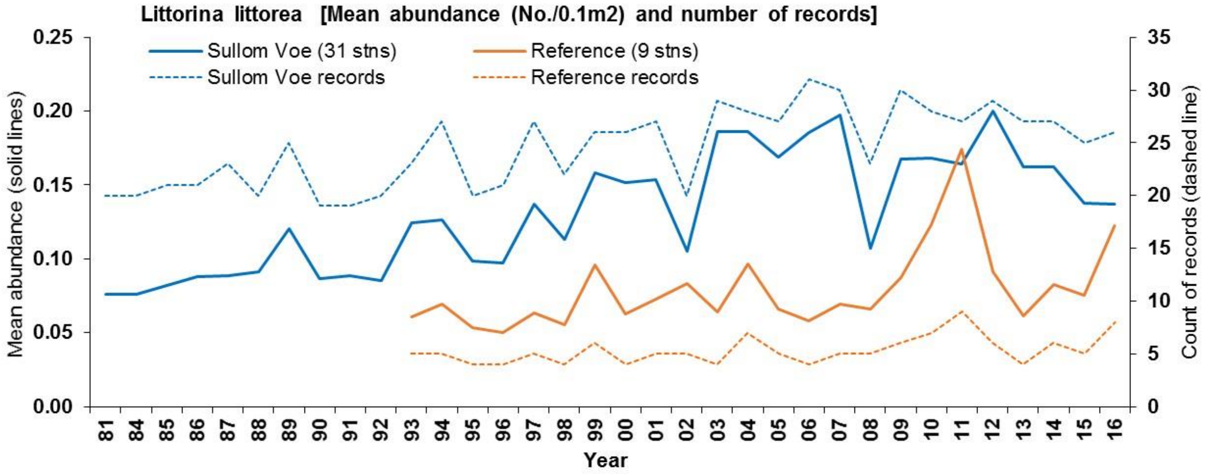
3.1.5 Patella ulyssiponensis

No individuals of this southern species of limpet were recorded in 2016, though it is likely that small numbers were present in suitable (permanently wet) habitat but are difficult to distinguish from *P.*

vulgata. It is also possible that the few individuals that were confirmed as *P. ulyssiponensis* in recent years, by prising them from the rock to view the foot, did not survive.

3.1.6 Littorina littorea

Large fluctuations are a common feature of the edible winkle populations recorded along many of the transect sites (table below) and are also apparent in the average densities (graph below). The graph suggests a notable reduction in average density over the last four years across the Sullom Voe sites, while densities have increased across the Reference sites. However, the long term data suggests very little synchrony in average densities between Sullom Voe and the Reference sites, so the recent disparity may not be significant.

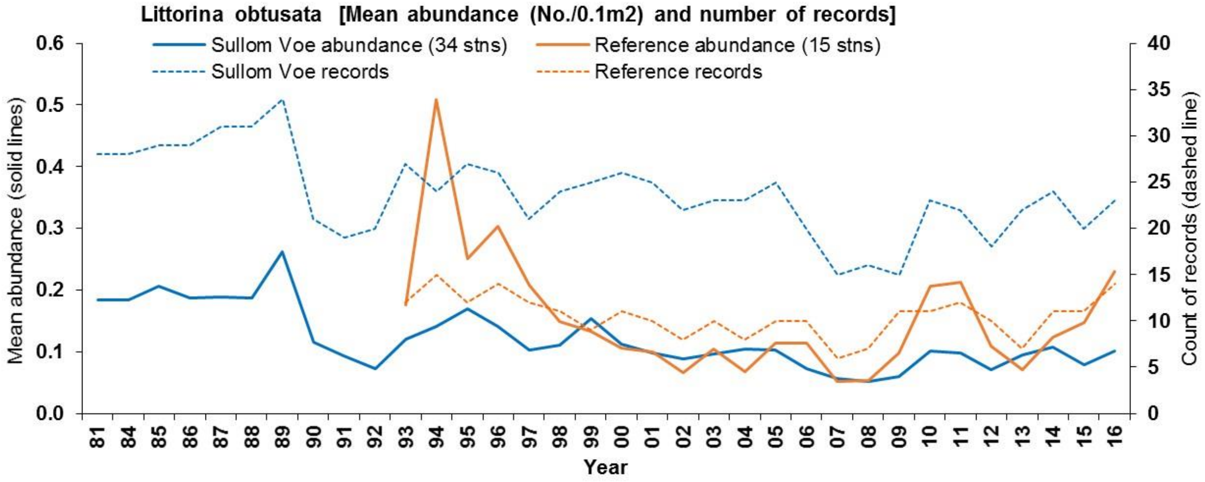


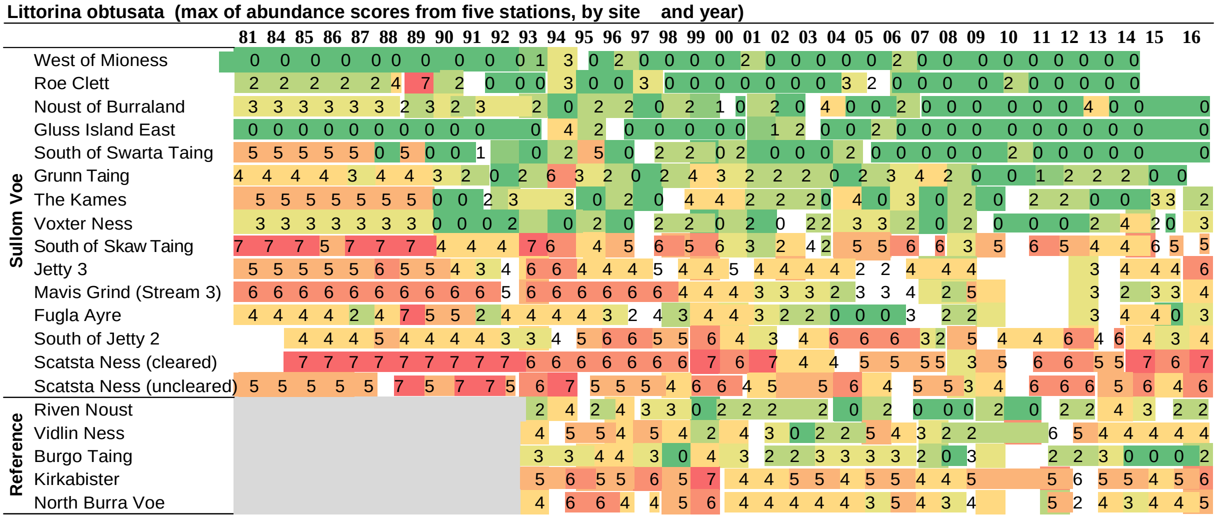
Littorina littorea (max of abundance scores from five stations, by site and year)

		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
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
	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
	Noust of Burraland	2	2	2	2	2	2	3	1	1	0	2	3	0	0	5	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	2	2	2
	Gluss Island East	0	0	0	0	0	0	3	0	0	0	3	3	2	3	3	2	3	3	2	0	2	2	3	3	3	3	2	3	4	4	3	3	3	2
	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
	Grunn Taing	0	0	0	0	0	0	0	0	0	2	2		2	4	2	0	3	2	3	2	2	3	2	3	4	1	2	2	3	4	0	4	2	2
	The Kames	1	1	1	1	1	2	2	2	2	0	2		0	2	3	4	0	3	0	3	0	3	4	2	4	2	2	3	3	3	3	2	3	2
	Voxter Ness	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
	South of Skaw Taing	3	3	3	3	3	3	6	4	5	5	5	6	6	4	5	6	4	4	5	4	6	7	6	7	5	4	5	5	5	6	6	5	5	6
	Jetty 3	2	2	2	4	3	5	5	4	4	4	6	5	4	5	3	4	5	4	4	5	4	6	5	5	6	4	5	5	5	4	4	5	5	6
	Mavis Grind (Stream 3)	3	3	3	3	4	3	3	3	3	3	5	4	2	3	3	4	4	4	4	4	6	5	4	4	5	4	4	3	5	4	2	3	3	2
	Fugla Ayre	2	2	3	2	2	7	6	5	5	2	5	3	2	0	2	0	2	3	4	5	4	3	3	0	0	0	3	3	3	3	5	2	0	0
	South of Jetty 2	3	3	3	3	4	6	4	4	5	5	4	7	4	5	5	5	5	5	6	4	6	6	7	5	6	5	6	5	5	6	7	7	5	5
	Scatsta Ness (cleared)	5	5	5	5	5	6	5	6	6	5	5	5	6	6	5	6	6	6	6	5	7	7	5	6	5	5	5	6	6	7	6	7	6	7
	Scatsta Ness (uncleared)	5	5	5	5	5	4	5	6	6	4	4	4	5	4	5	4	5	6	5	5	5	6	6	6	6	6	5	6	6	6	6	6	6	7
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
	Vidlin Ness											3	0	0	0	2	0	0	2	0	0	0	0	2	2	0	0	2	3	3	2	0	2	4	3
	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
	Kirkabister											4	4	4	4	4	5	4	6	5	6	5	6	5	5	4	5	7	5	6	6	4	5	4	5
	North Burra Voe											0	4	2	2	3	2	4	3	3	3	3	2	2	3	3	2	4	3	2	2	0	3	3	3

3.1.7 Littorina obtusata & L. mariae

Populations of flat winkles, which are not differentiated into the two species in this survey, are strongly correlated to the abundance of fucoid algae. Their recorded abundances have been generally lower in recent years than they were during the 1980s and 1990s. Records in 2016 show typical fluctuations at individual sites, with no obvious trends, although the average density at Reference sites has risen over the last four years.



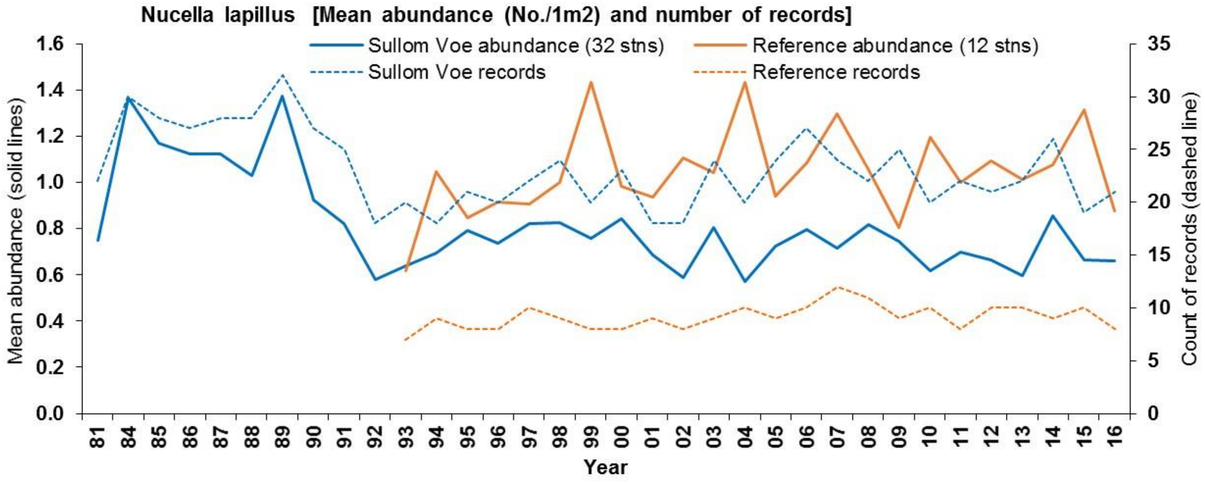


Littorina obtusata (max of abundance scores from five stations, by site and year)

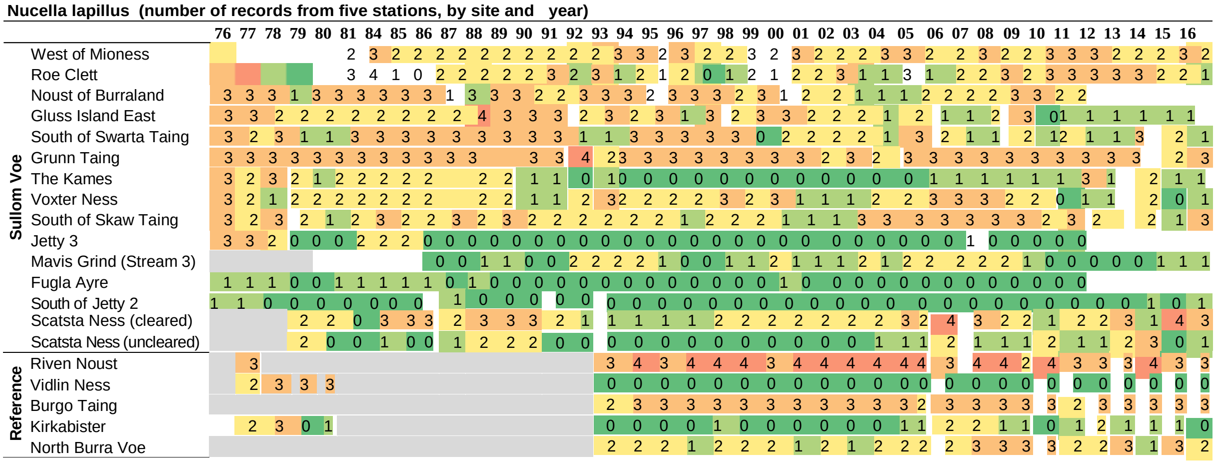
		81	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Sullom Voe	West of Mioness	0	0	0	0	0	0	0	0	0	0	1	3	0	2	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
	Roe Clett	2	2	2	2	2	4	7	2	0	0	0	3	0	0	3	0	0	0	0	0	0	0	3	2	0	0	0	0	2	0	0	0	0	0
	Noust of Burraland	3	3	3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

3.1.8 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.



Average abundance is higher across the Reference sites, but dogwhelks have still not been seen on the Vidlin Ness (3.8) transect site since 1980. The reason for this is not known.



Nucella lapillus (number of records from five stations, by site and year)

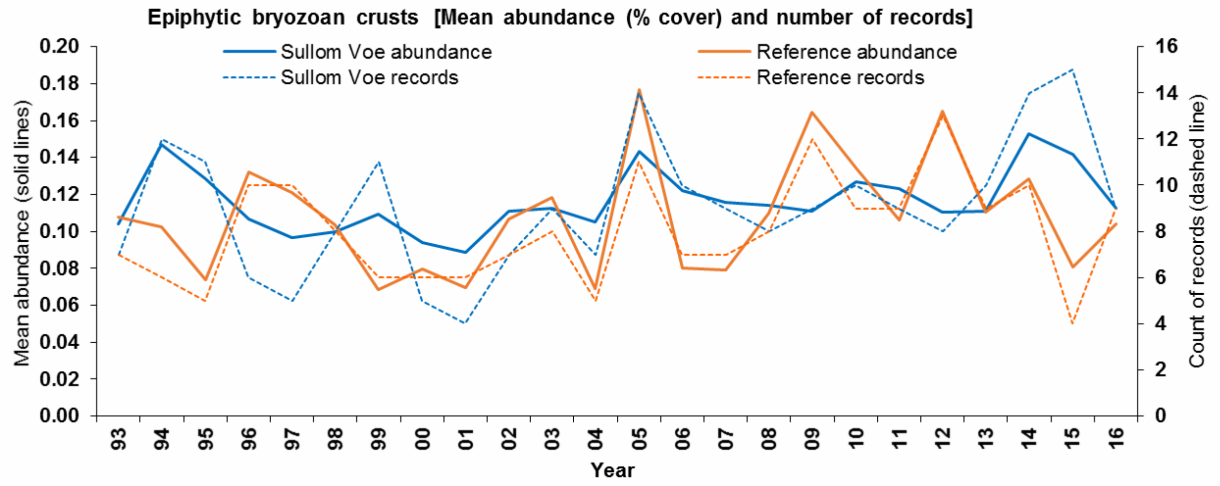
		76 77 78 79 80 81 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16
Sullom Voe	West of Mioness	2 3 2 2 2 2 2 2 2 2 2 2 3 3 2 3 2 2 3 2 3 2 2 2 3 3 2 2 3 2 2 3 3 3 2 2 2 3 2
	Roe Clett	3 4 1 0 2 2 2 2 2 3 2 3 1 2 1 2 0 1 2 1 2 2 3 1 1 3 1 2 2 3 2 3 3 3 3 3 2 2 1
	Noust of Burraland	3 3 3 1 3 3 3 3 3 3 1 3 3 3 2 2 3 3 3 2 3 3 3 2 3 1 2 2 1 1 1 2 2 2 2 3 3 2 2
	Gluss Island East	3 3 2 2 2 2 2 2 2 2 4 3 3 3 2 3 2 3 1 3 2 3 3 2 2 2 1 2 1 1 2 3 01 1 1 1 1 1
	South of Swarta Taing	3 2 3 1 1 3 3 3 3 3 3 3 3 3 1 1 3 3 3 3 3 0 2 2 2 2 1 3 2 1 1 2 12 1 1 3 2 1
	Grunn Taing	3 3 3 3 3 3 3 3 3 3 3 3 3 3 4 23 3 3 3 3 3 3 3 2 3 2 3 3 3 3 3 3 3 3 3 3 2 3
	The Kames	3 2 3 2 1 2 2 2 2 2 2 2 1 1 0 10 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 3 1 2 1 1
	Voxter Ness	3 2 1 2 2 2 2 2 2 2 2 2 1 1 2 32 2 2 2 3 2 3 1 1 1 2 2 3 3 3 2 2 0 1 1 2 0 1
	South of Skaw Taing	3 2 3 2 1 2 3 2 2 3 2 3 2 2 2 2 2 2 1 2 2 2 1 1 1 3 3 3 3 3 3 3 2 3 2 2 1 3
	Jetty 3	3 3 2 0 0 0 2 2 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 1 0 0 0 0 0
	Mavis Grind (Stream 3)	0 0 1 1 0 0 2 2 2 2 1 0 0 1 1 2 1 1 1 2 1 2 2 2 2 2 1 0 0 0 0 0 1 1 1
	Fugla Ayre	1 1 1 0 0 1 1 1 1 1 0 1 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
	South of Jetty 2	1 1 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 1 0 1
	Scatsta Ness (cleared)	2 2 0 3 3 3 2 3 3 3 2 1 1 1 1 1 2 2 2 2 2 2 2 3 2 4 3 2 2 1 2 2 3 1 4 3
	Scatsta Ness (uncleared)	2 0 0 1 0 0 1 2 2 2 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 2 1 1 1 2 1 1 2 3 0 1
Reference	Riven Noust	3 3 4 3 4 4 4 3 4 4 4 4 4 4 3 4 4 2 4 3 3 3 4 3 3
	Vidlin Ness	2 3 3 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
	Burgo Taing	2 3 3 3 3 3 3 3 3 3 3 3 2 3 3 3 3 3 2 3 3 3 3 3
	Kirkabister	2 3 0 1 0 0 0 0 1 0 0 0 0 0 0 1 1 2 2 1 1 0 1 2 1 1 1 0
	North Burra Voe	2 2 2 1 2 2 2 1 2 1 2 2 2 2 3 3 3 3 2 2 3 1 3 2

A single adult dogwhelk was found in one of the South of Jetty 2 (6.2) stations. Only the second recorded since the population was impacted by TBT antifouling paints. Numerous dogwhelks were found in a boulder tumble between Jetty 3 and Jetty 4 – which has been searched annually since 2004. Occasional single individuals have been recorded there since 2012, with a few more in 2015; but many more, at a range of sizes, were present in 2016.

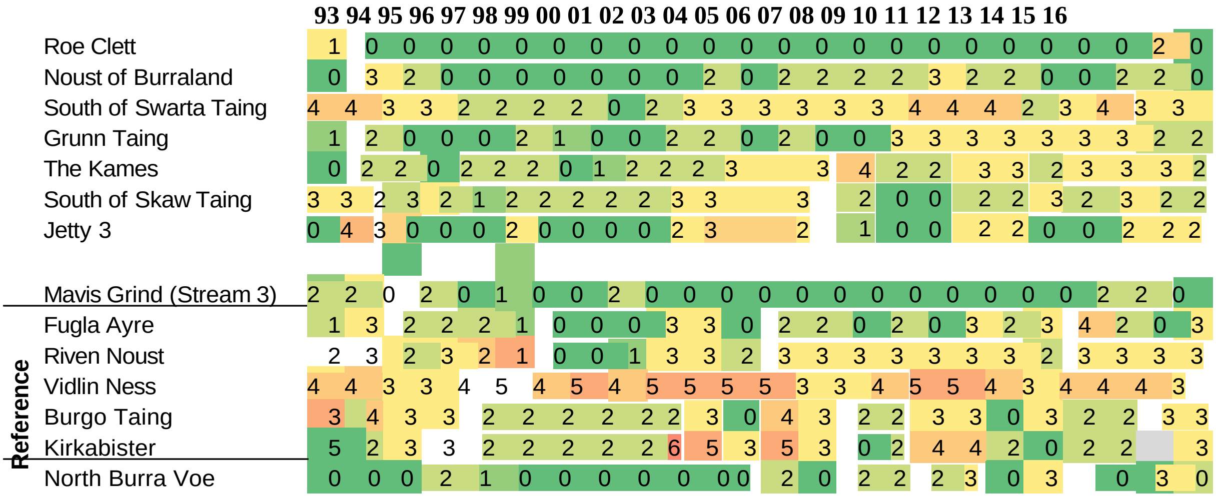
South of Jetty 2 (site 6.2) – Dogwhelk, Nucella lapillus, Station 11 (lower mid shore), July 2016. Only the second individual to be recorded from this site since 1987.

3.1.9 Flustrellidra hispida & Alcyonidium spp.

The average abundance of epiphytic bryozoa, growing on serrated wrack and other lower shore algae, was lower at several Sullom Voe sites in 2016. Flustrellidra hispida is the most abundant and frequently recorded species at the transect sites, but *Alcyonidium hirsutum* and *A. gelatinosum* are often present. However, there were no records of the latter from any site in 2016.



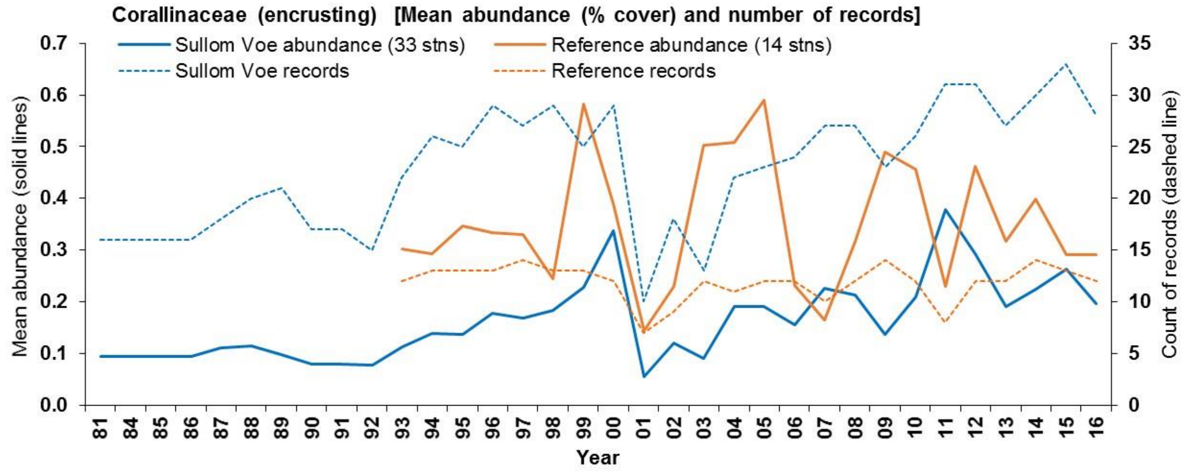
Flustrellidra hispida (abundance in lower shore station, by year at selected sites)

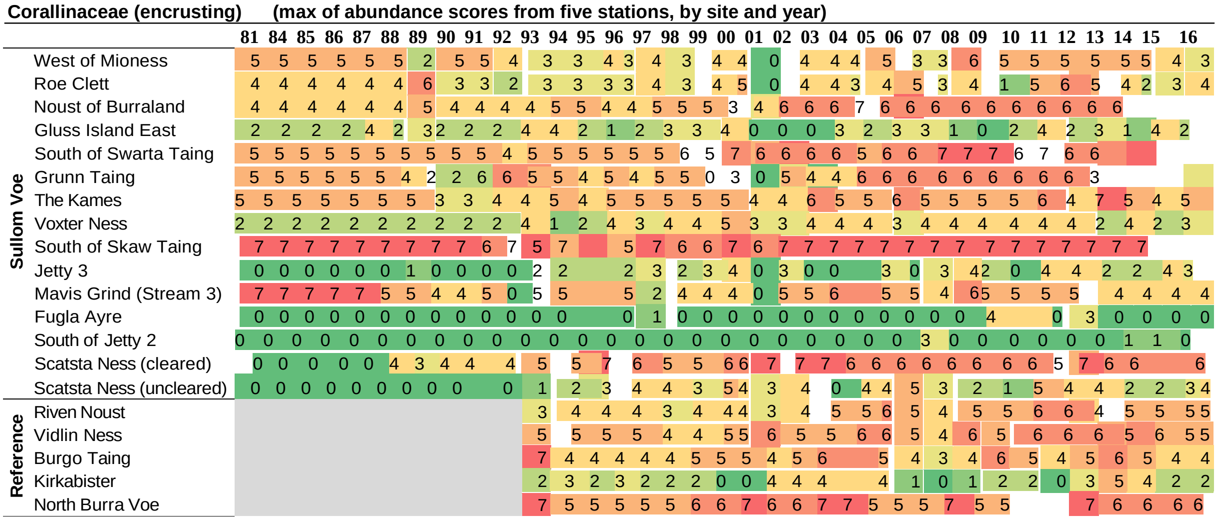


		93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
	Roe Clett	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
	Noust of Burraland	0	3	2	0	0	0	0	0	0	0	2	0	2	2	2	2	3	2	2	0	0	2	2	0
	South of Swarta Taing	4	4	3	3	2	2	2	2	0	2	3	3	3	3	3	3	4	4	4	2	3	4	3	3
	Grunn Taing	1	2	0	0	0	2	1	0	0	2	2	0	2	0	0	3	3	3	3	3	3	3	2	2
	The Kames	0	2	2	0	2	2	2	0	1	2	2	2	3	3	4	2	2	3	3	2	3	3	3	2
	South of Skaw Taing	3	3	2	3	2	1	2	2	2	2	2	3	3	3	2	0	0	2	2	3	2	3	2	2
	Jetty 3	0	4	3	0	0	0	2	0	0	0	0	2	3	2	1	0	0	2	2	0	0	2	2	2
	Mavis Grind (Stream 3)	2	2	0	2	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0
Reference	Fugla Ayre	1	3	2	2	2	1	0	0	0	3	3	0	2	2	0	2	0	3	2	3	4	2	0	3
	Riven Noust	2	3	2	3	2	1	0	0	1	3	3	2	3	3	3	3	3	3	3	2	3	3	3	3
	Vidlin Ness	4	4	3	3	4	5	4	5	4	5	5	5	5	3	3	4	5	5	4	3	4	4	4	3
	Burgo Taing	3	4	3	3	2	2	2	2	2	2	3	0	4	3	2	2	3	3	0	3	2	2	3	3
	Kirkabister	5	2	3	3	2	2	2	2	2	6	5	3	5	3	0	2	4	4	2	0	2	2		3
	North Burra Voe	0	0	0	2	1	0	0	0	0	0	0	0	2	0	2	2	2	3	0	3		0	3	0

3.1.10 Encrusting coralline algae

Coralline crust cover is difficult to record accurately, because of different lighting, wetness and overgrowth by other algae and animals. Differences between recorders will also be a factor. Recorded abundances therefore fluctuate considerably, as shown in the graph below. However, the apparent gradual rise in abundances and numbers of records between 2001 and 2016 is interesting, and there was also a gradual rise in abundance through the 1990s.



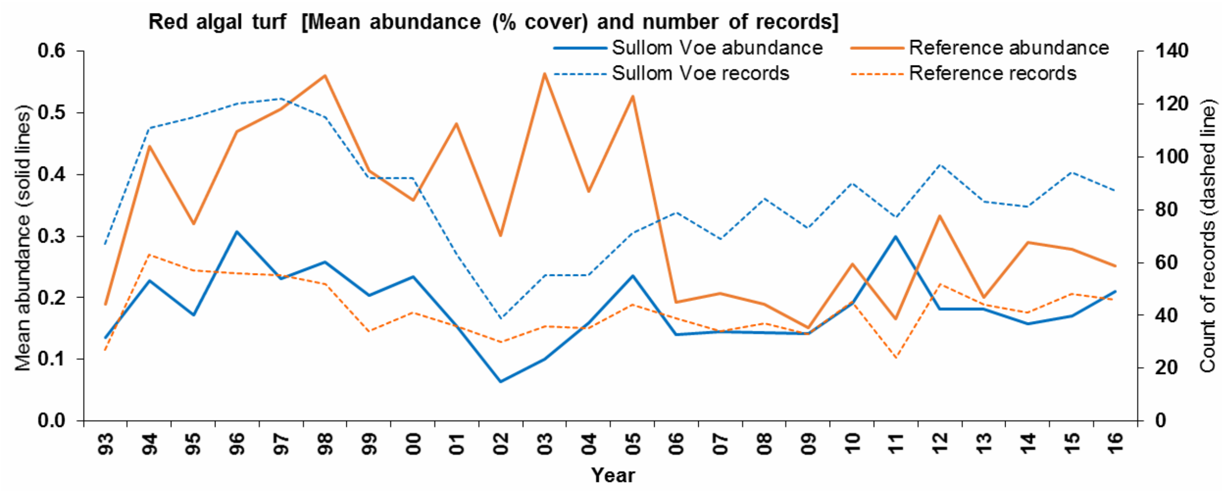


Corallinaceae (encrusting) (max of abundance scores from five stations, by site and year)

		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
Sullom Voe	West of Mioness	5 5 5 5 5 5 2 5 5 4 3 3 4 3 4 3 4 4 0 4 4 4 5 3 3 6 5 5 5 5 5 5 4 3
	Roe Clett	4 4 4 4 4 4 6 3 3 2 3 3 3 3 4 3 4 5 0 4 4 3 4 5 3 4 1 5 6 5 4 2 3 4
	Noust of Burraland	4 4 4 4 4 4 5 4 4 4 4 5 5 4 4 5 5 5 3 4 6 6 6 7 6 6 6 6 6 6 6 6 6 6
	Gluss Island East	2 2 2 2 4 2 3 2 2 2 4 4 2 1 2 3 3 4 0 0 0 3 2 3 3 1 0 2 4 2 3 1 4 2
	South of Swarta Taing	5 5 5 5 5 5 5 5 5 5 4 5 5 5 5 5 5 6 5 7 6 6 6 6 5 6 6 7 7 7 6 7 6 6
	Grunn Taing	5 5 5 5 5 5 4 2 2 6 6 5 5 4 5 4 5 5 0 3 0 5 4 4 6 6 6 6 6 6 6 6 6 3
	The Kames	5 5 5 5 5 5 5 3 3 4 4 5 4 5 5 5 5 5 4 4 6 5 5 6 5 5 5 5 6 4 7 5 4 5
	Voxter Ness	2 2 2 2 2 2 2 2 2 2 4 1 2 4 3 4 4 5 3 3 4 4 4 3 4 4 4 4 4 4 2 4 2 3
	South of Skaw Taing	7 7 7 7 7 7 7 7 7 6 7 5 7 5 7 6 6 7 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
	Jetty 3	0 0 0 0 0 0 1 0 0 0 0 2 2 2 3 2 3 4 0 3 0 0 3 0 3 4 2 0 4 4 2 2 4 3
	Mavis Grind (Stream 3)	7 7 7 7 7 5 5 4 4 5 0 5 5 5 2 4 4 4 0 5 5 6 5 5 4 6 5 5 5 5 4 4 4 4
	Fugla Ayre	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 4 0 3 0 0 0 0
	South of Jetty 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 3 0 0 0 0 0 0 1 1 0
	Scatsta Ness (cleared)	0 0 0 0 0 4 3 4 4 4 5 5 7 6 5 5 6 6 7 7 7 6 6 6 6 6 6 6 6 5 7 6 6 6
	Scatsta Ness (uncleared)	0 0 0 0 0 0 0 0 0 0 1 2 3 4 4 3 5 4 3 4 0 4 4 5 3 2 1 5 4 4 2 2 3 4
Reference	Riven Noust	3 4 4 4 3 4 4 4 3 4 5 5 6 5 4 5 5 6 6 4 5 5 5 5
	Vidlin Ness	5 5 5 5 4 4 5 5 6 5 5 6 6 5 4 6 5 6 6 6 5 6 5 5
	Burgo Taing	7 4 4 4 4 4 5 5 5 4 5 6 5 4 3 4 6 5 4 5 6 5 4 4
	Kirkabister	2 3 2 3 2 2 2 0 0 4 4 4 4 1 0 1 2 2 0 3 5 4 2 2
	North Burra Voe	7 5 5 5 5 5 6 6 7 6 6 7 7 5 5 5 7 5 5 7 6 6 6 6

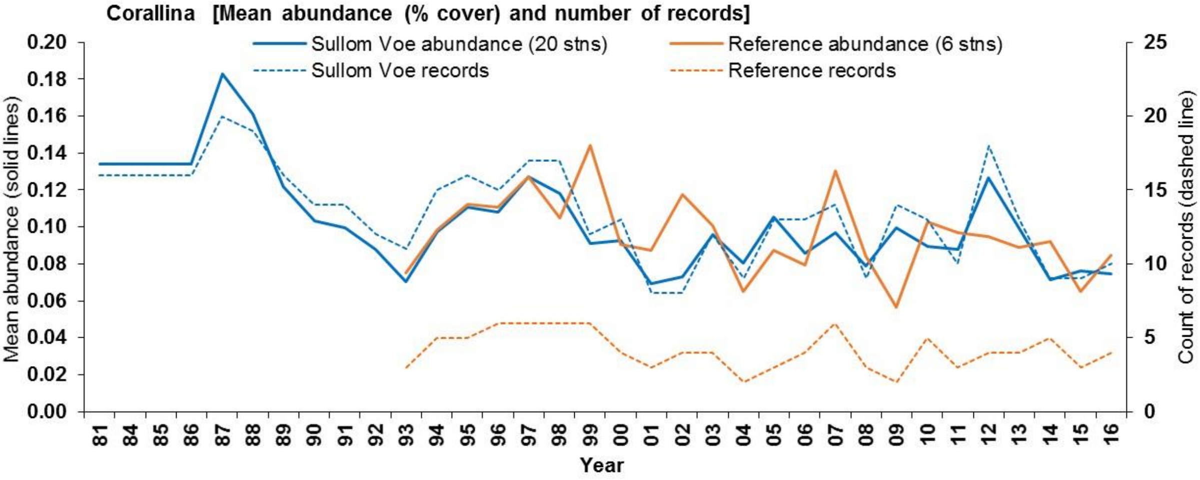
3.1.11 Red algal turf species

The graph below summarises the mean abundances of red algal turf species across all transect sites and stations. There was little change in 2016 and levels were well within the normal range.

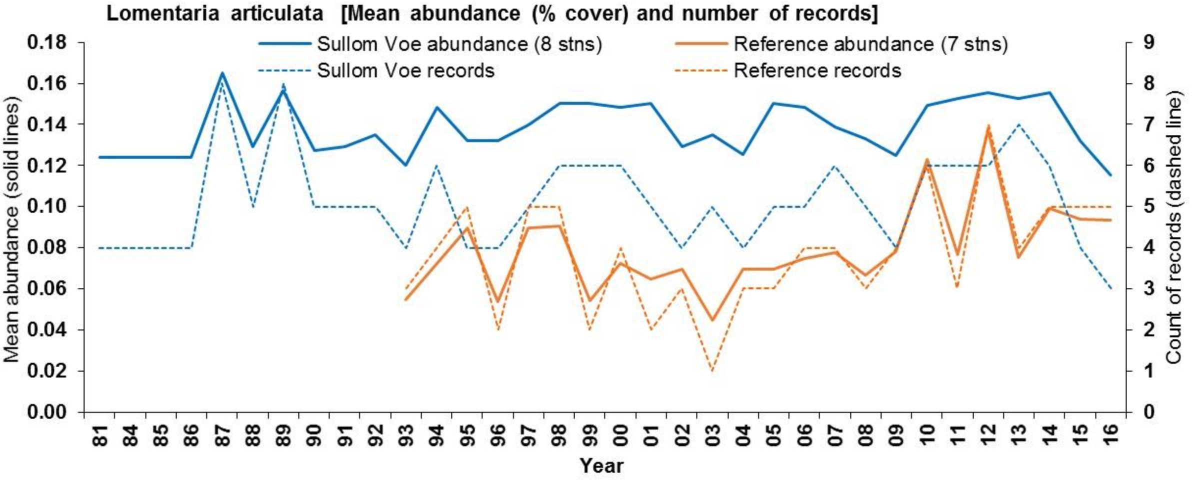


Approximately 20 individual species of red algae are regularly recorded from the transect sites each year; 10 contributing most to the recorded abundances. Fluctuations occur from year to year and site to site. While some of the fluctuations in individual species populations are relatively large, none appear to be related to the oil terminal and they are all considered to be natural. The following three graphs have been selected to illustrate some of the larger changes between 2015 and 2016.

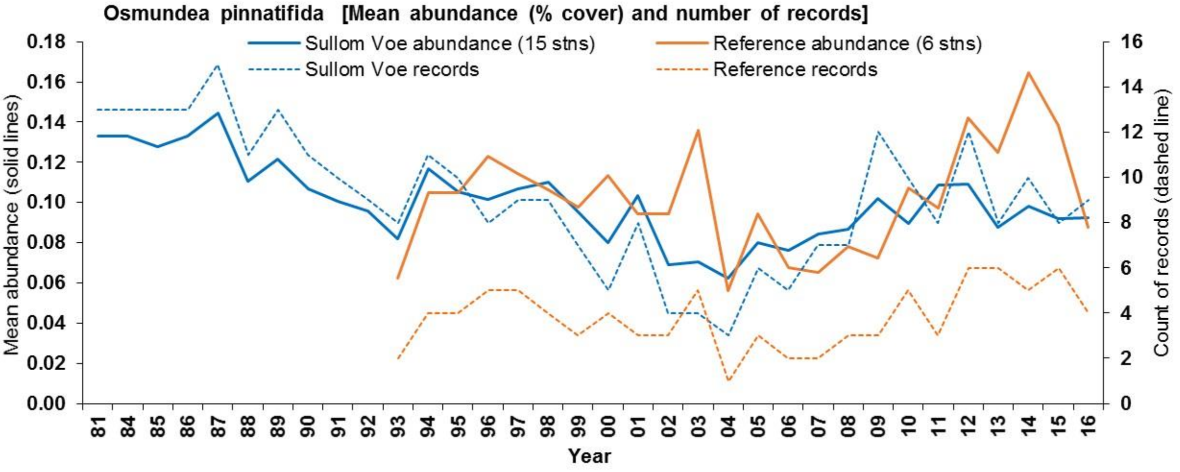
Corallina is a calcareous perennial species that can form a dense turf on the lower shore at various sites; including West of Mioness (1.1) where abundances decreased in 2016 and Riven Noust (2.9) where there was an increase in 2016 but where fluctuations have been surprisingly large.



Lomentaria articulata is also a perennial species of lower and mid shore moderately wave exposed rocks. It is typically present in moderate abundance at Grunn Taing (4.1), S. of Swarta Taing (3.5) and Noust of Burraland (3.3), but abundances were notably reduced at those sites in 2016. Reductions were also recorded from two Reference sites.



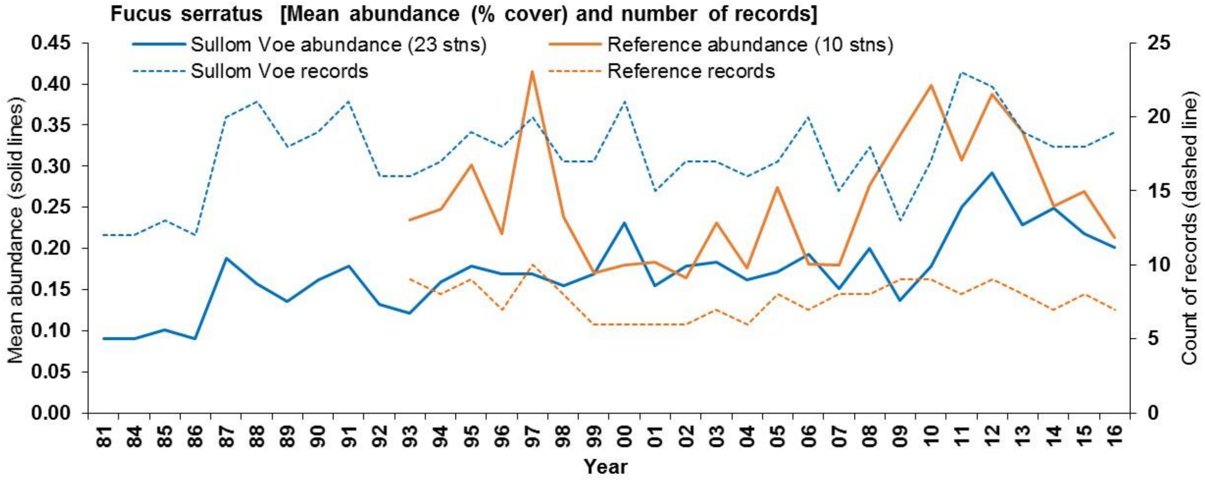
Osmundea pinnatifida is another perennial species from similar habitats that can form dense turfs. It was particularly abundant at the Burgo Taing Reference site in 2015, but declined to previous levels in 2016. There were increases and decreases at various sites in Sullom Voe.

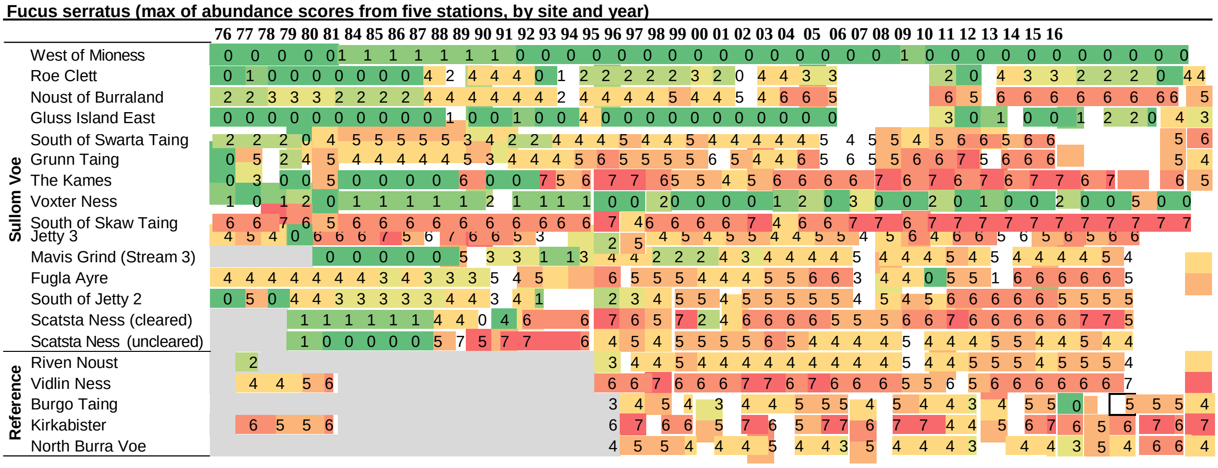


Lastly, recorded abundances of *Plumaria plumosa* have been higher in the last 2 years than previous surveys, particularly at South of Swarta Taing, South of Skaw Taing and Grunn Taing.

3.1.12 Fucus serratus

Average abundance of serrated wrack on lower shores continued to decline at both Sullom Voe sites and Reference sites, but inspection of the individual site data shows that this masks some variability. The distribution of increases and decreases shows no obvious geographic trends, but the most notable decreases were all on boulder shores, particularly South of Jetty 2 (see Section 3.2.1) and Scatsta Ness (cleared). Further inspection shows that the largest decreases at many sites were in the lower mid shore stations, rather than the lower shore stations. Note: the apparent increase at Kirkabister is because the lower shore station (E) was not surveyed in 2015. There was also a decrease in abundance in the lower mid shore station (D) at that site.

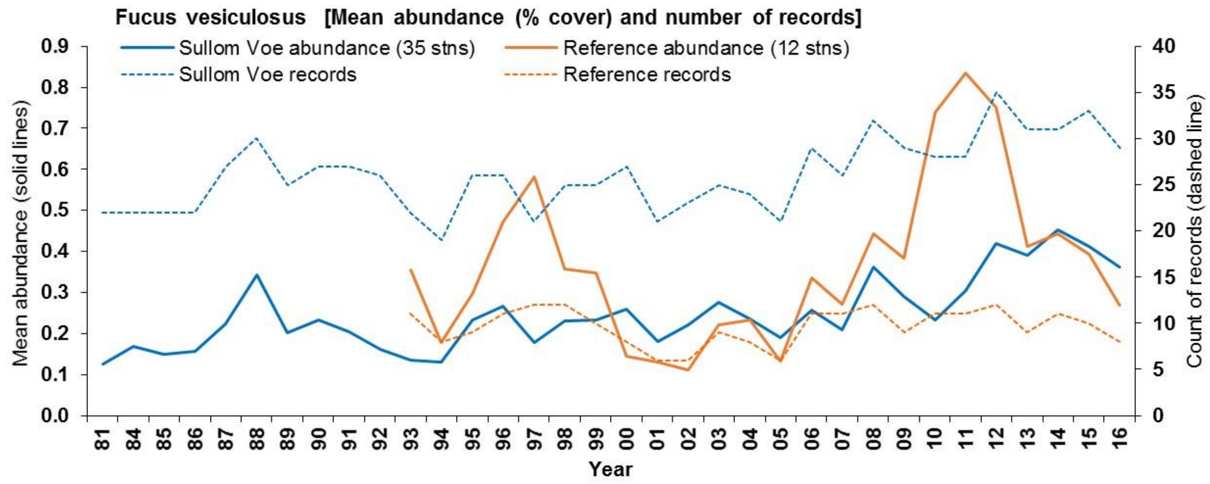



Fucus serratus (max of abundance scores from five stations, by site and year)

		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
Sullom Voe	West of Mioness	0 0 0 0 0 1 1 1 1 1 1 1 0 0 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
	Roe Clett	0 1 0 0 0 0 0 0 0 4 2 4 4 4 0 1 2 2 2 2 2 3 2 0 4 4 3 3 2 0 4 3 3 2 2 2 0 4 4
	Noust of Burraland	2 2 3 3 3 2 2 2 2 4 4 4 4 4 4 2 4 4 4 4 5 4 4 5 4 6 6 5 6 5 6 6 6 6 6 6 6 6 5
	Gluss Island East	0 0 0 0 0 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 2 0 4 3
	South of Swarta Taing	2 2 2 0 4 5 5 5 5 5 3 4 2 2 4 4 4 5 4 4 5 4 4 4 4 4 5 4 5 5 4 5 6 6 5 6 6 5 6
	Grunn Taing	0 5 2 4 5 4 4 4 4 4 5 3 4 4 4 5 6 5 5 5 5 6 5 4 4 6 5 6 5 5 6 6 7 5 6 6 6 5 4
	The Kames	0 3 0 0 5 0 0 0 0 6 0 0 7 5 6 7 7 65 5 4 5 6 6 6 6 7 6 7 6 7 6 7 7 6 7 6 5
	Voxter Ness	1 0 1 2 0 1 1 1 1 1 2 1 1 1 1 0 0 20 0 0 0 1 2 0 3 0 0 2 0 1 0 0 2 0 0 5 0 0
	South of Skaw Taing	6 6 7 6 5 6 6 6 6 6 6 6 6 6 6 7 46 6 6 6 7 4 6 6 7 7 6 7 7 7 7 7 7 7 7 7 7 7
	Jetty 3	4 5 4 0 6 6 6 7 5 6 7 6 6 5 3 2 5 4 5 4 5 5 4 4 5 5 4 5 6 4 6 6 5 6 5 6 5 6 6
	Mavis Grind (Stream 3)	0 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
	Fugla Ayre	4 4 4 4 4 4 4 3 4 3 3 3 5 4 5 6 5 5 5 4 4 4 5 5 6 6 3 4 4 0 5 5 1 6 6 6 6 6 5
	South of Jetty 2	0 5 0 4 4 3 3 3 3 3 4 4 3 4 1 2 3 4 5 5 4 5 5 5 5 5 4 5 4 5 6 6 6 6 6 5 5 5 5
	Scatsta Ness (cleared)	1 1 1 1 1 1 4 4 0 4 6 6 7 6 5 7 2 4 6 6 6 6 5 5 5 6 6 7 6 6 6 6 6 7 7 5
	Scatsta Ness (uncleared)	1 0 0 0 0 0 5 7 5 7 7 6 4 5 4 5 5 5 5 6 5 4 4 4 4 5 4 4 4 5 5 4 4 5 4 4
Reference	Riven Noust	2 3 4 4 5 4 4 4 4 4 4 4 4 4 5 4 4 5 5 5 4 5 5 5 4
	Vidlin Ness	4 4 5 6 6 6 7 6 6 6 7 7 6 7 6 6 6 5 5 6 5 6 6 6 6 6 6 7
	Burgo Taing	3 4 5 4 3 4 4 5 5 5 4 5 4 4 3 4 5 5 0 5 5 5 4
	Kirkabister	6 5 5 6 6 7 6 6 5 7 6 5 7 7 6 7 7 4 4 5 6 7 6 5 6 7 6 7
	North Burra Voe	4 5 5 4 4 4 5 4 4 3 5 4 4 4 3 4 4 3 5 4 6 6 4

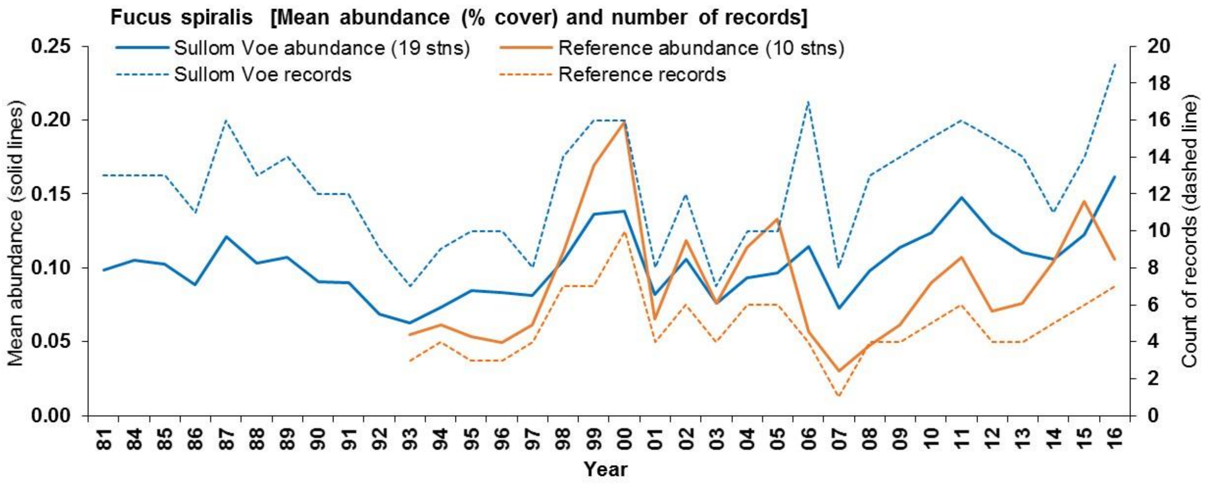
3.1.13 Fucus vesiculosus and Fucus spiralis

The average abundance of bladder wrack decreased in 2016, following a period of relatively high abundance at the Sullom Voe sites. There was also a decrease at the Reference sites. The individual site data show that decreases occurred across many sites and stations, although some increases were also recorded. For example, a large increase at Roe Clett was due to a recent dense settlement in Station D (see photos below). Occasional *F. vesiculosus* sporelings are not unusual at this station, but it is too wave exposed for them to grow to maturity. Dense settlement was last recorded there in 2002.



Roe Clett (site 2.3) – Lower mid shore station (17) in July 2012 (left) and July 2016 (right). The dense sward of juvenile <u>Fucus vesiculosus</u> in 2016 is unusual for this station.

In contrast to the above, a notable increase in the average abundance of *F. spiralis* in 2016 at Sullom Voe sites is shown in the graph below; while there was a decrease in the average abundance at Reference sites. Inspection of the underlying data shows increases in abundance at many of the Sullom Voe sites, and the photographs from some stations provide further evidence of some of those increases. However, the 2016 average abundance is greater than at any previous time in the monitoring programme and coincides with a change in algal surveyor, so the data were studied in detail. This analysis found that some of the 2016 *F. spiralis* records are new records for upper mid shore stations where *F. vesiculosus* was recorded in 2015. Photographs from one of those stations (Fugla Ayre, Station B) show the same small plant in both years, so one of the records must be a misidentification. The two species often overlap on the upper mid shore, and in some situations distinguishing between them can be difficult especially as the species are known to hybridize. The plant in the Fugla Ayre photograph shows some characteristics of both species and it is possible therefore that this and some of the other 2016 changes may also have been due to differences in surveyors' identification. Similar small but notable shifts between the two species have occurred in other periods of the long-term data (e.g. at Mavis Grind and Burgo Taing), suggesting that the issue may not be new. However, it is also clear that there was a real increase in *F. spiralis* in 2016 at several of the monitoring sites.



Fugla Ayre (site 6.1) – Fucoid algae in Station B (upper mid shore) in July 2016. These plants, that are also present in a photograph from 2015 (but looking less well developed), were identified as <u>Fucus vesiculosus</u> in 2015 but as <u>F. spiralis</u> in 2016.

5-1 S.of Skaw Taing		93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Fucus spiralis	**B**																					1		2	2
	C			1	2	4		3	3	2			3				1	1	1						3
Fucus vesiculosus	**B**				4																				
	C				3												4	4	4	2	4	4	3	3	
	D	6	5	5	6	6	5	5	4	5	4	5	6	5	6	6	7	7	7	6	4	6	6	6	7

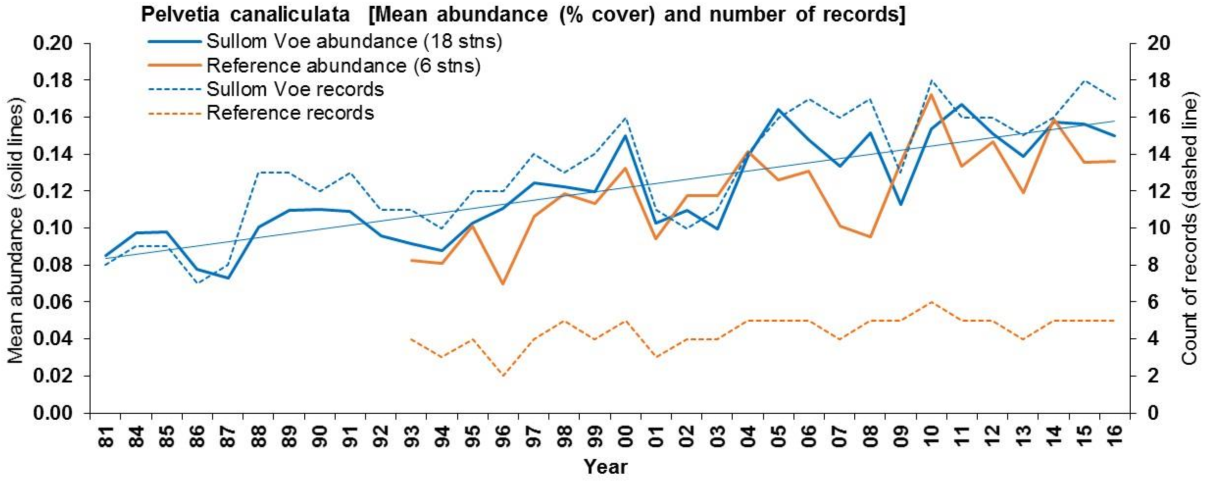
6-1 Fugla Ayre

Fucus spiralis	**B**								2									1		1		1			3
	C	3	2	3	2	4	4	4	5	4	3	4			1		1	3		4	4	4			
Fucus vesiculosus	**B**																				1		5	4	
	C	1			4		3	1	4	4	4	4	4	4		2				1	4	5	5	6	5
	D	5	5	5	6	5	4	4	4	6	5	5	3		1	2	2	3		4	4	6	6	4	5
	E	3	2	2	3		4	4	4	4	4	4					2			2		4	4		

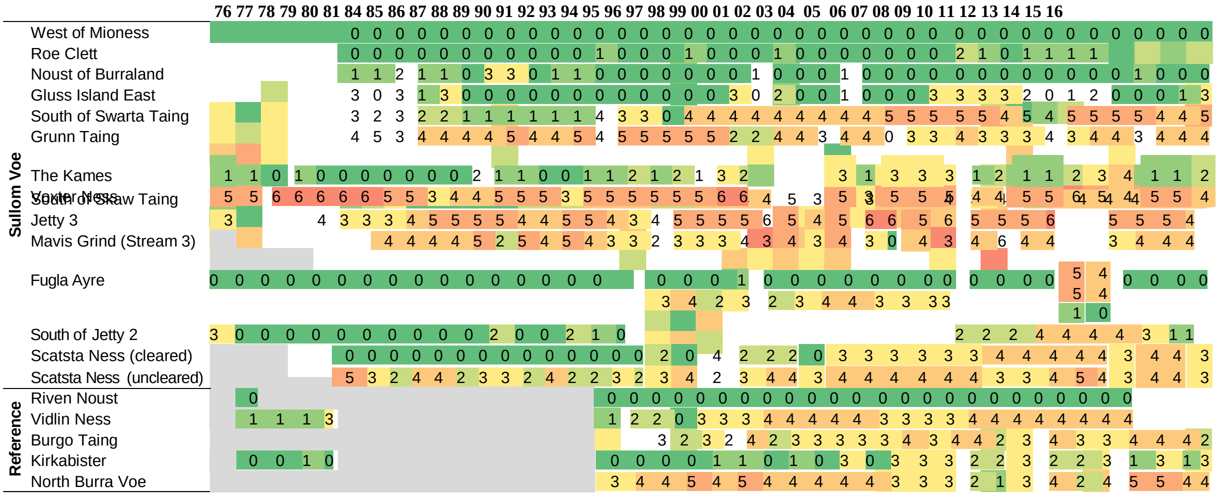
3.1.14 Pelvetia canaliculata

Numbers of records and mean abundance of channelled wrack, which lives in the upper intertidal, have increased over the course of the monitoring programme. While the graph below shows some large fluctuations, the trendline indicates that mean abundance has increased considerably. Numbers of records at Sullom Voe sites have almost doubled since 1981. A trendline for the Reference sites has not been included (to reduce complexity of the graph), but the graph indicates a similar rate of increase in mean abundance. There was little apparent change in numbers of records from four Reference sites, but data from Kirkabister (6.11) suggest that the presence of channelled wrack (in the monitored station) became increasingly more reliable.

The 2016 data show some small fluctuations in abundance since 2015, but no obvious trends.



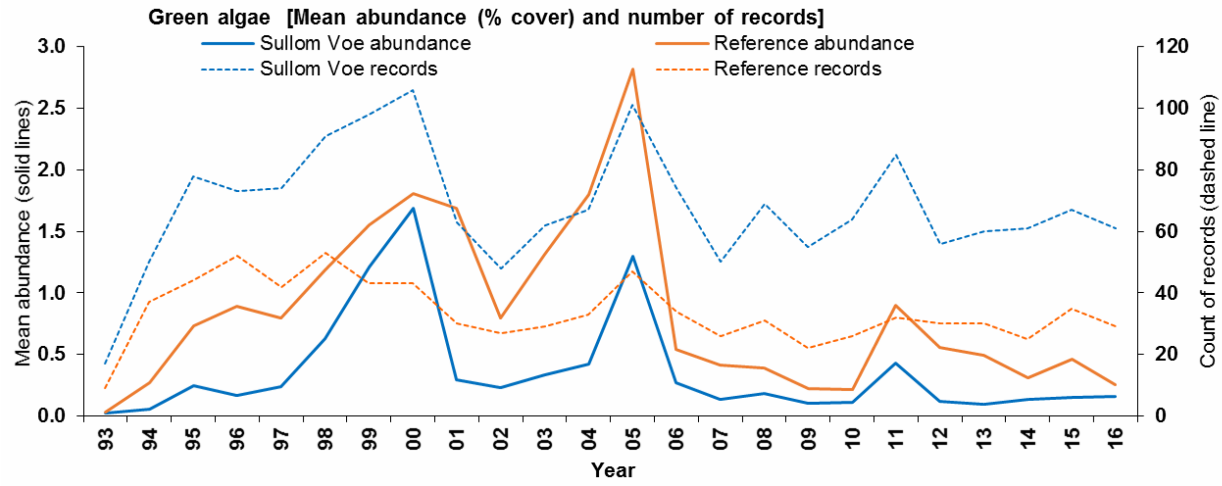
Pelvetia canaliculata (max of abundance scores from five stations, by site and year)



		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
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
	Roe Clett	0 0 0 0 0 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
	Noust of Burraland	1 1 2 1 1 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
	Gluss Island East	3 0 3 1 3 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 2 0 1 2 0 0 0 1 3
	South of Swarta Taing	3 2 3 2 2 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
	Grunn Taing	4 5 3 4 4 4 4 5 4 4 5 4 5 5 5 5 5 2 2 4 4 3 4 4 0 3 3 4 3 3 3 4 3 4 4 3 4 4 4
	The Kames	1 1 0 1 0 0 0 0 0 0 0 2 1 1 0 0 1 1 2 1 2 1 3 2 3 1 3 3 3 1 2 1 1 2 3 4 1 1 2
	Vexter Ness South of Skaw Taing	5 5 6 6 6 6 6 5 5 3 4 4 5 5 5 3 5 5 5 5 5 5 6 6 4 5 3 5 3 5 5 5 4 4 5 5 6 4 5 4 4 4 5 5 4
	Jetty 3	3 4 3 3 3 4 5 5 5 5 4 4 5 5 4 3 4 5 5 5 5 6 5 4 5 6 6 5 6 5 5 5 6 5 5 5 4
	Mavis Grind (Stream 3)	4 4 4 4 5 2 5 4 5 4 3 3 2 3 3 3 4 3 4 3 4 3 0 4 3 4 6 4 4 3 4 4 4
	Fugla Ayre	0 0 0 0 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 5 4 0 0 0 0
		3 4 2 3 2 3 4 4 3 3 3 3 5 4
		1 0
	South of Jetty 2	3 0 0 0 0 0 0 0 0 0 0 2 0 0 2 1 0 2 2 2 4 4 4 4 3 1 1
	Scatsta Ness (cleared)	0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 0 4 2 2 2 0 3 3 3 3 3 3 4 4 4 4 4 3 4 4 3
	Scatsta Ness (uncleared)	5 3 2 4 4 2 3 3 2 4 2 2 3 2 3 4 2 3 4 4 3 4 4 4 4 4 4 3 3 4 5 4 3 4 4 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
	Vidlin Ness	1 1 1 3 1 2 2 0 3 3 3 4 4 4 4 4 3 3 3 3 4 4 4 4 4 4 4 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
	Kirkabister	0 0 1 0 0 0 0 0 1 1 0 1 0 3 0 3 3 3 2 2 3 2 2 3 1 3 1 3
	North Burra Voe	3 4 4 5 4 5 4 4 4 4 4 3 3 3 2 1 3 4 2 4 5 5 4 4

3.1.15 Green algae

Green algae, comprising *Ulva* (tubular and flat forms), *Cladophora*, *Codium* and various other taxa, were again present in relatively low abundances compared to some previous years.



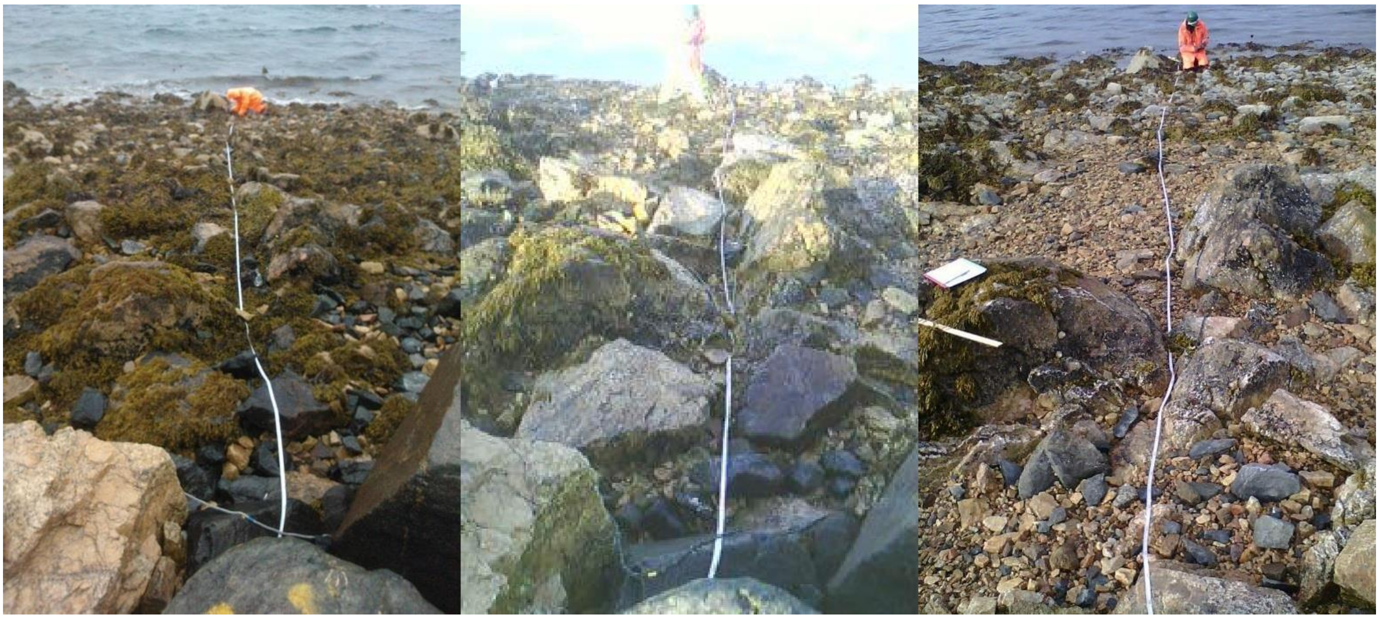
3.2 Site-specific descriptions

3.2.1 South of Jetty 2

The temporary containment area at the top of the shore between Jetty 1 and Jetty 2, used to remove oil lost from the dirty water drainage system in August 2012, was removed between the 2015 and 2016 surveys. Remediation of the backshore included construction of a track from the top of the bank behind, with some movement of large boulders from the shore. This movement of boulders has altered the topography and substrata along Transect 6.2 (*South of Jetty 2*), which lies approximately 25m north of the site of the containment area. The loss of the boulders on the upper and midshore of the transect can be seen in the photographs below.

Impacts of this physical disturbance to the rocky shore communities along the transect were mainly on abundance (percentage cover) of fucoid algae on the upper and midshore. Particularly in Station C where removal of stable boulders also removed the knotted wrack (*Ascophyllum nodosum*). Abundance of channelled wrack (Pelvetia canaliculata) and spiral wrack (Fucus spiralis), in Stations A and B were also much lower than they have been in recent years, but most of those reductions had already occurred in 2015, and may have been natural fluctuations.

		93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Pelvetia canaliculata	**A**													2	1	1	2	1	3	2	1	4	2	1	
	B	1		3	4	2	3	2	3	4	4	3	3	3	3	2		2	4	4	4	3	3		1
Fucus spiralis	**B**			3	4	6	6	6	5	4	4	4	4	3	2		4	5	5	5	6	4	5	3	3
Ascophyllum nodosum	**C**	2							2	4	4	4	4	4	2	2	4	1	4	4	4	5	5	4	
	D	2											4	3	1					2		4	4	3	3
Fucus vesiculosus	**C**			4	6	5	5	5	4	4	4	5	6	5	4	1	4	5	5	6	5	6	5	4	4
	D	4	5	7	6	6	7	6	4	4	5	6	5	5	4	3	6	5	7	6	4	5	6	4	5
	E	3	5	6	4	4	5	4	5	4	4	5	5	4	2	5	5	5	5	5	4	4	5	4	4
Fucus serratus	**D**	1	1		1	2		2	4	4	3	3			2	2	4	4	4	4	2		4	3	
	E	2	3	4	5	5	4	5	5	5	5	5	4	5	4	5	6	6	6	6	6	5	5	5	5



South of Jetty 2 (6.2) – View down transect in July 2012, 2015 and 2016 (left to right), showing loss of boulders from the upper and mid shore.

South of Jetty 2 (site 6.2) – Restructured upper shore, to make track, including boulders moved from mid shore, with fucoid algae still attached (on large boulder in middle of photo), July 2016.

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 compared to recent years.

4 Discussion

4.1 Changes in rocky shore communities

There were few notable changes in rocky shore communities around Sullom Voe between 2015 and 2016. The fluctuations described in the results sections are all considered to be natural and mostly within typical levels for those shores and the survey methodology. None of the recorded fluctuations are considered to be related to the terminal.

Average abundances of barnacles and fucoids over the last five years are all higher than in any other period of the monitoring programme. The trend of increasing abundance in channelled wrack, *Pelvetia canaliculata*, is particularly striking. Increases in fucoid algae have been reported from around Scotland generally (Burrows *et al.* 2016) and are an expected feature of climate change (Burrows 2016). The barnacle *Semibalanus balanoides* is a northern species that has started to decline in the south of UK, but is obviously still well within its thermal niche in Shetland.

There was a change in algal surveyor in 2016 which inevitably resulted in some differences in recording. Very few notable differences have been identified, but the change has highlighted an issue with identification of some fucoid algae: *Fucus spiralis* (spiral wrack) and *F. vesiculosus* (bladder wrack). The potential for hybridisation between the two species has been mentioned in a previous report, but it now seems that difficulties in identification in some upper middle shore stations could cause notable changes in average abundances, which might be misinterpreted. Closer study and some sampling for expert identification will be appropriate during the next survey.

4.2 Effects of terminal operations and oil spills

During the period 1st August 2015 to 1st August 2016 there was only one pollution incident reported within Sullom Voe (Simon Skinner, pers. comm.). That was a small quantity of sheen from a light processed oil spilled from a tanker at the terminal in September 2015.

As described in Section 3.2.1, remediation of the temporary containment area between Jetty 1 and Jetty 2 has altered the topography and substrata along rocky shore transect 6.2 (*South of Jetty 2*). Recorded impacts on the rocky shore communities were not severe, except for the loss of knotted wrack from one station. This fucoid alga is long lived and requires stable substrata for attachment. The affected station may not now include suitable stable boulders for recolonization. The population on this transect took many years to recover from the original disturbance of the terminal construction. Impacts to other species were relatively limited and recovery of those populations is likely to be rapid, unless the restructuring results in destabilisation of the shore. Monitoring of population abundances and species richness over the next few years should determine whether this occurs.

A practical consequence of the changes to the *South of Jetty 2* transect is that the site marker at the top of the transect has gone. The large stable boulders have been moved (see photos below). Fortunately, Station B is marked on a more stable piece of rock and Station A could be relevelled from there. However, the transect relocation sheet will need to be updated.

South of Jetty 2 (site 6.2) – Movement of boulders at top of transect, July 2012 (left) and 2016 (right).

Apart from that, terminal activities during the past 12 months appear to have had no other obvious impacts upon the rocky shore communities of Sullom Voe.

4.3 Survey methodologies

The revised design of average abundance graphs used in this report highlights an apparent lack of synchrony in abundance changes, for many species, between Sullom Voe and the Reference sites. This lack of synchrony is partly due to real differences in habitats between the sites and partly to other natural and small scale fluctuations. The five Reference sites do not adequately represent the rocky shore characteristics and variability of the fifteen Sullom Voe sites, so statistical comparisons are limited. If more detailed statistical comparisons are required, then it would be appropriate to expand the suite of Reference sites. This was also one of the recommendations given in the recent review of the rocky shore monitoring programme (Jenkins 2015).

Levelling of the five monitored stations on each of the twenty transects was carried out successfully (see Appendix 2). However, comparison of station heights between sites gives some unexpected differences when related to the observed zonation of fucoids and other species. Local meteorological effects on tidal height could have caused some errors, but reference to data available from the Lerwick tide gauge (www.ntslf.org/data/realtime?port=Lerwick) shows no notable differences between predicted and observed tide heights during the survey period. It would be appropriate to repeat the levelling operation again during the next survey, possibly incorporating real time reference to the Lerwick tide gauge and / or calibration of predicted tides with a tide gauge at Sella Ness.

Jenkins (2015) included other recommendations for improvement of the programme that have not yet been fully considered.

5 References

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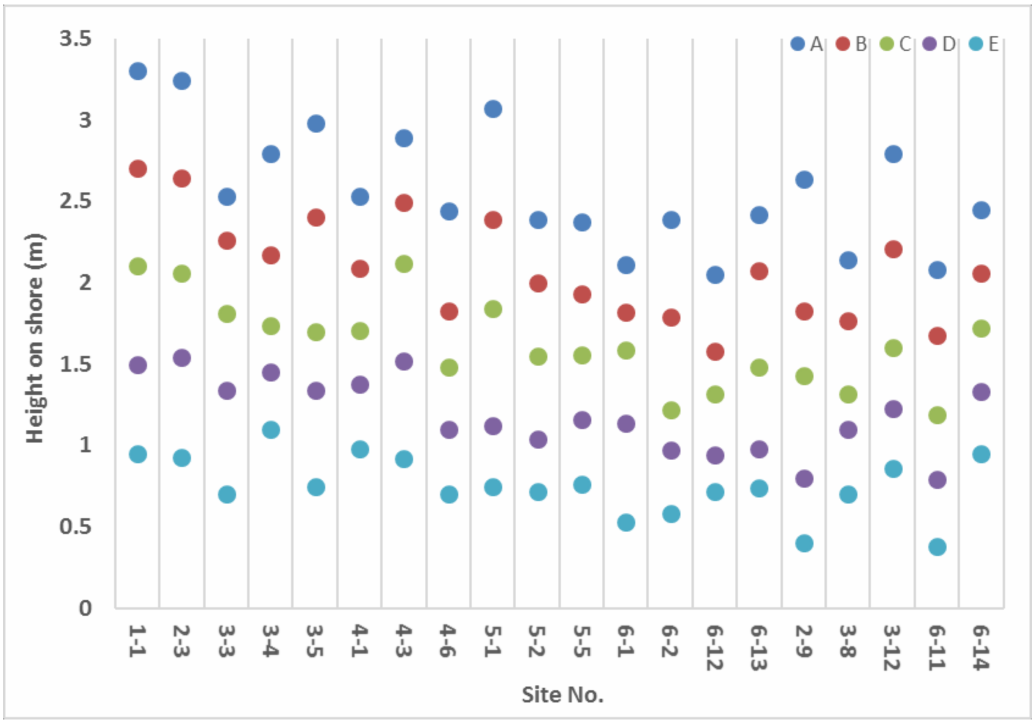
Appendix 1 Abundance scales used for intertidal organisms

1. Live barnacles (except *B. perforatus*) (record adults, spat, cyprids separately); *Littorina neritoides; Littorina 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. *Pomatoceros* 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. *Balanus perforatus* 7 Ex 300 or more per 0.01 m^2 6 S 100-299 per 0.01 m^2 5 A 10-99 per 0.01 m^2 4 C 1-9 per 0.01 m^2 3 F 1-9 per 0.1 m^2 2 O 1-9 per m^2 1 R Less than 1 per m^2	**8. Spirorbinidae** 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 mariae/obtusata* (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 mariae/obtusata* 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, lithothamnia** 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. *Monodonta lineata, 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** 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 Tidal heights of monitoring stations

Results of station levelling carried out during the July 2016 survey. See Section 2.2.2 for a description of the methodology and Section 4.3 for a discussion of the results.

		Sea level			Metres above chart datum				
Site	**No.**	**Date**	**Time (bst)**	**Height (m)**	**E**	**D**	**C**	**B**	**A**
W. of Mioness	1-1	20 July	15:00	0.70	0.95	1.50	2.10	2.70	3.30
Roe Clett	2-3	22 July	16:00	0.80	0.93	1.54	2.06	2.64	3.24
Noust of Burraland	3-3	21 July	18:00	0.40	0.70	1.34	1.81	2.26	2.53
Gluss Island East	3-4	21 July	17:03	0.40	1.10	1.45	1.74	2.17	2.79
S. of Swarta Taing	3-5	24 July	07:35	0.30	0.75	1.34	1.70	2.40	2.98
Grunn Tang	4-1	21 July	15:40	0.70	0.98	1.38	1.71	2.09	2.53
The Kames	4-3	20 July	16:34	0.40	0.92	1.52	2.12	2.49	2.89
Voxter Ness	4-6	20 July	17:50	0.50	0.70	1.10	1.48	1.83	2.44
South of Skaw Taing	5-1	22 July	17:30	0.40	0.75	1.12	1.84	2.39	3.07
Jetty 3	5-2	23 July	06:15	0.20	0.72	1.04	1.55	2.00	2.39
Mavis Grind	5-5	21 July	05:30	0.20	0.76	1.16	1.56	1.93	2.37
Fugla Ayre	6-1	22 July	18:55	0.45	0.53	1.14	1.59	1.82	2.11
South of Jetty 2	6-2	23 July	07:40	0.30	0.58	0.97	1.22	1.79	2.39
Scatsta Ness Cleared	6-12	24 July	19:57	0.50	0.72	0.94	1.32	1.58	2.05
Scatsta Ness Uncleared	6-13	24 July	20:49	0.60	0.74	0.98	1.48	2.07	2.42
Riven Noust	2-9	20 July	07:25	0.70	0.40	0.80	1.43	1.83	2.64
Vidlin Ness	3-8	22 July	05:15	0.55	0.70	1.10	1.32	1.77	2.14
Burgo Taing	3-12	23 July	17:23	0.60	0.86	1.23	1.60	2.21	2.79
Kirkabister	6-11	22 July	06:40	0.20	0.38	0.79	1.19	1.68	2.08
North Burra Voe	6-14	23 July	18:45	0.50	0.95	1.33	1.72	2.06	2.45



Appendix 3 Chronology of personnel changes and methodology during SOTEAG rocky shore monitoring programme

Contractors: Oil Pollution Research Unit, Field Studies Council Research Centre, Cordah Ltd., BMT Cordah Ltd., Aquatic Survey & Monitoring Ltd.

Survey staff: Annette Little (AL), Tony Thomas (AT), Ben James (BJ), Christine Howson (CH), David Emerson (DE), David Levell (DL), 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 and Gubbins 2015)

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