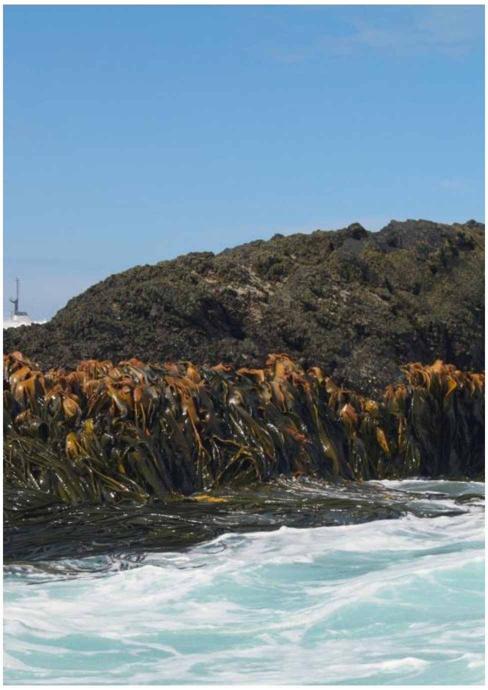
Intertidal assemblages of South Georgia

Report for the South Georgia Heritage Trust
September 2011



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Executive Summary

The intertidal macrofaunal community of Cumberland East Bay, South Georgia is examined. This region may be prone to higher levels of acute or chronic impacts from anthropogenic sources, and thus a baseline of the biodiversity and ecology is prudent. Thirty four macrofaunal species or putative species were found throughout all sites. However, species accumulation curves show that further sampling is needed for a complete species inventory. Between-site differences are noted, particularly at Maiviken that may be in part, due to proximity to the open coast. Other sites were similar in their species composition, but varied in their species abundance. Typical of intertidal communities, intertidal zones were structured along a gradient of low to high tidal height, and communities across all sites could be broadly grouped into those categories. Within sites, species showed extremely patchy distributions across scales of less than 1 meter, and can be related to concurrent variability in habitat (rock pools, cobble, boulders, seaweeds etc). Of significance were the eight species of free-living platyhelminth (turbellarian flatworms) flatworms found, of which 2 are new to science, representing an almost three-fold increase in the number of intertidal species reported for South Georgia compared to previously reported work. We suggest that future monitoring should expand the spatial extent of sampling at each site, as well as spatial resolution, although this is not necessary at all sites. Future work should include meiofaunal sampling, as this would complete the Platyhelminthes inventory. It has been reported previously that the South Georgia (and generally in the sub-Antarctic) intertidal communities show strong seasonal variation, and this should be examined in Cumberland East Bay if robust monitoring programmes are planned.

Acknowledgements

We thank the South Georgia Heritage trust for supporting this work. We are grateful for the assistance and enthusiasm of King Edward Point research station staff, in particular the superb volunteer assistance of Ali Massey in the field and laboratory. Taxonomic expertise was kindly provided Mike Thurston (Amphipoda, National Oceanography Centre, Southampton), and Katrin Linse (Mollusca, BAS). Additional support came from the British Antarctic Survey, the Government of South Georgia and South Sandwich Islands, the Falkland Island Fisheries Department, the Joint Nature Conservation Committee, and a Darwin Initiative (DEFRA) grant.

Introduction

The marine intertidal zone can be broadly defined as the area of coastline that is exposed periodically to air and sea; the mid-zone is exposed at every tidal cycle, while extreme highs and lows of the zone are submerged or exposed respectively only during certain lunar phases and atmospheric conditions. At low tide, marine organisms are exposed to extreme conditions compared to their submerged existence. For example, temperatures can range between highs of 24^{o}C, and lows of -15^{o}C on South Georgia's shores (Davenport 1997). Exposure to cold (risk of freezing), heat (risk of desiccation), rain (osmotic stress), oxygen depletion, predators, and any number of physical risks such as shifting rock, ice scouring, and wave action are defended against by either physiological or behavioural adaptation (Figure 1).

Figure 1. Intertidal shore at Royal Bay showing various environmental stressors e.g. sunlight, ice scour, marine mammals, humans.

In many parts of the world, the intertidal zone has been very well studied; its easy access has captured the attention of amateur and professional naturalists for centuries. When used as a "natural laboratory", many fundamental aspects of ecology have been explored. Within the intertidal zone, species distributions are structured along the vertical gradient above low tide. Community stratification can be highly exaggerated and well defined, such as on exposed rocky shores, or highly constrained within a narrow band, such as on sheltered rocky shores (Figure 2). In locations such as South Georgia, where the tidal range is very small, such zonation will exist, albeit highly compact and possibly blurred by prevailing conditions.

Figure 2. Zonation can be highly structured (left; Prince Olav) or barely evident (right; Sooty Bluff, Cumberland Bay)

The intertidal zone is the boundary between land and sea. As such it is exposed to a wide range of potential anthropogenic impacts from terrestrial and marine sources. This makes the intertidal zone community particularly susceptible to perturbations, and at the same time, makes it an ideal habitat for monitoring acute or chronic causes of such change. Therefore, it is vital that good baseline data are established in order to best detect change and promptly address possible causes.

The intertidal habitats of South Georgia have been poorly studied. Sporadic collections have been made in an unstructured way during historic expeditions in the early part of the 20th century. More recently, South Georgia's and other sub-Antarctic and Antarctic shores have been studied as models of ecological response of benthic communities to disturbance by ice and iceberg scour. Pugh and Davenport (1997) compared intertidal communities of Cumberland West Bay and Husvik Harbour for effects of ice scour, providing some quantitative data on community composition and zonation in those locations. A series of studies based in Husvik Harbour examined the environmental tolerances in specific species groups, such as the Halacaridae marine mites (Pugh and Bartsch 1993), the amphipod *Orchestia scutigerula* (Moore et al 1995), molluscs (Davenport and Macalister 1996, Davenport 1997), and tide pool copepods (Davenport et al 1997). South Georgia's intertidal habitats have been included in latitudinal gradient studies across the Scotia archipelago (eg Barnes and Arnold 1999). Most recently in South Georgia, Barnes et al (2006) made general species collections at Maiviken and Bird Island. The Shallow Marine Survey Group has made intertidal collections in other locations beyond Cumberland East Bay, and these results are forthcoming.

Survey Objectives

Given the paucity of quantitative intertidal surveys carried out in South Georgia, it is highly likely that the baseline species inventory of these habitats is incomplete. The spatial structure of the intertidal community is virtually unknown in South Georgia.

Global climate change models predict that marine communities of sub-polar regions will be dramatically affected by ocean warming, leading to species redistribution and/or species loss, and having direct (Cheung et al 2009, Pereira et al 2010) and indirect effects (Sorte et al 2010) on contemporary diversity patterns. Furthermore, South Georgia is a centre of increasing foreign fishing vessel and tourism activity, suggesting a parallel increase in potential for species invasion or catastrophic impacts on the marine environment.

Our objectives for this study are;

- To enhance the species inventory of the Cumberland East Bay intertidal habitats.
- To quantitatively describe the spatial structure of intertidal communities at small (< 1 meter), intermediate (10s of meters), and large (kms) spatial scales.
- To establish a survey methodology for future intertidal habitat monitoring.

Methods

The study was based at King Edward Point Research station during November, 2010. Six quantitative survey sites were chosen based on apparent variety of habitats, distance from KEP, and access by the survey team (Figure 3). Surveys were conducted at low tide according to the local maritime almanac. At each site, a transect tape measure was run from the water's edge to what was considered to be the high tide drift line. Up to 3 replicate transect surveys were done at each site, placed within 10s of meters of each other. Placement of transect lines was chosen for its representativeness, and where the full survey could be carried out without disruption from fur seals (*Arctocephalus gazelle*).

Paired 0.25m^2 quadrates were placed on each side of the tape measure (replicate quadrates), and at intervals along the transect line (Figure 4). The number of paired replicate quadrates along the transect was dependant on total distance between low and high tide levels, and adjusted for maximising time before flood tide. Table 1 presents number of quadrates per site.

Each quadrate was initially photographed for habitat mapping purposes. It was then searched for flora and fauna for 5 mins, including crevasses and undersides of rocks. This method standardised search effort, while at the same time, maximised the time before the flooding tide.

Samples were collected in plastic bags, sorted in the KEP laboratory, and preserved in 96% ethanol. Detailed sample examination was done in the Fisheries Deptartment laboratory in Stanley, Falkland Islands where preliminary species or putative species identifications were assigned. Species identities are being confirmed by taxonomic specialists, and this work is currently ongoing. All specimens will ultimately reside in curated museum collections.

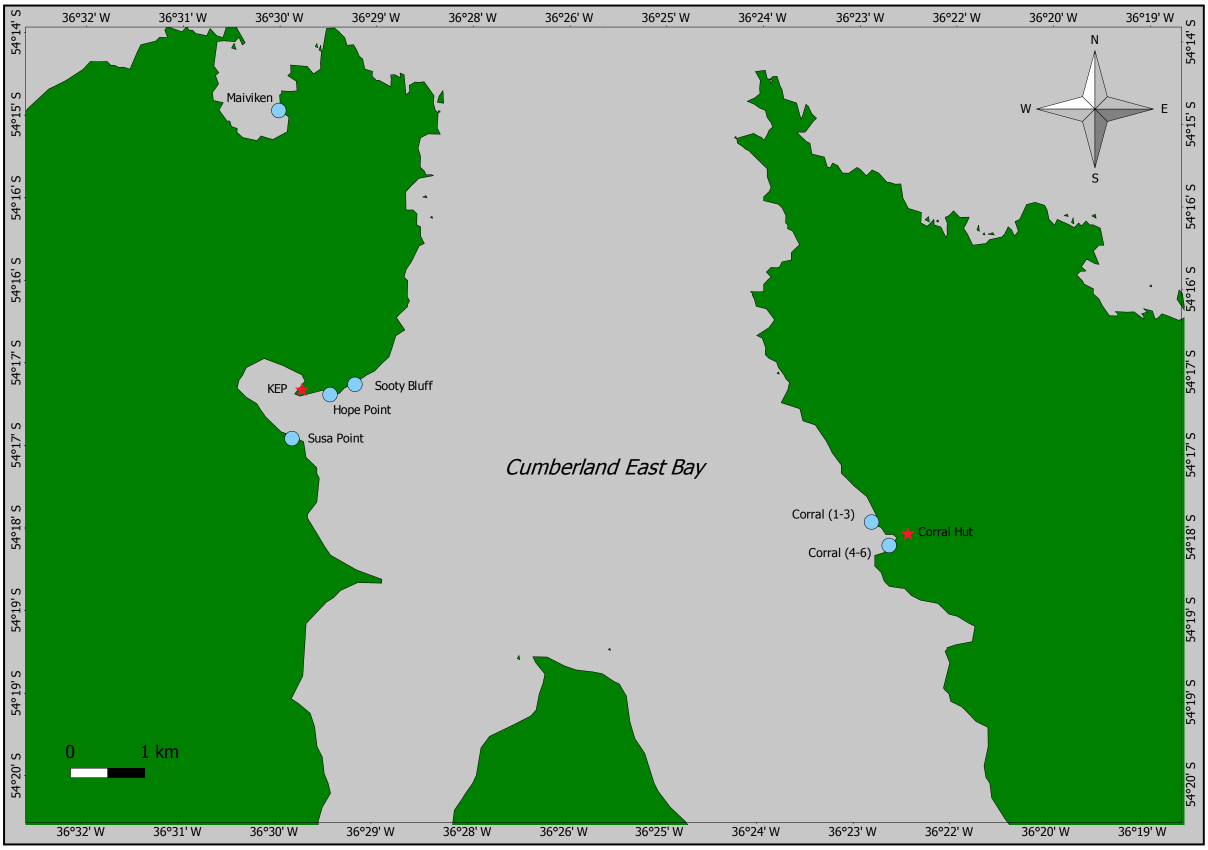


Figure 3. Quantitative survey site locations in Cumberland East Bay, South Georgia.

Table 1. Summary of site locations and data collected.

Site	Transect	Lat (S) / Lon (W)	distance b/w low and high tide (m)	number of photo quadrats
Sooty Bluff	1	54° 16.936' / 36° 29.030'	7	12
Sooty Bluff	2	54° 16.936' / 36° 29.030'	5	12
Sooty Bluff	3	54° 16.936' / 36° 29.030'	4	10
Hope Point	1	54° 17.011' / 36° 29.351'	3	12
Hope Point	2	54° 17.011' / 36° 29.351'	4	13
Susa Point	1	54° 17.336' / 36° 29.815'	20	22
Susa Point	2	54° 17.336' / 36° 29.815'	16	18
Corral Bay	1	54° 19.927' / 36° 22.632'	13	13
Corral Bay	2	54° 19.927' / 36° 22.632'	5	8
Corral Bay	3	54° 19.927' / 36° 22.632'	6	11
Corral Bay	4	54° 18.081 / 36° 22.366'	10	12
Corral Bay	5	54° 18.081 / 36° 22.366'	8	9
Corral Bay	6	54° 18.081 / 36° 22.366'	8	10
Maiviken	General collection 1	54° 15.001' / 36° 29.985'		
Maiviken	General collection 2	54° 14.968' / 36° 30.061'		
Grytviken	General collection 1	54° 16.830' / 36° 29.950'		

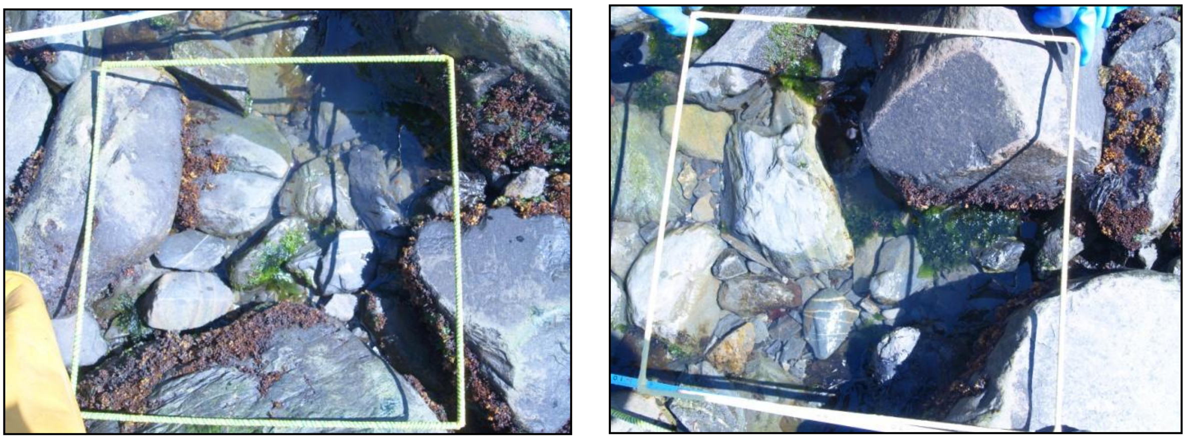


Figure 4. Pair of quadrat replicates, Susa Point, 2m.

The Maiviken survey was not conducted differently to the other five sites due to extremely high number of fur seals. Consequently, the Maiviken survey was limited to lower, mid and upper shore general collections. A low tide general collection was also made adjacent to the road between KEP and Grytviken.

Species accumulation curves were computed in EstimateS (v8.2.0). Principal component Analysis was carried out in R (v2.13.1). SIMPER was carried out in PRIMER (v6.1.13).

Results / Analysis

A total of 41.25 m^2 of intertidal shoreline was quantitatively sampled and photographed. An analysis of the mobile macrofaunal assemblage (e.g. those species retained on a 0.5mm mesh) is presented in this report. Some general qualitative commentary on flora will also be presented in the site by site narratives (below). Examination of photographs is presently ongoing.

Did sampling result in a complete inventory?

Figure 5 shows the observed and predicted species accumulation curves for all sites. This analysis indicates how robust the present species inventory is, and how close this effort is to the predicted total species inventory. All subsequent analyses should be considered in light of this analysis.

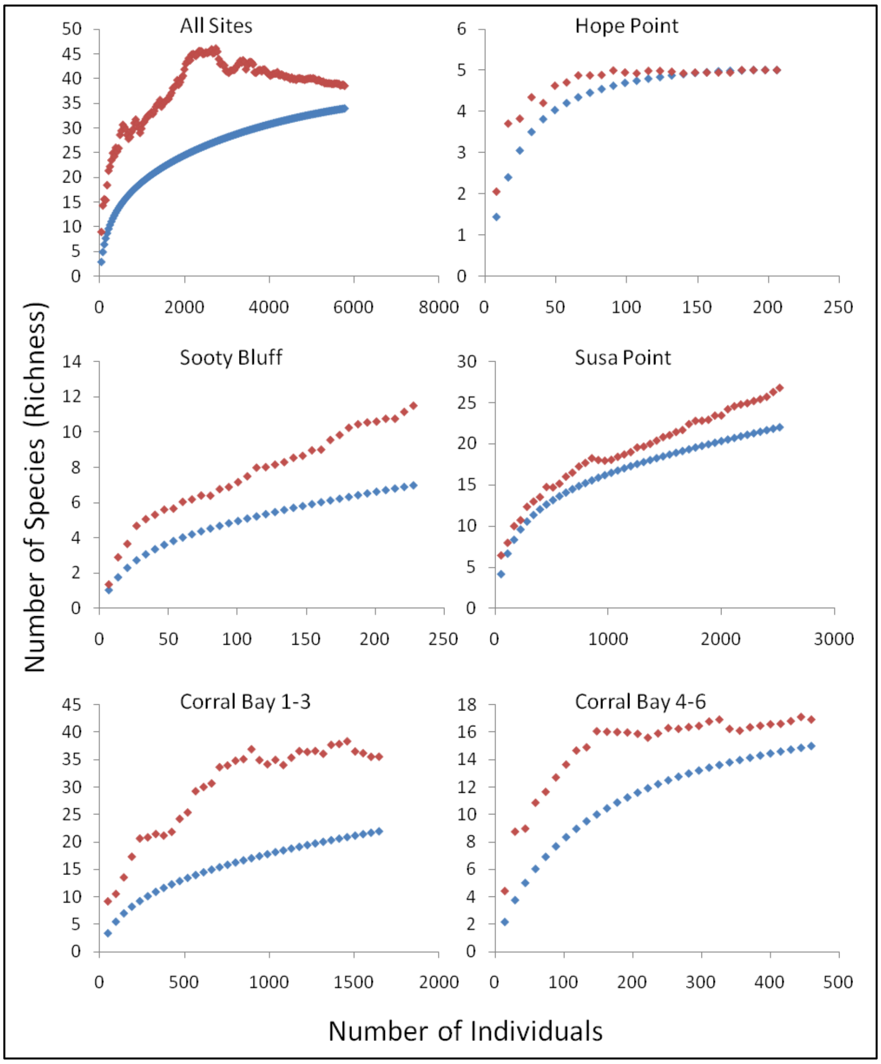


Figure 5. Species accumulation curves for All Sites Pooled, and for individual sites. Shown in each plot is the observed number of species accumulated as number of individuals increase (blue diamonds) and predicted total number of species based on Chao 2 species richness estimator (red diamonds). Note differences in scales between plots. Also note that Maiviken is not shown due to insufficient sampling.

For All Sites Pooled, the observed species richness (number of species) is increasing, where a complete richness estimate would be indicated by a flat curve (i.e. reaching asymptote). This suggests that more sampling is needed across the region for a complete inventory. The predicted number of species (Chao 2 total richness estimator) is showing convergence with the observed, suggesting that the observed number of species is nearing a complete inventory, and may be used as a realistic approximation.

Analysis of species accumulation at each site shows that the total observed and predicted species richness varies widely between sites. However, robust inventories were not achieved at all sites. The only site where a complete species inventory was achieved was at Hope Point, as indicated by flat observed and predicted species richness curves. Here, there are likely to be few species overall, and a complete inventory can be achieved with little sampling effort. In contrast, at the Susa Point, Sooty Bluff, and Corral Bay 1-3 sites, there is little sign of either observed or predicted curves levelling off, suggesting that more sampling is needed for a complete species inventory. This is despite having sampled over 2000 individuals at Susa Pt, for example, giving an indication of the effort that is needed for a complete inventory. The observed and predicted species richness curves for Corral Bay 4-6 show some degree of convergence and levelling off, suggesting a more robust species inventory at this site.

Additions to the current intertidal species inventory

A list of macrofaunal species and putative species found during the present survey can be found in Appendix 1. Once identification of all specimens has been completed, additional species will be added to this list. In particular, the amphipod genus *Paramoera*, and the polychaete family Syllidae have highly cryptic morphological characteristics. Thus, the species list to date can be considered to be a conservative estimate.

Unlike previous work, this study has paid particular attention to the free-living Platyhelminthes, as it was immediately evident from their abundance and distribution that they are likely to be important members of the intertidal community. Furthermore, it is rare among sub-Antarctic studies that this group is examined in detail. Closer taxonomic examination of this group revealed that there are at least eight species that occur in the Cumberland East Bay region, two of which are new to science (Appendix 1), and two are new records for South Georgia. The remainder of species with confirmed identities are thought to be typical of the intertidal fauna reported elsewhere.

Between-Site Comparisons

An examination of between-site species composition can be done using Principal Component Analysis (PCA). This analysis reduces multi-dimensional data (ie multi-variate) to 2-dimensions, such that the main gradients of species distributions can be displayed and analysed more easily. Data were presence/absence transformed prior to analysis, removing effects of patchiness in species' abundance.

Figure 6 shows the first two principal component axes of the reduced multi-variate data. Total variation explained is in the first 2 axes is 41%. This shows that on a "which species is found where" basis, the intertidal species composition at Maiviken is different to the other sites. Of the inner Cumberland East Bay sites, there is a great deal of overlap of species composition between sites, although Susa Point and Sooty Buff show clear separation along the PC1 axis.

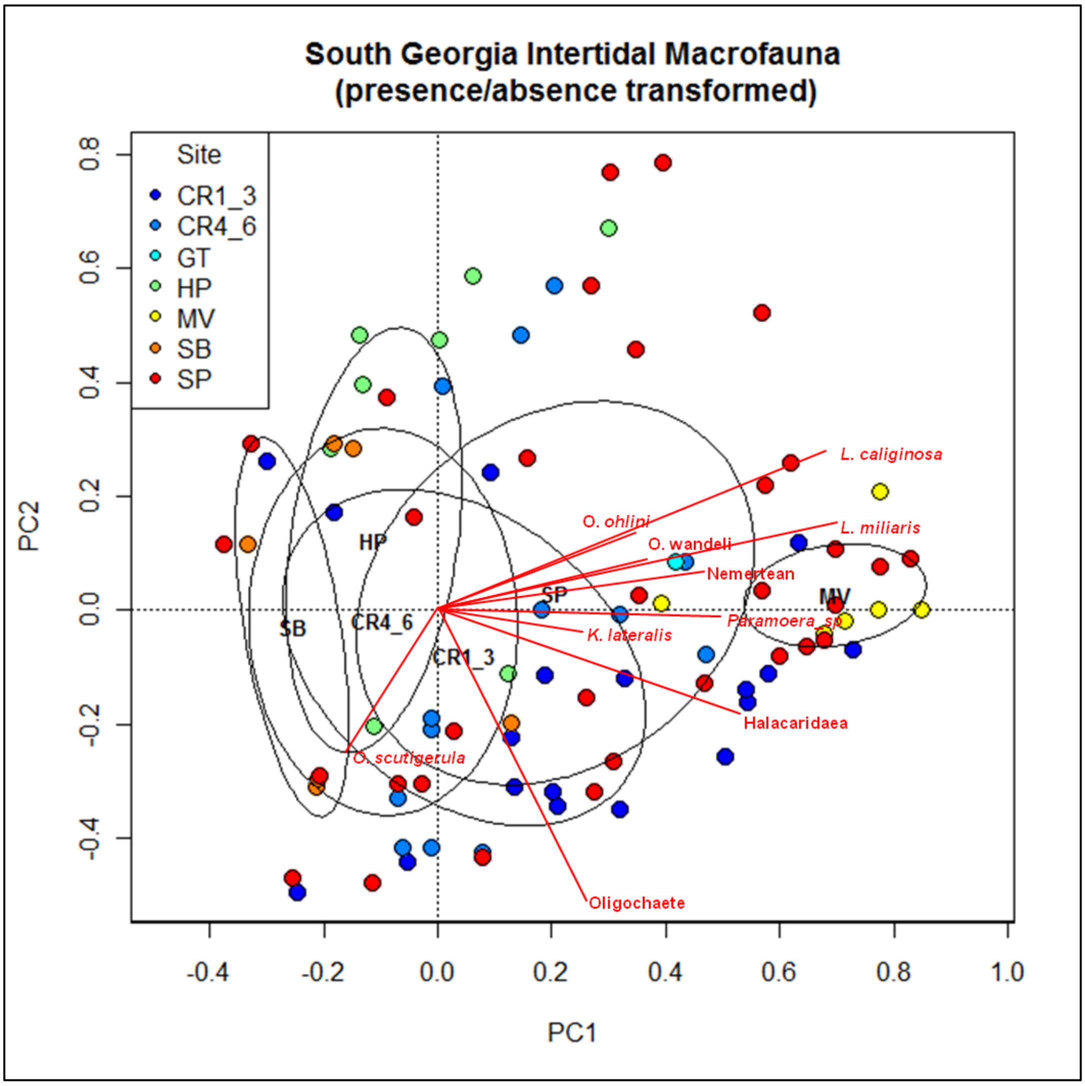


Figure 6. PCA of sample x species matrix, coded for sites. Data has been presence / absence transformed before analysis. Site codes are Corral Bay 1-3 (CR1_3), Corral Bay 4-6 (CR4_6), Grytviken (GT), Hope Pt (HP), Maiviken (MV), Sooty Bluff (SB), Susa Pt (SP). Axes units are arbitrary, where PC1 explains 29% of total variation, and PC2 represents 12% of total variation. Ellipsoids represent the standard error surrounding the mean position of sample distribution of each site. Species vectors shown indicate the main species driving the differences between sites.

Also in this analysis, the species presence or absence driving the differences in site pattern are indicated by species vectors. This analysis shows that the primary species driving the separation of Maiviken from other sites are the amphipod *Paramoera* sp, nemertean worms, the gastropods *Laevilitorina caliginosa* and *Kerguelenella lateralis*, the bivalve *Lissarca miliaris*, and the platyhelminths *Obrimoposthia ohlini* and *O. wandeli*.

As described in the Introduction, intertidal communities are generally structured along a gradient of shore height from low tide. We examine this gradient by re-running the previous PCA analysis, but recoding quadrates for their relative Upper, Mid, or Lower position on the shore (Figure 7). This was done by dividing the distance between low and high tide by three. Dividing the shore into 3rds is somewhat arbitrary, however imposing this structure across all shores means that they will be comparable on a relative basis.

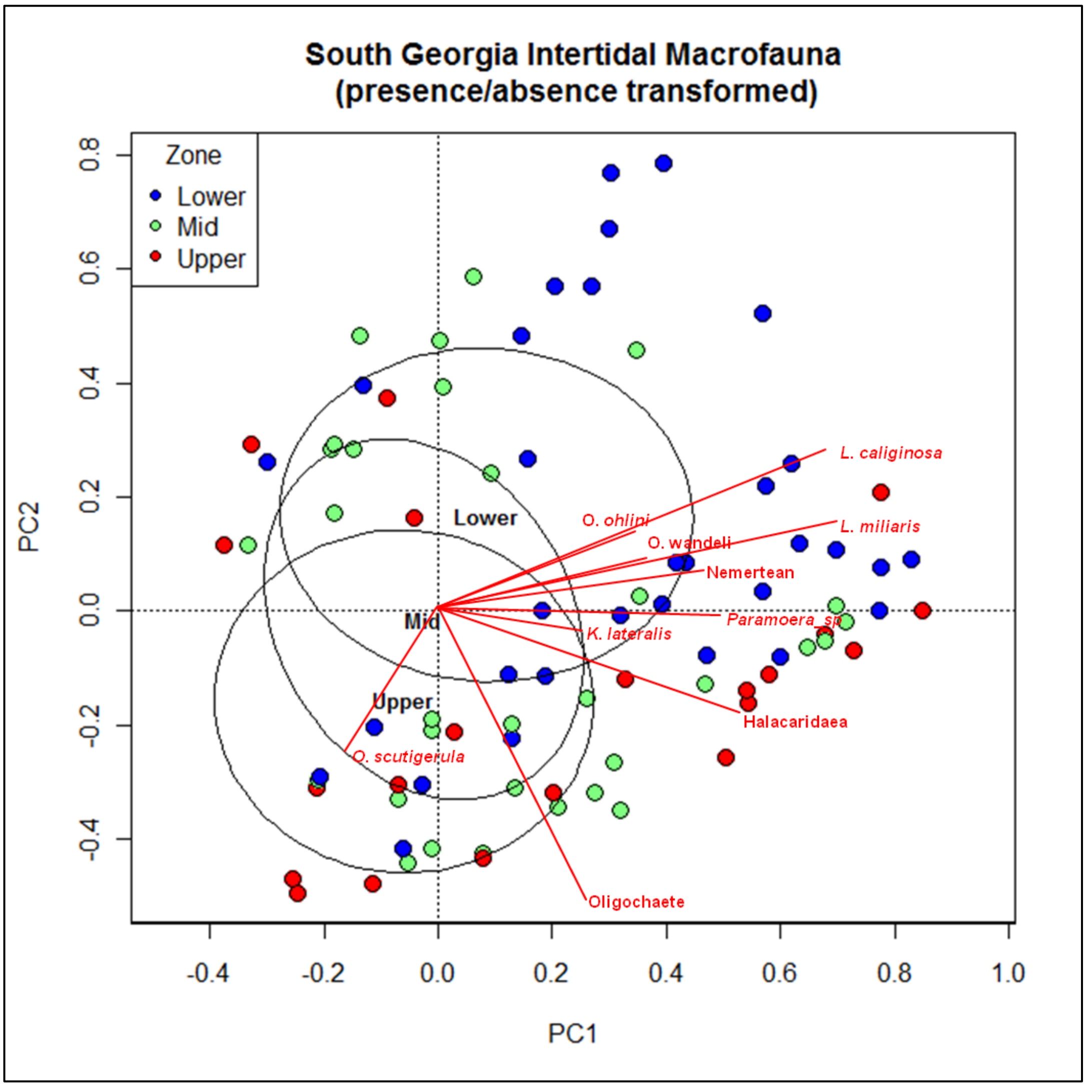


Figure 7. PCA of sample x species matrix, coded for intertidal zone; Lower shore, Mid shore, Upper shore. Data has been presence / absence transformed before analysis. Axes units are arbitrary, where PC1 explains 29% of total variation, and PC2 represents 12% of total variation. Ellipsoids represent the standard error surrounding the mean position of shore height distribution of each site. Species vectors shown indicate the main species driving the differences between shore height species composition.

This analysis confirms that there is generally a gradient of change in species composition from Lower to Upper shore across all sites. This gradient is most evident along the PC2 axis (Figure 7). Species vectors show that the upper shore pattern is driven primarily by the presence of the amphipod *Orchestia scutigerula* and Oligochaetes. The position of the other main pattern driving species suggests that their distribution is spread throughout the intertidal zone.

Site Commentary

Hope Point

Hope Point is a south facing, medium sloping, narrow beach consisting of varied coarse sand to rounded boulder substrates unevenly distributed throughout the shore (Figure 8). Apart from abundant drift, seaweeds are restricted to the low tide level (Figure 9).

Hope Point is characterised by low macrofaunal density and very high levels of patchiness at the between-quadrate, within transect, and between transect spatial scales (Figure 10). Over-all species richness (number of species) was low (S = 5), as was Shannon-Weiner diversity (number of species and their relative abundance) (H' = 1.34). In general, species were comparatively evenly distributed among individuals (ie high Shannon evenness) (J' = 0.83).

Figure 8. Typical scene at Hope Point,, Cumberland East Bay.

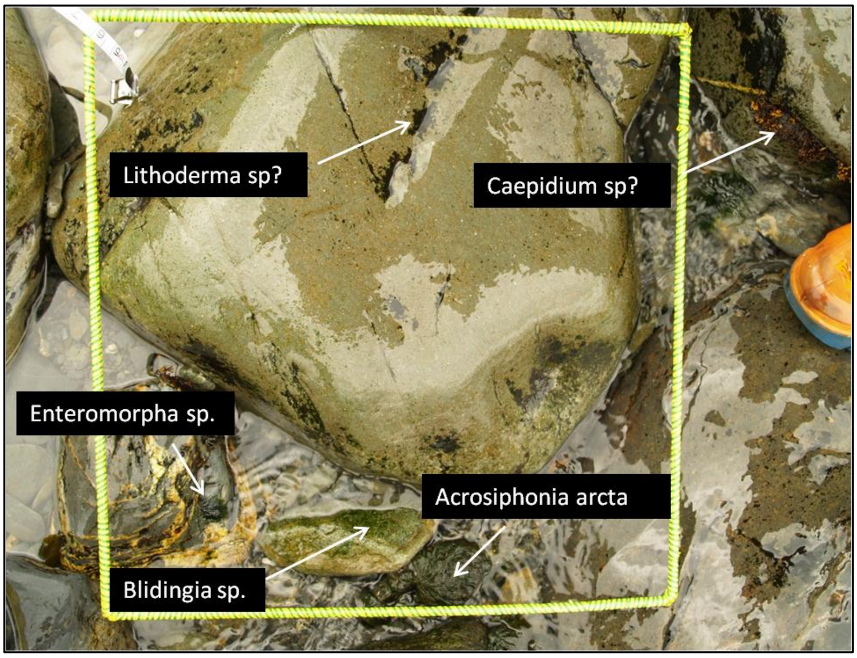


Figure 9 Seaweeds found at Hope Point. Photoquadrate T1-0.0m.

Characteristic macrofauna (% contribution identified by SIMPER tests) include oligochaetes (45%), *Paramoera sp* (27%), and *L. caliginosa* (23%).

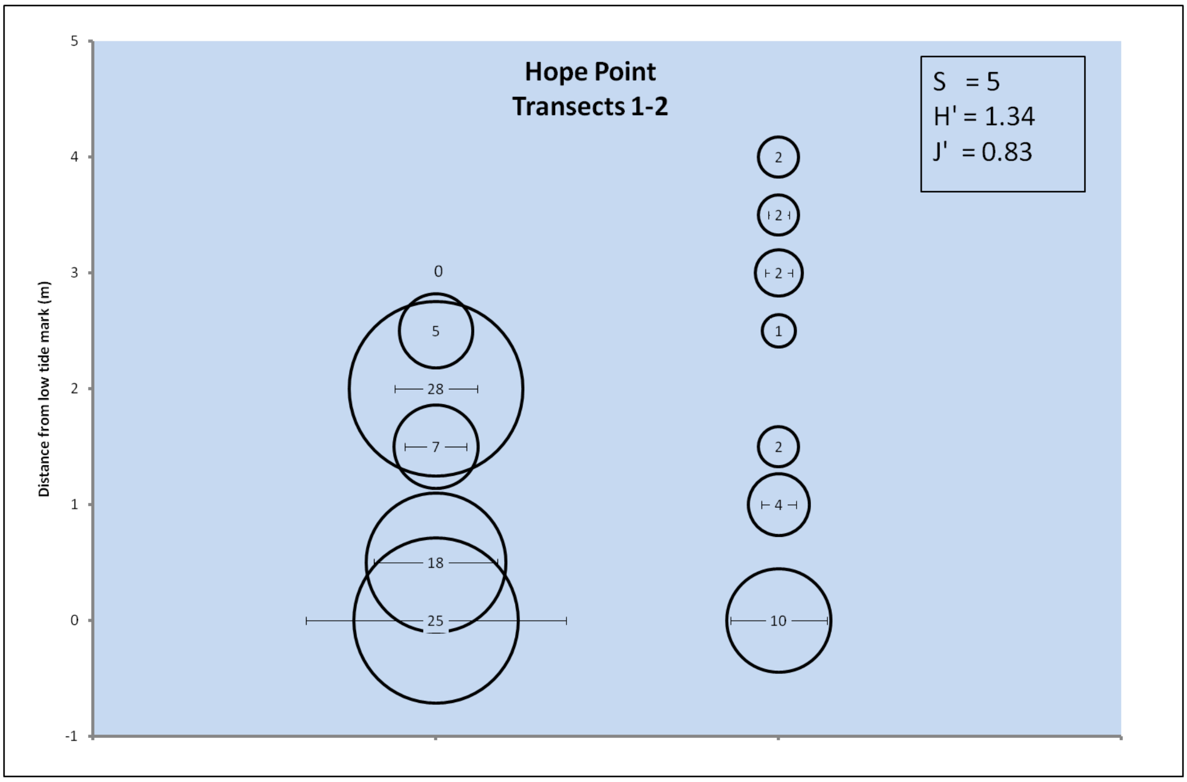


Figure 10. Hope Point. Density of species found in each quadrate. Circle represents mean relative density between levels on the shore. Numbers are actual mean densities of quadrate pairs. Error bars are the standard error of the mean. Over-all S (richness), H' (Shannon-Weiner diversity), and J' (Shannon evenness) are also shown.

Sooty Bluff

Sooty Bluff is characterised by a narrow band of SSE-facing, mildly sloping cobble beach, meeting a steep shingle cliff face (Figure 11). Rock surfaces are smooth, suggesting that this is a high-energy mobile beach. Ten's of meters off shore are large boulders and visible *Macrosystis pyrifera* beds.

Figure 11. Sooty Bluff with numerous fur seals (*Arctocephalus gazelle*)

Algal species and distribution was similar to Hope Point, and drift algae was found throughout the intertidal zone. No rock pools were present, and there was little evidence of encrusting species, also suggesting highly mobile beach substrate.

Species richness was higher at Sooty Bluff compared to neighbouring Hope Point (S = 7). (Figure 12). However, overall Shannon diversity and evenness were lower (H' = 0.83, J' = 0.53), suggesting that most species found here were rare with a few species found in large

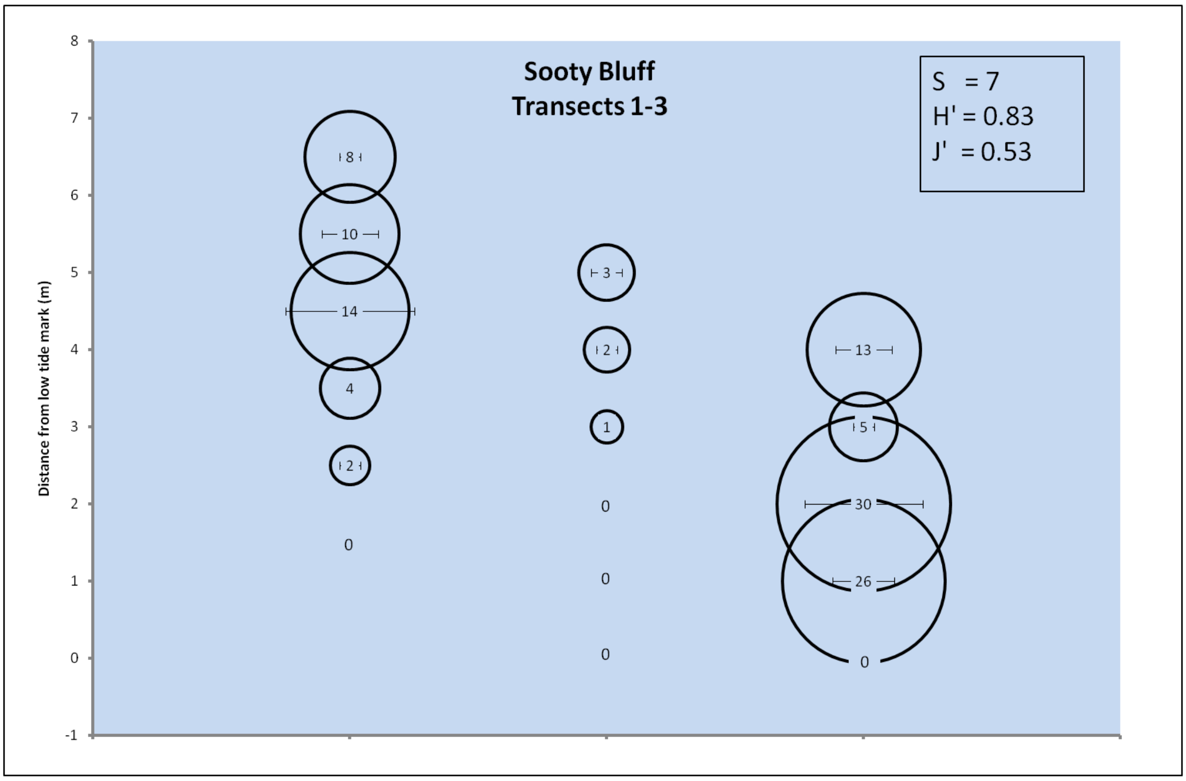


Figure 12. Sooty Bluff. Density of species found in each quadrate. Circles represent mean relative density between levels on the shore. Numbers are actual mean densities of quadrate pairs. Error bars are the standard error of the mean. Over-all S (richness), H' (Shannon-Weiner diversity), and J' (Shannon evenness) are also shown.

numbers. Mean density of individuals was highly patchy at between-quadrate, within transect, and between transect spatial scales. SIMPER identified oligochaetes (76%) and *O. scutigerula* (19%) as being characteristic of this site.

Susa Point

The Susa Pt site is a north facing, wide, moderately sloping shore, with a mixed substrate of sand, cobbles and boulders (Figure 13). Cobbles and boulders are more angular than those at previous sites, suggesting lower energy shore. There are many crevasses and rock-pools that remain wet throughout the tidal cycle offering refuge for dense aggregations of the bivalve *Lissarca miliaris*, the topshell *Laevilitorina caliginosa*, and numerous seaweeds (Figure 14).

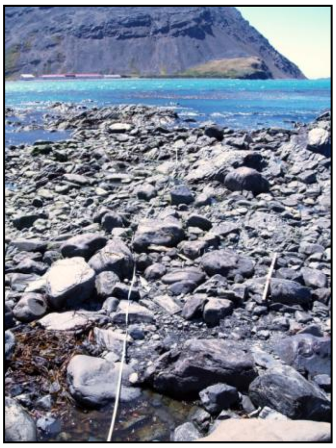
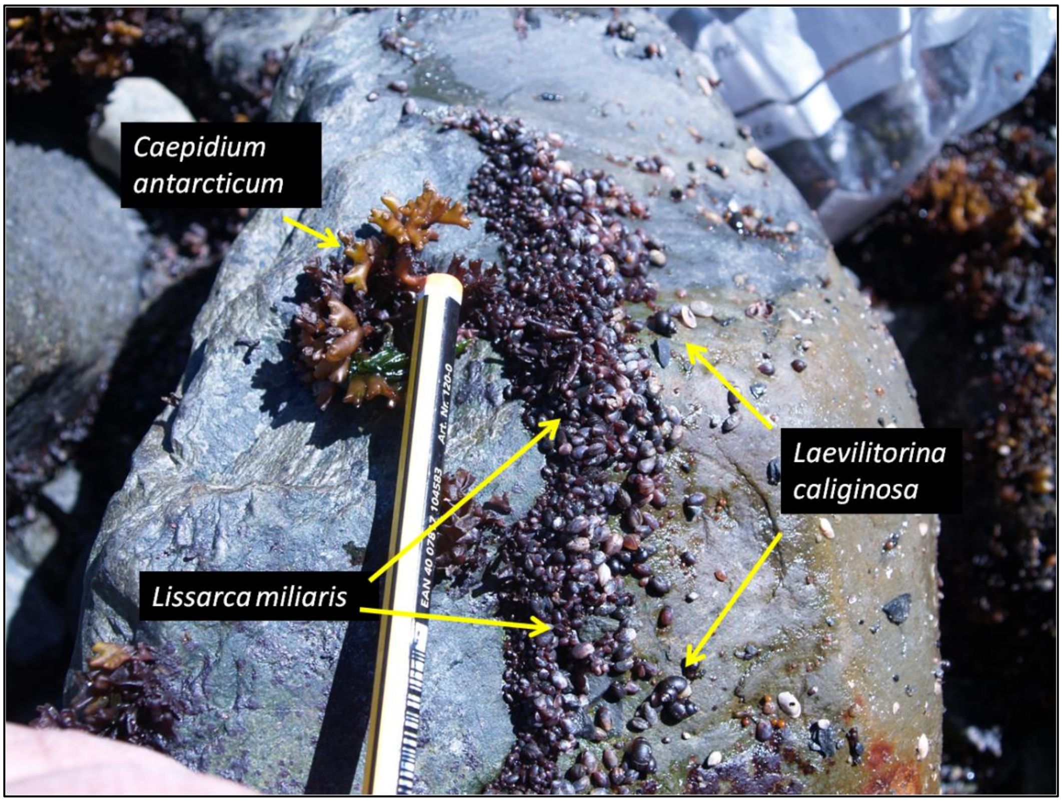


Figure 13. Susa Pt Site, with King Edward Point research station in the background.

A wide variety of algal species were found at Susa Point (Figure 14). Because of the shallow shore slope and frequency of rockpools, seaweeds were generally distributed throughout the intertidal zone.



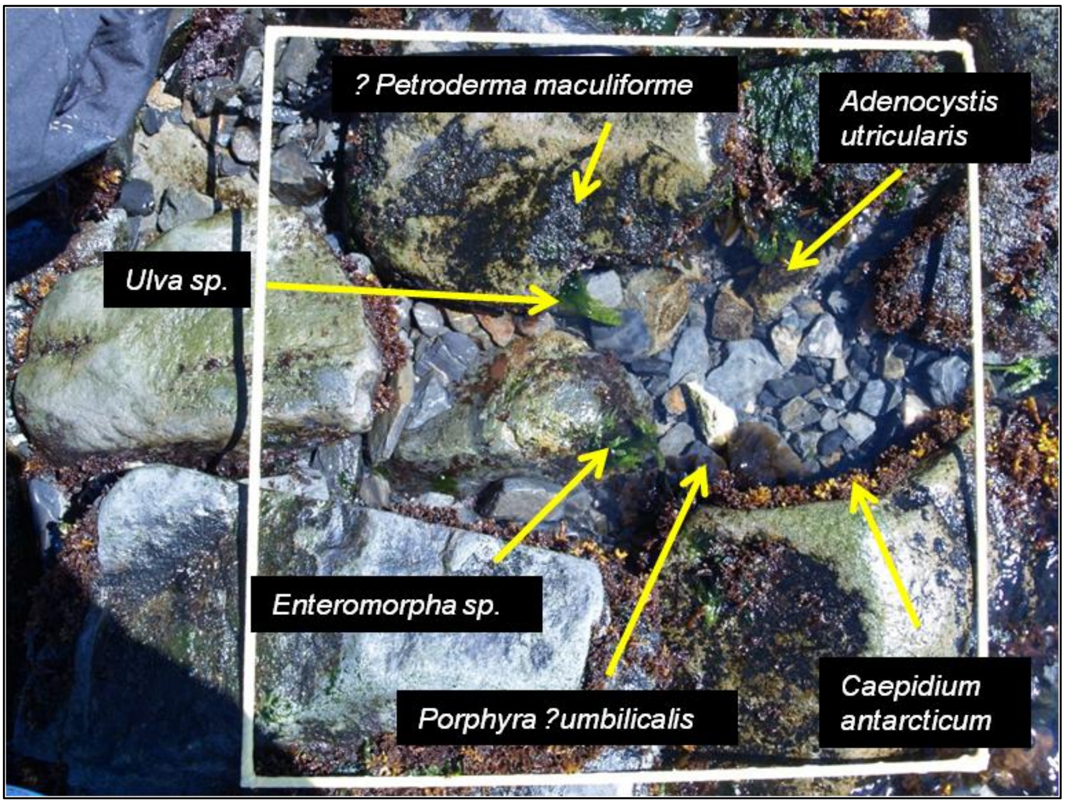


Figure 14. Top -Example of dense clusters of *Lissarca miliaris* and *Laevilitorina calignosa* under rock at Susa Point (Transect 1, approx 4m up shore). Bottom - Rock pool at Susa Point (photo-quadrate T01-0.0m)

Total density was very high at Susa Point, and also very patchy across all spatial scales measured. Exceptionally high patchiness was found particularly in the lower shore due to dense aggregations of mollusc as reported above. Community richness and Shannon diversity were relatively high (S = 22, H' = 1.49). However, evenness was very low (J' = 0.48), suggesting most species are rare with only a few species contributing to overall density of individuals (Figure 15).

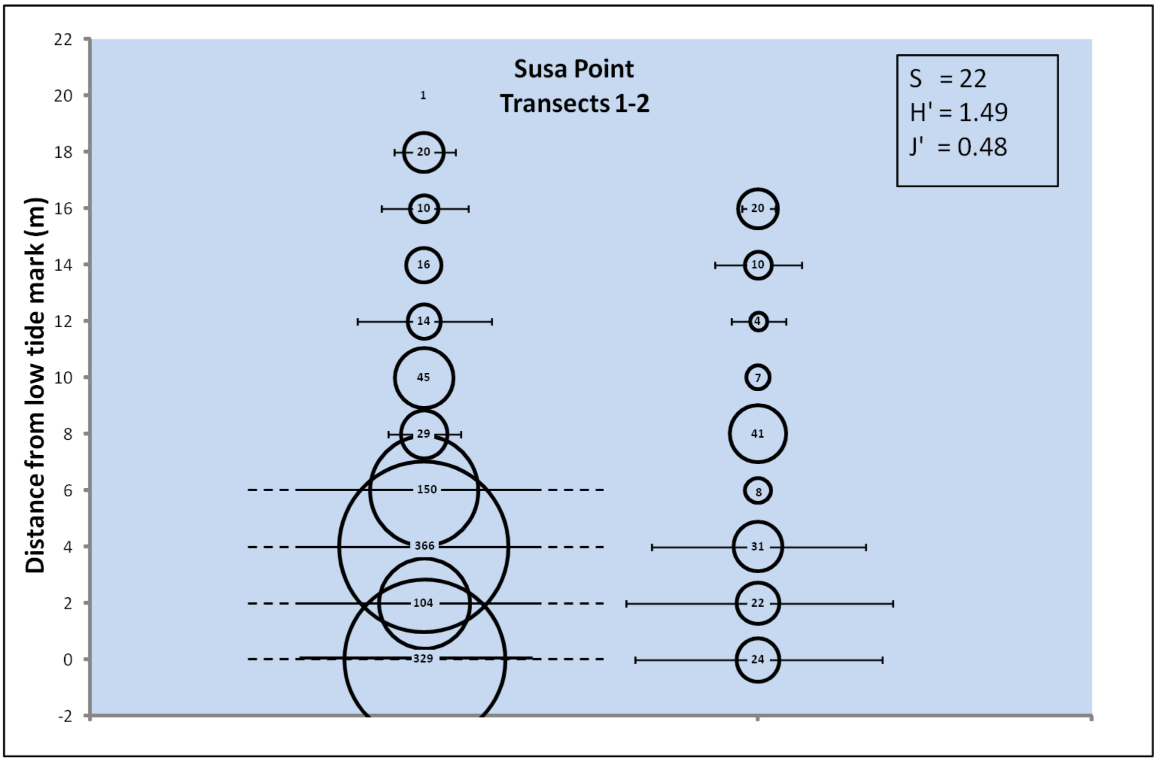


Figure 15. Susa Point. Density of species found in each quadrate. Circles represent mean relative density between levels on the shore. Numbers are actual mean densities of quadrate pairs. Error bars are the standard error of the mean. Dashed error bars indicate that they extend beyond the scale of the plot. Overall S (richness), H' (Shannon-Weiner diversity), and J' (Shannon evenness) are also shown.

Of the 22 macrofaunal species recorded, six were determined to be characteristic by SIMPER; *Paramoera sp* (33%), oligochaetes (27%), *Lissarca miliaris* (9%), *Obrimoposthia ohlini* (7%), Halacaridae (7%), and *Laevilitorina caliginosa* (7%)

Corral Bay

Two sites were chosen at Corral Bay on the eastern side of Cumberland East Bay. They are approximately west facing, with steep bedrock promontories bounded on either side by medium sloping cobble/boulder beaches. The upper shore is bordered by low-lying terrain of dense tussock with two streams in the immediate vicinity (Figure 16).

Corral1-3 was characterised by bedrock, crevasses, and rock pools that remained flooded throughout the tidal cycle. The lower shore was a steep rock face rising to a rocky platform within the first meter (Figure 17). Here strong zonation could be seen, particularly among

Figure 16. Left - Shoreline at Corral Bay1-3, facing south with Nordenskjöld Glacier in background. Right - Corral Bay4-6 showing multiple beach users.

the algal assemblage. Algal diversity decreased further up the shore, with rock pools containing primarily *Enteromorpha sp.* with patches of *Porphyra sp.*, *Caepidium sp.* and *Blidingia*

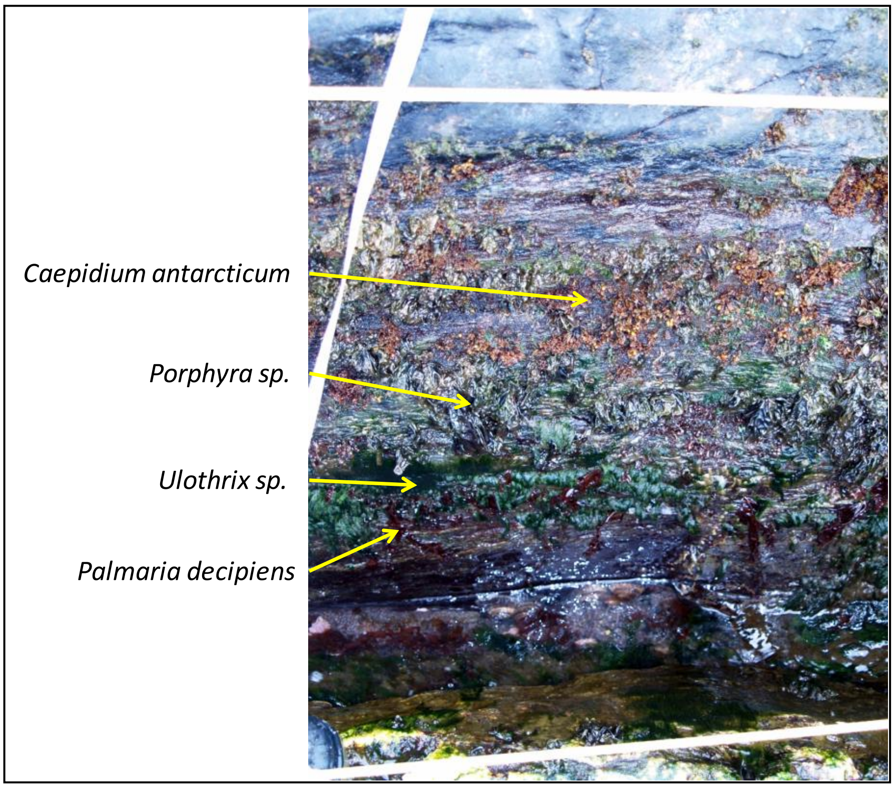


Figure 17. Example of zonation of algal assemblage on vertical rock surface. Corral1-3, 2m.

Overall species richness at this site was high (S = 23), as was Shannon diversity (H' = 1.61) compared to other sites (Figure 18). However, overall evenness was low (J' = 0.51) suggesting that similar to other sites, there are a few species that are numerically dominant at this site, with most species relatively rare. Also, similar to other sites, high spatial heterogeneity in density at the scales of meters to 10s of meters, both horizontally along shore vertically throughout the intertidal zone was observed.

Characteristic species identified using SIMPER at this site include the Halacaridae (43%), oligochaetes (32%), *Lissarca miliaris* (11%), and *Kerguelenella lateralis* (3%).

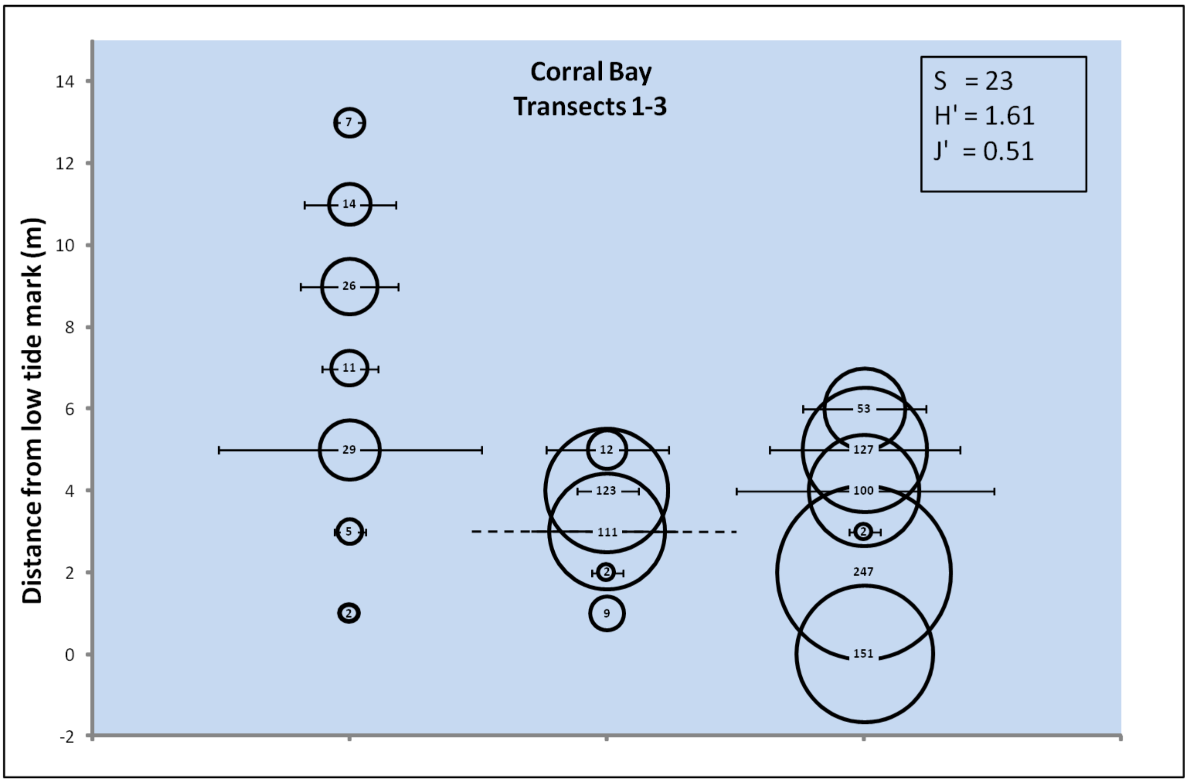


Figure 18. Corral1-3. Density of species found in each quadrate. Circles represent mean relative density between levels on the shore. Numbers are actual mean densities of quadrate pairs. Error bars are the standard error of the mean. Dashed error bars indicates that they extend beyond the scale of the plot. Over-all S (richness), H' (Shannon-Weiner diversity), and J' (Shannon evenness) are also shown.

The Corral4-6 site is mildly sloping, with an even distribution of cobble/boulders and bedrock throughout the shore. Seaweed species composition and distribution was less varied compared to Corral1-3, consisting mainly of *Caepidium sp. Ulothrix sp,* and *Blidingia sp.* on the lower shores, and *Enteromorpha sp. Blidingia sp.* on the mid and upper shore.

Although overall species richness was lower here compared to Corral1-3 (S = 15), diversity and evenness were higher (H' = 1.94, J' = 0.71) (Figure 19). This suggests that species showed less overall dominance in numbers of individuals, and that most species were found with similar levels of abundance.

Overall species density was lower at Corral Bay4-6, as was the variability observed between quadrate pairs, within transects, and between transects compared to other sites surveyed (Figure 19). SIMPER analysis identified oligochaetes (60%), *Paramoera sp*. (21%), *Lissarca miliaris* (5%), and *Orchestia scutigerula* (4%) as characteristic of this site.

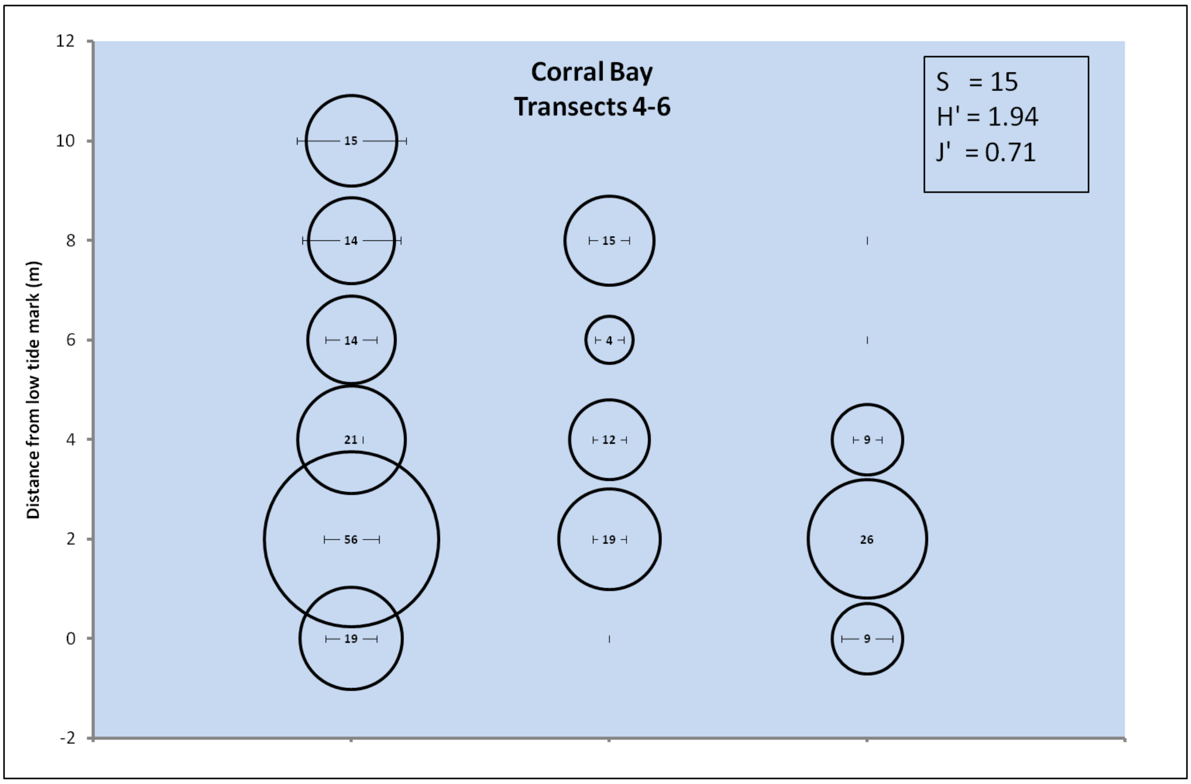


Figure 19 Corral4-6. Density of species found in each quadrate. Circles represent mean relative density between levels on the shore. Numbers are actual mean densities of quadrate pairs. Error bars are the standard error of the mean. Over-all S (richness), H' (Shannon-Weiner diversity), and J' (Shannon evenness) are also shown.

Maiviken

The Maiviken site was heavily populated with fur seals, and as a result a full quantitative survey was not possible. General collections were made at approximately low, mid and upper shore heights. This site was located on a rocky headland exposed to the open coast. It consisted of deeply crevassed bedrock, with intermittent channels of deep water leading into the beach, and deep rock pools throughout the mid and upper shore (Figure 20). Also unlike other sites, Maiviken is likely to be heavily impacted by iceberg fragments (Figure 21).

Figure 20. Maiviken upper shore rock pool.

The lower shore seaweeds found at Maiviken were similar to the rockpool assemblages observed, consisting of foliose reds, *Ulva* sp, and *Enteromorpha* sp. There was a conspicuous band of the lichen *Caloplaca marina* in the splash zone (above high tide), typical of open coasts.

We collected 978 individuals among the two collection sites, consisting of 17 taxa. Other diversity statistics are not likely to be meaningful given the unstructured sampling at this site. Species found here were similar to those found elsewhere. However, interesting faunal elements were collected that were not found elsewhere, such as the limpet *Nacella sp*. and spirorbid polychaetes (229 in total were counted in the lower, mid and upper shores).

Figure 21. Area of general collections at Maiviken. In the foreground are iceberg fragments and growlers, and the open coast (Cumberland West Bay) in the background.

Platyhelminthes composition

We draw particular attention to the free- living Platyhelminthes of South Georgia's intertidal assemblages. At least eight species were recorded in the intertidal zone. Of these *Obrimoposthia ohlini* and *Monocelis sp* are new records for South Georgia, two are new to science (*Allogenus n. sp., Macrostomum n. sp.*), and *Macrostomum n. sp.* represents a new

Order (Macrostomida) recorded in South Georgia. Taxonomic investigation is ongoing. Observed colour variations in Tricladida and Monocelididae may be resolved as two additional species, and the Otoplanidae and Typhloplanoida may either be new species or new records for South Georgia.

This collection represents approximately 1/3 of the previously reported species for all of South Georgia's intertidal and subtidal marine habitats. Of the 28 species previously reported 18 are subtidal and 4 intertidal; the remaining 6 are of unknown subtidal or intertidal origin. The four previously reported intertidal species are *O. wandeli* (also found in the present study), *Orthoplana bregazzii, Synsiphonium anderssoni* and *Leptoteredra maculata* (not found in the present study). Therefore, results from this work increase the number of intertidal species from 4 to 12-14. Putting this in a regional context, in the Magellan Strait area, Tierra del Fuego and King George Island (South Shetlands) there are approximately 10 microturbellarian species per each macroturbellarian species (See Table 2 for grouping). If this ratio holds true for South Georgia, then we might expect to find at least 40 species in the intertidal zone alone. In terms of their biogeography, it is thought that microturbellarians should not be able to disperse long distances because they do not have planktonic larvae, and adults are not adapted to planktonic life. This makes the Typhloplanid found in the present study particularly interesting as the same species has been found at King George Island, thereby connecting both islands biogeographically across the region.

Table 2 shows the list of free-living platyhelminthes species found, and their frequency and distribution along the shore, pooled among sites. Ecologically, the assemblage reflects a strong freshwater influence. The occurrence of microturbellarians in the mid- and upper shore is unusual, but may be reflective of upper shore algal distributions, and/or that they were not well detected by our methods in the lower shore. Furthermore, interesting yet presently unexplained morphological variations were observed in South Georgia species compared to those found in Magellanica, the Scotia Arc and Antarctica, and this may be related to ecological characteristics unique to South Georgia.

Table 2. Free-living Platyhelminthes in Cumberland East Bay. Data are pooled across sites and position on shore.

Group	Species		Shore Height	
		Lower shore	Mid shore	Upper shore
Macroturbellaria	*Obrimoposthia ohlini*	40	29	7
Macroturbellaria	*Obrimoposthia wandeli*	48	8	4
Microturbellaria	*Monocelis sp*	1	12	5
Macroturbellaria	unid Tricaldida	23	2	
Microturbellaria	Otoplanidae		4	
Microturbellaria	*Macrostomum n. sp.*		4	2
Microturbellaria	Typhloplanoida		2	
Macroturbellaria	*Allogenus n. sp.*			1

Recommendations

We report the first quantitative baseline study of the intertidal macrofaunal assemblages of Cumberland East Bay. This study, including all archived samples and photographs, will benefit future marine scientific and monitoring programs in the Cumberland East Bay region, South Georgia, and the South Atlantic region. All data will be added to web-accessible biodiversity databases such as SCAR-MarBin. In addition, this work will be published across a number of peer-reviewed publications. The Convention on Biological Diversity (Article 7) suggests that identifying and monitoring vulnerabilities to biodiversity are key first steps in reducing biodiversity loss; this study will help achieve these goals in South Georgia.

Among the macrofaunal assemblages, we show strong between-site variability in species composition and abundance across small (e.g. between neighbouring Hope Point and Sooty Bluff), medium (eastern vs western shores of Cumberland East Bay), and large spatial scales (eg Corral Bay vs Maiviken). Within sites, there is strong variation in assemblage composition between transects (scales of 10s of meters), and at scales between replicate quadrates (scales of less than 1m). The intertidal zone is structured at all sites, although this structure also varies between sites.

Further elucidation of these patterns can be achieved through the analysis of photo-quadrates, which is in progress. This analysis will relate such factors as substrate variability (gravel, cobble, bedrock) with species occurrence and abundance. A closer examination of algal species composition and distribution is also in progress. Seaweeds provide both critical substrate (e.g. *Lissarca miliaris*) and cover (e.g. amphipods, Platyhelminthes) for survival in extreme habitats. Ongoing analysis of seaweed distribution and abundance will facilitate additional habitat monitoring tools and additional factors for deeper ecological investigation.

Future monitoring strategies should incorporate sites surveyed here. A primary objective should be to achieve a better estimate of species richness across all communities by extending the spatial extent of sampling at each site. Additionally, interstitial meiofauna (species smaller than 0.05mm) should be examined, completing the free-living Platyhelminthes fauna. Although good richness estimates were achieved in some sites (e.g. Hope Point, Corral Bay4-6), our effort at other sites was inadequate for providing good richness estimates, despite multiple transects, quadrates and thousands of individuals collected (e.g. Susa Point). This study provides a guide for additional effort that is required for a complete species inventory.

Further research targeted on the biodiversity and ecology of free-living Platyhelminthes in South Georgia is to be encouraged. This group is a good ecological indicator of contemporary habitat type, and may be very useful as a tool for future ecological monitoring.

Critically, this study represents only a snap-shot of ecological pattern; it is strongly recommended that the next phase of discovery in the intertidal zone focuses on gaining a better understanding of seasonal patterns. Strong seasonality is typical in sub-Antarctic regions (Peck et al 2006). Potential drivers of seasonality in South Georgia's intertidal faunal and floral assemblages include physical factors (eg ice, freshwater, sunlight/shadow, presence of marine mammals and birds), and biological factors (reproductive cycles, trophic interactions). Without better understanding of seasonal factors, any detected ecological change in future could be confounded. The Shallow Marine Surveys Group have plans to carry out a second follow-up dive expedition in South Georgia in April 2012, and we propose that a second intertidal survey be carried out at that time.

Who is monitoring whom?

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Appendix I - Species occurrence

		Site						
Group	Species	Sooty Bluff	Hope Pt	Grytviken	Susa Pt	Corral Bay 1-3	Corral Bay 4-6	Maiviken
Platyhelminthes								
	Obrimoposthia ohlini		+	+	+	+	+	+
	Obrimoposthia wandeli				+	+	+	+
	unid Tricladida				+			+
	Otoplanidae						+	
	Monocelis sp				+	+		+
	Typhloplanoida				+	+		
	Macrostomum n. sp.				+	+		
	Allogenus n. sp.					+		
Nemertea								
	?Parborlasia corrugatus				+	+	+	+
Polychaeta								
	unid polychaete 1				+		+	
	Capitellidae	+			+	+		+
	Phyllodocidae	+			+	+		
	Syllidae 01				+	+		+
	Syllidae 02				+			
	Syllidae 03							+
	Cirratulidae							+
Oligochaeta								
	unid oligochaete	+	+	+	+	+	+	+
Insecta								
	Springtails					+		
Amphipoda								
	Paramoera sp	+	+	+	+	+	+	+
	Paramoera. ?gregaria						+	
	Paramoera. aff. brachyura						+	
	Gondogeneia sp					+		
	Orchestia scutigerula	+			+	+	+	
	Metaleptamphopus pectinatus				+	+		
	unid amphipod 01	+					+	
	unid amphipod 02				+			
Oribatida								
	Halacaridae				+	+	+	+
Bivalvia								
	Lissarca miliaris	+	+	+	+	+	+	+
	Gaimardia sp					+	+	
	bivalve 7				+			
	Philobrya_sp					+		
Gastropoda								
	Laevilitorina caliginosa		+	+	+	+	+	+
	Kerguelenella lateralis				+	+		+
	Nacella sp							+

Appendix II - Trip log

28 Nov 2010	1800hrs P Brewin arrives at King Edward Point. Meet with Alley Massey (outgoing KEP crew, volunteer).
29 Nov 2010	0830hrs KEP orientation, planning etc. with base commander. Set up lab space.
30 Nov 2010	0800hrs 2 transects at Hope Point.
	2000hrs General collection along Grytviken Rd.
01 Dec 2010	0900hrs 3 transects at Sooty Bluff. 2000hrs Present video+photo montage to KEP crew.
02 Dec 2010	0900hrs Walk to Discovery Point. Cut short as held up negotiating through fur seals. Survey Susa Pt - 2 transects.
03 Dec 2010	0900hrs Walk to Maiviken. Beach and rocky points heavily populated with fur seals. Transects impossible. Carry out general collections from 2 sites at high, mid and low intertidal areas.
04 Dec 2010	Saturday - base crew day off. Outgoing crew packing.
05 Dec 2010	Weekend. Heavy snow. Planning for trip to Corral Bay.
06 Dec 2010	0900 hrs Depart KEP for Corral Bay (Barff Peninsula) by boat. 3 transects completed. Camp overnight.
07 Dec 2010	Corral Bay, 3 transects completed. Return to KEP.
08 Dec 2010	Post-trip gear breakdown and clean. Process previous 2 days collections.
09 Dec 2010	Late tide. Conflict with Brewin's rostered domestic duties on Base.
10 Dec 2010	Snowing heavily.
11 Dec 2010	Low pressure, low tide is very high. Pack up, ready for possible departure on 12th.
12 Dec 2010	Depart KEP for Stanley. Expedition complete.