Exxon Valdex Oil Spill
Gulf Ecosystem Monitoring and Research Project Final Report

Alaska Natural Geography In Shore Areas: An Initial Field Project for the Census of Marine Life

Gulf Ecosystem Monitoring and Research Project 040666
Final Report

Brenda Konar
Katrin Iken

School of Fisheries and Ocean Sciences
University of Alaska Fairbanks
213 O'Neill Building
University of Alaska Fairbanks
Fairbanks, Alaska 997775

For:

Alaska Department of Fish and Game
Habitat and Restoration Division
333 Raspberry Road
Anchorage, Alaska 99518

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Study History: Project 040666 originated from a need to establish a biological inventory of intertidal and shallow subtidal communities for future monitoring purposes in the Gulf of Alaska. This project was funded continually by the Gulf Ecosystem Monitoring Program from 1 January 2003 through 30 June 2005. While the project was initially recommended by the Trustee Council for two years of funding, the second year of funding was only continued after a new proposal was submitted following the first year due to the annual funding cycle of the GEM program at that time. The primary objective of the proposal did not change for the second year, except that more detailed objectives were targeted. The second year funding ended on 31 December 2004. A contingency proposal was approved by the EVOS TC in February 2005 for additional funding until 30 June 2005. The much higher species richness in the samples required more processing time than previously anticipated. The goal of the contingency proposal was the completion of the initial objective.

Quarterly reports were submitted in a timely fashion throughout the funding period. An annual report was submitted at the end of the first project year. Presentations about the project were given at various meetings, including the annual science meetings in Anchorage (2004 and 2005), Alaska Forum on the Environment in Anchorage (2004), international NaGISA Steering Group meetings (2003 and 2004), Western Society of Naturalists meeting in Monterey, CA (2002 and 2003), Arctic Biodiversity Workshop in Fairbanks (2003), the Northwest Algal Symposium in Canada (2003), and various community and school groups. The results of this project are intended to be published in peer-reviewed journals soon. This final report covers the objectives and results of the entire 2.5 year duration of the project.

Abstract: This project established a biological inventory of intertidal and shallow subtidal communities for future monitoring purposes in the Gulf of Alaska. Cores areas and years surveyed included Prince William Sound, Kachemak Bay, and Kodiak Island in 2003 and 2004. The data from these surveys are part of a pole-to-pole latitudinal biodiversity gradient of macroalgal rocky bottom communities, which is applying standardized protocols developed under the Census of Marine Life program. When the Ocean Biogeographic Information System database that is being produced for the International Natural Geography In Shore Areas Project is fully operational, these data will be added to this database for public access. The specific outcomes of this project include biodiversity species lists for each site and core area and various biodiversity analyses. A total of 242 invertebrate species/higher taxa groups and 237 macroalgal species/higher taxa groups were counted and/or weighed. Analyses of invertebrate and macroalgal groups showed that each core area and depth strata had unique descriptive genera/groups, however annual differences were not noted. Analyses also showed that intertidal communities differ in composition, biomass, and diversity than subtidal communities. Also, intertidal communities can not be used as an indicator for subtidal communities. These datasets are informative and should be used for current regional and global comparisons and future long-term monitoring programs.

Key Words: Biodiversity, Nearshore Communities, Rocky Intertidal, Shallow Subtidal, Invertebrates, Macroalgae, Alaska, NaGISA, Census of Marine Life

Project Data: *Description of data* – The sampling design and resulting dataset is hierarchically structured. Data are first grouped by three core areas: Prince William Sound, Kachemak Bay, and Kodiak Island and then by replicate sites within each core area. Generally, within each site the following data were collected for five replicates along the high, mid, and low intertidal and for 1, 5, 10, and 15 m (when available) water depths:

a. Abundance and biomass of invertebrates within larger taxonomic groups from a 25 x 25 cm area (2003)
b. Species richness (sometimes at genus or family level), abundance, and biomass for mollusks and polychaetes (2003).
c. Species richness (sometimes by genus) and biomass of macroalgae within a 50 x 50 cm area (2003 and 2004).
d. Percent cover estimates of sessile organisms and counts for kelp stipes within a 1x1 m area (2003 and 2004).

For each site, the following environmental parameters were collected at the day of sampling: light in air at surface, in water directly below the surface, and at 1m, 5m, 10m, and 15m water depths. Salinity was measured at each site for surface water, but equipment failure during some field trips prevented the collection of complete datasets for all sites. Temperature data were collected using continuous data loggers. Measurements were taken hourly at each site at each stratum, but only few data loggers were retrieved so that incomplete datasets are available for temperature.

Format – Data are available in the format of Excel tables.

Custodian – Currently, data are in the process of being submitted into the Ocean Biogeography Information System (OBIS) database for permanent storage, which will allow for public accessibility of data (www.iobis.com). General queries are not access limited and distribution information for species can be obtained freely. For other access, contact Brenda Konar or Katrin Iken, School of Fisheries and Ocean Sciences, 214 O'Neill Bldg, University of Alaska Fairbanks, Fairbanks, Alaska 99709

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Executive Summary: The main objective of this project was to provide biodiversity data according to a standardized sampling protocol to serve as local baseline data for biodiversity comparisons and monitoring purposes and as part of a large-scale longitudinal biodiversity gradient. We expanded on this original objective in year two of our proposal to include: 1) comparison of biodiversity on local, regional, and larger (global) geographical scales, 2) examination of temporal variability of biodiversity in the Gulf of Alaska, 3) relating biological diversity to ambient environmental parameters, and 4) increasing capacity building through local community involvement in sampling efforts.

To accomplish our objectives, biodiversity in intertidal and subtidal large macrophyte communities were sampled in the cores area of Prince William Sound, Kachemak Bay, and Kodiak Island using the standardized Natural Geography In Shore Areas (NaGISA) sampling protocols developed under the Census of Marine Life (CoML) program. These protocols include visual estimates of abundance and percent cover in larger sampling plots ($1m^2$) as well as exact counts and weight measurements of all organisms in smaller plots ($25m^2$ for macroalgae and $0.0625m^2$ for invertebrates). Samples obtained in 2003 and 2004 were sorted to species or larger taxonomic group and the more abundant taxa were identified to species. Species identifications of the 2003 samples are available for polychaetes, mollusks, and macroalgae. Species identifications of the 2004 samples are available for macroalgae.

Within each of the core areas, three sites for large macroalgal communities and one site with a seagrass community were sampled. This final report focuses on the macroalgal communities. Most sites were sampled both in 2003 and 2004 for temporal resolution of macroalgal community structure and biodiversity. Some sites in Kodiak and Kachemak Bay were changed after the first year for a more representative cover of the area or to better include local communities in the sampling program (e.g., inclusion of a sampling site in Port Graham, Kachemak Bay).

A total of 242 invertebrate species/higher taxa groups and 237 macroalgal species/higher taxa groups were counted and/or weighed from a combination of the 2003 and 2004 collections. Analyses of invertebrate and macroalgal groups showed that each core area and depth strata were different and had unique descriptive genera/groups, however annual differences were not noted. Analyses also showed that intertidal communities differed in composition and biomass from subtidal communities. Typically, more species were needed to describe intertidal communities as they were more variable than subtidal communities. Similarly, intertidal communities were more different between sites and core areas than the subtidal communities. It was also found that intertidal communities cannot be used as an indicator for subtidal communities. These datasets are informative and should be used for current regional and global comparisons and future long-term monitoring programs.

Introduction: One of the main goals of the GEM Program is to "sustain a healthy and biologically diverse marine ecosystem in the northern Gulf of Alaska (GoA) and the human use of the marine resources in that ecosystem through greater understanding of how its productivity is influenced by natural changes and human activities". In establishing the GEM Program, the Trustee Council explicitly recognized that complete recovery from the *Exxon Valdez* oil spill may take decades. Full restoration of injured resources will most likely be achieved through long-term observation and, as needed, restoration actions. The Council further recognized that conservation and improved management of injured resources and services will require substantial ongoing investment to improve understanding of the marine and coastal ecosystem that support the resources, as well as the people, of the spill region. In addition, prudent use of the natural resources of the spill area without compromising their health and recovery requires increased knowledge of critical ecological information about the northern GoA. This information can only be provided through ecosystem-oriented research and long-term monitoring.

One of the habitat types particularly severely affected by the spill was the nearshore system, including the intertidal and shallow subtidal region. Assessment of injury within this habitat after the spill was hampered because little information was available about species occurrence and community structure from the time before the spill. This also impeded recovery assessments as little was known about what the "natural" status of the habitat had been. In addition, little was known about the natural variability of the GoA system over seasonal, annual, and decadal time spans. The EVOS Trustee Council recognized that improved ecosystem understanding and the initiation of long-term monitoring had to start with a thorough assessment of the biodiversity and community structure. This agrees with other studies that have shown the need for nearshore biodiversity studies on large spatial scales for the intent of conservation and establishment of Marine Protected Areas (Shaffer et al. 2002, Ten Kate 2002, Eiswerth & Haney 2001, Cabeza & Moilanen 2001, Zacharias & Roff 2000, Vanderklift et al. 1998, Costello 1998, Waugh 1996, Norse 19954).

In general, the ecological and economical consequences of marine biodiversity, and the potential loss of it, have recently initiated an increasing number of studies trying to identify the importance of biodiversity for ecosystem functioning (Loreau et al. 2001, Pachepsky et al. 2001, Cardinale et al. 2002, Pfisterer & Schmid 2002). Biodiversity is one potential measure of ecosystem health, though criteria are not always clear; high biodiversity may not necessarily represent the natural state of an ecosystem. But biodiversity can definitely be a measure of biological interactions such as competition, disturbance, facilitation, predation, recruitment, and productivity of a system (Petraitis et al. 1989, Bourget et al. 1994, Elis et al. 1996, Worm et al. 1999, Mittelbach et al. 2001, Yamamura et al. 2001, Paine 2002). On a larger scale, biodiversity measurements can serve as an indicator of the balance between speciation and extinction (McKinney 1998 a,b, Charles et al. 2001, Rosenzweig 2001).

Apart from our increasing appreciation of deep-sea species richness (Grassle & Maciolek 1992, Butler et al. 2001), biodiversity in coastal areas other than coral reefs has started to receive more and more attention (Gray 1997). Coastal marine biodiversity can be very high (Ray 1996) because the three-dimensional structure of macroalgal habitats and seagrass communities support and enhance species richness (Van Oppen et al. 1996, Walker & Kendrick 1998, Wysor et al. 2000, 2001, Duarte 2000, Engelhardt & Ritchie 2001, Duffy et al. 2001, Somerfield et al. 2002, Bulleri et al. 2002). Shallow water coastal areas, however, are also the areas most impacted by humans, and human impact such as fisheries, pollution, invasive species, recreational activities, and habitat fragmentation have severe effects on nearshore biodiversity (Beatley 1991, Gray 1997, Walker & Kendrick 1998, Cury 1999, Bax et al. 2001, Tilman & Lehman 2001, Piazzi et al. 2001, Barnes 2002). On a larger scale, humanly induced global climate change can have a significant impact (Scheffer et al. 2001). We have now started to understand that biologically diverse communities are more resilient to environmental and ecological stress and disturbances, e.g. from invasive species (Kennedy et al. 2002).

Biodiversity and community structure assessments are particularly valuable if local data can be compared to those at other geographic regions. Although many attempts have been made to measure and evaluate biodiversity, small- and large-scale comparisons are hampered because usually different methods have been applied (France & Rigg 1998). For a comparative biodiversity assessment on multiple scales, within an area, between areas or among global gradients, a unified approach is needed (e.g. Rabb & Sullivan 1995, Mikkelsen & Cracraft 2001). The Census of Marine Life with its associated projects, such as NaGISA is such a framework for global study of biodiversity.

NaGISA successfully competed in the GEM Phase II Invitation, where proposals were requested to "conduct baseline research on diversity and distribution of marine organisms at one or more locations within the GEM area". As such, NaGISA used the standard protocols set up under the Census of Marine Life to sample multiple sites within Prince William Sound, Kachemak Bay, and Kodiak Island in 2003 and 2004.

Objectives: The original objective of this project was to provide biodiversity data according to a standardized sampling protocol to serve as local baseline data for biodiversity comparisons and monitoring purposes and as part of a large-scale longitudinal biodiversity gradient. We expanded on this objective in year two of our proposal to include: 1) comparison of biodiversity on local, regional and larger (global) geographical scales, 2) examination of temporal variability of biodiversity in the Gulf of Alaska, 3) relating biological diversity to ambient environmental parameters, and 4) increasing capacity building through local community involvement in sampling efforts.

Achievement of these objectives has created a baseline for long-term monitoring and management programs as well as for further understanding of ecosystem functioning through process-oriented projects. By being part of a global biodiversity effort, the overall outcome will be larger than the local and regional scope alone. The use of standardized sampling and analysis protocols will allow incorporating biodiversity data from the Gulf of Alaska into larger-scale comparisons and thus eventually help answer important ecological and biogeographical questions about biodiversity and latitude.

Methods: Sites sampled for biodiversity within this project spanned longitudinally from 147˚06'W to 154˚15'W and latitudinally from 56˚45'N to 60˚39'N. In each of our core areas (Kodiak, Prince William Sound, and Kachemak Bay), we sampled multiple study sites in 2003 and 2004 (Table 1).

In Kodiak, Old Harbor in Sitkalidak Straight (OH), Akhiok in Alitak Bay (AB), and Larson Bay by Uyak Bay (UB) were sampled in 2003. In 2004, Old Harbor was replaced by Woody Island (WI) because it was decided that one of the permanent sites should be located adjacent to the town of Kodiak. For all 2003 Kodiak sampling, the Youth Area Watch Program (Teri Schneider) assisted us in the destructive intertidal sampling. This allowed us to involve kids from various native villages so that we could interact with and teach them how to collect biological samples and help increase their interest and awareness in their natural resources. Also, in 2003, undergraduates from University of Alaska Fairbanks (UAF), and for both years, graduate students from UAF assisted in our sampling.

Table 1. Summary of sampling in the Gulf of Alaska.

area	site	year sampled	habitat	lat	long	# of samples	min depth	max depth
PWS	Montague Island (MI)	2003, 2004	rocky	60 22 85 N	147 06 74 W	140	high intertidal	15 m
PWS	Green Island (GI)	2003, 2004	rocky	60 17 95 N	147 24 52 W	140	high intertidal	15 m
PWS	Knight Island (KI)	2003, 2004	rocky	60 29 04 N	147 43 92 W	140	high intertidal	15 m
PWS	Naked Island (NI)	2003, 2004	seagrass	60 39 37	147 26 17	20	2m	3 m
KOD	Old Harbor (OH)	2003, 2004	rocky	57 09 63 N	153 23 34 W	60	high intertidal	10 m
KOD	Alitak Bay (AB)	2003, 2004	rocky	56 56 88 N	154 07 98 W	140	high intertidal	15 m
KOD	Uyak Bay (UB)	2003, 2004	rocky	57 33 12 N	153 51 93 W	140	high intertidal	15 m
KOD	Woody Island (WI)	2004	rocky	57 46 24 N	152 21 16 W	70	high intertidal	15 m
KOD	Port Lions (PI)	2003, 2004	seagrass	57 49 36 N	152 43 77 W	20	2m	3 m
KB	Outside Beach (OB)	2003, 2004	rocky	59 27 85 N	151 42 56 W	120	high intertidal	15 m
KB	Cohen Island (CI)	2003, 2004	rocky	59 32 50 N	151 32 50 W	140	high intertidal	15 m
KB	Port Graham (PG)	2004	rocky	59 22 24 N	151 53 39 W	70	high intertidal	10 m
KB	Elephant Island (EI)	2003, 2004	rocky	59 32 50 N	151 30 50 W	70	high intertidal	10 m
KB	Jacolof Bay (JB)	2003, 2004	seagrass	59 26 94 N	151 29 94 W	20	intertidal	3 m

PWS=Prince William Sound
KOD=Kodiak
KB=Kachemak Bay

In Prince William Sound, we sampled Knight Island (KI), Green Island (GI), and Montague Island (MI) in both 2003 and 2004. For these sites, we involved undergraduate and graduate students from the UAF in our sampling. These students had the opportunity to learn about an unfamiliar habitat type and gain field experience. This experience has profoundly increased their awareness about coastal systems and the connectivity to oceanic processes. As a result, one undergraduate student is now pursuing a Masters degree in Marine Biology with emphasis on kelp forest ecology.

In Kachemak Bay, we sampled Cohen Island (CI), Elephant Island (EI), and Outside Beach (OB) in 2003. In 2004, we replaced Elephant Island with Port Graham (PG) to get better spatial coverage across the bay and because the community of Port Graham wanted to become involved in biodiversity sampling in their area. Sampling in Kachemak Bay for both years involved various UAF undergraduate and graduate students, multiple UAF summer field courses and the communities of Port Graham and Seldovia.

Sampling protocol: The NaGISA project follows the standardized sampling procedure developed within the CoML for baseline nearshore biodiversity coverage to ensure comparability of our data with those of other NaGISA study sites (Nakashizuka & Stork 2002). All sampling sites for this report were centered in large algal/hard bottom communities, which are highly complex and globally distributed, and which also represent important habitat types along the Alaska seashore. This report focuses on the initial taxonomic analysis of the visible organisms (>0.5mm) associated with large algal communities, but a full spectrum of samples including meiofauna (>63µm) was collected and preserved for later analysis. Discussions are currently being held for the transfer of meiofaunal samples to taxonomic specialists. As part of this project, we sorted and identified all macro-organisms collected with the help of graduate and undergraduate students, and various interns. We gathered a group of taxonomic specialists to assist in species identification. Voucher specimens for all organisms were collected and digital photographs are currently being taken with the support from the International NaGISA and the Sloan Foundation.

Each of our three core areas (Prince William Sound, Kachemak Bay, and Kodiak Island) had multiple study sites (Table 1). At each site, the standardized protocols called for five replicate samples to be taken randomly along the high, mid, and low intertidal strata and at 1, 5, 10, and 15m water depths (Figure 1). Every replicate consisted of three different sized quadrats that were sampled at two levels of increasing difficulty. Within a 1x1m quadrat, a photographic image record (non-destructive) was made immediately prior to sampling. All macrophytes and conspicuous macrofauna (>2cm length) within the 1x1m quadrat were identified *in-situ*, and either counted (large solitary macroflora and conspicuous fauna such as crabs, seastars, sea cucumbers, etc.) or an estimate of percent cover made (small macroflora and colonial organisms).

Adjacent to the 1x1m quadrat, a 50x50cm quadrat was placed, and within each 50x50cm quadrat, a 25x25cm quadrat was placed always in the same position within the larger sample (Figure 1). Within the 50x50cm quadrat all macroalgae were completely removed, except for those in the 25x25cm area. This 50x50cm sample was taken to ensure sufficient algal reference material to support the *in-situ* observation. In each 25x25cm quadrat, a photographic image record was made immediately prior to sampling. All macrophytes and fauna within the quadrat were carefully and completely removed and collected into a 63µm mesh bag (destructive sampling).

All quantitative samples were sieved immediately after sampling on nested meshes of 0.5mm and 63µm. Macroflora retained on the 0.5mm mesh was sorted, wet weight taken and a herbarium voucher prepared. Taxonomic expertise was given by Dr. Gayle Hanson (Oregon State University). Macrofauna retained on the 0.5mm mesh was preserved in buffered 5% seawater-formalin solution for later sorting and identification. Mollusks were identified by Dr. Nora Foster and polychaetes were identified by Max Holberg (both University of Alaska Fairbanks). Polychaetes from Alitak Bay 2003 (Kodiak Island) are still in the process of being identified by Dr. Sergey Gagaev (Zoological Institute St. Petersburg, Russia). Meiofauna retained on the 63µm mesh also were preserved and stored for later identification as more resources become available.

Physical descriptions at each sampling site included temperature (deployment of dataloggers at each depth strata to obtain hourly temperature readings for one year), as well as lights readings at each sampling strata and salinity measurements at the day of sampling.

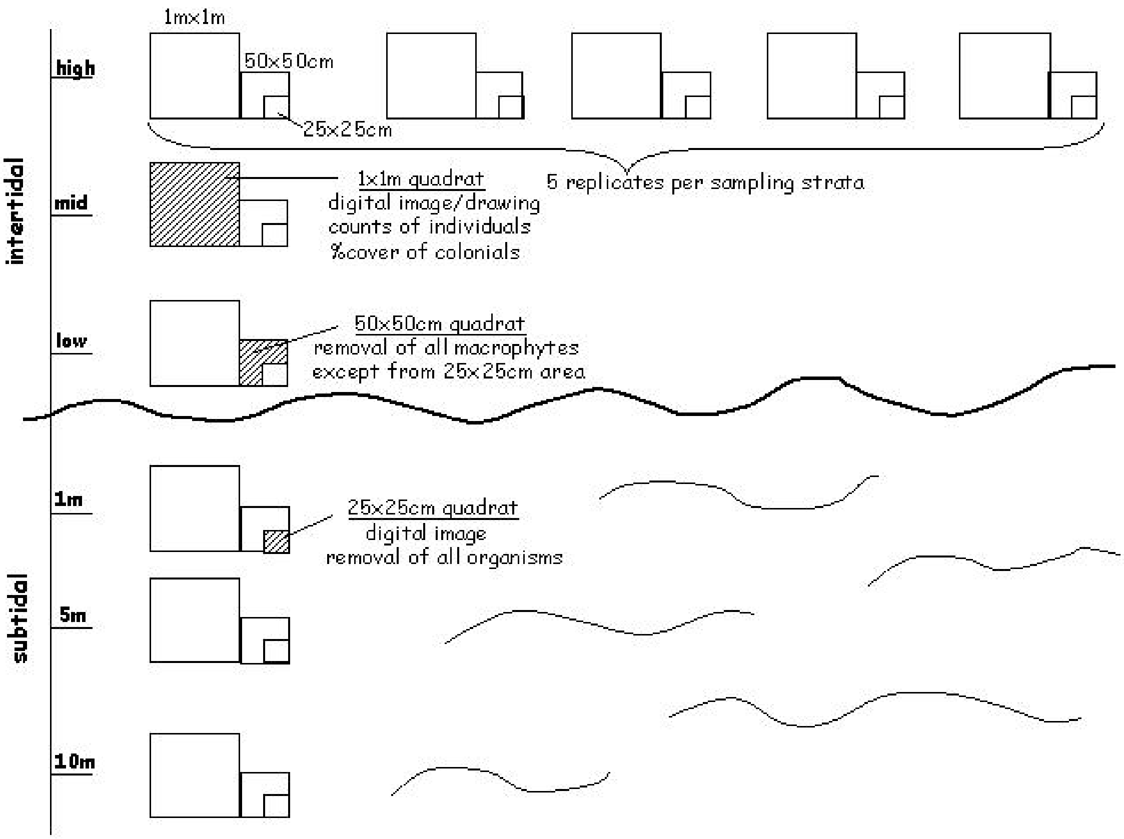

Figure 1. Summary of NaGISA sampling protocol.

Statistical analysis: The obtained dataset of community structures was multivariate and required a multivariate approach for analysis. Because biological community datasets, such as the one produced during this study are usually not normally distributed and also cannot be transformed into normal distribution, a non-parametric multivariate approach was chosen. Data were analyzed using the software package Primer (v6, Plymouth Marine Laboratories, Clarke & Warwick 2001). Within Primer the following analysis applications were used:

1. Similarity analysis: Similarities between every pair of samples were analyzed using the Bray-Curtis similarity analysis, a permutation procedure especially appropriate for ecological samples.
2. Cluster analysis was used to display the similarity between samples where samples are combined within a dendrogram based on their level of similarity.
3. Multidimensional scaling (MDS) was used as a tool to map ranks of similarity of multivariate community information in a 2-dimensional fashion. The contribution of taxonomic groups to this distribution pattern was demonstrated by overlying bubble plots onto the MDS plot. The size of a bubble thereby is positively correlated to the measuring unit used, either abundance or biomass.
4. ANOSIM (Analysis of similarity) was used as a non-parametric analogy to an ANOVA routine to statistically test for differences between groups of samples. The obtained R coefficient is close to zero if sample groups are similar, and close

to 1 when sample groups are dissimilar. R values above 0.15 indicate statistically significant differences between groups at the 0.1% significance level.

5. Diversity was measured using a variety of indices, such as Shannon-Wiener's diversity index (calculated using natural logarithm to the base e), Margalef's species richness index, and Pielou's evenness index. Differences in diversity indices were analyzed by Analysis of Variance (ANOVA) using SPSS 10.0 at a significance level of α=0.05.
6. The importance of individual species or groups of species attributing most to the observed community structure was analyzed using the BVSTEP procedure within the Primer routine.

Results:

Primary Objective: Species lists: The primary objective of this project was to provide biodiversity data according to a standardized sampling protocol to serve as local baseline data for biodiversity comparisons and monitoring purposes and as part of a large-scale longitudinal biodiversity gradient. Key organisms identified to the lowest possible taxonomic level with the help of local experts included macroalgae, mollusks, and polychaetes. The species lists produced by this project contain 242 invertebrates (including 108 mollusks and 78 polychaetes) and 237 macroalgae (including 36 Chlorophyta, 60 Heterokontophyta, and 141 Rhodophyta) (Appendices 1-4). It is important to note that these are not intended to be all inclusive lists for all species in the Gulf of Alaska. These lists refer to species found within the randomly placed quadrats of this study. With that said, the spatial extent within the GoA was broad, encompassing multiple sites in Prince William Sound, Kachemak Bay, and Kodiak Island. All species lists produced by this project will be provided to the Ocean Biogeographic Information System (OBIS; www.iobis.com) NaGISA database as soon as the database is operational so that the data will be publicly accessible. A link to the OBIS website will be put on the NaGISA web page (http://www.nagisa.coml.org/).

Our primary objective of establishing a biological inventory of intertidal and shallow subtidal communities was expanded in year two of the project to include: 1) comparison of biodiversity on local, regional and larger (global) geographical scales, 2) examination of temporal variability of biodiversity in the Gulf of Alaska, 3) relating biological diversity to ambient environmental parameters, and 4) increasing capacity building through local community involvement in sampling efforts. The reason for much of this expansion was to demonstrate the potential for NaGISA standardized sampling for monitoring and examining trends at the community and ecosystem levels.

Secondary Objective 1: Biodiversity comparisons:

Invertebrate data: 2003 invertebrate samples were counted and weighed within larger taxonomic groups, except for mollusks and polychaetes, which were also analyzed on species to family level (see below). Taxonomic groups within the Arthropoda included amphipods, isopods, copepods, tanaids, cumaceans, ostracods, cirripedia, decapods (including brachyurans, lithodids, and pagurids), insects, pycnogonids, and euchelicerates (mites and pseudoscorpions). The Echinodermata included asteroids, ophiuroids, holothurians, and echinoids. Species data for the Molluska were combined into gastropod, bivalve, and chiton groupings. Other taxonomic groups found within the invertebrate samples were cnidarians (anemones, stauromedusae, and hydroids), polychaetes, oligochaetes, sipunculids, nemertines, platyhelminthes, bryozoans, brachiopods, and ascideans. Vertebrates included in the analysis were demersal fishes that were collected within the 25 x 25 cm quadrats. Abundance data do not exist for groups where individuals could not be distinguished once they were cleared from the substrate (such as barnacles and bryozoans).

Analysis of invertebrate community composition based on abundance data demonstrated two main large groups that were similar only at the 50% level, while most subsequent groupings had a similarity level between 70-80% (Figure 2). MDS ordination of the communities (Figure 3) and subsequent ANOSIM analysis of the similarity matrix showed that differences between communities were significant between intertidal versus subtidal groupings (R=0.419). Intertidal samples included the high, mid and low intertidal as well as the 1m stratum. For all analyses in this report, the 1m tidal height was included as intertidal because this stratum is occasionally exposed to air during extreme low tides and always grouped closer to the intertidal samples whereas subtidal strata are always submerged. The subtidal samples included the 5m, 10m, and 15m samples. Tidal stratum (high, mid, low etc.) also were significantly different but on a lower R level (R=0.337). No significant relationships were detected when samples were analyzed across areas (R=0.093) or sites (R=0.099).

Diversity indices for invertebrate abundances are given in Appendix 5. Shannon-Wiener's diversity index was significantly lower for KI high and MI high than for most other samples (p≤0.05, ANOVA), due to the dominance of *Mytilus trossulus* and very low abundance of other invertebrate groups. Shannon Wiener diversity indices were not significantly different among areas (p=0.240) or sites (p=0.157) but were significantly higher for subtidal versus intertidal realms (p=0.023). The latter was also seen for Margalef's species richness index (p≤0.001) but not for Pielou's eveness index.

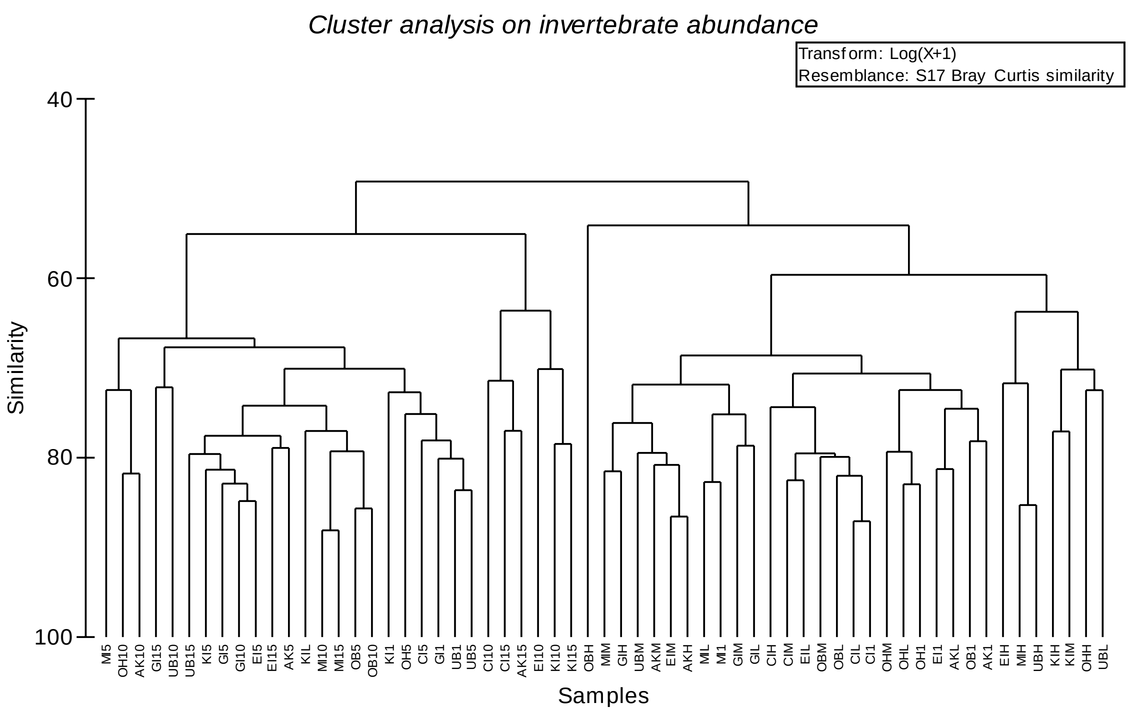

Figure 2. Cluster analysis on invertebrate abundance based on means from randomly placed quadrats. Abbreviations for sites can be found in Table 1. Also, H=High, M=Midtidal, L=Low, 1=1m, 5=5m, 10=10m, 15=15m. Abbreviations are consistent for all tables and figures in this report.

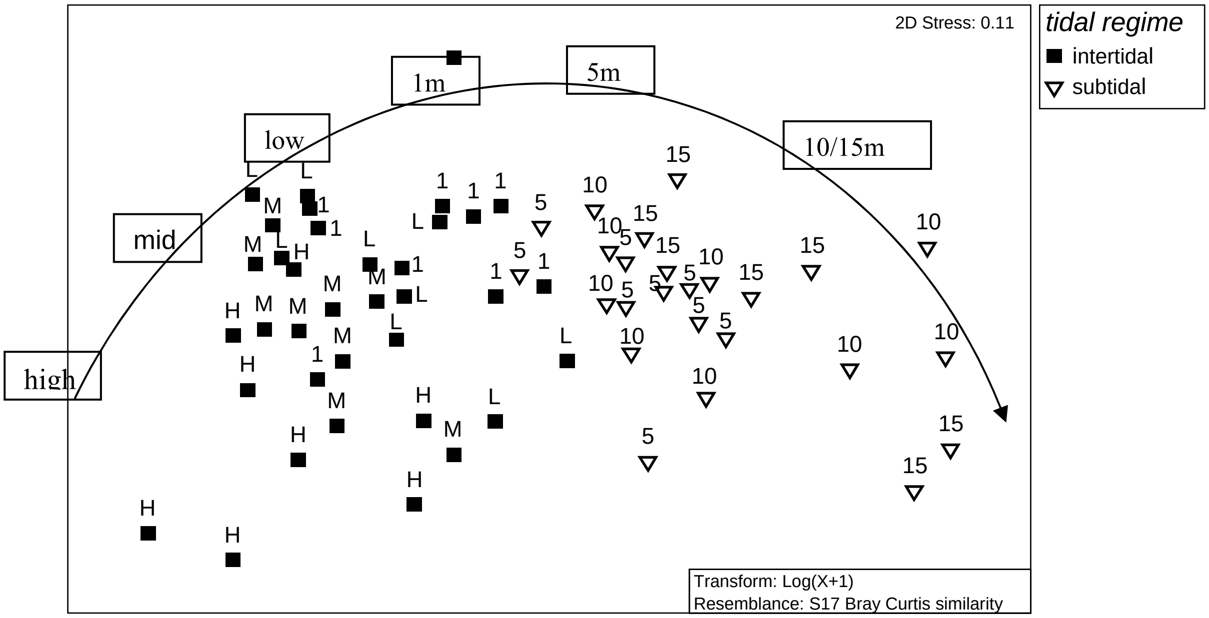

Figure 3. MDS ordination of invertebrate communities based on abundance. Note the upward trend in the intertidal communities (high, mid, low, and 1m) shift downward at the subtidal communities (5m, 10m, and 15m), indicting very different communities.

Sample placement in the MDS plot followed roughly a parabolic-shaped pattern from high intertidal to 15m water depth as shown by the superimposed trajectory in Figure 3. The continuous shift in sample placement along a straight trajectory indicates a change in the dominant (abundant) taxonomic group that contributes to the community. Seven out of the 26 invertebrate groups explained 95% of the community distribution pattern based on abundance (BVSTEP). These groups were the bivalves, polychaetes, amphipods, copepods, holothurians, insects, and chelicerates. Examples of these are shown as bubble plots in Figure 4.

Invertebrate communities were driven by different taxonomic groups, depending on tidal height (Figure 4). While bivalves, characterized by high abundances of *Mytilus trossulus*, drove the community pattern in the high and mid intertidal, amphipods and polychaetes explained other portions of the intertidal region. The change in trajectory direction was indicative of a major community composition change with overall highly reduced abundances within the taxonomic groups. The apex of the parabolic-shaped community pattern coincided with the change from intertidal to subtidal.

Invertebrate samples also were analyzed based on biomass. This dataset included non-enumerable organisms such as barnacles, bryozoans, colonial ascidians, and hydroids. Again, communities divided between intertidal and subtidal (R= 0.301), but the division was not as clear as when abundance was considered (Figure 5). Tidal stratum did have a significant contribution to the community patterns (R= 0.295). As before, site and region did not explain any of the overall distribution patterns of invertebrate biomass (R= 0.073 and R= 0.065, respectively; ANOSIM).

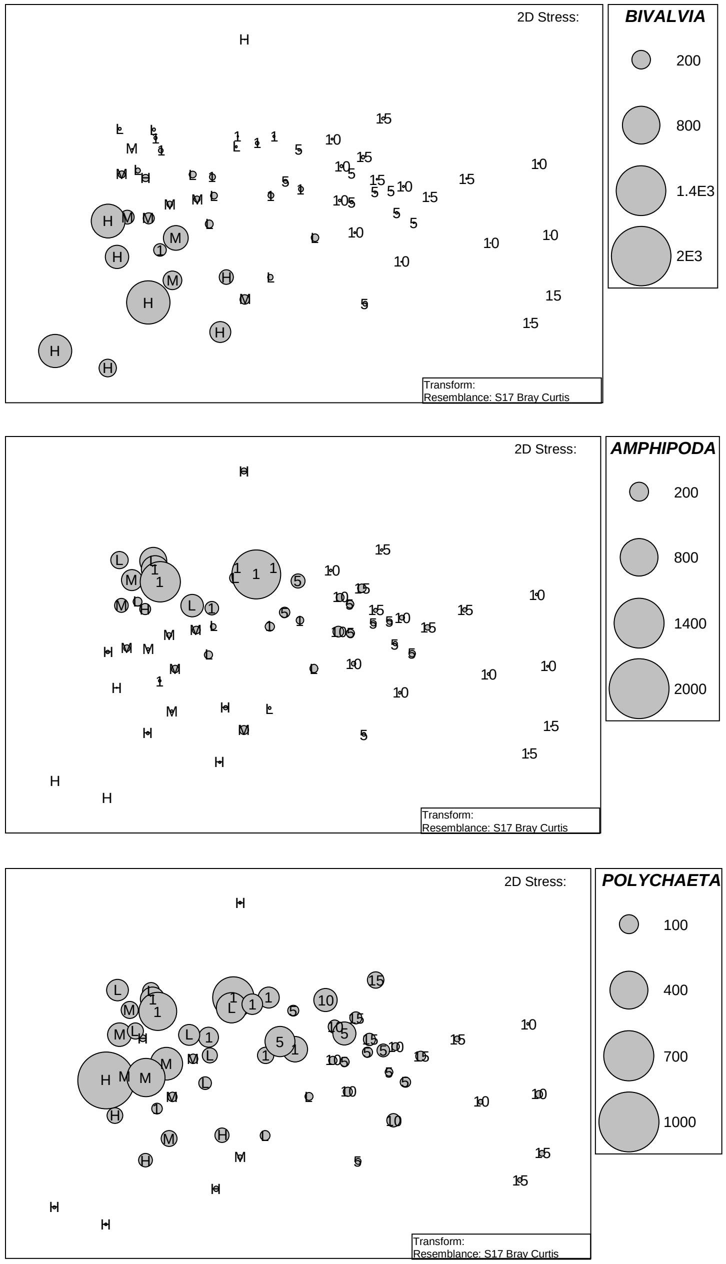

Figure 4. MDS ordination of invertebrate communities showing importance of bivalve (top), amphipod (center), and polychaete (bottom) groups. Abbreviations as in Figure 2.

Diversity indices for invertebrate biomass are given in Appendix 6. The Shannon Wiener diversity index for UB 1m stratum was significantly higher ($p \leq 0.05$, ANOVA) than for many other samples, but overall Shannon Wiener diversity indices were not significantly different when compared among areas ($p=0.477$), sites ($p=0.22$) or between tidal regimes ($p=0.266$).

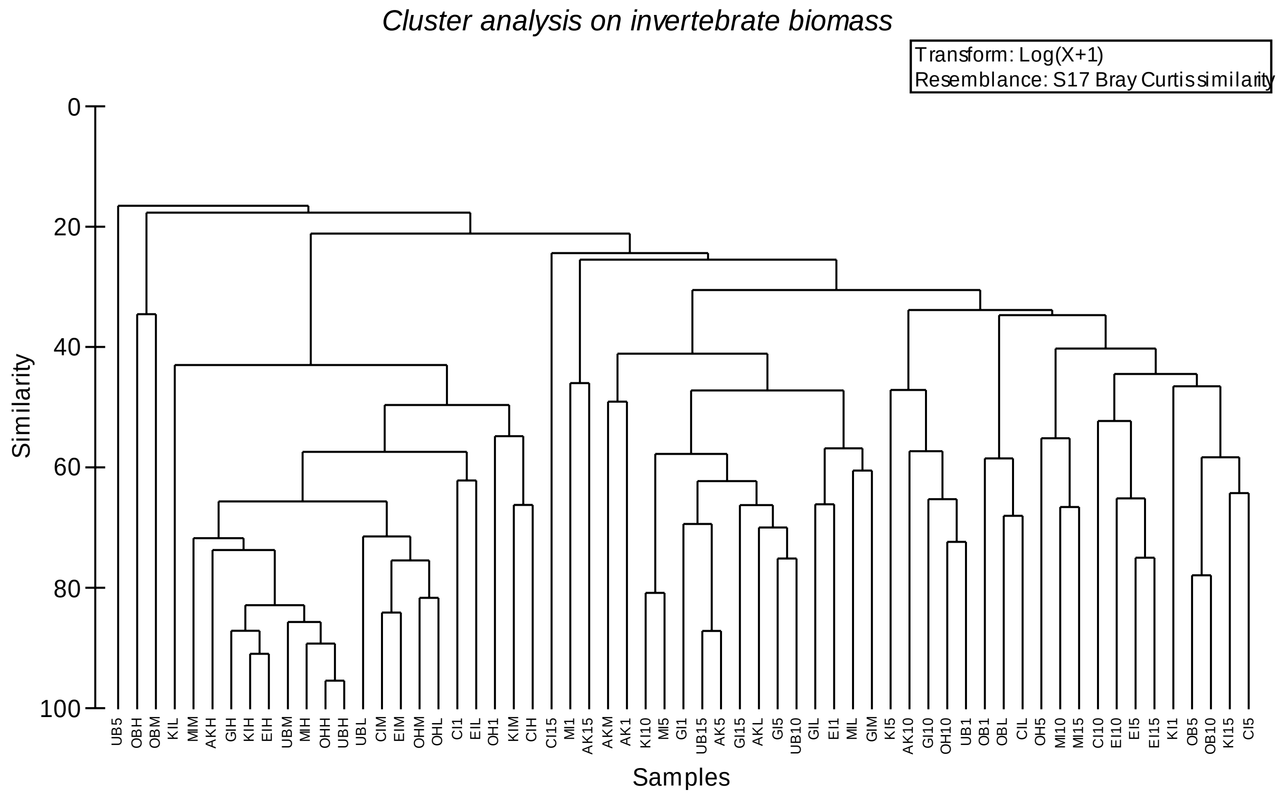

Figure 5. Cluster analysis on invertebrate group biomass. Abbreviations as in Figure 2.

The MDS ordination showed a general left to right distribution representing continuous composition change from high intertidal to 15m water depth, respectively. This general trend is visualized by the trajectories in Figure 6. Intertidal strata seemed to separate out more distinctly from each other than subtidal strata. Community comparison based on biomass also indicated that communities clustered together more closely at higher tidal strata. As seen in the cluster dendrogram (Figure 5), most high intertidal communities were similar at an 85% level, while most mid intertidal communities showed only about 70% similarity. Similarity levels of communities of subsequent lower tidal strata were decreasing, e.g. most low communities were only about 40% similarity, and communities no longer showed clear tidal strata clustering.

The BVSTEP procedure revealed that seven out of 29 taxa explained 95% of the community structure: bivalves, gastropods, polyplacophora, barnacles, holothurians, asteroids, and bryozoans. High and mid intertidal communities were particularly driven by the high bivalve (especially *Mytilus trossulus*) and barnacle biomass (Figure 7). Gastropods and polychaetes were other important biomass contributors, but being more evenly distributed among the sampling strata (Figure 8). Asteroid biomass seemed to have driven much of the lower portion of the MDS ordination (Figure 9). The lack of asteroids in explaining much of the invertebrate abundance distribution (see above) was because individual adult seastars were very large and contributed much to biomass but not to abundance. Bryozoans were a conspicuous member of the subtidal communities (Figure 10).

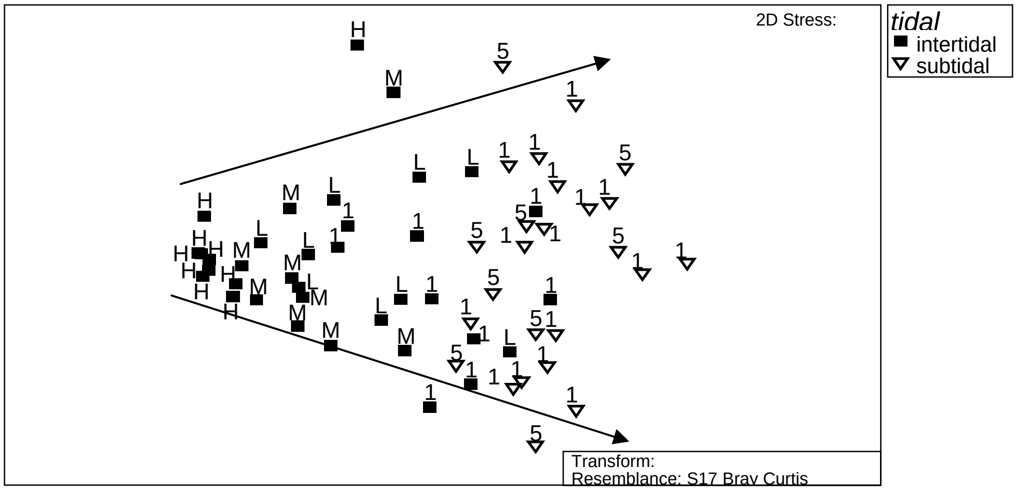

Figure 6. MDS ordination of invertebrate communities based on biomass. Note the general left to right distribution representing a continuous composition change from high intertidal to 15m water depth. Abbreviations as in Figure 2.

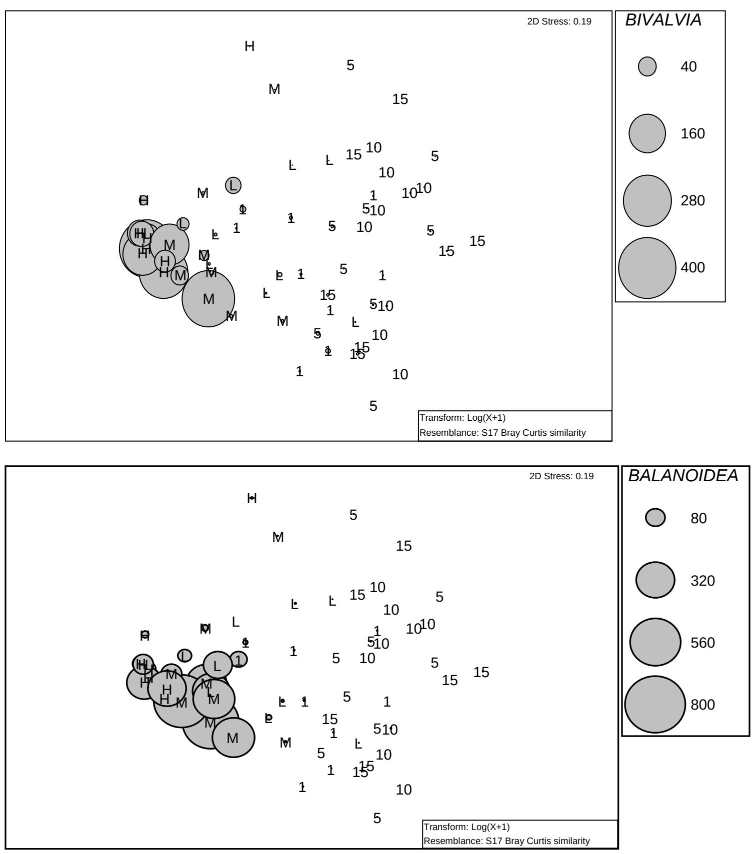

Figure 7. MDS ordination of invertebrate communities based on abundance showing importance of the bivalve (top) and balanoid (bottom) groups. Abbreviations as in Figure 2.

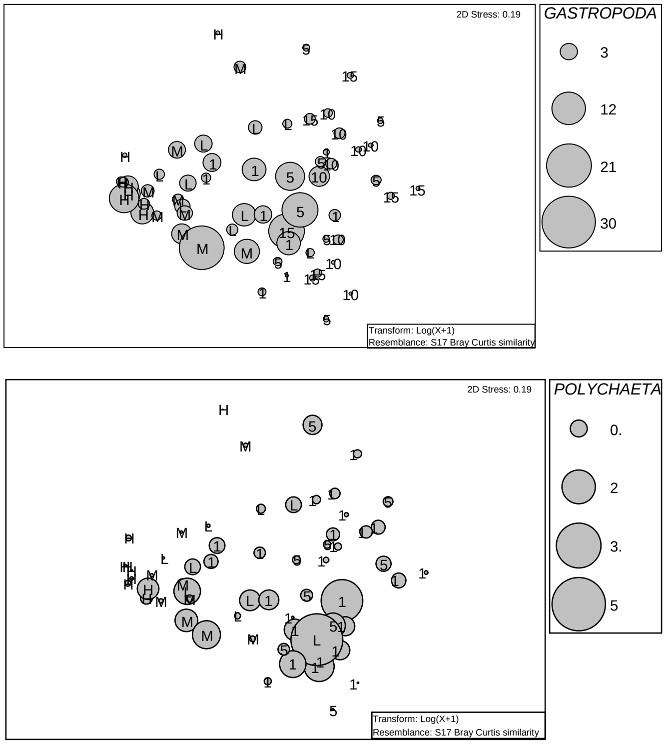

Figure 8. MDS ordination of invertebrate communities based on biomass showing importance of gastropod (top) and polychaete (bottom) groups. Abbreviations as in Figure 2.

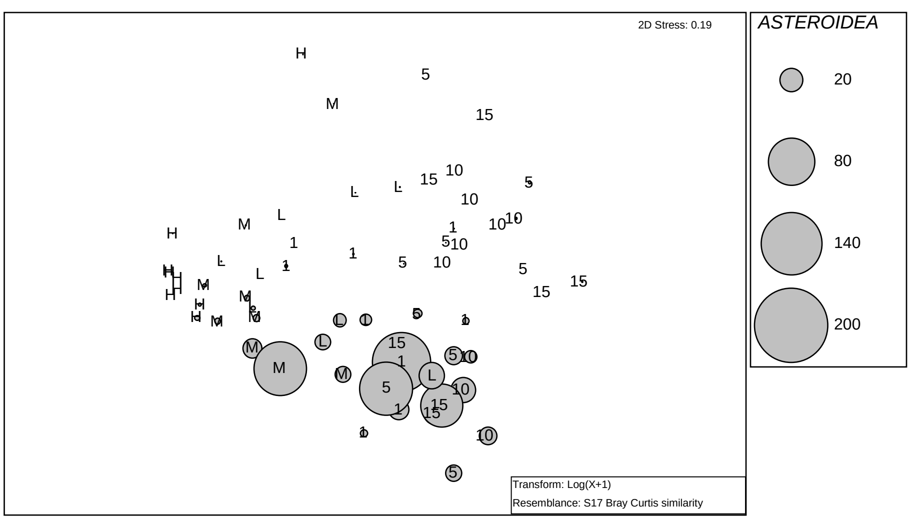

Figure 9. MDS ordination of invertebrate communities based on biomass showing importance of echinoderm asteroids. Abbreviations as in Figure 2.

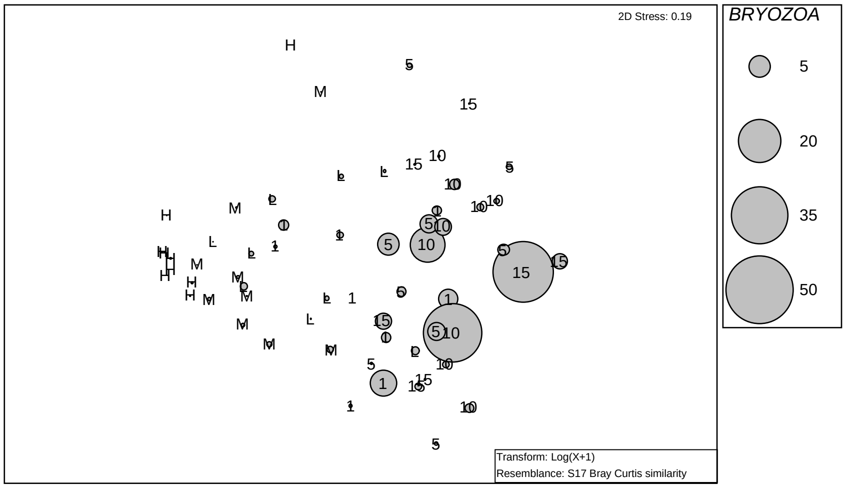

Figure 10. MDS ordination of invertebrate communities based on biomass showing importance of bryozoans in subtidal communities. Abbreviations as in Figure 2.

Mollusk data: Identification of 148 mollusks was completed to species or higher taxonomic level, where species identification was impossible (Appendix 2).

Community composition analysis based on abundance data of mollusks showed a split into two main clusters in the dendrogram at approximately 25% similarity level (Figure 11). This represented a distinction between intertidal and subtidal sites; however, it is noteworthy that six intertidal samples (low and -1m) from UB, AK, EI and OH (Uyak Bay, Alitak Bay, Elephant Island, and Old Harbor) were more similar (at approx. 45%) to subtidal sites than intertidal sites.

Community structure was significantly influenced by the area (R = 0.235, ANOSIM, Figure 12). This area effect also was noticeable for the sampling sites (R = 0.218), where sites from different areas were significantly different but not sites within an area. Both tidal stratum as well as tidal regime had significant effects on mollusk abundance (R = 0.328 and 0.379, respectively; Figure 12).

Shannon Wiener diversity indices (see Appendix 7) were significantly different between PWS and the other two areas ($p \leq 0.001$, ANOVA) but not between KOD and KB. This resulted in similar significant differences between PWS and other sites ($p \leq 0.001$), with especially GI and MI having high diversities. Also tidal regime had a significant effect on diversity ($p \leq 0.001$) with higher diversity in the subtidal than intertidal.

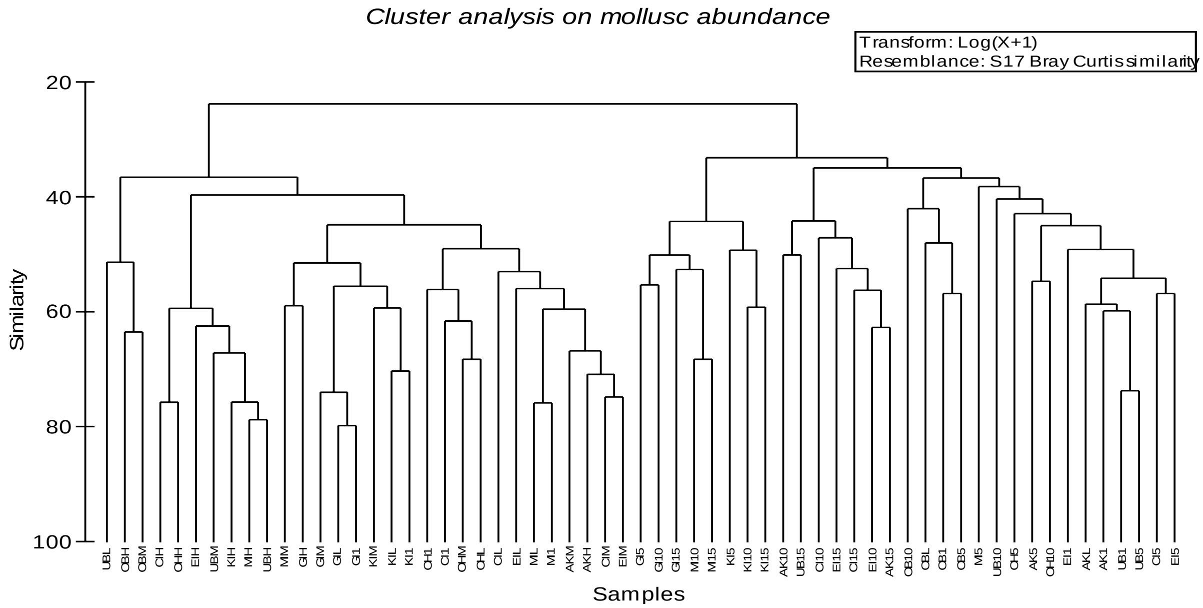

Figure 11. Cluster analysis on mollusk abundance. Abbreviations as before.

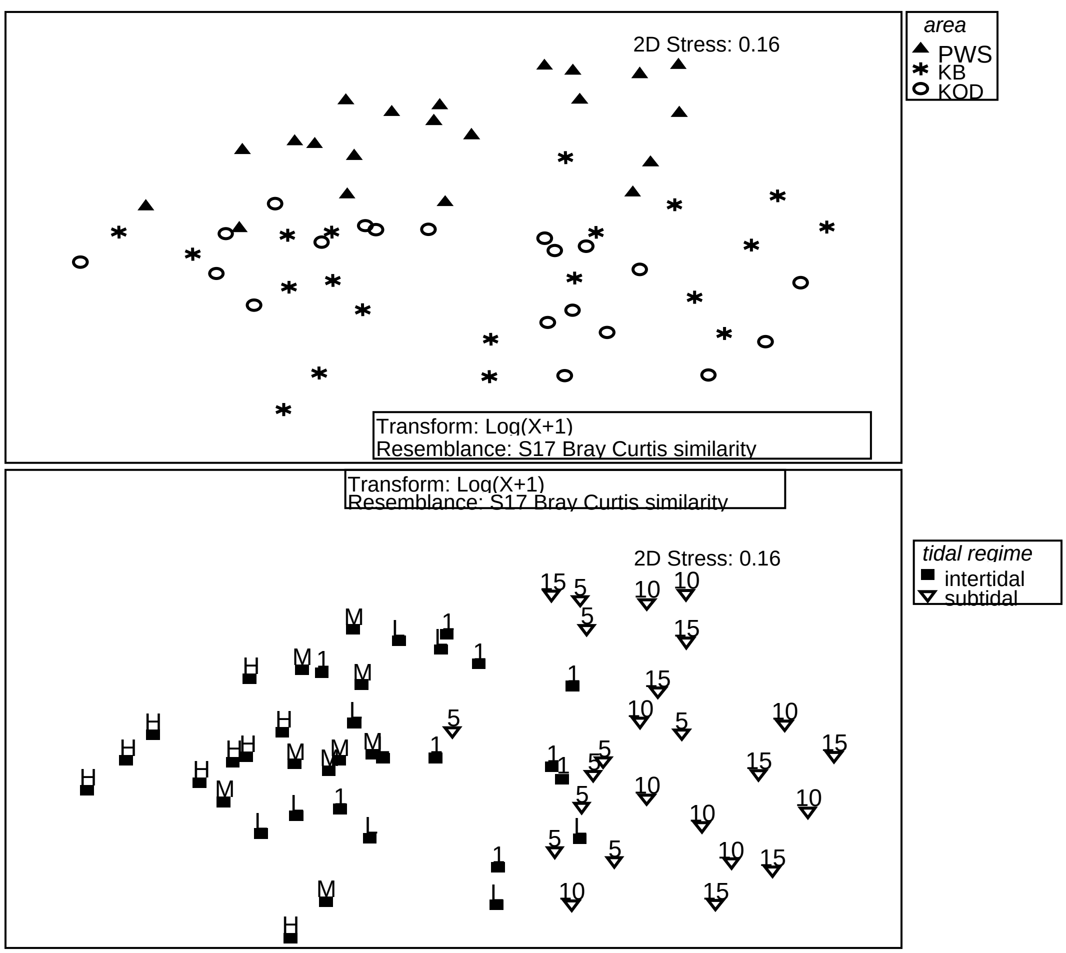

Figure 12. MDS ordination of mollusk communities based on biomass showing area and tidal regime groupings. Abbreviations as before.

Approximately 95% of mollusk community patterns based on abundance from all areas and sites in 2003 were explained by only 19 taxa (Table 2).

Table 2. Taxa that explain 95% of the mollusk community patterns based on abundance from all areas and sites in 2003.

Polyplacophora	*Katharina tunicata*
	Tonicella spp
	Mopalia spp
Patellacea	*Cryptobranchia spp*
	Lottia spp
Gastropoda	*Alvania sanjuanensis*
(except Patellacea)	*Cingula katherinae*
	Crepipatella spp
	Crepidula spp
	Homalopoma subobsoletum
	Lacuna spp
	Lirabuccinum dirum
	Littorina spp
	Onchidella borealis
	Onoba carpenteri
	Trichotropis spp
Bivalvia	*Hiatella arctica*
	Mytilus trossulus

Differences in mollusk community structure became more pronounced when analyzed based on biomass. Intertidal and subtidal communities were only similar at approximately 6%, although again some mixing between the groups occurred (Figure 13). While tidal regime seemed to be the main separating factor among the communities, subsequent groupings were less clear. As in the mollusk abundance analysis, area and site were significant factors in community composition, although marginally ($R = 0.179$ and $R = 0.177$, respectively, ANOSIM). Tidal stratum ($R = 0.340$) and tidal regime ($R = 0.399$) were both driving mollusk community composition based on biomass (Figure 14).

Shannon Wiener diversity indices based on mollusk biomass (Appendix 8) were significantly different between tidal regimes ($p=0.01$, ANOVA), with higher diversity in the subtidal than intertidal. An overall area effect on diversity indices with significantly higher diversity in PWS than the other two areas (KB and KOD, $p \leq 0.001$) also caused a significant site effect on diversity ($p \leq 0.001$).

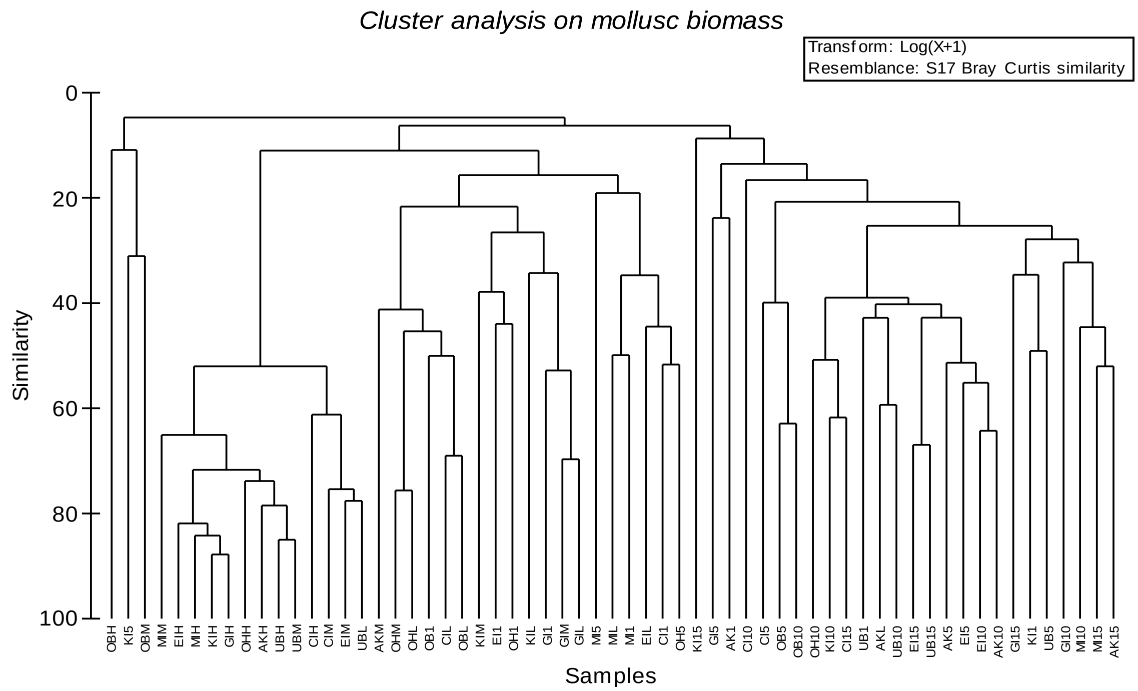

Figure 13. Cluster analysis on mollusk biomass. Abbreviations as before.

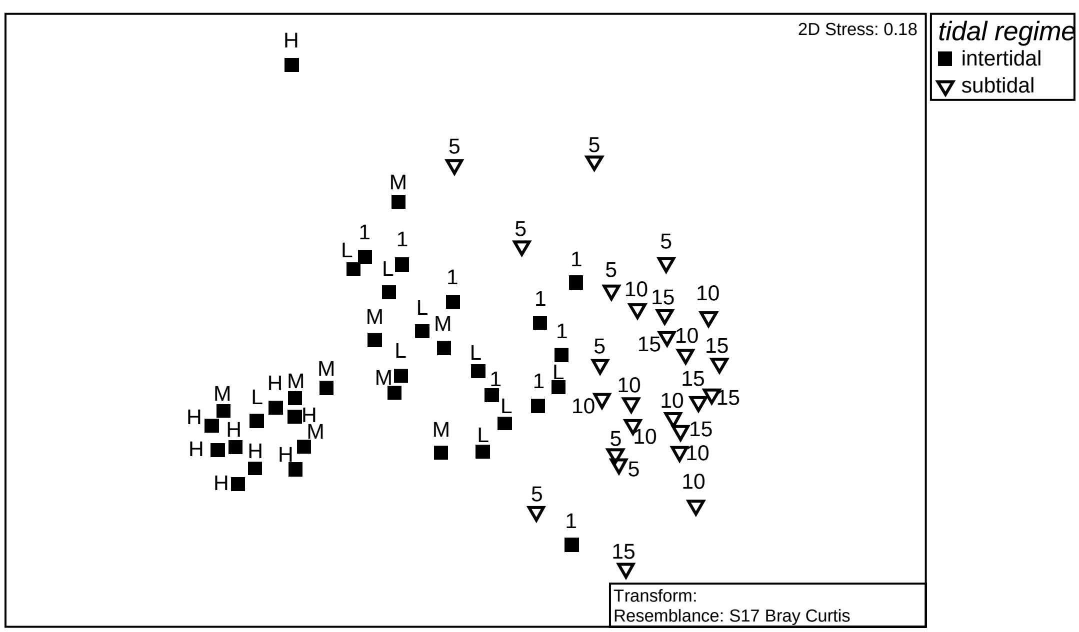

Figure 14. MDS ordination of mollusk communities based on biomass showing tidal regime groupings. Abbreviations as before.

Approximately 95% of the mollusk community patterns based on biomass from all areas and sites for 2003 were explained by 10 taxa (BVSTEP, Table 3). This is nine less than when abundance data were used.

Table 3. Taxa that explain 95% of the mollusk community patterns based on biomass from all areas and sites in 2003.

Polyplacophora	*Tonicella spp*
	Cryptochiton stelleri
	Katharina tunicata
Patellacea	*Acmea mitra*
	Lottia spp
Gastropoda	*Fusitriton oregonensis*
(except Patellacea)	*Lacuna spp*
	Lirabuccinum dirum
	Margarites spp
Bivalvia	*Mytilus trossulus*

To a large extent, the molluskan taxa driving community structure overlapped when abundance and biomass data are compared. Biomass analysis, however, is biased towards those species that are large but do not occur often in the sampling grid. Examples for these are *Cryptochiton stelleri* and *Fusitriton oregonensis*. Other taxa, like *Mytilus trossulus* and *Tonicella* spp, have comparable emphasis on similar portions of the community structure when biomass and abundance are regarded.

Polychaete data: Identification of 109 polychaete species or higher taxonomic levels were identified for our core areas within the Gulf of Alaska in 2003 (Appendix 3). Polychaetes from Alitak Bay, Kodiak Island, could not be identified within the funding framework of this project but are currently in the process of identification by Dr. Sergey Gagaev (Zooligical Institute St. Petersburg, Russia) within a Census of Marine Life collaboration. A total of 109 species or higher taxonomic levels were identified for the Gulf of Alaska in 2003.

Cluster analysis of polychaete abundance data revealed that samples were mainly different between intertidal and subtidal levels (only about 17% similarity) but there was not a complete separation between these categories (Figure 15). A number of samples clustered together at higher similarities between categories (tidal regime) than within one regime (Figure 16). This was also obvious from ANOSIM results, which showed significant effects of regime ($R = 0.183$) and stratum ($R = 0.198$), although these R values are lower in comparisons to other samples (e.g. mollusk samples, invertebrate samples). Area and site did not significantly influence polychaete species distribution ($R = 0.054$ and $R = 0.078$, respectively).

Polychaete abundance Shannon Wiener diversity indices (see Appendix 9) were significantly ($p \leq 0.001$, ANOVA) different between intertidal and subtidal regimes, with higher overall diversity in subtidal regions. There also was a significant site effect ($p=0.007$), which was caused by higher diversity at GI than at the two other sites in PWS, KI and MI. Since these differences were within one core area there was no significant area effect on polychaete abundance diversity (p=0.891).

Abundance distribution patterns were explained by 14 taxa: *Capitella capitata*, *Cirratulus cirratus*, *Dorvillea pseudorubrovittata*, *Harmothoe* spp., Nereidae, *Orbiniella nuda*, *Paleanotus occidentale*, *Platynereis bicanaliculata*, *Pseudochitinopoma occidentalis*, Sabellidae, Spirobidae, Syllidae, *Typosyllis* sp.

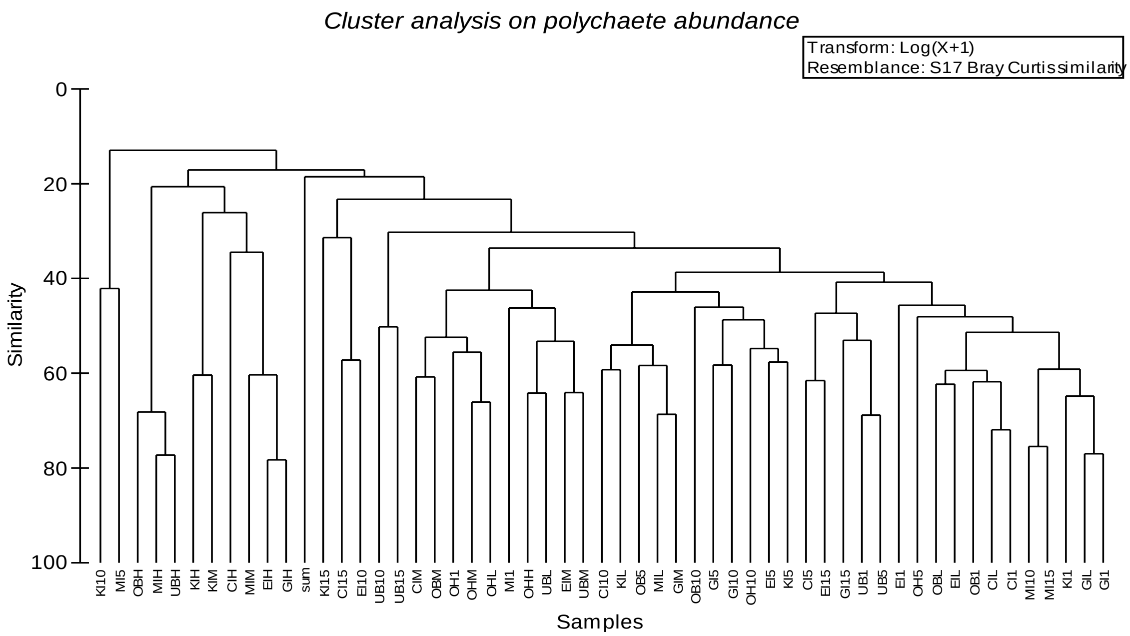

Figure 15. Cluster analysis on polychaete abundance. Abbreviations as before.

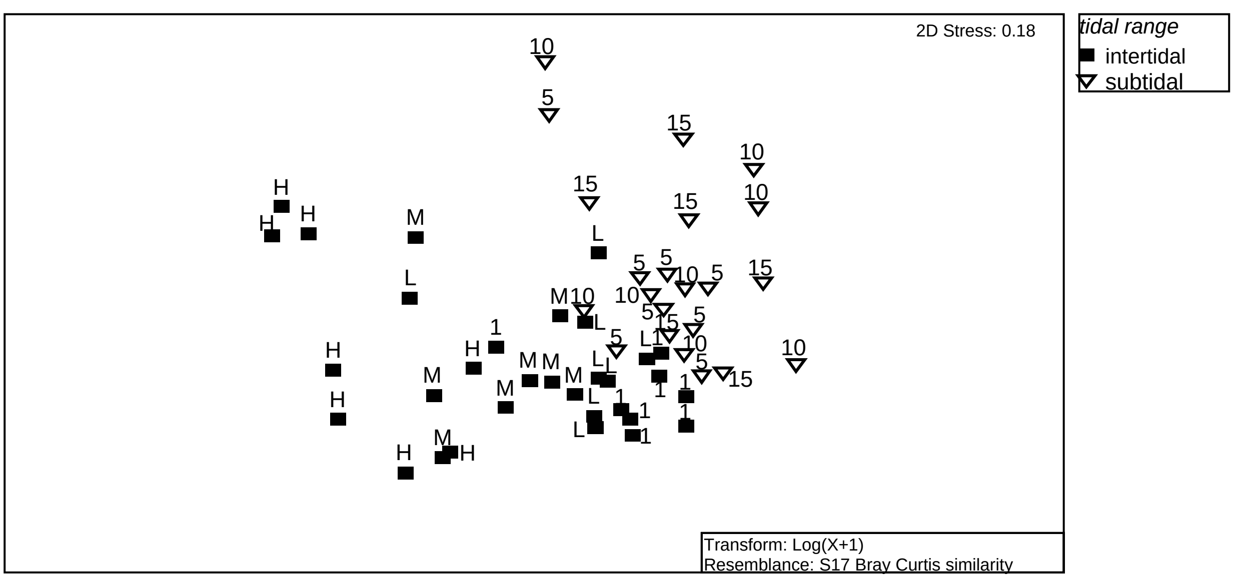

Figure 16. MDS ordination of polychaete communities based on abundance showing tidal regime groupings. Abbreviations as before.

Community composition analysis of polychaetes based on biomass did not show any clear clustering of samples, not even between intertidal and subtidal samples (Figure 17). There were, however, marginally significant tidal regime as well as stratum effects (R = 0.15 and R = 0.154, respectively; ANOSIM), while area (R = 0.014) and site (R = 0.05) had no effect on the community composition of polychaetes based on biomass. These tidal regime and strata effects can be seen in the MDS ordination (Figure 18).

Different from the diversity results based on abundance, polychaete biomass Shannon Wiener diversity indices (see Appendix 10) were not significantly different between tidal regimes (p=0.168, ANOVA). There was, however, a site effect (p=0.001) caused by significantly higher diversity indices at OH (KOD) compared to MI and KI (PWS). This also resulted in an overall area effect with significant differences (p≤0.001) between PWS and KOD.

Species that are driving biomass composition in polychaetes were quite different from those driving abundance, due to several numerous but very small species and less abundant but large (heavy) species. 95% of polychaete biomass community composition when areas and sites were combined was driven by 12 species: *Crucigera zygophora*, *Eulalia viridis*, *Harmothoe* spp, Nereidae, *Nereis pelagica*, *Nereis* sp, Orbiniidae, *Platynereis bicanaliculata*, Polynoidae, *Pseudochitinopoma occidentalis*, Spiorbidae, *Typosyllis* sp.

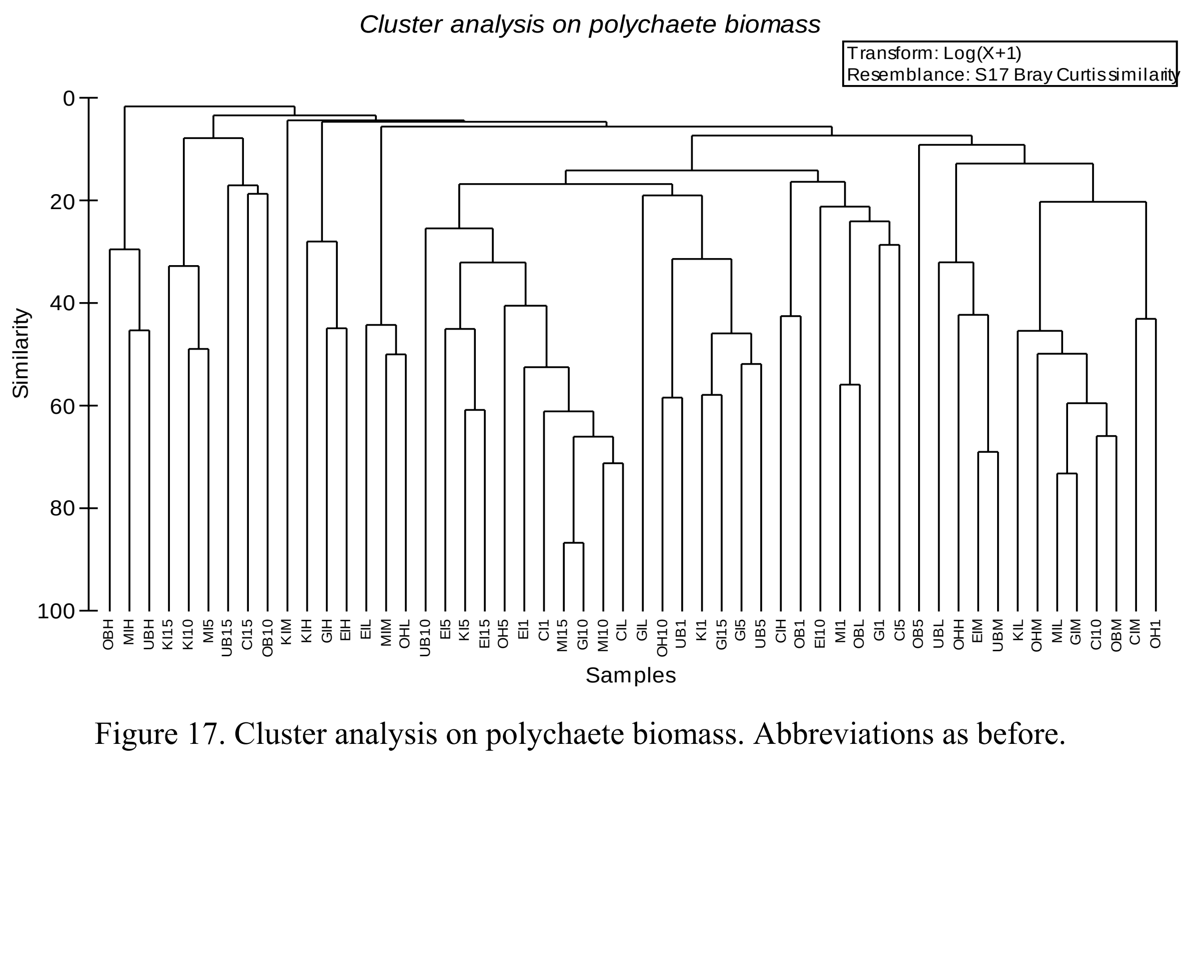

Figure 17. Cluster analysis on polychaete biomass. Abbreviations as before.

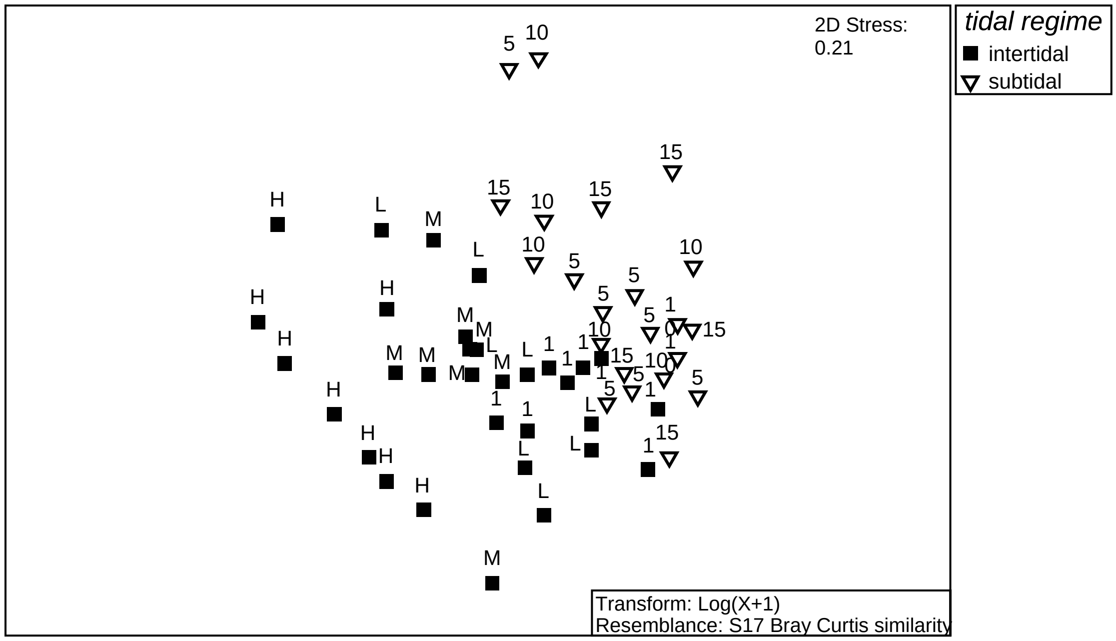

Figure 18. MDS ordination of polychaete communities based on biomass showing tidal regime groupings. Abbreviations as before.

Macroalgal data: 2003 and 2004 macroalgal samples from the 50 x 50 cm quadrats (including the macroalgae cleared from the embedded 25 x 25 quadrats) were sorted and weighed to species or lowest taxonomic level possible. Species spanned all three macrolagal phyla (Chlorophyta, Rhodophyta, and Heterokontophyta) (Appendix 4). Macroalgal stipe counts on the Laminariales were acquired in 2003 and 2004 from the 1 x 1 m quadrats and are analyzed separately. Included in these 1 x 1 m quadrats are percent cover estimates of sessile organisms (macroalgae and invertebrates). These percent cover data also are presented separately.

Macroalgal biomass: Analysis of the 2003 macroalgal community composition based on biomass data demonstrated two main large groups that were similar only at the <10% level (Figure 19). Similarly, analysis of the 2004 macroalgal community showed a comparable <10% similarity grouping (Figure 20). These two main groupings that separated out very early were the subtidal versus intertidal communities. In both 2003 and 2004, all depth strata, sites, and areas combined averaged approximately 60% similar; with no single transect being more than approximately 90% similar. MDS ordination of the 2003 macroalgal community (Figure 21) and subsequent ANOSIM analysis of the similarity matrix showed that differences between communities were significant between intertidal versus subtidal groupings (R=0.614). Tidal height also was significant for 2003 macroalgal communities but at a lower R level (R=0.485). Core areas were not significantly different in 2003 (R=0.088). Likewise, MDS ordination of the 2004 community (Figure 22) and subsequent ANOSIM analysis of the similarity matrix showed similar significant differences. Tidal regime (R=0.697) and tidal height (R=0.523) were both significantly different, while the core areas were similar when tidal heights and regimes were combined (R=0.140).

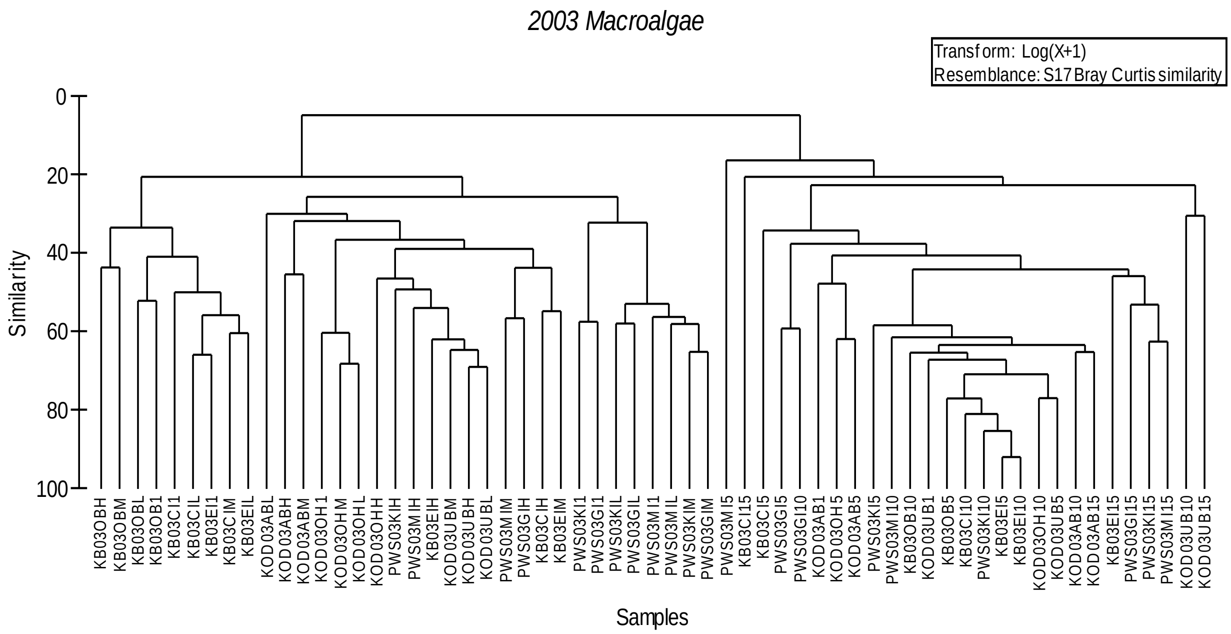

Figure 19. Cluster analysis on 2003 macroalgal biomass by site. Abbreviations as before.

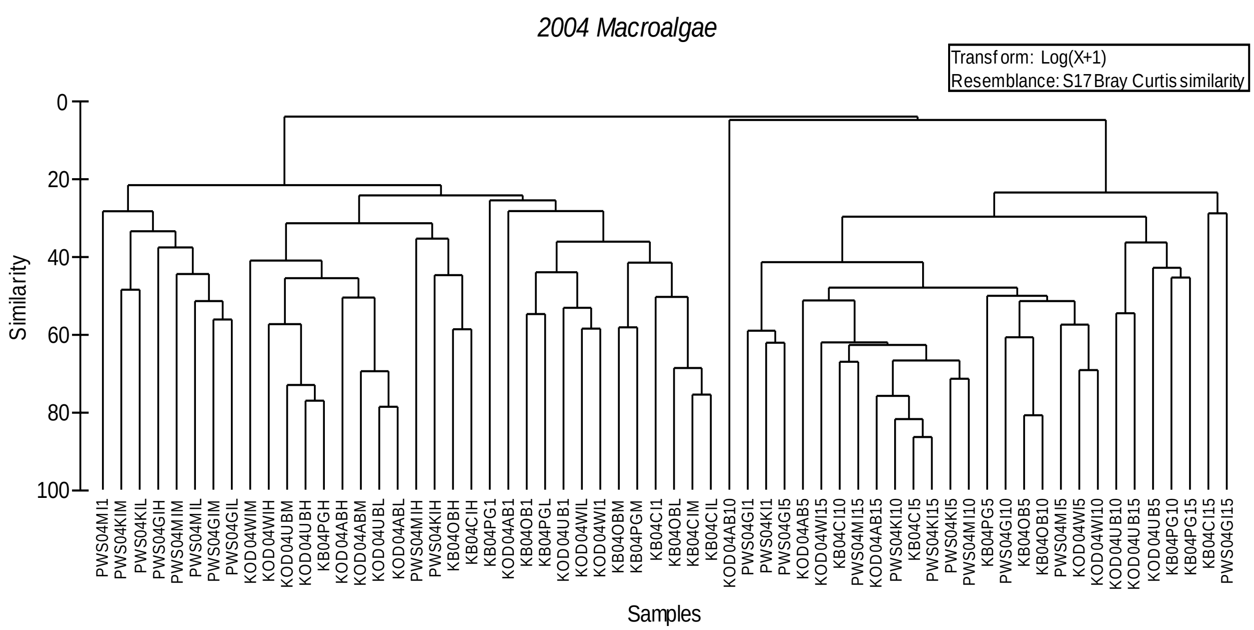

Figure 20. Cluster analysis on 2004 macroalgal biomass by site. Abbreviations as before.

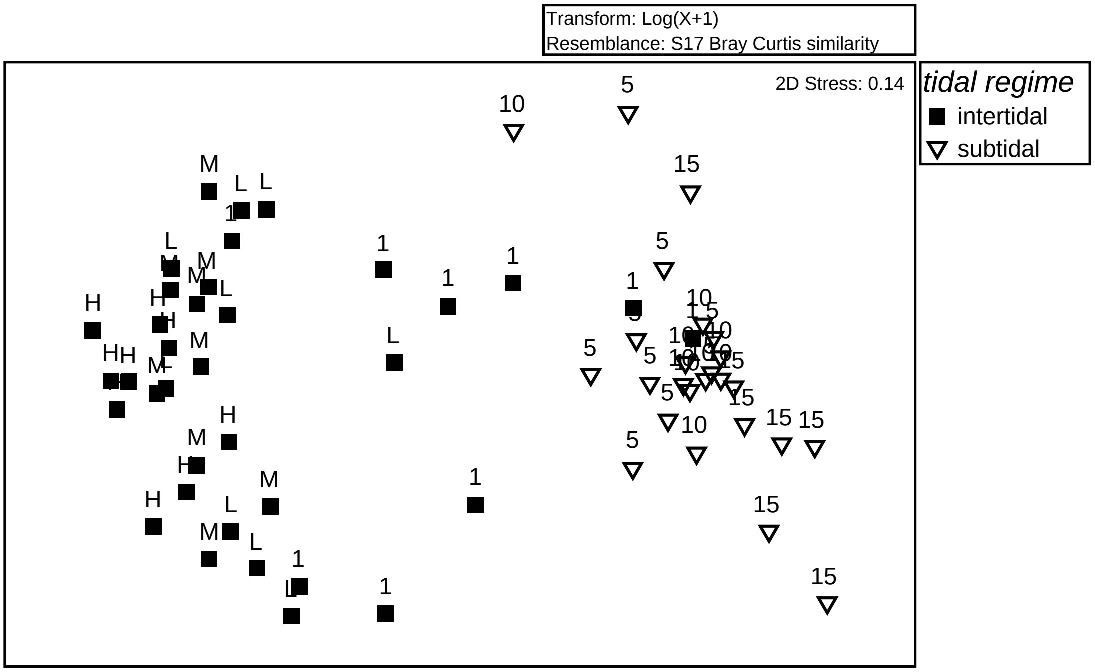

Figure 21. MDS ordination of 2003 macroalgal community based on biomass. Abbreviations as before.

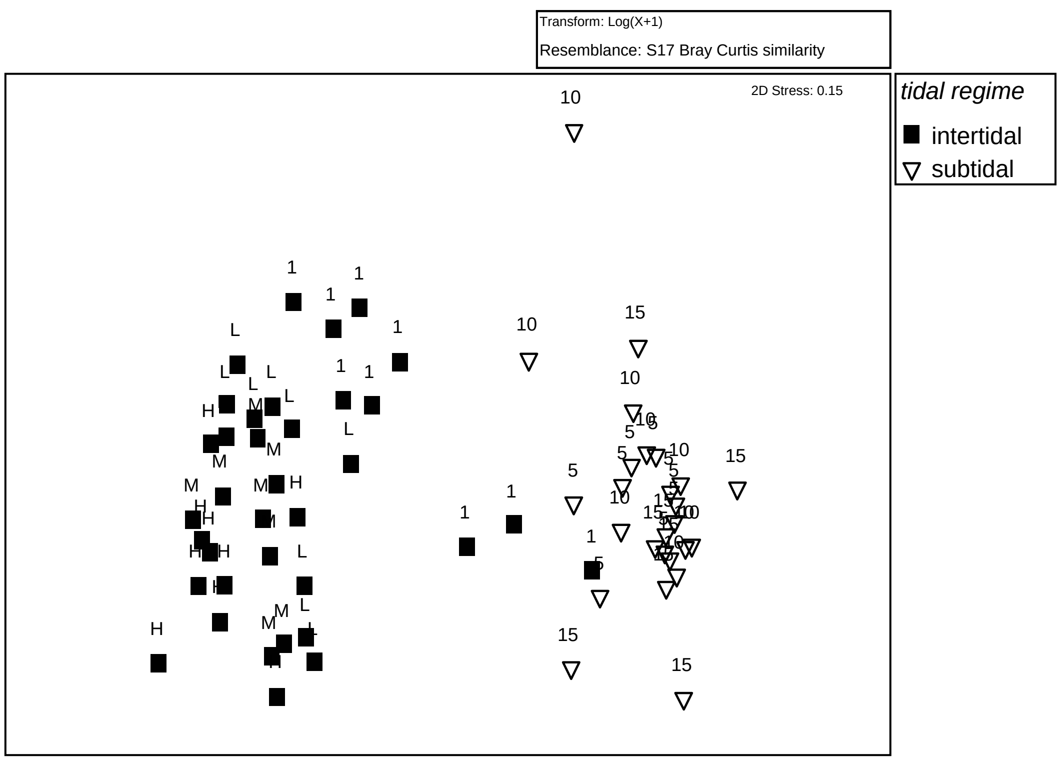

Figure 22. MDS ordination of 2004 macroalgal community based on biomass. Abbreviations as before.

Total biomass of macroalgae was not significantly different between areas (p=0.2467), sites (p=0.1809), or tidal regime (p=0.8112) (Appendix 11). However, depth strata were significantly different in biomass (p<0.0001) with the intermediate tidal zones (low, 1m, 5m, and 10m) having significantly more biomass.

The total number of taxa were significantly different between areas (p<0.0002), sites (p<0.0096), tidal regime (p<0.0001), and strata (p<0.0001) (Appendix 11). In general there were fewer macroalgal taxa in the subtidal compared to the intertidal, with the highest number of taxa in the mid, low and 1m zones. Overall area differences (with fewer taxa at Kodiak) were the driving force in the site differences that were noted. In particular, Alitak Bay and Uyak Bay had fewer macroalgal taxa than other sites in all areas.

Diversity indices based on 2003 and 2004 macroalgal biomass are given in Appendix 11. While no significant differences were found in the Shannon Wiener diversity indices between areas (p=0.1624) and sites (p=0.5115), tidal regime was significantly different (p<0.0001) with a higher index in the intertidal than the subtidal zone (1.44±0.07 s.e. versus 0.99. ±0.06 s.e., respectively). This tidal regime difference in diversity indices is largely driven by significant differences found with strata (p<0.0001), with the mid, low, and 1m zones having higher indices.

The BVSTEP procedure revealed that when all years, areas, sites, and depth strata are combined, seven genera explained 95.3% of the variability. These included *Agarum, Alaria, Laminaria, Fucus*, the *Neorhodomela/Odonthalia* complex, upright corallines, and the *Acrosiphonia/Cladophora/Rhizoclonium* complex. When examining depth strata separately, different genera/taxonomic groupings explained the community structure of each depth strata (Appendix 12 and 13). Many genera overlapped depths, such as *Agarum* being found in all subtidal depths (Figure 23) and *Fucus* and the *Ulva/Ulvaria/Monostroma* complex found in most intertidal strata (Figures 24 and 25). But a general trend was discovered with fewer species needed to describe deeper depth strata than shallower ones. With all areas combined, the subtidal strata needed an average of 4.4 species to accurately describe the community structure while the intertidal strata needed an average of 7.2 species.

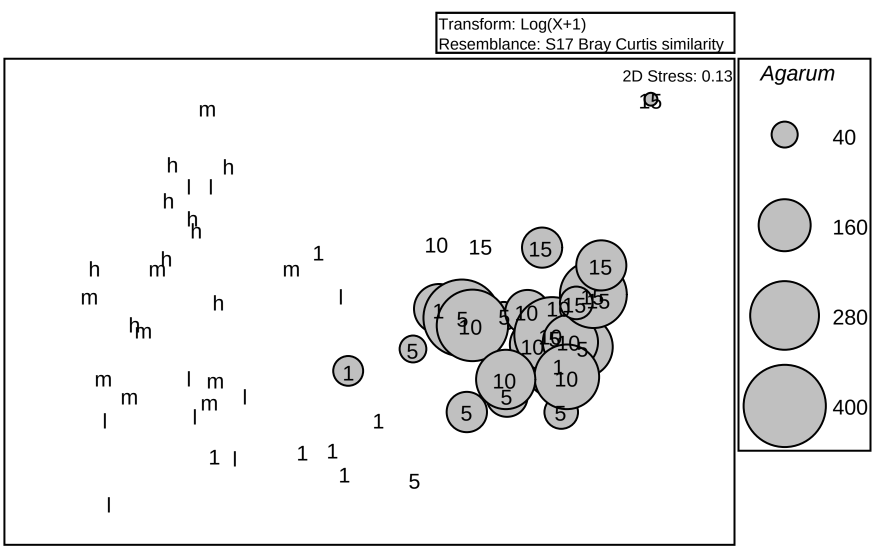

Figure 23. MDS ordination of macroalgal communities based on biomass showing importance of *Agarum* to subtidal communities. Abbreviations as in Figure 2.

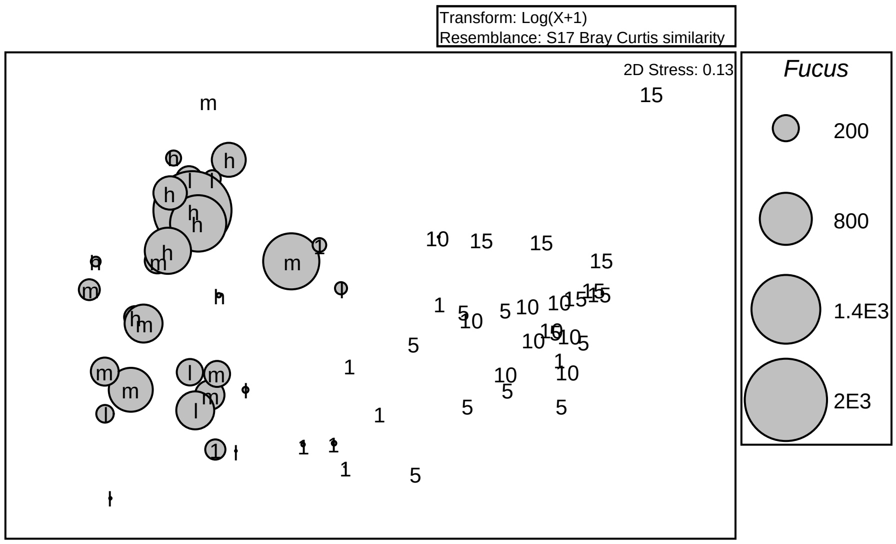

Figure 24. MDS ordination of macroalgal communities based on biomass showing importance of *Fucus* to intertidal communities. Abbreviations as in Figure 2.

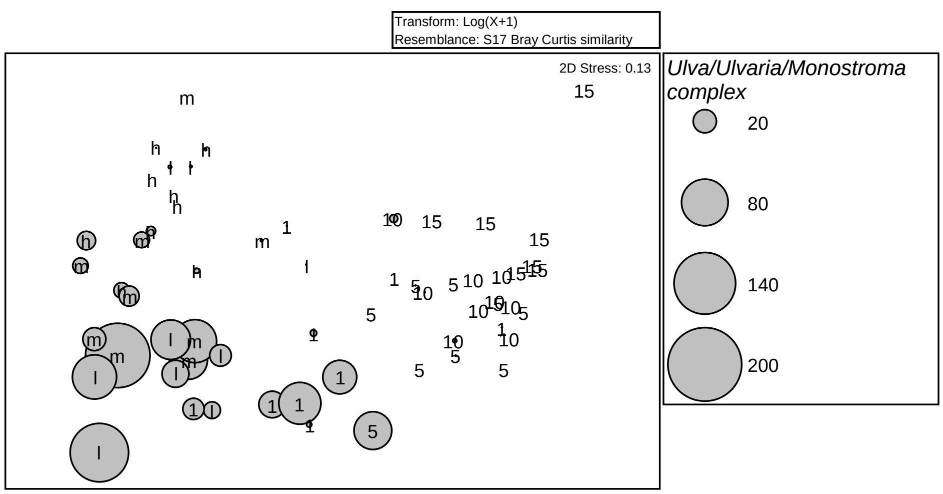

Figure 25. MDS ordination of macroalgal communities based on biomass showing importance of the *Ulva/Ulvaria/Monostroma* complex to lower intertidal communities. Abbreviations as in Figure 2.

Macroalgal stipe count data: Stipe counts for all Laminariales were enumerated within 1 x 1 m quadrats in 2003 and 2004 at all areas and sites. Based in these counts, analysis of community composition demonstrated two notable trends. First, many of the transects showed 0% similarity (Figures 26 and 27). These were primarily high and mid zones, which was expected because of the few number of kelp stipes found in this high intertidal area. The second trend was that at approximately 10% similarity, where the remaining intertidal sites separated from the subtidal sites. MDS ordination of communities (Figures 28 and 29) and subsequent ANISOM analysis of the similarity matrix showed that there were significant differences between communities based on stipe counts. For 2003, differences were among tidal heights (R=0.371) and between tidal regimes (R=0.299), but not between areas (R=0.067). Similar differences were found in 2004 among tidal heights (R=0.424) and between tidal regimes (R=0.372), but not between areas (R=0.005). The BVSTEP procedure revealed that when all years, areas, sites, and depth strata were combined, *Laminaria* and *Agarum* were important in structuring the subtidal community (except for Kachemak Bay 15m). This was evident in the MDS plots shown in Figures 30 and 31.

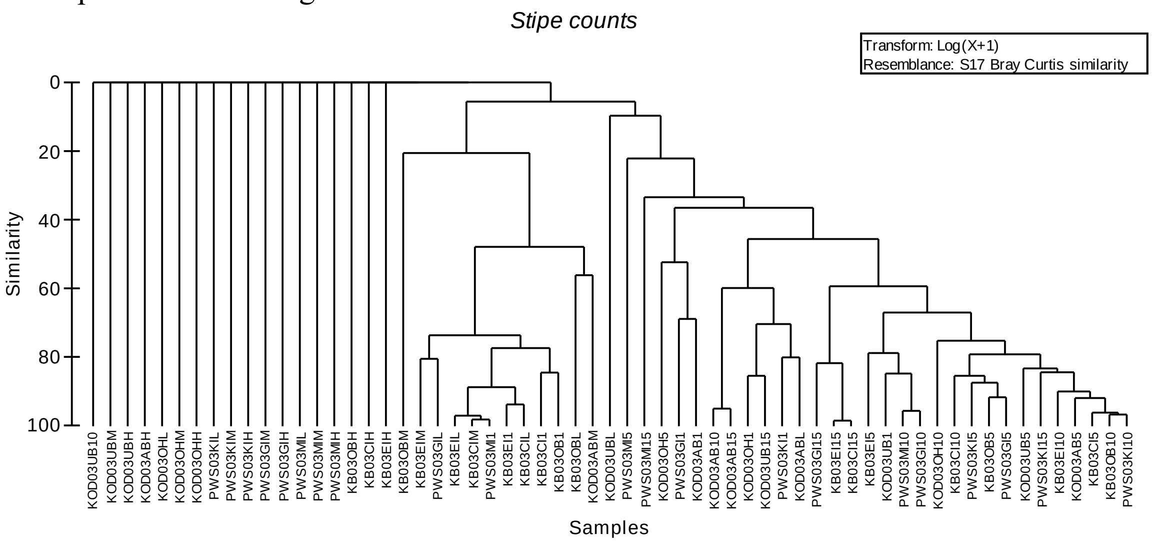

Figure 26. Cluster analysis on 2003 macroalgal stipe counts by site. Abbreviations as before.

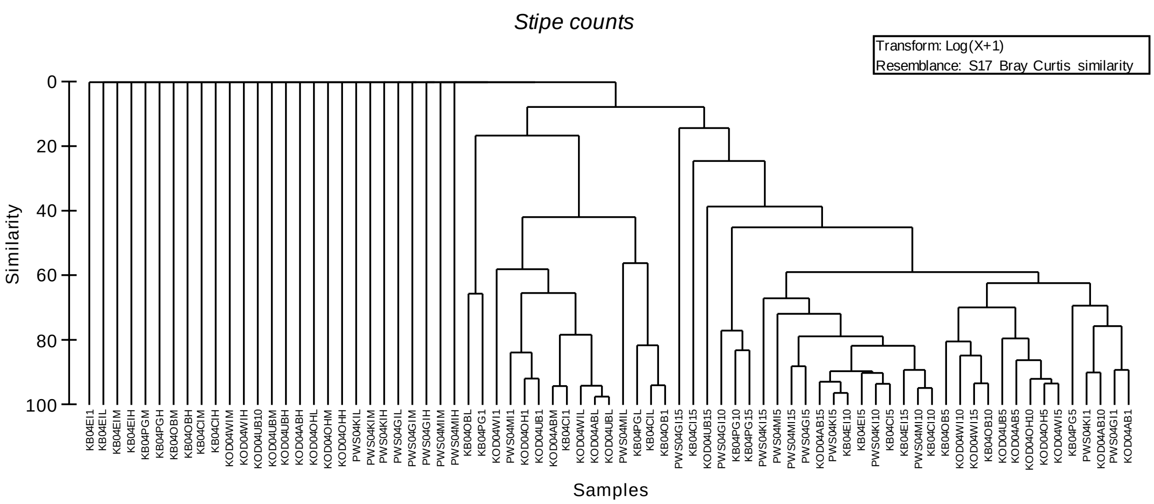

Figure 27. Cluster analysis on 2004 macroalgal stipe counts by site. Abbreviations as before.

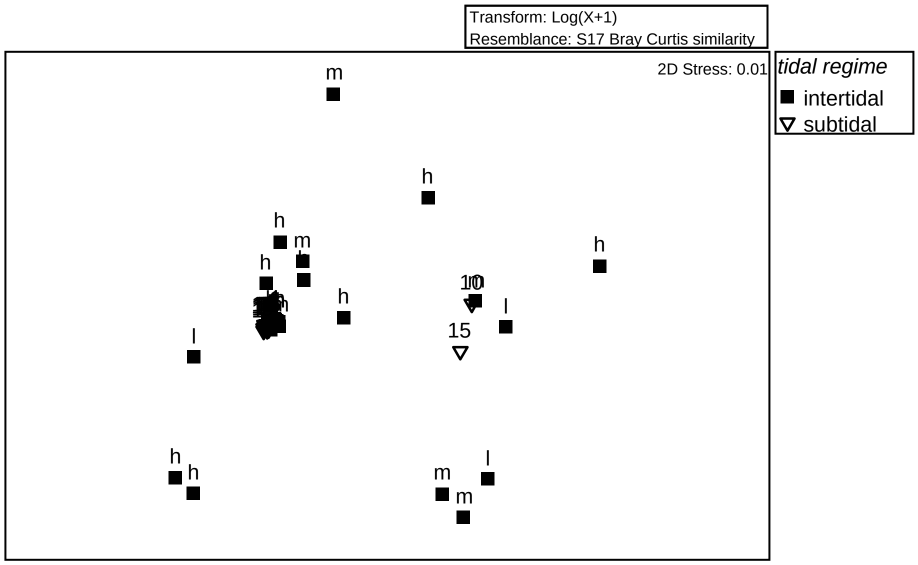

Figure 28. MDS ordination of 2003 macroalgal community based on kelp stipe counts. Abbreviations as before.

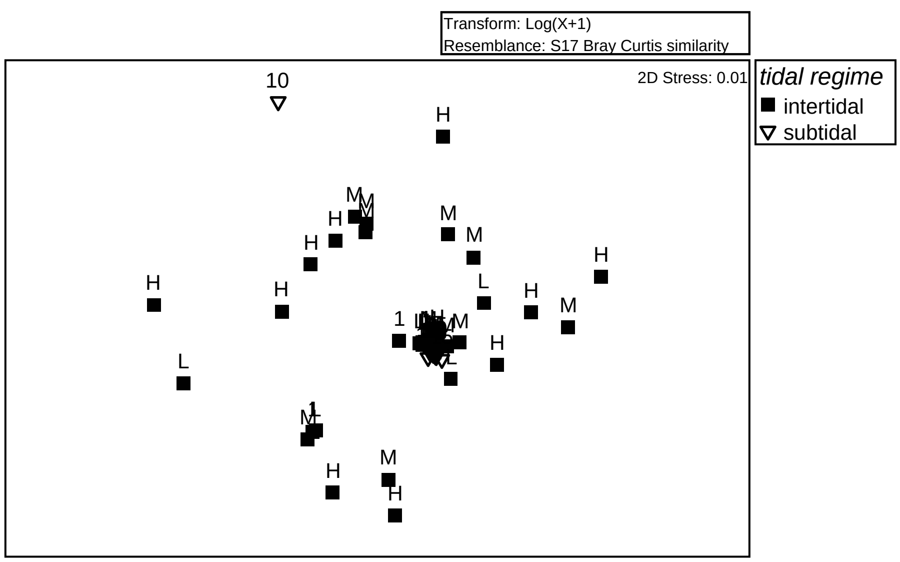

Figure 29. MDS ordination of 2004 macroalgal community based on kelp stipe counts. Abbreviations as before.

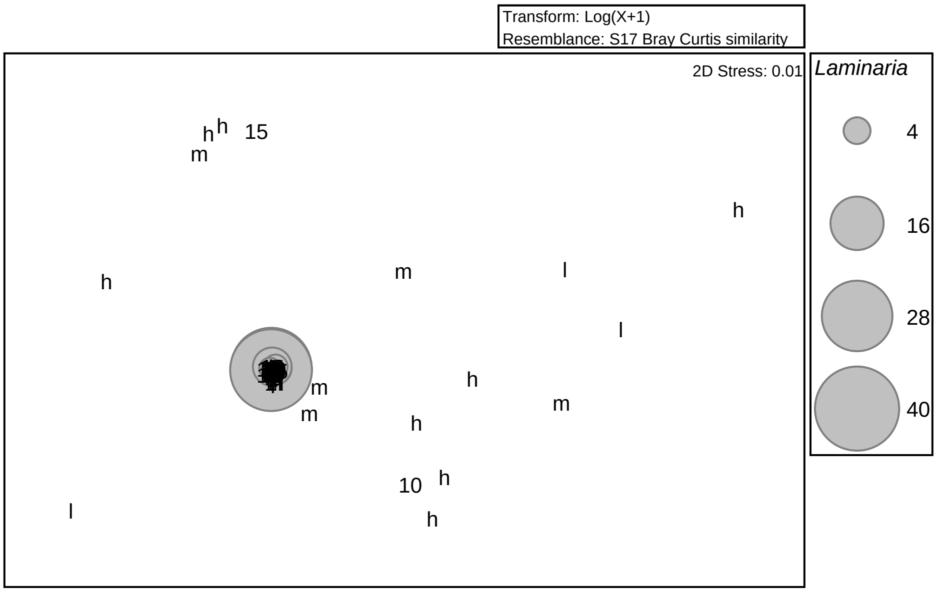

Figure 30. MDS ordination of 2003 macroalgal communities based on kelp stipe counts showing importance of *Laminaria* to subtidal communities. Abbreviations as in Figure 2.

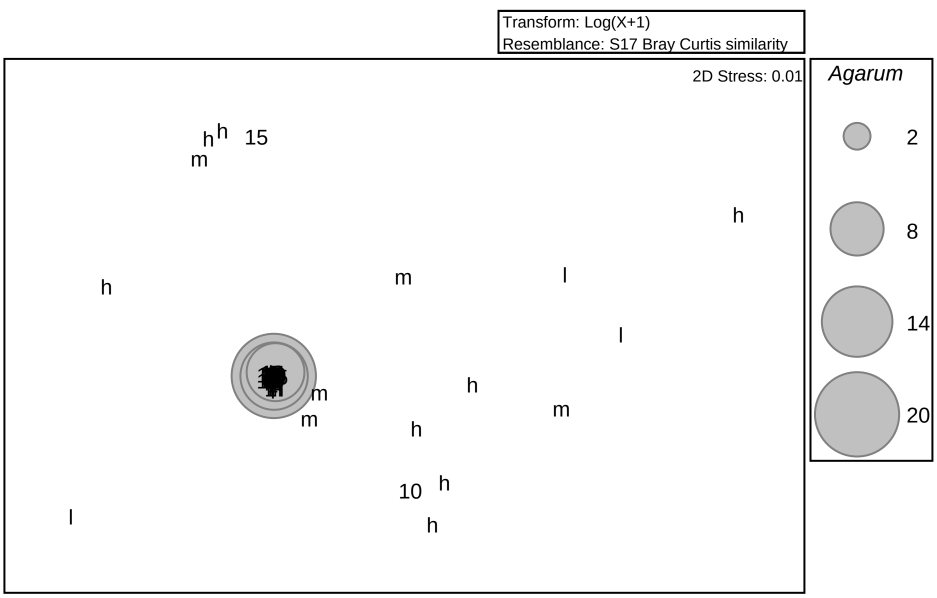

Figure 31. MDS ordination of 2003 macroalgal communities based on kelp stipe counts showing importance of *Agarum* to subtidal communities. Abbreviations as in Figure 2.

Percent cover estimates of sessile organisms: Percent cover of sessile organisms was estimated within 1 x 1 m quadrats in 2003 and 2004 at all areas and sites. Sessile organisms included the larger taxonomic groupings of macroalgae [Chlorophyta, Heterokontophyta (not including the Laminariales), and Rhodophyta], kelp (Laminariales only), seagrass, corallines (upright and encrusting), invertebrates (barnacles, mussels, and other encrusting invertebrates) and rock type (bare rock, sand/cobble, shell hash).

Analysis of the sessile community based on percent cover demonstrated the usual separation of the intertidal and subtidal communities (Figures 32 and 33). In 2003, intertidal and subtidal communities were less than 50% similar while in 2004, most intertidal groupings separated at approximately 30% with the remaining break at 55%. MDS ordination of the 2003 communities (Figure 34) and subsequent ANOSIM analysis of the similarity matrix showed that differences existed between tidal height (R=0.433) and tidal regime (R=0.433) but not among areas (R=0.145). Similar results were found for the 2004 communities (Figure 35). MDS ordination and subsequent ANOSIM analysis demonstrated that differences existed between tidal height (R=0.564) and tidal regime (R=0.683), but not among areas (R=0.115).

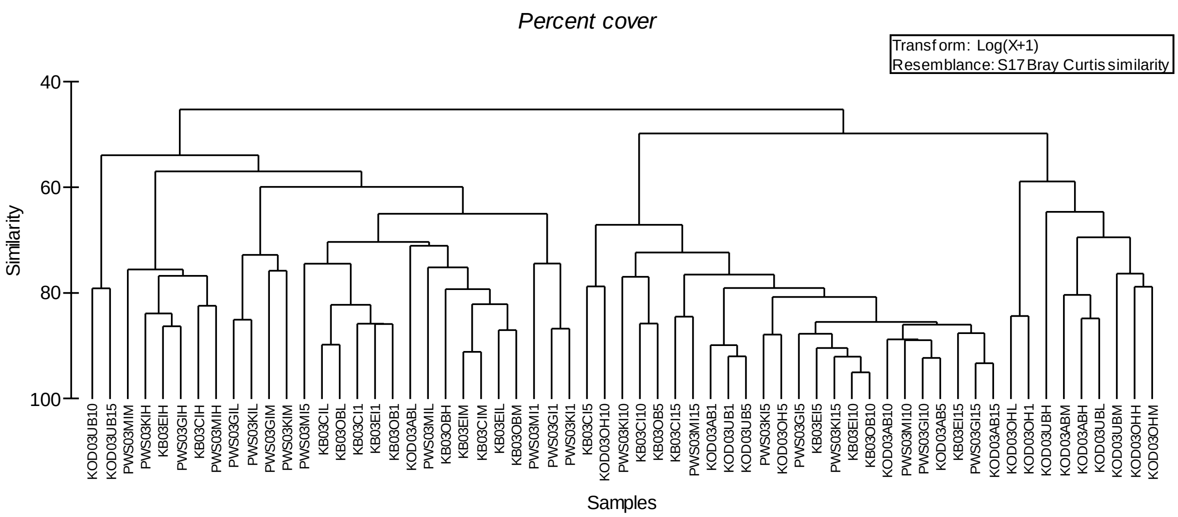

Figure 32. Cluster analysis on 2003 macroalgal percent cover estimates of sessile organisms by site. Abbreviations as before.

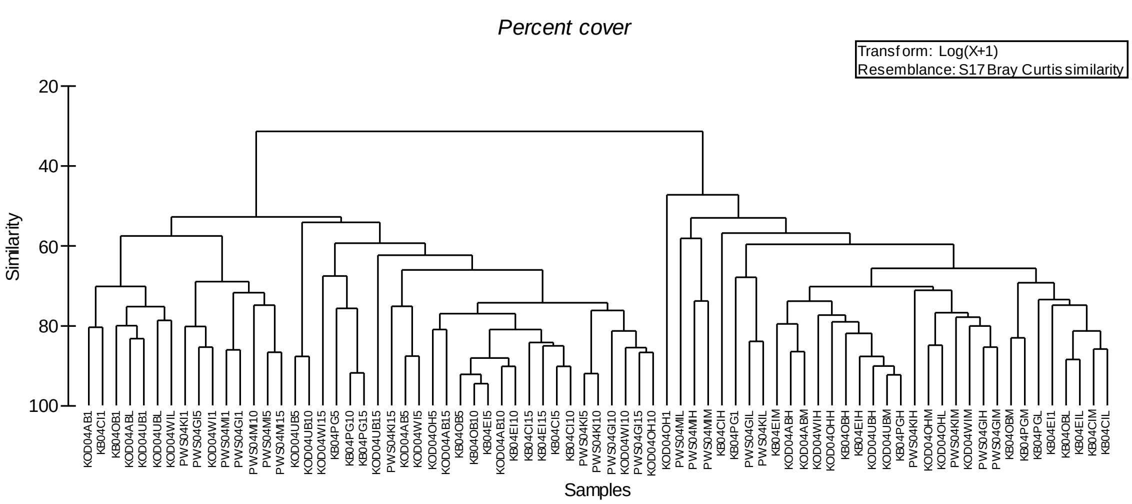

Figure 33. Cluster analysis on 2004 macroalgal percent cover estimates of sessile organisms by site. Abbreviations as before.

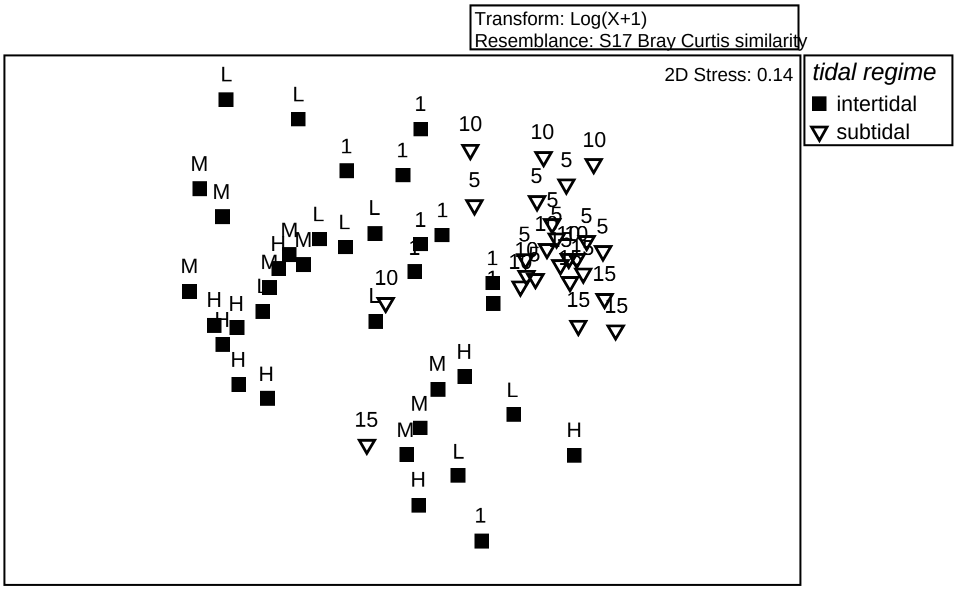

Figure 34. MDS ordination of 2003 macroalgal community based on percent cover estimates of sessile organisms. Abbreviations as before.

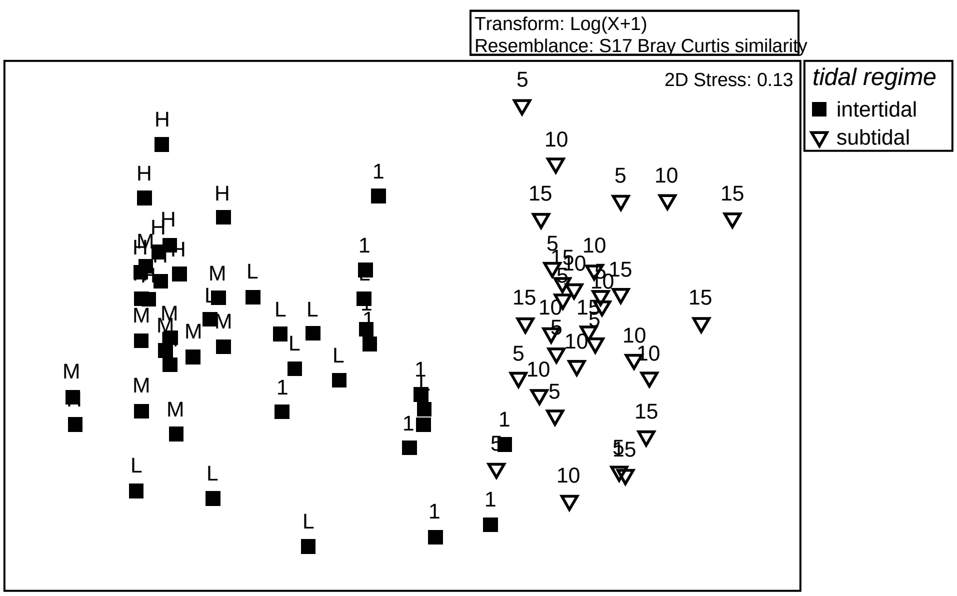

Figure 35. MDS ordination of 2004 macroalgal community based on percent cover estimates of sessile organisms. Abbreviations as before.

Analysis of the sessile community showed that different groups out of the fourteen possible were needed to explain 96% (for 2003) and 97% (for 2004) of the community structure (BVSTEP). In 2003, the important groups were the Laminariales, Rhodophyta, Heterokontophyta (not including the Laminariales), encrusting corallines, and rock. Similar groups were found for 2004, except other encrusting invertebrates were not as important as barnacles and sand/cobble. Laminariales are particularly important for subtidal communities, while barnacles are important for intertidal communities (Figures 36 and 37). Some groups, such as the red algae, are important for overall community structure (Figure 38).

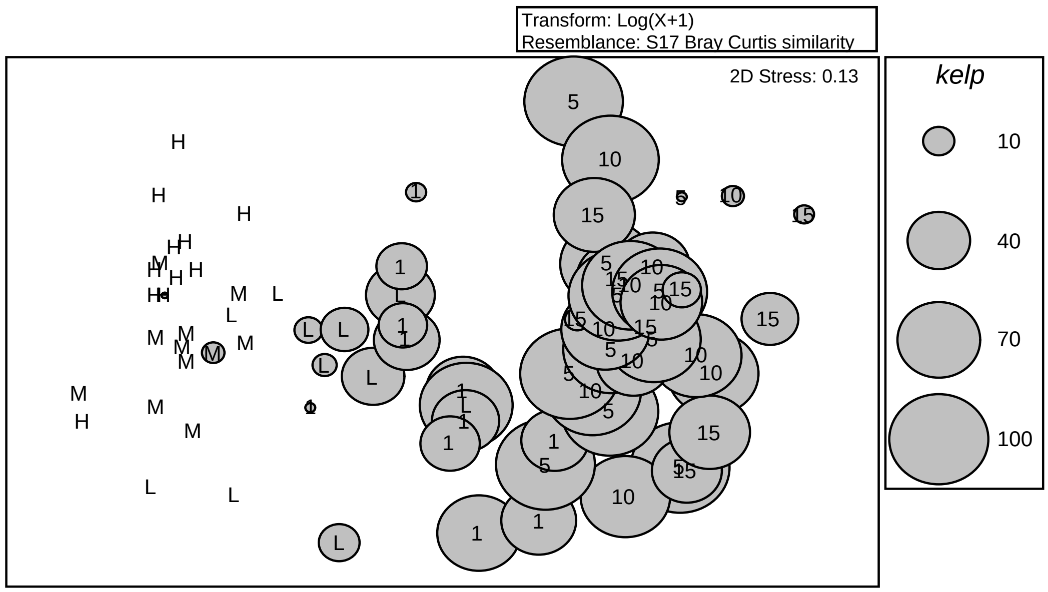

Figure 36. MDS ordination of 2004 macroalgal communities based on percent cover estimates of sessile organisms showing importance of Laminariales to subtidal communities. Abbreviations as in Figure 2.

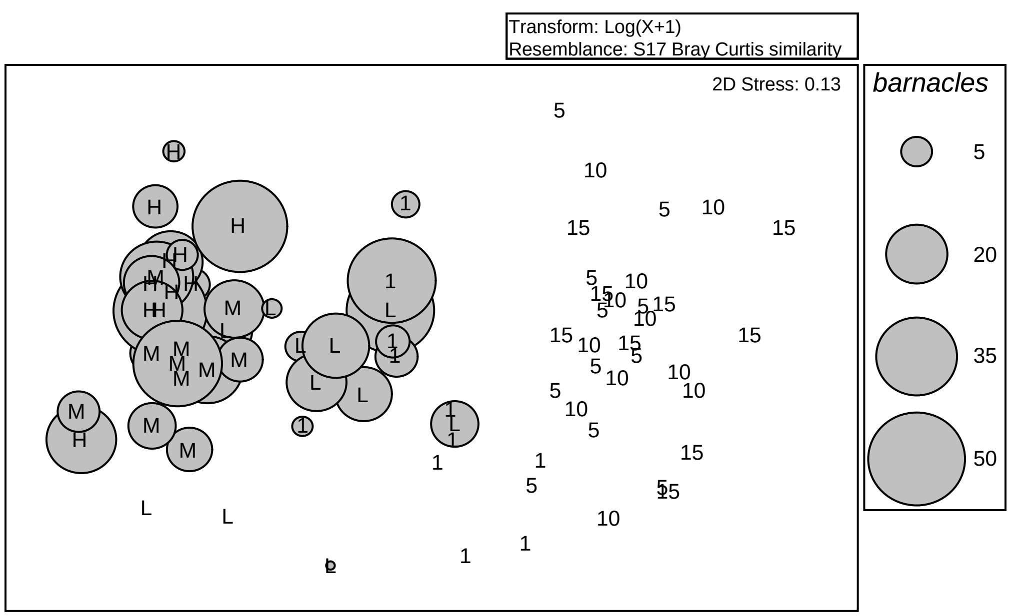

Figure 37. MDS ordination of 2004 macroalgal communities based on percent cover estimates of sessile organisms showing importance of barnacles to the intertidal communities. Abbreviations as in Figure 2.

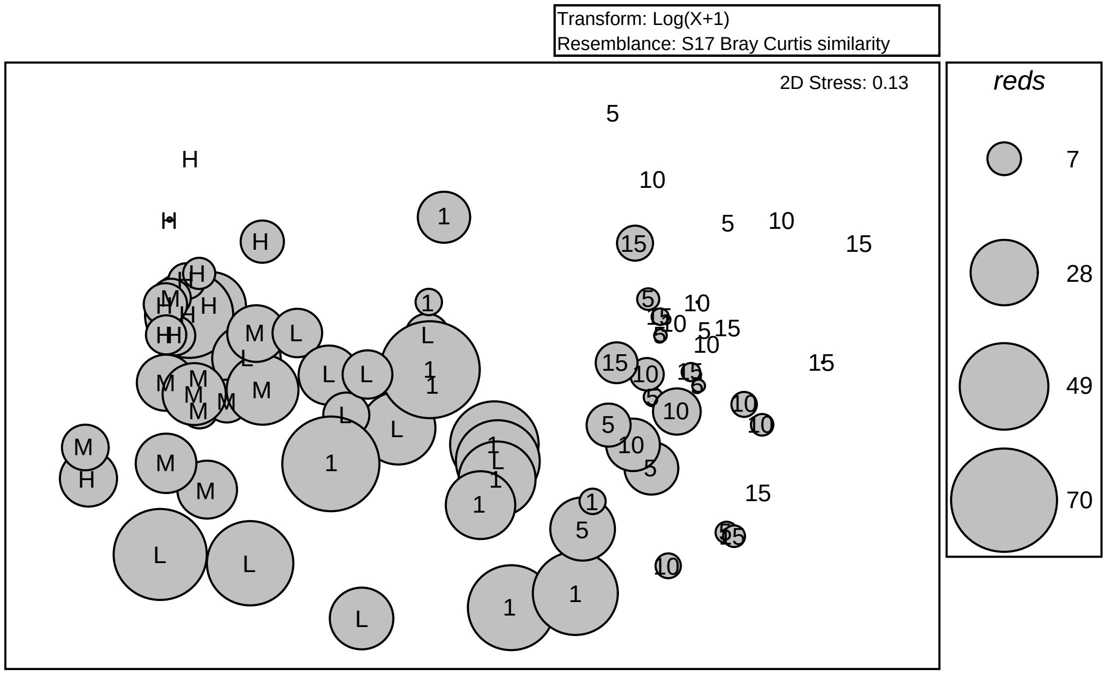

Figure 38. MDS ordination of 2004 macroalgal communities based on percent cover estimates of sessile organisms showing importance of red algae to overall community structure. Abbreviations as in Figure 2.

<u>Secondary Objective 2: Temporal variability:</u> Temporal variation was examined between 2003 and 2004 for macroalgal biomass, stipe counts, and percent cover of sessile organism. No significant differences were found between years in the Shannon Wiener diversity indices (p=0.8777), total amount of macroalgal biomass (p=0.6706), or total number of macroalgal taxa (p=0.5014). MDS ordination of the macroalgal community based on biomass and subsequent ANISOM demonstrated that there were no significant differences between years (R=0.029). MDS ordination based on stipe counts and subsequent ANISOM also showed that there were no significant differences between years (R=-0.011). Variation between years was explored for sessile community percent cover (MDS for each year is shown in Figures 33 versus 34). An ANOSIM analysis of the similarity matrix for 2003 and 2004 showed that no differences existed between years (R=0.07).

Comparisons of the important species structuring the macroalgal community between 2003 and 2004 revealed some differences and some similarities by area and tidal height (Appendices 12 and 13). One obvious point to note is that for all areas and both years, fewer species are important (ie needed to describe) for subtidal strata than intertidal strata (Table 4 and 5). Similarly, important species change more between years in the intertidal than the subtidal.

Based on an ANISOM analyses, stipe counts were not significantly different between years (R=-0.012). Stipe count cluster analyses and MDS ordinations for both years are shown in Figures 26-29.

Similar to all other temporal comparisons, percent cover of sessile organisms did not significantly differ by year (R=0.07, ANOSIM). However, visual comparisons of the cluster analyses and MDS ordinations for each year showed that there was a greater separation between the intertidal and subtidal communities in 2004 than 2003 (Figures 32-35).

Table 4. Matrix showing important macroalgal species in the intertidal for 2003 and 2004. PWS=Prince William Sound, KB=Kachemak Bay, KOD=Kodiak Island

			2003			2004
area	corr	# species	species	corr.	# species	species
PWS	0.957	8	*Ulva/Monostroma/Ulvaria* complex, *Alaria, Fucus, Laminaria, Neorhodomela/Odonthalia* complex, *Pterosiphonia, Tokidadendron*, upright corallines	0.952	9	*Ulva/Monostroma/Ulvaria* complex, *Fucus, Laminaria, Pilayella, Constantinea, Mazzaella/Mastocarpus* complex, *Neorhodomela/Odonthalia* complex, *Pterosiphonia*, upright corallines
KB	0.954	6	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Ulva/Monostroma/Ulvaria* complex, *Alaria, Fucus, Neorhodomela/Odonthalia* complex, *Palmaria*	0.955	7	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Ulva/Monostroma/Ulvaria* complex, *Fucus, Mazzaella/Mastocarpus* complex, *Neoptilota, Neorhodomela/Odonthalia* complex, *Palmaria*
KOD	0.954	5	*Ulva/Monostroma/Ulvaria* complex, *Desmarestia, Fucus, Laminaria, Neorhodomela/Odonthalia* complex	0.96	7	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Alaria, Desmarestia, Fucus, Neorhodomela/Odonthalia* complex, *Porphyra, Pterosiphonia*

Table 5. Matrix showing important macroalgal species in the subtidal for 2003 and 2004. PWS=Prince William Sound, KB=Kachemak Bay, KOD=Kodiak Island

			2003			2004
area	corr	# species	species	corr.	# species	species
PWS	0.958	4	*Agarum, Cymathere, Laminaria,* upright corallines	0.0953	4	*Agarum, Laminaria, Constantinea,* upright corallines
KB	0.957	5	*Codium, Agarum, Cymathere, Laminaria, Constantinea*	0.954	4	*Agarum, Laminaria, Neoptilota, Pterosiphonia*
KOD	0.952	3	*Agarum, Desmarestia, Laminaria*	0.956	3	*Agarum, Desmarestia, Laminaria*

Secondary Objective 3: Environmental parameters: Light attenuation was variable between sites and areas, particularly nearer the surface (Figure 39). The large variation below the surface and at 1m is probably largely due to conditions on the surface (ie sunny versus overcast day). An interesting note is that at deeper depths (10m and 15m), very little variation is seen. At no depth were the differences between areas significant (p=0.609).

Surface salinity was variable in 2004, ranging from 22ppt at Old Harbor in Kodiak to 31ppt around Green Island in Prince William Sound. Readings were only done on one day so they are very dependent on the daily conditions, such as precipitation, proximity of freshwater streams, tidal cycle, and currents. Salinity readings were not taken in 2003.

Temperature data demonstrated obvious differences between intertidal and subtidal zones. An example of this is illustrated in Figure 40 with a mid tidal profile shown against a 15m profile from Cohen Island, Prince William Sound. Important to note is that much more daily and overall variation occurs in the intertidal compared to subtidal zone.

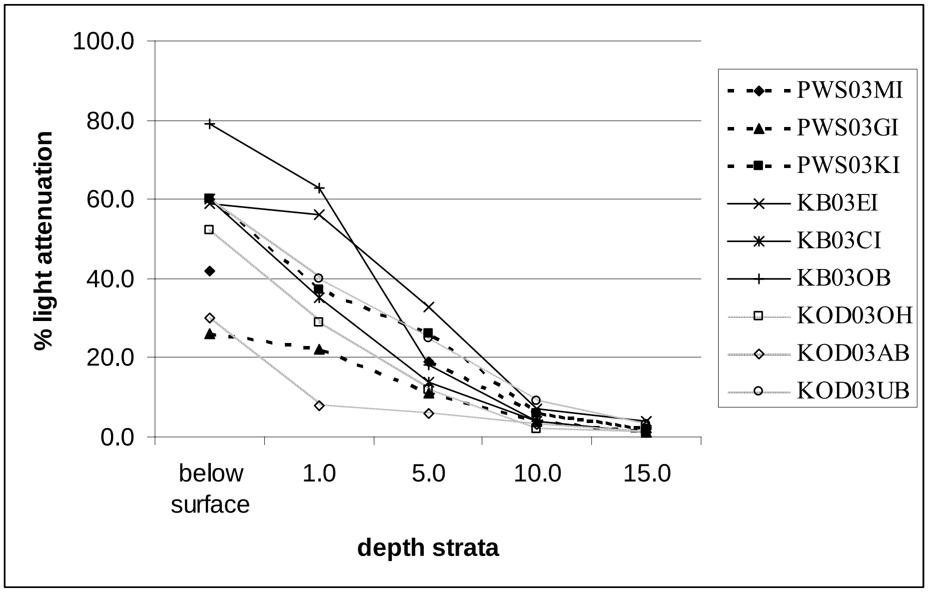

Figure 39. Percent light attenuation for 2003 at each site. Abbreviations as before.

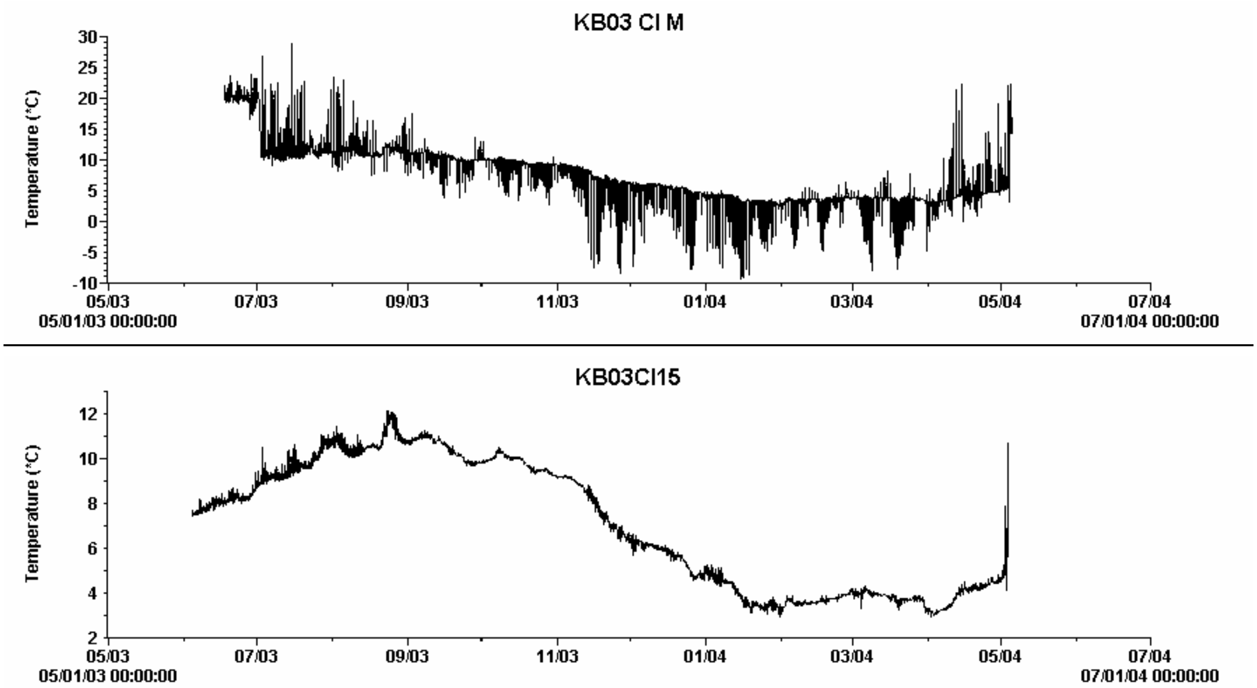

Figure 40. Temperature profiles for Kachemak Bay, Cohen Island in 2003. Top graph represents the midtidal zone, while the bottom graph represents 15m. The spike at the end of each graph is when the datalogger was brought to the boat and subsequently downloaded.

Secondary Objective 4: Capacity building: This project had a strong outreach component, which resulted in much capacity building. At the onset of the project, initial site selection in all areas was done in collaboration with the local communities and scientists with past and present research in the area. 2004 site changes in Kachemak Bay were initiated by discussions with the native community and scientists during the 2003 Wisdomkeeper Workshop in Port Graham. The new site in Port Graham Bay was chosen in collaboration with the GEM-funded "Bidarki" project by Anne Solomon and Jennifer Ruesink (University of Washington). Likewise, one of our 2004 Kodiak sites was changed so that we would have one site close to the town of Kodiak and logistically easier to involve school kids in any future sampling.

Along with site selection, sampling also involved community and K-12 groups and university classes. In Kachemak Bay and Kodiak Island, local and native communities were involved in the intertidal sampling. In Kachemak Bay specifically, we received assistance from the Boys and Girls Club, while in Kodiak, we involved native communities. In all areas, University of Alaska Fairbanks summer classes (Kelp Forest Ecology and the Marine Biology and Ecology Field Course) were involved in sampling of all sites.

Outside of the field work, our outreach efforts also involved presentations. Several presentations about the NaGISA project with focus on Alaska were made in native communities (e.g., Port Graham), at local/coastal high schools (e.g., Seldovia High School during Sea Days), and at non-coastal K-12 schools (e.g., Pearl Creek Elementary in Fairbanks). Outreach also was extended to the scientific community, where presentations were made at various meetings and symposiums, including the annual science meetings in Anchorage (2004 and 2005), Alaska Forum on the Environment in Anchorage (2004), international NaGISA Steering Group meetings (2003 and 2004), Western Society of Naturalists meeting in Monterey, CA (2002 and 2003), Arctic Biodiversity Workshop in Fairbanks (2003), and the Northwest Algal Symposium in Canada (2003).

Discussion: Two years of sampling invertebrate and macroalgal communities in three distinct areas in the Gulf of Alaska resulted in an excellent description of overall community structure. We report 242 invertebrate and 237 macroalgal species/taxonomic groups for our sampling effort (Appendices 1-4). A previous study in Prince William Sound that spanned 26 sites over a five year period (1989-1995) reported 499 invertebrate species (Foster and Hoberg 2003). Although both of these studies sampled quantitatively, the reason for the greater number of species found in the Foster and Hoberg study was probably due to the sampling effort (three sites for two years versus 26 sites for five years) but more importantly to the degree to which organisms were identified. This current study only had invertebrate taxonomists for the mollusks and polychaetes, resulting in many organisms not being identified to the species level. If funding was available for more taxonomists for this NaGISA study (particularly for various crustacean groups), the number of species would increase dramatically.

A website for Kachemak Bay has documented 407 species of marine invertebrates and 155 species of macroalgae (http://www.habitat.adfg.state.ak.us/geninfo/kbrr/coolkbayinfo/kbec_cd/html/ecosys/species/sppintro.html). While the invertebrate species numbers presented in the NaGISA study are low compared to this web site list, our macroalgal list is comparable. Out of our 237 macroalgal species/taxonomic groups in this current study, 160 were found in Kachemak Bay (Appendix 4).

It should be noted that because the website list is cumulative and not quantitative, the number of species would naturally be high.

In waters around Kodiak (from the intertidal to any depth within one day steam of the town of Kodiak-including the Alaska Peninsula), 750 species of invertebrates and macroalgae have been recorded (http://www.afsc.noaa.gov/kodiak/facilities/Kodiakspeclist.pdf). This list is much longer than that reported in this NaGISA project but the Kodiak list includes many organisms that would not be sampled under the NaGISA protocol because of depth limitations, such as those found in the seamounts 250 miles off of Kodiak. This Kodiak list also is non-quantitative and cumulative over many years.

Overall invertebrate communities that were sampled in this NaGISA project were best described by bivalves, balanoids, gastropods, polychaetes, asteroids, and bryozoans. Interestingly, these taxa that explained biomass patterns also explained abundance patterns, except for bryozoans and barnacles as these were not included in the abundance analysis. Abundance patterns, however, required nearly double the amount of species to explain 95% of the observed patterns. This is due to the much larger differences in biomass than abundance, where the biomass of single taxa overpowers the remaining community. While biomass is very valuable in detecting these dominant groups and also is important to include those groups that are not enumerable into the analysis, abundance data seems to be more evenly distributed and give a similar but more finely structured picture of community analysis. The shortcomings of abundance data can be overcome in monitoring applications where percent cover of organisms can replace abundance and thus include encrusting or colonial organisms.

Macroalgal communities differed greatly among sites and depths according to the biomass data. Important macroalgal species were acknowledged by tidal regime and site (Tables 4 and 5), however it is recommended that specific species and complexes, such as those given in Appendix 12 and 13 be used for monitoring purposes. Interestingly, kelp biomass and stipe counts gave similar information as far as important species. Because destructive sampling is time consuming, stipe counts appear to be a much more efficient way to get the same information on the kelp as does destructive sampling.

Compared to the invertebrate community, algal communities were less similar across sites. Cluster analyses revealed that algal communities were typically never more than 80% similar between sites, but usually closer to 50% (Figure 19 and 20), whereas invertebrate communities were typically never more than 90% similar but usually closer to 80% similar (Figure 2). These analyses demonstrate that if resources are limited and only certain taxonomic groups can be monitored, macroalgal communities will offer a more distinct picture of sites because of the more dissimilar communities. It must be noted though that the important macrolagal species/taxonomic groups that structure the community is site and depth dependent (Appendices 12 and 13).

Another interesting result in this study came from the diversity indices analyses (Appendices 7-11). Data demonstrated that mollusks and polychaetes had higher diversity indices in the subtidal than intertidal zones. This is in contrast to the macroalgal community, where higher indices were seen in the intertidal, particularly the mid through 1m zone, than the subtidal zone. This infers that higher macroalgal diversity does not necessarily correspond to higher invertebrate diversity. If monitoring programs are interested in overall community diversity, it is important to note that biodiversity inferences can not be made between different taxonomic groups and all groups must be monitored equally.

This study has shown that targeted species and depth strata are imperative for any monitoring effort. One of the key results of this study was the BVSTEP analysis for important species structuring the communities. Targeted lists now exist for mollusks (Tables 2 and 3), polychaetes (see Polychaete data section), and macroalgae (Tables 4 and 5 and Appendices 12 and 13, depending on desired detail). We also provide a summary table for invertebrates, fish, and other parameters, along with their ideal measuring units, which can and should be used for future monitoring efforts (Appendix 14). Macroalgae are not included in this appendix as detailed lists for this group have been provided elsewhere (Tables 4 and 5 and Appendices 12 and 13) but it should be noted that macroalgal measuring units should be percent cover on targeted species. Using these target lists is particularly important for macroalgae, since these are typically harder for field workers to identify. We found that descriptors that are commonly used, such as “kelp”, “red algae” or “green algae” do not successfully describe communities and should not be used for monitoring purposes. As example, the primary canopy forming “kelp” species has changed over the last 30 years in Kachemak Bay from *Alaria fistulosa* to *Nereocystis luetkeana* (Lees and Driskell 1980, 1981). This change is discussed to be due to global warming (Sandra Lindstrom, pers comm.). If “kelp” were the monitoring unit, this change would not be detected.

While the destructive sampling was very useful and provided a plethora of data, the initial non-destructive sampling was lacking in detail. This was primarily because of the monitoring unit that was chosen. As example, percent cover of Chlorophyta was estimated in the non-destructive sampling. Ecologically and functionally, there is much variation in this phyla. Some areas had high concentrations of the *Ulva/Monostroma/Ulvaria* complex, while others were dense with the *Acrosiphonia/Cladophora/Rhizoclonium* complex. The *Ulva* complex includes the weedy Sea Lettuce. This complex is typically very thin (1 to a few cell layers thick), and as such has very fast growth rates but is susceptible to grazers. The *Acrosiphonia* complex typically is longer lived, strand-like, and a later colonizer than the *Ulva* complex. The difference in structure alone makes these two complexes ecologically and functionally very different (one sheet-like and one strand-like). The strand-like structure of the *Acrosiphonia* complex is more storm and grazer resistant, and offers much microhabitat to small invertebrates, particularly amphipods. By monitoring only the Chlorophyta, changes in the green algal community, which might influence other parts of the community, would be missed.

Overall, no temporal differences were found with the analyzed data. 2003 and 2004 showed similar trends for macroalgal communities based on biomass and stipe counts, and for sessile organisms. It should be noted that a lack of temporal differences for the sessile organisms may have been due to the broad taxonomic groups that were used for the analysis. A more detailed analysis with more finely targeted species may have found different results. Interestingly though, no significant differences were seen with the more targeted biomass measurements. This suggests that for long-term monitoring, sites may not need to be sampled on a yearly basis, however, more data are needed to determine the ideal sampling interval.

Physical data were interesting but supplied little information that could be used to correlate to community patterns. Light and salinity data were only taken on the day of sampling so variation is large because these parameters can fluctuate hourly, daily, etc. The results of this study recommend that if possible, dataloggers should be used to obtain year-long and hence more accurate information. Also, one year is insufficient time to make valid comparisons between community structure and physical parameters. We suggest that light, salinity, and temperature be monitored over multiple years with dataloggers if correlations to community structure are expected to be examined.

Capacity building and outreach was very successful throughout this project, from site selection to sampling, to presenting results. The NaGISA project was found to be particularly well suited for community, K-12, and university student involvement for field collections. While intertidal scrapings do take time, it is an ideal situation to bring researchers, students, and the public together working towards a bigger goal. Interactions in the field benefit everyone by making the community part of the project. Likewise, the NaGISA project is an excellent model to take to the community and classes to introduce biodiversity and the need for monitoring and conserving our nearshore regions.

Conclusions: This project demonstrated the high diversity associated with nearshore rocky ecosystems in the Gulf of Alaska. Four hundred and seventy nine species/taxonomic groups were sampled in our destructive quadrats over the two year period of this study (2003 and 2004). Because these data were obtained from quantitative, standardized protocols, they can be used as a baseline for future comparisons. In fact, we would recommend that this sampling be repeated at 5-10 year intervals to monitor overall biodiversity in the Gulf of Alaska.

While the destructive sampling was very informative, we found that the initial non-destructive sampling was lacking in detail. At the onset of this project, we were unclear about which species/taxonomic groupings should be targeted in the non-destructive sampling, and as such, we used general taxonomic units. We could have obtained better data with clearer trends and more useful information for monitoring purposes had we known which species/taxonomic grouping to target. Based on the BVSTEP analysis that we were able to do with the destructive sampling, we have now determined which species are important in structuring communities, and therefore useful for future monitoring. A list of recommended target groups and measuring units is given in Appendices 12, 13, and 14. A note should be made that repeated destructive sampling at 5-10 years spans will allow the updating of these targeted lists.

Overall, large differences were seen in community structure between subtidal and intertidal communities, including some physical parameters, such as temperature. Analysis of community structure demonstrated that communities within the core study areas of Prince William Sound, Kachemak Bay, and Kodiak Island always clearly separated out between intertidal and subtidal communities, independent of which taxon grouping was considered. This is important as it clearly indicates that intertidal and subtidal communities are very different in all aspects of their structure and that no or only very limited inferences can be made from one to the other tidal regime. One important application of this is the development of a monitoring plan of the Gulf of Alaska nearshore region under the GEM program. The GEM program defines the nearshore region as the intertidal and shallow subtidal zone to 20m depth. This project showed that this definition reflects well the biological characteristics of this nearshore region and should be maintained for future programmatic planning.

For a successful monitoring program to correlate physical parameters to community structure, dataloggers for these parameters must be used year-round and for multiple years. This study was unable to make such correlations due to the large variability associated with one-day recordings. Physical parameters, such as light, salinity, and temperature are important and should be considered for future monitoring efforts.

Future monitoring efforts should include community and school involvement. NaGISA was found to be an ideal model for these types of interactions. Whatever type of monitoring that GEM decides to pursue should involve local communities, K-12, and university students at various levels.

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Sandra Lindstrom, Department of Botany, #3529 - 6270 University Blvd. University of British Columbia, Vancouver, BC, Canada V6T 1Z4

Appendix 1. Invertebrate species list for 2003.

Taxonomic affiliation		Prince William Sound			Kachemak Bay			Kodiak Island		
		Montague	**Green**	**Knight**	**Outside B.**	**Cohen**	**Elephant**	**Uyak**	**Old Harbor**	**Alitak**
Porifera	Porifera indet	x	x	x	x	x	x	x	x	x
	Halichondria panicea	x	x			x			x	x
	Suberites suberea									x
Cnidaria										
Hydrozoa		x	x		x	x	x	x	x	x
	Hydractinia milleri			x	x					
	cf Abietinaria sp						x		x	x
Anthozoa										
	Actinaria	x	x	x	x	x	x	x		x
	Stauromedusae				x	x			x	
Nematoda		x	x	x	x	x	x	x	x	x
Platyhelminthes		x	x	x	x	x	x	x	x	x
Sipuncula		x	x	x						x
Nemertea		x	x	x	x	x	x	x	x	x
Mollusca		x	x	x	x	x	x	x	x	x
Annelida										
Polychaeta		x	x	x	x	x	x	x	x	x
Oligochaeta		x	x	x		x			x	x
Crustacea										
Cirripedia		x	x	x	x	x	x	x	x	x
Copepoda		x	x	x	x	x	x	x	x	x
Tanaidacea		x	x	x	x	x	x	x	x	x
Cumacea		x	x	x			x		x	x
Ostracoda		x	x		x	x	x	x	x	x
Isopoda		x	x	x	x	x	x	x	x	x
Amphipoda		x	x	x	x	x	x	x	x	x
	Caprellidae	x	x	x	x	x	x	x	x	x
Euphausiacea		x	x	x		x		x		
Decapoda										
	Brachyura	x	x	x		x				x
	Pugettia spp	x	x	x	x	x	x	x	x	x
	Oregonia gracilis		x		x					
	Cancer oregonensis	x	x	x	x	x	x	x	x	x
	Cryptolithodes spp		x			x				
	Thelmessus cheiragonus	x		x						
	Paguridae	x	x	x	x	x	x	x	x	x
Insecta		x	x	x	x	x	x	x	x	x

Taxonomic affiliation		Prince William Sound Montague	 Green	 Knight	Kachemak Bay Outside B.	 Cohen	 Elephant	Kodiak Island Uyak	 Old Harbor	 Alitak
Chelicerata	Euchelicerata	x	x	x	x	x	x	x	x	x
	Pycnogonidae	x								
Echinodermata										
Asteroidea										
	Asteroidea indet				x			x		
	Leptasterias hexactis	x	x	x	x	x	x	x	x	x
	Evasterias troschelli	x	x	x		x	x	x		x
	Pycnopodia helianthoides	x	x	x				x		x
	Henricia leviuscula		x				x			x
	Solaster stimpsoni					x				x
	Dermasterias imbricata		x	x						x
	Crossaster papposus		x							
	Orthasterias koehleri	x	x							
Ophiuroidea										
	Ophiuroidea indet	x	x	x	x	x	x	x	x	x
	Ophiopholis aculeata	x	x	x	x	x	x	x	x	x
Holothuroidea										
	Holothuroidea indet				x	x	x	x	x	x
	Cucumaria vegae	x	x	x	x	x	x	x	x	x
	Parastichopus californiensis							x		
Echinoidea										
	Echinoidea indet			x		x	x	x	x	x
	Strongylocentrotus droebachiensis		x			x	x	x	x	x
Bryozoa										
	Bryozoa indet	x	x	x	x	x	x	x	x	x
	Heteropora sp	x		x					x	x
	Microporina borealis	x	x	x		x				x
	Flustrellidae				x	x				x
Brachiopoda						x				
Ascideacea	solitary		x			x				
	colonial	x	x	x		x	x	x	x	x
	Didemnum album	x			x	x				
Pisces										
	Pisces indet	x	x						x	
	Stichaeidae/Pholidae	x	x	x	x	x	x			
	Scorpaenidae		x							
	Liparidae				x		x	x		

(indet: not determined further)

Appendix 2: Mollusk Species List for 2003.

GASTROPODA		Prince William Sound			Kachemak Bay			Kodiak Island		
Family	**Species**	**Montague**	**Green**	**Knight**	**Outside B.**	**Cohen**	**Elephant**	**Uyak**	**Old Harbor**	**Alitak**
Archaeogastropoda										
FISSURELLIDAE	Puncturella sp		x							
FISSURELLIDAE	Puncturella cooperi									x
FISSURELLIDAE	Puncturella cucullata			x						
FISSURELLIDAE	Puncturella galatea									x
FISSURELLIDAE	Puncturella multistriata	x								
ACMAEIDAE	Acmaea mitra	x	x	x	x	x	x	x	x	x
ACMAEIDAE	Collisella triangularis								x	
LOTTIIDAE		x	x	x	x	x	x		x	
LOTTIIDAE	Lottia sp	x	x	x	x	x	x		x	
LOTTIIDAE	Lottia borealis	x	x	x		x	x	x	x	x
LOTTIIDAE	Lottia digitalis	x	x			x	x	x		x
LOTTIIDAE	Lottia instabilis					x				
LOTTIIDAE	Lottia pelta	x	x	x	x	x	x	x	x	x
LOTTIIDAE	Lottia ochracea	x	x	x	x		x		x	x
LOTTIIDAE	Lottia triangularis			x					x	
LOTTIIDAE	Tectura sp							x		
LOTTIIDAE	Tectura pelta		x	x						
LOTTIIDAE	Tectura persona	x						x		
LOTTIIDAE	Tectura fenestrata	x								
LOTTIIDAE	Tectura scutum	x	x	x	x	x	x	x	x	x
LEPETIDAE			x							
LEPETIDAE	Cryptobranchia sp						x			x
LEPETIDAE	Cryptobranchia alba							x	x	
LEPETIDAE	Cryptobranchia concentrica	x			x	x		x	x	x
SIPHONARIIDAE	Siphonaria thersites	x	x	x	x	x	x	x		x
PATELLACEA									x	x
CALLIOSTOMATIDAE	Calliostoma ligatum	x	x		x	x			x	
TROCHIDAE			x		x					
TROCHIDAE	Lirularia lirulata	x	x	x						
TROCHIDAE	Lirularia succincta	x	x							
TROCHIDAE	Margarites sp	x				x	x	x		x
TROCHIDAE	Margarites beringensis	x	x	x		x	x			
TROCHIDAE	Margarites marginatus	x	x	x	x					x
TROCHIDAE	Margarites pupillus	x	x	x	x	x	x	x	x	x
TURBINIDAE	Homalopoma subobsoletum		x						x	

GASTROPODA		Prince William Sound			Kachemak Bay			Kodiak Island		
Family	**Species**	**Montague**	**Green**	**Knight**	**Outside B.**	**Cohen**	**Elephant**	**Uyak**	**Old Harbor**	**Alitak**
Mesogastropoda										
LITTORINIDAE	Lacuna sp	x	x	x	x		x	x	x	x
LITTORINIDAE	Lacuna marmorata								x	
LITTORINIDAE	Lacuna variegata		x					x	x	x
LITTORINIDAE	Lacuna vincta	x	x	x	x	x	x	x	x	x
LITTORINIDAE	Littorina aleutica						x			
LITTORINIDAE	Littorina scutulata	x	x	x		x	x	x	x	
LITTORINIDAE	Littorina sitkana	x	x	x	x	x	x	x	x	x
RISSOIDAE			x			x	x			x
RISSOIDAE	Alvania sanjuanensis		x	x			x			
RISSOIDAE	Cingula katherinae	x	x	x		x	x	x	x	x
RISSOIDAE	Onoba carpenteri	x	x	x	x	x	x	x	x	x
EULIMIDAE				x						
EULIMIDAE	Balcis sp	x							x	
CAECIDAE	Caecum crebricinctum	x								
CALYPTRAEIDAE	Crepidula sp			x	x	x				
CALYPTRAEIDAE	Crepidula nummaria				x					
CALYPTRAEIDAE	Crepipatella dorsata	x	x	x		x		x	x	
CALYPTRAEIDAE	Crepipatella lingulata			x						
CALYPTRAEIDAE	Crepipatella nummaria								x	
CAPULIDAE	Trichotropis sp					x	x	x	x	x
CAPULIDAE	Trichotropis cancellata	x	x	x	x	x	x	x	x	x
CAPULIDAE	Trichotropis insignis	x	x	x						
RANELLIDAE	Fusitriton oregonensis				x					
VITRINELLIDAE	Vitrinella columbiana	x		x	x	x	x	x		x
CERITHIIDAE		x	x	x						
CERITHIIDAE	Stylidium eschrichtii		x	x						
VELUTINIDAE	Velutina	x								
CERITHIOPSIDAE	Cerithiopsis stejnegeri	x	x	x	x	x			x	x

GASTROPODA		Prince William Sound			Kachemak Bay			Kodiak Island		
Family	Species	Montague	Green	Knight	Outside B.	Cohen	Elephant	Uyak	Old Harbor	Alitak
Neogastropoda										
BUCCINIDAE	Buccinum baeri	x					x			
BUCCINIDAE	Lirabuccinum dirum	x	x	x	x	x	x		x	x
MURICIDAE		x	x						x	
MURICIDAE	Boreotrophon clathratus	x	x							
MURICIDAE	Boreotrophon multicostatus				x					x
MURICIDAE	Boreotrophon stuarti						x			
MURICIDAE	Nucella sp					x				x
MURICIDAE	Nucella canaliculata	x				x				
MURICIDAE	Nucella lamellosa	x	x		x					x
MURICIDAE	Nucella lima	x	x				x	x	x	
MURICIDAE	Ocinebrina interfossa	x	x	x	x	x			x	
MURICIDAE	Scabrotrophon maltzani	x	x		x	x	x			x
CONIDAE	Oenopota sp						x			
CONIDAE	Oenopota levidensis		x							
CONIDAE	Oenopota tabulata					x				
NASSARIIDAE	Nassarius mendicus	x		x						
COLUMBELLIDAE	Alia gausapata	x	x	x						
COLUMBELLIDAE	Amphissa columbiana	x	x	x	x	x	x	x	x	x
COLUMBELLIDAE	Astyris gausapata	x	x	x		x				
CYSTISCIDAE	Granulina margaritula	x	x	x						
Opisthobranchia										
LIMACINIDAE	Limacina sp		x							
NUDIBRANCHIA					x			x		x
SACCOGLOSSA										
STILIGERDAE	Hermaea vancouverensis				x	x			x	
PYRIMIDELLIDAE	Odostomia sp	x	x	x	x	x	x	x	x	x
CYLICHNIDAE	Acteocina harpa		x							
DIAPHANIDAE	Diaphana sp	x	x	x				x		
OLIVIDAE	Olivella baetica							x		
Pulmonata										
ONCHIDIIDAE	Onchidella borealis	x	x	x	x	x	x	x		x

BIVALVIA		Prince William Sound			Kachemak Bay			Kodiak Island		
Family	**Species**	**Montague**	**Green**	**Knight**	**Outside B.**	**Cohen**	**Elephant**	**Uyak**	**Old Harbor**	**Alitak**
ANOMIIDAE										
	Pododesmus macroschisma		x	x				x		
MYTILIDAE				x	x	x			x	
MYTILIDAE	Modiolus modiolus	x	x	x	x	x	x	x	x	
MYTILIDAE	Musculus sp				x	x		x		
MYTILIDAE	Musculus discors		x		x					
MYTILIDAE	Musculus glacialis	x	x							
MYTILIDAE	Mytilus trossolus	x	x	x	x	x	x	x	x	x
MYTILIDAE	Vilasina sp				x	x				
MYTILIDAE	Vilasina seminuda	x	x	x	x		x			
MYTILIDAE	Vilasina vernicosa	x		x	x				x	
PECTINIDAE	Chlamys sp		x	x						
PECTINIDAE	Chlamys C. hastata	x	x	x						
PECTINIDAE	Chlamys rubiela		x					x		
HIATELLIDAE	Hiatella arctica	x	x	x	x	x	x	x	x	x
LASAEIDAE	Kellia suborbicularis	x	x							
LASAEIDAE	Rochefortia tumida	x	x			x		x	x	x
LYONSIIDAE	Entodesma navicula					x				
LYONSIIDAE	Lyonsia sp							x		
MAYIDAE	Mya pseudoarenaria								x	
TELLINIDAE	Macoma balthica		x							
TELLINIDAE	Tellina sp							x		
TURTONIIDAE	Turtonia minuta	x	x	x	x	x	x	x	x	x
VENERIDAE									x	x
VENERIDAE	Protothaca staminea		x	x		x	x		x	x
VENERIDAE	Saxidomus gigantea	x		x					x	

POLYPLACOPHORA		Prince William Sound			Kachemak Bay			Kodiak Island		
Family	**Species**	**Montague**	**Green**	**Knight**	**Outside B.**	**Cohen**	**Elephant**	**Uyak**	**Old Harbor**	**Alitak**
ACANTHOCHITONIDAE	Cryptonchiton stelleri		x							
ISCHNOCHITONIDAE	Stenonemus alba									x
ISCHNOCHITONIDAE	Dendrochiton flectens	x			x					
ISCHNOCHITONIDAE	Ischnochiton trifidis					x				
ISCHNOCHITONIDAE	Lepidochitona							x		
ISCHNOCHITONIDAE	Lepidochitona dentiens	x								
ISCHNOCHITONIDAE	Lepidozona interstincta	x	x			x	x			
ISCHNOCHITONIDAE	Lepidozona trifida					x	x			
LEPTOCHITONIDAE	Leptochiton rugatus		x				x		x	x
MOPALIIDAE	Amicula sp								x	
MOPALIIDAE	Katharina tunicata	x	x		x	x	x	x	x	x
MOPALIIDAE	Mopalia sp		x		x		x			
MOPALIIDAE	Mopalia ciliata				x	x		x		
MOPALIIDAE	Mopalia cirrata	x	x		x	x		x		x
MOPALIIDAE	Mopalia lignosa		x							
MOPALIIDAE	Mopalia sinuata	x								
MOPALIIDAE	Mopalia spectabilis								x	
MOPALIIDAE	Mopalia swanii				x					
MOPALIIDAE	Placiphorella rufa				x		x			
SCHIZOPLACIDAE	Schizoplax brandtii						x			
TONICELLIDAE	Boreochiton beringensis		x		x		x			
TONICELLIDAE	Tonicella sp	x		x		x	x	x	x	x
TONICELLIDAE	Tonicella insignis	x	x	x	x	x	x	x	x	x
TONICELLIDAE	Tonicella lineata	x	x	x	x	x	x	x	x	x
TONICELLIDAE	Tonicella venusta		x	x						

Appendix 3: Polychaeta Species List for 2003.

		Prince William Sound			Kachemak Bay			Kodiak Island	
Family	**Species**	**Montague**	**Green**	**Knight**	**Outside B.**	**Cohen**	**Elephant**	**Uyak**	**Old Harbor**
Polynoidae		x	x	x	x	x	x	x	x
	Harmothoe imbricata	x						x	
	Harmothoe sp	x	x	x				x	
	Arctonoe pulchra		x		x	x	x		x
	Arctonoe vittata					x	x		
	Gattyana iphionelloides				x				
	Halosydna brevisetosa						x	x	x
Pholoidae									
	Pholoe minuta	x			x	x	x		x
	Peisidice aspera	x	x	x	x	x	x	x	x
Chrysopetalidae									
	Paleanotus occidentale	x	x	x	x	x	x	x	x
Euphrosinidae									
	Euphrosine heterobranchia		x						
Phyllodocidae		x	x	x		x	x	x	
	Anaitides sp	x	x		x	x	x		x
	Eteone sp	x	x	x	x	x	x	x	x
	Eulalia viridis	x	x	x	x	x	x	x	x
	Notophyllum imbricatum	x	x				x	x	
	Notophyllum sp	x	x	x					
Hesionidae			x			x			
Syllidae		x	x	x	x	x	x	x	x
	Autolytus sp								
	Exogone sp	x	x	x	x	x	x	x	
	Sphaerosyllus erinaceus	x	x	x	x	x	x	x	
	Sphaerosyllis sp	x	x	x	x	x	x	x	x
	Syllis sp	x							
	Typosyllis armillaris	x	x	x	x	x	x	x	x
	Typosyllis sp	x	x	x	x	x	x	x	x
	Trypanosyllis gemmipara		x						
Nereididae								x	
	Nereidae	x	x	x	x	x	x	x	x
	Nereis neoneanthes		x						
	Nereis pelagica	x	x	x	x	x	x	x	x
	Nereis sp	x	x	x	x	x	x	x	x
	Micronereis nanaimoensis	x	x	x	x	x	x	x	x
	Platynereis bicanaliculata	x	x	x		x	x	x	x

		Prince William Sound			Kachemak Bay			Kodiak Island	
Family	**Species**	**Montague**	**Green**	**Knight**	**Outside B.**	**Cohen**	**Elephant**	**Uyak**	**Old Harbor**
Nephtydae									
	Nephtys sp							x	
Sphaerodoridae						x			
	Sphaerodorum papillifer	x	x						
	Sphaerodoropsis sphaerulifer							x	x
	Sphaerodoropsis minuta		x		x				
Glyceridae									
	Glycera capitata		x				x	x	
Goniadidae								x	
	Glycinde picta							x	
Dorvilleidae		x	x	x	x	x		x	x
	Dorvillea pseudorubrovittata	x	x		x			x	
Lumbrineridae		x			x	x			x
	Lumbrineris sp	x	x		x			x	x
Onuphidae									
	Onuphis sp	x							
Eunicidae									
	Eunice valens		x		x				x
Orbiniidae		x			x				x
	Orbiniella nuda	x	x		x	x	x	x	
	Protoariciella oligobranchia	x			x	x	x		x
	Naineris dendritica				x				
	Naineris quadricuspida							x	x
	Naineris sp				x				
	Scoloplos armiger							x	
Spionidae		x	x	x	x	x	x	x	x
	Polydora sp	x	x	x	x	x	x	x	x
	Prionospio cirrifera	x	x	x	x		x	x	x
	Prionospio steenstrupi		x			x	x	x	x
	Prionospio sp		x		x			x	
	Spio filicornis					x		x	
	Spio sp		x		x	x	x	x	x
	Pygospio elegans							x	x
	Rhynchospio glutaeus								x
Cirratulidae			x	x	x	x	x	x	x
	Dodecaceria concharum			x					
	Cirratulus cirratus				x	x	x		x
	Chaetozone sp							x	x

Family	Species	Prince William Sound			Kachemak Bay			Kodiak Island	
		Montague	Green	Knight	Outside B.	Cohen	Elephant	Uyak	Old Harbor
Flabelligeridae									
	Flabelligera affinis						x		
	Pherusa plumosa	x							
Opheliidae			x						
Scalibregmidae									
	Scalibregma inflatum							x	
Capitellidae		x						x	x
	Capitella capitata							x	x
Maldanidae									
	Nicomache personata	x							x
	Praxillela sp		x						
Oweniidae									
	Owenia fusiformis		x			x		x	x
Sabellariidae									
	Idanthyrsus ornamentatus		x			x			
Amphictenidae									
	Cistenides granulata							x	
Ampharetidae								x	x
	Neosabellides sp							x	x
Terebellidae		x	x	x	x	x	x	x	x
	Pista sp					x			
	Thelepus sp						x		
	Neoamphitrite robusta							x	
	Terebella ehrenbergi							x	
	Thelepus sp							x	
Sabellidae		x	x	x	x	x	x	x	x
	Potamilla occelata					x	x	x	x
	Potamilla sp								x
	Chone sp								x
Serpulidae				x					
	Crucigera zygophora		x	x		x	x	x	x
	Pseudochitinopoma occidentalis	x	x	x	x	x	x	x	x
	Serpula vermicularis		x	x				x	
Spirorbidae		x	x	x	x	x	x	x	x

Appendix 4: Algal Species List for 2003 and 2004.

		PWS			KACHEMAK BAY				KODIAK			
		MI	**GI**	**KI**	**OB**	**CI**	**EI**	**PG**	**AB**	**UB**	**OH**	**WI**
Chlorophyta												
Acrosiphonia sp.		3/4	3/4	3/4	3/4	3/4	3	4	3/4	4	3	4
	Acrosiphonia arcta/spinescens complex	3/4	3/4		3	3	3		3	3	3	
	Acrosiphonia coalita/Spongomorpha mertensii complex				3	3	3					
	Acrosiphonia saxatilis		4				3					
	Blidingia chadefaudii					3	3		4			
	Blidingia minima	3	4									
Chaetomorpha sp.					4		3					
	Chaetomorpha melagonium				4							
Chlorococcum sp.			4									
Cladophora sp.		3	4	4				4		3		
	Cladophora albida		4							4		
	Cladophora microcladioides			3						4		
	Cladophora sericea	3	4	3/4								
Codium sp.		4	4	4	4	3						4
	Codium ritteri				4	3						
	Derbesia marina		3	3/4								
	Entocladia viridis		4									
	Gayralia oxysperma		3/4			3	3					
	Halochlorococcum moorei		4									
Monostroma sp.		4	4	4	3/4	3/4	3	4	3/4	3/4	3	4
	Monostroma grevillei	3/4	3/4	3/4	3/4	3/4	3				3	
	Monostroma obscurum				3	3						
	Protomonostroma undulatum	3/4			3	3				4		
Rhizoclonium sp.		4		4				4		4		
	Rhizoclonium riparium				4	3	3					
	Rhizoclonium tortuosum			3		3/4		4	4			
	Ulothrix subflaccida			3								
Ulva sp.			4		3/4	3	3	4	3/4	4		4
	Ulva compressa	3										
	Ulva fenestrata	3/4	3/4	3/4	3/4	3/4	3		3/4	3/4		4

	PWS			KACHEMAK BAY				KODIAK			
	MI	GI	KI	OB	CI	EI	PG	AB	UB	OH	WI
Ulva intestinalis	4	4		3/4	3	3	4		3		
Ulva linza	3/4	4		3/4	3/4	3		4			4
Ulvaria sp				3/4			4	4	4		
Ulvaria obscura var. blyttii					3	3					
Ulvella setchellii		4									
Urospora sp.				4	4			4			
Heterokontophyta											
Acrothrix gracilis			4								
Agarum clathratum	3/4	3/4	3/4	3/4	3/4	3/4	4	3/4	3/4	3/4	4
Alaria sp.	3/4	3	3	3/4	3/4	3/4	4	3/4	3/4	4	4
Alaria angusta						3					
Alaria marginata	3	3		3/4	3	3	4	3		3	
Alaria nana					3				3		
Alaria praelonga	4										
Alaria taeniata	3/4					3		3			
Analipus japonicus	3/4	3		4	3/4		4	4		3/4	4
Chordaria flagelliformis	4			3	3						
Coilodesme sp			4	3/4			4		4		
Coilodesme bulligera				3/4							
Colpomenia bullosa	3	3					4	4	4		
Colpomenia peregrina	4	3/4	3				4	3		3	4
Costaria costata	3/4	3/4	3	4	3			3/4	3/4	3	4
Cymathere triplicata	3			3		3	4		3/4	3	
Cystoseira geminata	4										4
Desmarestiales	3					3					
Desmarestia sp.								3	3	3	
Desmarestia aculeata		3						3/4	3/4	3	
Desmarestia viridis			3			3	4	3/4	3/4	3	4
Dictyosiphon sp.	3/4										
Ectocarpus sp		4									
Ectocarpus acutus						3			3		
Ectocarpus siliculosus					3						
Elachista fucicola	4	4	4	3/4	3	3	4	4			4

	PWS			KACHEMAK BAY				KODIAK			
	MI	**GI**	**KI**	**OB**	**CI**	**EI**	**PG**	**AB**	**UB**	**OH**	**WI**
Eudesme virescens			4								
Fucus distichus	3/4	3/4	3/4	3/4	3/4	3/4	4	3/4	3/4	3/4	4
Hedophyllum sessile				3/4			4				4
Laminariales adults					3						
Laminariales juveniles	3	3/4	3/4	3/4	3/4	3	4	3/4	3/4	3	4
Laminaria sp.	3				3					3	
Laminaria bongardiana	3/4	3/4	3/4	3/4	3/4	3/4	4	3/4	3/4	3/4	4
Laminaria saccharina	3/4	3/4	3/4	3/4	3/4	3/4	4	3/4	3/4	3/4	4
Laminaria setchelli								3		3	
Laminaria yezoensis	3/4	3/4	3/4	4	3		4	3/4	3/4	3/4	4
Leathesia difformis	4	4	4		3	3				3	
Melanosiphon intestinalis	3/4	4	3/4	3/4	3/4	3	4	3/4	4	3	
Myrionema strangulans					3						
Nereocystis luetkeana				3/4	3/4	3/4	4				4
Omphalophyllum ulvaceum	3			3					3		
Petalonia fascia	3/4			3/4	3	3				3	
Pilayella littoralis	3/4	3/4	3/4	3/4	3/4	3	4	3/4	3/4	3	
Pilayella littoralis f. rupincola		4									
Pleurophycus gardneri	3/4										4
Punctaria sp	3			3				3	3		
Punctaria expansa									3		
Punctaria latifolia					3						
Ralfsia fungiformis	4	3/4	3/4	4			4	3/4			
Saundersella simplex	4										
Scytosiphon sp.	4	4		3/4	3	3	4	4	4	3/4	4
Scytosiphon dotyi					3						
Scytosiphon lomentaria	3	3/4		4	3/4	3				3	
Soranthera ulvoidea	4	4	3	3	3	3	4	3	3/4	3	4
Sphacelaria sp.			3/4								
Sphacelaria norrisii			3								
Sphacelaria plumigera		4	4		4						
Sphacelaria rigidula	4	4	3/4								
Sphaerotrichia divaricata					3						

	PWS			KACHEMAK BAY				KODIAK			
	MI	**GI**	**KI**	**OB**	**CI**	**EI**	**PG**	**AB**	**UB**	**OH**	**WI**
Stictyosiphon tortilis			3								
Rhodophyta											
Acrochaetium porphyrae	3/4										
Ahnfeltia fastigiata	4			4			4	4			4
Amplisiphonia pacifica	4										
Antithamnion densum		3/4	3								
Audouinella sp	3	3/4									
Bangia sp.				3							
Bangia atropurpurea				3	3						
Callithamnion sp.		4						4	4		
Callithamnion biseriatum	3/4								4		
Callithamnion pikeanum	3/4	3/4		4		3	4	3/4	3/4		
Callithamnion pikeanum var. laxum						3	4				
Callophyllis sp.		3/4	3/4	3/4	3/4	3			4	3	
Callophyllis cristata	3	3/4	4	3/4	3/4	3	4		3/4	3	4
Callophyllis flabellulata	3/4	3	3/4	3/4	3/4	3	4		3/4	3	4
Callophyllis okamurae	4										
Ceramium sp.	4	4	3/4								
Ceramium cimbricum	3/4		4								
Ceramium gardneri	3										
Ceramium kondoi	3										
Ceramium pacificum	4	4	4								
Ceramium washingtoniense		3	3								
Constantinea sp.							4	4		4	4
Constantinea rosa-marina				3							
Constantinea subulifera	4	3/4	3/4	3/4	3/4		4	3	3/4	3	4
Corallophila eatoniana		4									
Cryptonemia obovata											4
Cryptopleura sp.	4										
Cryptopleura peltata	4										
Cryptopleura ruprechtiana	4										
Cryptosiphonia woodii	3/4	3/4	3/4	3/4	3/4	3	4	3/4	3/4	3	4
Delesseriaceae	3			3	3						

	PWS			KACHEMAK BAY				KODIAK			
	MI	GI	KI	OB	CI	EI	PG	AB	UB	OH	WI
Delessaria sp.				4			4				
Delessaria decipiens				4	3		4				4
Dilsea californica	3										
Dumontia contorta								4			
Endocladia muricata	3/4	3/4		3	3/4	3	4	4	3/4	3	4
Endophyton ramosum					3						
Erythrotrichia carnea	4	4			3	3					
Gloiopeltis furcata	3/4	4	4	3	3			4	3/4	3/4	
Halosaccion sp.			4		3						
Halosaccion glandiforme	3/4	3/4	3/4	3/4	3/4	3	4	3/4	3/4	3	
Herposiphonia sp			4								
Herposiphonia plumula		3/4									
Hommersandia palmatifolia			4	3							
Hymenena ruthenica	4	4									
Irtugovia pacifica		4		4	3/4	3	4	3/4	4		4
Irtugovia spirographidis		4									
Kallymenia sp.	3				3/4						
Leachiella pacifica	3	4	3			3			3	3	
Mastocarpus sp.			3								
Mastocarpus pacificus			4								
Mastocarpus papillatus	3/4	4	4	4	3	3	3				4
Mazzaella sp.		3/4	3	3	3	3		3	3/4		3
Mazzaella affinis						3					
Mazzaella laminarioides				4	4		4	4	4		4
Mazzaella phyllocarpa	3/4	3/4	3/4	3/4	3/4	3	4	3/4	3	3	4
Membranoptera sp.							4				
Membranoptera multiramosa		3									
Membranoptera spinulosa				4	4						
Membranoptera weeksiae		3	3/4		4						
Microcladia sp	4	4									4
Microcladia borealis	3	3/4	3/4				4	3			
Mikrosyphar polysiphoniae	3/4										
Neodilsea borealis	4										

	PWS			KACHEMAK BAY				KODIAK			
	MI	**GI**	**KI**	**OB**	**CI**	**EI**	**PG**	**AB**	**UB**	**OH**	**WI**
Neoptilota asplenioides	3/4	3/4	3/4	4	4		4	3/4			4
Neorhodomela sp								3/4		3	4
Neorhodomela aculeata	3/4	3/4	3/4					3	3	3	
Neorhodomela larix	3/4	3/4	3/4				4	4		3	4
Neorhodomela oregona	3/4	3/4	3/4					3	3	3	
Nitophyllum hollenbergii	3				3						
Odonthalia sp.	3			3/4	3	3	4	3/4	3/4	3	4
Odonthalia floccosa	3/4	3/4	3/4	3/4	3/4	3	4	3/4	3/4	3	4
Odonthalia floccosa/annae complex	3		3		3						
Odonthalia kamtschatica	3		3		3						
Odonthalia kamschatica/setacea complex				3/4	3/4		4	3/4	4		
Odonthalia setacea	4	3/4	3/4	3	3			3		3	
Opuntiella californica	4	3/4		3/4		3	4				4
Palmaria sp.	3							3			
Palmaria callophylloides			3/4	3/4	3/4	3	4	3/4			
Palmaria hecatensis	3/4	3/4	3/4	3/4	3/4	3	4	3	3		4
Palmaria marginicrassa				3							
Palmaria mollis	3	3/4		4	3/4	3	4		3/4	3	4
Phycodrys riggii	4	3/4	3/4				4	3			
Phyllophora sp.			4								
Phyllophoraceae			4								
Pleonosporium squarrosum		4									
Plocamium violacea		4									
Pneophyllum nicholsii		4									
Polyneura latissima							4				
Polysiphonia sp.	3/4	3/4	3		3/4		4	3	3/4	3	
Polysiphonia hendryi var. gardneri	4	3/4			3			3		3	
Polysiphonia pacifica	3/4	4	3		3/4	3		3	3/4	3	
Polysiphonia pacifica var. delicatula			3			3					
Polysiphonia pacifica var. determinata						3					
Polysiphonia senticulosa		3/4	3					3	3		
Polysiphonia stricta	4										
Porphyra sp.	3/4	3/4	3/4	3/4	3/4	3	4	3/4	3/4	3	4

	PWS			KACHEMAK BAY				KODIAK			
	MI	**GI**	**KI**	**OB**	**CI**	**EI**	**PG**	**AB**	**UB**	**OH**	**WI**
Porphyra abbottiae	3			3							
Porphyra cuneiformis				3	3	3					
Porphyra fallax	3/4										
Porphyra fucicola				3	3	3					
Porphyra pseudolinearis				4	4						
Porphyra variegata		3	3								
Pterosiphonia sp.	4	3/4		3/4	4		4	4	3/4	3	4
Pterosiphonia bipinnata	3/4	3/4	3/4	3	3/4	3		3/4	3	3	4
Pterosiphonia gracilis	3/4	3/4	3/4								
Pterosiphonia hamata	3	4									
Pterothamnion sp			4								
Pterothamnion pectinatum	3										
Pterothamnion villosum			4								
Ptilota sp	4										
Ptilota serrata	3/4	3/4	3/4	3/4	4		4	3			
Pugetia sp.			4	3/4	3/4						
Pugetia fragilissima		3	3/4	3/4	3/4	3					
Rhodomela lycopodioides		4									
Scagelia sp		4					4				
Scagelia americana	3	4			4						
Scagelia pylaisaei		4					4				
Schizochlaenion rhodotrichum					3						
Sparlingia pertusa	3/4	3/4	4	3/4	3/4		4	3/4	3/4	3	4
Stylonema alsidii		4									
Tayloriella sp.					3	3					
Tayloriella abyssalis						3					
Tayloriella divaricata					3	3		3	3		
Tokidadendron kurilensis	3/4	3/4	3/4	3/4	3/4	3	4	3			4
Tokidaea chilkatensis					3						
Turnerella mertensiana				4	3	3	4		3		4
encrusting corallines	3/4	3/4	3/4	3/4	3/4	3	4	3/4	3/4	3	4
upright corallines	3/4	3/4	3/4	3/4		3	4	3/4	4	3	4

	PWS			KACHEMAK BAY				KODIAK			
	MI	**GI**	**KI**	**OB**	**CI**	**EI**	**PG**	**AB**	**UB**	**OH**	**WI**
Bossiella sp.	3/4	3/4								3	4
Bossiella californica	4	3/4						3		3	4
Bossiella californica subsp. schmittii	3/4	3									
Bossiella cretacea	4	3/4	4			3		3/4		3	4
Bossiella orbignyana		3									4
Corallina sp.	3/4	3	3			3				3	
Corallina frondescens	3/4	3/4	3/4								
Corallina officinalis	3/4	3/4	3/4	3			4			3	4
Corallina pilulifera	3/4	3/4	3								
Corallina vancouveriensis	3/4	3/4	3/4	3/4			4	3		3	4
Lithophyllum sp.				3						3	
Lithothamnion sp.				3							
rhodoliths		3	3/4	3							
Zostera marina	3	3/4								3	

Appendix 5. Invertebrate diversity indices based on 2003 abundance.

Area	Site	Stratum	# of taxa	total abundance	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
PWS	KI	KIH	12	336.49	1.8905	0.3866	0.9606
		KIM	15	161.74	2.7526	0.6585	1.7832
		KIL	13	190.50	2.2859	0.5559	1.4258
		KI1	23	318.10	3.8179	0.5390	1.6899
		KI5	13	95.77	2.6305	0.5738	1.4717
		KI10	9	15.90	2.8919	0.8801	1.9337
		KI15	9	34.12	2.2664	0.7891	1.7338
	MI	MIH	10	820.98	1.3412	0.3926	0.9041
		MIM	19	403.52	2.9999	0.5944	1.7503
		MIL	17	320.10	2.7736	0.7397	2.0957
		MI1	18	354.99	2.8951	0.7031	2.0321
		MI5	9	59.70	1.9563	0.7610	1.6721
		MI10	17	135.80	3.2579	0.6490	1.8386
		MI15	12	170.62	2.1403	0.6772	1.6828
	GI	GIH	17	801.89	2.3927	0.6224	1.7635
		GIM	18	263.65	3.0495	0.7321	2.1161
		GIL	21	326.72	3.4548	0.6598	2.0087
		GI1	19	258.88	3.2395	0.6069	1.7870
		GI5	12	112.11	2.3308	0.5908	1.4681
		GI10	15	56.96	3.4634	0.7136	1.9326
		GI15	18	120.28	3.5492	0.5244	1.5158
KB	OB	OBH	14	305.00	2.2726	0.2990	0.7891
		OBM	16	1272.80	2.0982	0.6448	1.7877
		OBL	18	3034.00	2.1203	0.3584	1.0358
		OB1	16	460.20	2.4463	0.6773	1.8778
		OB5	15	105.20	3.0070	0.6329	1.7138
		OB10	13	121.33	2.5008	0.5869	1.5053
	CI	CIH	16	475.20	2.4336	0.6548	1.8156
		CIM	18	1001.00	2.4606	0.7424	2.1459
		CIL	17	1517.20	2.1844	0.6606	1.8717
		CI1	18	1271.20	2.3784	0.5895	1.7039
		CI5	14	230.60	2.3894	0.4477	1.1815
		CI10	10	23.80	2.8394	0.5672	1.3061
		CI15	14	15.80	4.7101	0.7388	1.9497
KB	EI	EIH	13	1737.20	1.6086	0.4218	1.0819

Area	Site	Stratum	# of taxa	total abundance	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
		EIM	17	714.20	2.4349	0.7318	2.0734
		EIL	17	1495.00	2.1888	0.4265	1.2084
		EI1	19	1403.00	2.4840	0.3363	0.9902
		EI5	14	61.40	3.1573	0.6983	1.8429
		EI10	12	28.20	3.2941	0.7041	1.7495
		EI15	11	71.00	2.3459	0.7250	1.7384
KOD	OH	OHH	13	276.25	2.1347	0.6433	1.6500
		OHM	19	544.80	2.8570	0.5319	1.5661
		OHL	19	632.75	2.7907	0.5590	1.6460
		OH1	17	1756.20	2.1416	0.4759	1.3485
		OH5	15	262.40	2.5135	0.5763	1.5606
		OH10	14	111.20	2.7593	0.5903	1.5578
	UB	UBH	11	457.20	1.6326	0.4722	1.1323
		UBM	16	610.00	2.3388	0.5318	1.4744
		UBL	17	99.00	3.4820	0.7367	2.0873
		UB1	17	293.60	2.8158	0.4784	1.3553
		UB5	17	421.60	2.6472	0.4452	1.2614
		UB10	14	243.50	2.3657	0.4729	1.2479
		UB15	13	86.25	2.6922	0.6470	1.6594
	AK	AKH	18	2088.60	2.2239	0.5095	1.4726
		AKM	19	760.20	2.7135	0.5632	1.6584
		AKL	16	990.00	2.1746	0.5063	1.4037
		AK1	20	1541.27	2.5884	0.1918	0.5744
		AK5	10	77.40	2.0694	0.6005	1.3826
		AK10	12	83.00	2.4893	0.5155	1.2811
		AK15	9	17.20	2.8120	0.7021	1.5426

Appendix 6. Invertebrate diversity indices based on 2003 biomass.

Area	Site	Stratum	# of taxa	total biomass (g)	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
PWS	KI	KIH	13	465.876	1.9532	0.2330	0.5977
		KIM	17	14.420	5.9957	0.3364	0.9532
		KIL	16	35.127	4.2147	0.2469	0.6846
		KI1	25	14.652	8.9400	0.5961	1.9188
		KI5	14	1.397	38.8774	0.6801	1.7948
		KI10	10	12.487	3.5648	0.1911	0.4401
		KI15	10	22.946	2.8725	0.5028	1.1578
	MI	MIH	12	146.342	2.2062	0.3042	0.7558
		MIM	22	1064.023	3.0130	0.2399	0.7414
		MIL	19	20.619	5.9481	0.5233	1.5407
		MI1	21	7.460	9.9525	0.5634	1.7152
		MI5	13	10.030	5.2047	0.1229	0.3153
		MI10	21	55.697	4.9752	0.3430	1.0443
		MI15	16	46.685	3.9028	0.2304	0.6388
	GI	GIH	20	411.192	3.1566	0.2392	0.7165
		GIM	21	27.924	6.0069	0.5729	1.7441
		GIL	25	20.554	7.9390	0.5781	1.8608
		GI1	22	138.479	4.2590	0.1342	0.4149
		GI5	13	18.831	4.0879	0.4719	1.2103
		GI10	17	2.202	20.2651	0.7856	2.2256
		GI15	21	25.853	6.1493	0.3371	1.0262
KB	OB	OBH	15	1.583	30.4646	0.5607	1.5185
		OBM	18	4.537	11.2412	0.4763	1.3767
		OBL	20	28.023	5.7005	0.3635	1.0889
		OB1	19	15.235	6.6088	0.5058	1.4893
		OB5	19	17.040	6.3479	0.4443	1.3082
		OB10	17	20.156	5.3271	0.3611	1.0230
	CI	CIH	18	20.719	5.6086	0.3009	0.8697
		CIM	22	382.557	3.5313	0.0797	0.2464
		CIL	20	15.437	6.9426	0.3821	1.1447
		CI1	21	66.893	4.7584	0.1489	0.4533
		CI5	19	25.037	5.5894	0.5419	1.5955
		CI10	12	3.281	9.2591	0.5655	1.4053
		CI15	18	51.577	4.3113	0.1363	0.3941
KB							

Area	Site	Stratum	# of taxa	total biomass (g)	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
	EI	EIH	14	473.341	2.1105	0.2944	0.7768
		EIM	20	745.003	2.8730	0.1028	0.3079
		EIL	21	327.570	3.4532	0.0807	0.2457
		EI1	21	15.729	7.2582	0.6305	1.9197
		EI5	18	10.606	7.1990	0.5753	1.6628
		EI10	16	7.132	7.6351	0.5609	1.5550
		EI15	13	7.814	5.8368	0.4786	1.2277
KOD	OH	OHH	16	136.559	3.0508	0.2667	0.7394
		OHM	23	395.067	3.6795	0.0574	0.1801
		OHL	23	191.523	4.1865	0.0784	0.2459
		OH1	22	24.741	6.5452	0.6078	1.8786
		OH5	18	9.350	7.6050	0.5522	1.5960
		OH10	17	2.238	19.8568	0.6280	1.7794
	UB	UBH	13	164.816	2.3507	0.2843	0.7291
		UBM	18	283.439	3.0105	0.2498	0.7221
		UBL	21	61.474	4.8560	0.2858	0.8702
		UB1	22	3.818	15.6746	0.6187	1.9123
		UB5	21	307.327	3.4917	0.0209	0.0636
		UB10	19	26.231	5.5097	0.2184	0.6432
		UB15	17	68.331	3.7875	0.0691	0.1957
	AK	AKH	23	378.732	3.7057	0.1769	0.5546
		AKM	23	554.156	3.4824	0.3046	0.9552
		AKL	19	36.127	5.0180	0.3717	1.0943
		AK1	24	150.896	4.5848	0.2661	0.8456
		AK5	12	108.246	2.3482	0.0867	0.2153
		AK10	14	2.260	15.9477	0.4247	1.1208
		AK15	12	3.203	9.4495	0.5483	1.3625

Appendix 7. Mollusk diversity indices based on 2003 abundance.

Area	Site	Stratum	# of taxa	total abundance	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
PWS	KI	KIH	15	1030.45	2.0179	0.2909	0.7879
		KIM	20	381.92	3.1959	0.5849	1.7521
		KIL	27	624.65	4.0390	0.6470	2.1324
		KI1	24	239.50	4.1982	0.6589	2.0940
		KI5	18	125.83	3.5161	0.5810	1.6794
		KI10	15	40.50	3.7825	0.9028	2.4448
		KI15	14	32.92	3.7207	0.9545	2.5191
	MI	MIH	10	1097.30	1.2856	0.3714	0.8552
		MIM	26	1210.40	3.5218	0.3610	1.1762
		MIL	22	427.92	3.4660	0.6648	2.0550
		MI1	22	809.35	3.1361	0.5975	1.8470
		MI5	11	127.48	2.0627	0.5785	1.3871
		MI10	38	131.00	7.5894	0.8471	3.0815
		MI15	29	133.09	5.7247	0.8046	2.7092
	GI	GIH	23	1274.33	3.0768	0.5259	1.6491
		GIM	31	573.73	4.7228	0.7179	2.4653
		GIL	38	544.47	5.8732	0.6706	2.4394
		GI1	38	342.50	6.3397	0.6635	2.4136
		GI5	32	288.78	5.4715	0.5809	2.0132
		GI10	16	62.33	3.6298	0.8891	2.4650
		GI15	25	111.55	5.0907	0.8853	2.8498
KB	CI	CIH	10	122.17	1.8729	0.6771	1.5592
		CIM	22	277.98	3.7316	0.7461	2.3061
		CIL	25	405.00	3.9974	0.4296	1.3829
		CI1	16	799.33	2.2442	0.3176	0.8806
		CI5	17	58.85	3.9264	0.8355	2.3671
		CI10	7	17.50	2.0963	0.8889	1.7298
		CI15	13	26.00	3.6831	0.8776	2.2510
	OB	OBH	10	38.67	2.4624	0.7529	1.7335
		OBM	13	247.57	2.1772	0.3594	0.9218
		OBL	18	296.13	2.9873	0.5570	1.6100
		OB1	22	211.63	3.9217	0.6816	2.1069
		OB5	20	87.82	4.2456	0.8791	2.6335
		OB10	13	34.50	3.3889	0.9467	2.4283
KB	EI	EIH	9	1597.93	1.0845	0.4685	1.0293

Area	Site	Stratum	# of taxa	total abundance	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
		EIM	19	316.88	3.1258	0.7554	2.2243
		EIL	17	2390.92	2.0567	0.2464	0.6982
		EI1	14	834.00	1.9327	0.0650	0.1715
		EI5	13	74.17	2.7866	0.5665	1.4531
		EI10	12	33.83	3.1237	0.8468	2.1041
		EI15	13	45.00	3.1524	0.8371	2.1472
KOD	AK	AKH	22	1076.33	3.0080	0.3492	1.0795
		AKM	23	305.67	3.8445	0.6846	2.1466
		AKL	10	350.60	1.5359	0.1285	0.2959
		AK1	12	40.10	2.9799	0.8314	2.0660
		AK5	14	78.33	2.9810	0.6507	1.7172
		AK10	15	44.50	3.6886	0.8516	2.3062
		AK15	8	17.00	2.4707	0.8867	1.8439
	UB	UBH	6	427.40	0.8254	0.5755	1.0312
		UBM	11	524.65	1.5967	0.5054	1.2119
		UBL	14	82.08	2.9494	0.8084	2.1335
		UB1	13	146.90	2.4049	0.4200	1.0773
		UB5	12	134.75	2.2433	0.5544	1.3777
		UB10	14	78.67	2.9781	0.6622	1.7476
		UB15	10	33.50	2.5630	0.8783	2.0223
	OH	OHH	10	181.25	1.7308	0.5258	1.2107
		OHM	15	195.37	2.6541	0.5903	1.5986
		OHL	23	169.33	4.2869	0.6501	2.0385
		OH1	19	600.58	2.8134	0.2386	0.7026
		OH5	17	358.50	2.7202	0.1974	0.5591
		OH10	16	127.17	3.0957	0.6461	1.7913

Appendix 8. Mollusk diversity indices based on 2003 biomass.

Area	Site	Stratum	# of taxa	total biomass (g)	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
PWS	KI	KIH	16	364.823	2.5426	0.0341	0.0946
		KIM	20	4.086	13.4983	0.3599	1.0781
		KIL	26	32.187	7.2014	0.1841	0.5998
		KI1	26	1.669	48.8090	0.5644	1.8388
		KI5	19	0.366	nd	0.3796	1.1178
		KI10	15	0.479	nd	0.3844	1.0408
		KI15	15	14.162	5.2819	0.3758	1.0177
	MI	MIH	11	101.576	2.1641	0.0875	0.2098
		MIM	25	340.080	4.1172	0.0656	0.2111
		MIL	21	1.987	29.1327	0.7183	2.1869
		MI1	26	1.073	357.1818	0.6459	2.1045
		MI5	11	0.401	nd	0.5005	1.2002
		MI10	40	1.659	77.0515	0.6549	2.4158
		MI15	30	0.981	nd	0.7478	2.5435
	GI	GIH	24	295.799	4.0424	0.0401	0.1273
		GIM	32	7.555	15.3303	0.5883	2.0391
		GIL	42	8.347	19.3228	0.6835	2.5548
		GI1	41	6.536	21.3066	0.5031	1.8682
		GI5	32	2.096	41.8907	0.4897	1.6973
		GI10	17	0.844	nd	0.6617	1.8748
		GI15	26	1.333	86.9589	0.6324	2.0604
KB	CI	CIH	10	9.289	4.0380	0.0559	0.1287
		CIM	22	15.211	7.7148	0.3256	1.0065
		CIL	27	12.196	10.3953	0.2171	0.7154
		CI1	17	1.728	29.2493	0.4763	1.3495
		CI5	18	15.290	6.2335	0.6569	1.8987
		CI10	8	1.364	22.5542	0.7565	1.5731
		CI15	12	0.833	nd	0.4284	1.0645
	OB	OBH	10	0.151	nd	0.1455	0.3351
		OBM	13	1.453	32.1422	0.4578	1.1743
		OBL	17	22.177	5.1628	0.3305	0.9363
		OB1	22	12.814	8.2335	0.6686	2.0667
		OB5	21	10.748	8.4222	0.6615	2.0141
		OB10	13	5.370	7.1392	0.7028	1.8026
KB	EI	EIH	10	202.687	1.6944	0.1001	0.2304

Area	Site	Stratum	# of taxa	total biomass (g)	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
		EIM	20	44.667	5.0010	0.1756	0.5261
		EIL	17	3.072	14.2551	0.5631	1.5954
		EI1	15	4.792	8.9349	0.5542	1.5007
		EI5	13	2.287	14.5027	0.6442	1.6523
		EI10	12	2.787	10.7306	0.5832	1.4491
		EI15	15	2.365	16.2654	0.6475	1.7536
KOD	AK	AKH	16	53.436	3.7703	0.0843	0.2336
		AKM	22	36.804	5.8243	0.4036	1.2476
		AKL	11	2.208	12.6253	0.6698	1.6061
		AK1	11	121.345	2.0839	0.0718	0.1722
		AK5	16	3.425	12.1831	0.6011	1.6667
		AK10	11	1.972	14.7320	0.6914	1.6579
		AK15	11	0.629	nd	0.6007	1.4404
	UB	UBH	6	70.551	1.1747	0.0515	0.0924
		UBM	11	185.508	1.9146	0.0310	0.0743
		UBL	12	21.714	3.5738	0.2429	0.6035
		UB1	18	1.908	26.3204	0.5827	1.6843
		UB5	7	0.740	nd	0.7289	1.4183
		UB10	17	1.897	24.9837	0.4880	1.3825
		UB15	11	1.756	17.7698	0.3889	0.9326
	OH	OHH	10	73.255	2.0960	0.1446	0.3329
		OHM	17	9.401	7.1404	0.5429	1.5381
		OHL	20	7.320	9.5448	0.5512	1.6513
		OH1	20	7.455	9.4577	0.5528	1.6560
		OH5	19	1.129	148.5481	0.4871	1.4343
		OH10	16	1.279	61.0027	0.6329	1.7548

nd: not determined (Margalef's species richness index is not defined for values < 1)

Appendix 9. Polychaete diversity indices based on 2003 abundance.

Area	Site	Stratum	# of taxa	total abundance	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
KB	CI	CIH	10	12.20	3.5979	0.6575	1.5140
		CIM	18	155.20	3.3699	0.3837	1.1091
		CIL	21	130.00	4.1089	0.5849	1.7806
		CI1	27	161.60	5.1130	0.6755	2.2264
		CI5	22	146.80	4.2092	0.2453	0.7583
		CI10	5	15.00	1.4771	0.4040	0.6502
		CI15	11	5.60	5.8046	0.8225	1.9723
	OB	OBH	6	2.00	7.2135	0.8982	1.6094
		OBM	9	81.20	1.8195	0.4548	0.9993
		OBL	21	78.60	4.5826	0.6764	2.0592
		OB1	29	112.80	5.9252	0.8312	2.7990
		OB5	17	23.40	5.0750	0.5927	1.6791
		OB10	14	18.67	4.4418	0.8748	2.3085
	EI	EIH	5	51.00	1.0173	0.5142	0.8276
		EIM	15	29.40	4.1408	0.7671	2.0774
		EIL	18	69.40	4.0095	0.6107	1.7652
		EI1	20	473.00	3.0849	0.1297	0.3886
		EI5	19	16.60	6.4071	0.8612	2.5358
		EI10	10	5.80	5.1199	0.8394	1.9328
		EI15	15	26.25	4.2844	0.4884	1.3225
PWS	KI	KIH	4	5.80	1.7066	0.5865	0.8131
		KIM	7	4.40	4.0497	0.5522	1.0746
		KIL	10	17.40	3.1507	0.4046	0.9317
		KI1	27	125.00	5.3849	0.6760	2.2280
		KI5	13	45.20	3.1487	0.4101	1.0519
		KI10	6	1.60	10.6382	0.9306	1.6675
		KI15	13	9.40	5.3554	0.7805	2.0019
	MI	MIH	3	1.80	3.4026	0.8528	0.9369
		MIM	15	67.80	3.3202	0.4628	1.2533
		MIL	12	43.75	2.9112	0.5486	1.3633
		MI1	10	29.20	2.6673	0.4510	1.0385
		MI5	7	9.40	2.6777	0.6663	1.2966
		MI10	27	47.20	6.7455	0.8048	2.6524
		MI15	20	40.00	5.1506	0.8028	2.4048
PWS	GI	GIH	10	65.20	2.1544	0.4560	1.0500

Area	Site	Stratum	# of taxa	total abundance	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
		GIM	12	24.40	3.4433	0.5350	1.3293
		GIL	23	62.60	5.3182	0.7391	2.3173
		GI1	24	72.60	5.3676	0.7186	2.2838
		GI5	27	28.80	7.7372	0.8810	2.9036
		GI10	25	16.75	8.5155	0.8625	2.7762
		GI15	26	71.00	5.8649	0.8070	2.6293
KOD	OH	OHH	9	56.00	1.9874	0.3531	0.7759
		OHM	15	297.20	2.4586	0.2265	0.6134
		OHL	21	123.75	4.1509	0.6182	1.8820
		OH1	26	393.40	4.1842	0.2339	0.7620
		OH5	26	32.80	7.1624	0.8046	2.6214
		OH10	20	22.80	6.0766	0.7742	2.3192
	UB	UBH	3	2.00	2.8854	0.7298	0.8018
		UBM	9	23.20	2.5444	0.6937	1.5243
		UBL	7	26.60	1.8288	0.2485	0.4835
		UB1	21	179.20	3.8547	0.4151	1.2637
		UB5	29	253.40	5.0587	0.3701	1.2464
		UB10	34	147.60	6.6073	0.6356	2.2412
		UB15	24	32.40	6.6127	0.7213	2.2924

Appendix 10. Polychaete diversity indices based on 2003 biomass.

Area	Site	Stratum	# of taxa	total biomass (g)	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
PWS	KI	KIH	4	0.021	nd	0.3515	0.4873
		KIM	7	0.005	nd	0.5200	1.0118
		KIL	10	0.020	nd	0.4329	0.9967
		KI1	29	1.587	60.6644	0.4686	1.5781
		KI5	13	0.156	nd	0.4582	1.1752
		KI10	6	0.003	nd	0.3238	0.5802
		KI15	13	0.012	nd	0.6609	1.6952
	MI	MIH	3	0.002	nd	0.5807	0.6380
		MIM	14	0.863	nd	0.4236	1.1180
		MIL	13	0.055	nd	0.4819	1.2360
		MI1	10	0.068	nd	0.4066	0.9363
		MI5	7	0.007	nd	0.5489	1.0682
		MI10	27	0.626	nd	0.1764	0.5813
		MI15	21	0.353	nd	0.3222	0.9810
	GI	GIH	10	0.167	nd	0.5828	1.3419
		GIM	12	0.051	nd	0.4343	1.0792
		GIL	24	0.689	nd	0.3263	1.0368
		GI1	26	0.318	nd	0.6581	2.1443
		GI5	28	1.035	786.619	0.4866	1.6214
		GI10	25	0.315	nd	0.3097	0.9970
		GI15	26	1.254	110.501	0.3320	1.0818
KB	CI	CIH	10	0.054	nd	0.3417	0.7869
		CIM	18	0.201	nd	0.4481	1.2950
		CIL	21	0.402	nd	0.2441	0.7432
		CI1	27	0.323	nd	0.4539	1.4961
		CI5	24	0.215	nd	0.6144	1.9526
		CI10	5	0.027	nd	0.1284	0.2067
		CI15	11	0.022	nd	0.7053	1.6912
	OB	OBH	6	0.000	nd	0.7980	1.4299
		OBM	9	0.030	nd	0.5857	1.2870
		OBL	21	0.131	nd	0.5638	1.7167
		OB1	29	0.190	nd	0.6632	2.2333
		OB5	17	0.108	nd	0.4716	1.3361
		OB10	14	0.050	nd	0.5896	1.5561
	EI	EIH	5	0.056	nd	0.6192	0.9966

Area	Site	Stratum	# of taxa	total biomass (g)	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
		EIM	15	0.026	nd	0.7067	1.9137
		EIL	19	1.224	89.0974	0.2471	0.7277
		EI1	20	0.688	nd	0.5021	1.5041
		EI5	20	0.100	nd	0.5853	1.7535
		EI10	10	0.072	nd	0.6343	1.4605
		EI15	16	0.124	nd	0.4023	1.1153
KOD	OH	OHH	9	0.009	nd	0.6089	1.3378
		OHM	15	0.079	nd	0.5265	1.4257
		OHL	23	0.401	nd	0.3483	1.0921
		OH1	27	0.360	nd	0.2806	0.9249
		OH5	26	0.371	nd	0.6014	1.9594
		OH10	20	0.260	nd	0.6006	1.7993
	UB	UBH	3	0.002	nd	0.4393	0.4826
		UBM	9	0.017	nd	0.6925	1.5215
		UBL	7	0.007	nd	0.4160	0.8095
		UB1	21	0.281	nd	0.6092	1.8546
		UB5	30	0.616	nd	0.5892	2.0039
		UB10	34	0.573	nd	0.4588	1.6178
		UB15	24	0.058	nd	0.6597	2.0966

nd: not determined (Margalef's species richness index is not defined for values < 1)

Appendix 11. Macroalgal diversity indices based on 2003 and 2004 biomass.

Year	Area	Site	Stratum	# of taxa	total biomass (g)	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
2004	KOD	WI	H	8	103.02	1.510273155	0.684054293	1.422450914
			M	20	1001.3	2.750014518	0.463028185	1.387108476
			L	25	1643.02	3.241363563	0.231691949	0.745787614
			1	26	1181.38	3.533849352	0.348953342	1.136923677
			5	20	1548.66	2.586742559	0.53173562	1.592937559
			10	19	943.48	2.627900207	0.447694676	1.318209655
			15	13	218.04	2.228545294	0.341386564	0.875639249
		UB	H	14	749.3	1.964001533	0.126601799	0.334109407
			M	17	306.24	2.79506784	0.381810382	1.081750269
			L	15	817.4	2.087642647	0.370607681	1.003624206
			1	15	603.4	2.186618408	0.396813966	1.074592142
			5	17	1404.22	2.207737847	0.427799147	1.212046251
			10	21	1188.3	2.824747446	0.445344811	1.35586227
			15	8	798.66	1.047443924	0.60376042	1.255484499
		AB	H	20	192.24	3.613029625	0.544496186	1.631164797
			M	16	690.16	2.294657434	0.564687339	1.565645747
			L	12	1293.44	1.535227766	0.309562884	0.769234868
			1	32	944.58	4.525058353	0.441969396	1.531749205
			5	11	807.28	1.493948633	0.375400528	0.900171152
			10	6	6.56	2.658173833	0.154327816	0.276518326
			15	8	440.52	1.14981123	0.611851956	1.272310374
	KB	OB	H	13	375.38	2.024312381	0.047210411	0.121092313
			M	28	381.32	4.542671648	0.478570398	1.594694437
			L	35	489.46	5.489801066	0.604955183	2.150826236
			1	27	1471.74	3.564475566	0.337275308	1.111604393
			5	22	1691.54	2.825088809	0.274822059	0.849486651
			10	21	1942.44	2.641414674	0.341580326	1.039948968
		CI	H	17	188.6	3.053651685	0.123420741	0.34967729
			M	23	325.18	3.803346993	0.750364135	2.352762404
			L	28	676	4.143523632	0.592727258	1.975088444
			1	24	789.52	3.447539233	0.380297119	1.208604716
			5	19	615.42	2.802732058	0.373188283	1.098830127
			10	12	428.86	1.81484295	0.291944511	0.725454856

Year	Area	Site	Stratum	# of taxa	total biomass (g)	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
			15	21	40.12	5.417301561	0.653472586	1.98951195
		PG	H	17	246.32	2.905587561	0.435256897	1.233175649
			M	32	422.3	5.127597822	0.599449503	2.077533665
			L	39	312.9	6.61343012	0.611401478	2.239907004
			1	27	1381.24	3.595760746	0.431178274	1.421093253
			5	23	373.54	3.714318216	0.562550286	1.763873167
			10	22	554.22	3.324067248	0.197512646	0.610519975
			15	6	86.88	1.119939255	0.32427352	0.58102015
	PWS	KI	H	16	742.4	2.269327345	0.175268121	0.485946417
			M	29	277.96	4.975586557	0.338127514	1.138575367
			L	25	507.76	3.852321948	0.572663032	1.843331188
			1	35	840.98	5.048579302	0.288861681	1.027003818
			5	16	1825.2	1.997484541	0.456579832	1.265908094
			10	10	3897.02	1.088538394	0.256306441	0.59016739
		MI	15	22	525	3.352812502	0.287969171	0.890124932
			H	14	712.48	1.979067	0.311944892	0.823240454
			M	39	1410.72	5.240038228	0.327256571	1.198924621
			L	41	1328.82	5.561699218	0.54248775	2.014567354
			1	36	1536.86	4.770019212	0.596254569	2.136689541
			5	19	1327.32	2.503157751	0.600843926	1.769148277
			10	19	696.8	2.749561495	0.38415316	1.131115539
			15	16	495.2	2.417420231	0.234858865	0.651167041
		GI	H	28	402.16	4.502363726	0.572482184	1.907627716
			M	56	653.54	8.484507014	0.524501634	2.111303539
			L	56	1186.42	7.769793014	0.476220546	1.916955181
			1	36	1100.72	4.997344418	0.61112626	2.189982528
			5	24	1081.32	3.292328199	0.342893014	1.089732457
			10	21	1148.8	2.838299308	0.352786885	1.074067588
			15	12	100.94	2.38377665	0.022029137	0.054740349
2003	KOD	OH	H	16	137.02	3.048701853	0.564499731	1.565125588
			M	28	1316.18	3.75914261	0.358753836	1.195441151
			L	26	519.74	3.997870775	0.547124212	1.782583502
			1	23	1303.16	3.067250572	0.610101856	1.91297084
			5	17	5344.7	1.863963148	0.158309024	0.448523239

Year	Area	Site	Stratum	# of taxa	total biomass (g)	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
			10	12	1206.24	1.55033005	0.279991727	0.695753303
		UB	H	13	359.58	2.039104351	0.107603866	0.275998467
			M	18	307.06	2.968372946	0.436463151	1.261540765
			L	16	135.82	3.05416222	0.398278893	1.104263568
			1	17	1313.02	2.228385843	0.486208671	1.377532895
			5	6	691.4	0.764675827	0.764959523	1.37062347
			10	21	325.98	3.456120045	0.358933671	1.092781616
			15	9	280.64	1.419176302	0.313833997	0.689563771
		AB	H	25	140.28	4.854722014	0.555545341	1.788231469
			M	17	397.82	2.672903601	0.318777547	0.903164799
			L	20	1834.96	2.528351482	0.278321239	0.833775919
			1	18	4184.06	2.038604613	0.324130517	0.936857693
			5	11	1354.5	1.386734123	0.185632176	0.445126517
			10	10	474.92	1.460293081	0.386693482	0.890394648
			15	8	156.84	1.384705601	0.488137982	1.015054398
	KB	OB	H	27	63.64	6.260169459	0.611515046	2.015453832
			M	30	564.06	4.57762663	0.578962272	1.969164965
			L	32	740.16	4.692088234	0.555594118	1.925542481
			1	29	938.4	4.091069368	0.340552751	1.146741859
			5	14	1397.32	1.795007048	0.312038055	0.823486316
			10	21	662.68	3.078679241	0.341966341	1.041124197
		CI	H	46	286.48	7.953806096	0.530213022	2.029995525
			M	42	754.1	6.188188874	0.516647671	1.931058304
			L	32	592.16	4.856059452	0.580169589	2.010714575
			1	25	1055.78	3.447267878	0.460763664	1.483141019
			5	18	1221.66	2.391682841	0.251356445	0.72651357
			10	14	323.08	2.249952416	0.441629672	1.165486024
			15	12	10.4	4.697229792	0.099976688	0.248432737
		EI	H	18	1839.44	2.261475388	0.050025538	0.144592401
			M	33	710.98	4.873113045	0.412629146	1.442760931
			L	46	1097.86	6.427544757	0.611037904	2.339445015
			1	32	642.74	4.794501267	0.367478297	1.273582727
			5	10	1200.4	1.26932009	0.432892164	0.996771044
			10	14	776.12	1.953621874	0.417366752	1.101454786

Year	Area	Site	Stratum	# of taxa	total biomass (g)	Margalef Index d (species richness)	Pielou's Index J' (evenness)	Shannon-Wiener Index H' (diversity)
			15	6	127.84	1.030762173	0.409842423	0.734339043
	PWS	KI	H	11	1031.94	1.441089181	0.142760792	0.342325429
			M	22	1047.72	3.019683308	0.509512721	1.574925453
			L	21	1681.8	2.692652585	0.492089807	1.498178457
			1	19	1071.52	2.579966979	0.50013717	1.472623378
			5	31	732.72	4.547684539	0.328041838	1.126491475
			10	12	608.46	1.715819387	0.439609618	1.092388862
			15	8	275.34	1.245993531	0.082091163	0.170703775
		MI	H	13	428.22	1.980316616	0.298366157	0.765294084
			M	27	509.96	4.170454635	0.6148655	2.026496382
			L	33	606.82	4.99357685	0.615356251	2.151597784
			1	33	1430.38	4.404258387	0.603586196	2.110443699
			5	21	870.74	2.954496285	0.397812405	1.211148792
			10	14	519.9	2.078790481	0.529003276	1.396069972
			15	24	129.22	4.731034149	0.320410087	1.018280504
		GI	H	12	884.56	1.621201699	0.365109486	0.90726299
			M	23	881.44	3.244092797	0.617595877	1.936468301
			L	29	1324.82	3.894822066	0.440960835	1.484845581
			1	24	1441.12	3.162304943	0.696656641	2.214012305
			5	27	760.32	3.919358064	0.50217037	1.655071619
			10	22	1006.28	3.03730872	0.250898191	0.775536961
			15	15	156.34	2.771161562	0.097501852	0.264039909

Appendix 12. Matrix showing important macroalgal species for each area and tidal height for 2003.

	Prince William Sound			Kachemak Bay			Kodiak Island		
	corr.	**#**	**species**	**corr.**	**#**	**species**	**corr.**	**#**	**species**
high	0.962	6	*Fucus, Pterosiphonia, Endocladia, Neorhodomela/Odonthalia* complex, *Melanosiphon, Ulva/Monostroma/Ulvaria* complex	0.953	5	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Fucus, Callithamnion, Halosaccion, Neorhodomela/Odonthalia* complex	0.968	5	*Fucus, Pterosiphonia, Neorhodomela/Odonthalia* complex, *Alaria*
mid	0.950	13	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Ulva/Monostroma/Ulvaria* complex, *Ulothrix, Fucus, Scytosiphon, Cryptosiphonia, Endocladia, Halosaccion, Palmaria, Porphyra, Pterosiphonia, Ptilota, Tokidadendron*	0.952	7	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Ulva/Monostroma/Ulvaria* complex, *Alaria, Elachista, Pilayella, Halosaccion, Neorhodomela/Odonthalia* complex	0.947	4	*Desmarestia, Fucus, Pterosiphonia, Neorhodomela/Odonthalia* complex
low	0.951	12	*Ulva/Monostroma/Ulvaria* complex, *Alaria, Colpomenia, Fucus, Mazzaella/Mastocarpus* complex, *Neorhodomela/Odonthalia* complex, *Palmaria, Pterosiphonia, Ptilota, Tokidadendron,* upright corallines, *Zostera*	0.953	10	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Ulva/Monostroma/Ulvaria* complex, *Alaria, Elachista, Fucus, Laminaria, Soranthera, Neorhodomela/Odonthalia* complex, *Palmaria, Pterosiphonia*	0.952	5	*Desmarestia, Fucus, Scytosiphon, Tokidadendron, Neorhodomela/Odonthalia* complex
1m	0.952	7	*Protomonostroma, Alaria, Fucus, Laminaria, Constantinea, Microcladia,* upright corallines	0.956	7	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Ulva/Monostroma/Ulvaria* complex, *Agarum, Laminaria, Soranthera, Neorhodomela/Odonthalia* complex, *Hedophyllum*	0.953	3	*Desmarestia, Laminaria, Neorhodomela/Odonthalia* complex
5m	0.965	5	*Agarum, Cymathere, Laminaria, Constantinea*, upright corallines	0.969	5	*Agarum, Laminaria, Neorhodomela/Odonthalia* complex, *Opuntiella, Codium*	0.969	4	*Desmarestia, Laminaria, Costaria, Agarum*
10m	0.958	6	*Agarum, Laminaria, Pleurophycus, Opuntiella, Ptilota*, upright corallines	0.959	7	*Agarum, Laminaria, Omphalophyllum, Constantinea, Neorhodomela/Odonthalia* complex, *Opuntiella, Schizochlaenion*	0.958	4	*Desmarestia, Laminaria, Agarum, Neorhodomela/Odonthalia* complex
15m	0.984	3	*Agarum, Laminaria*, upright corallines	0.976	3	*Agarum, Laminaria, Turnerella*	0.999	5	*Desmarestia, Laminaria, Agarum, Polysiphonia, Tayloriella*

Appendix 13. Matrix showing important macroalgal species for each area and tidal height for

2004.

	Prince William Sound			Kachemak Bay			Kodiak Island		
	corr.	**#**	**species**	**corr.**	**#**	**species**	**corr.**	**#**	**species**
high	0.956	7	*Elachista, Fucus, Leathesia, Cryptosiphonia, Endocladia, Neorhodomela/Odonthalia* complex, *Pterosiphonia*	0.953	5	*Urospora, Fucus, Pilayella, Endocladia, Neorhodomela/Odonthalia* complex	0.951	5	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Fucus, Neorhodomela/Odonthalia* complex, *Porphyra, Pterosiphonia*
mid	0.952	9	*Ulva/Monostroma/Ulvaria* complex, *Elachista, Fucus, Leathesia, Pilayella, Cryptosiphonia, Halosaccion, Neorhodomela/Odonthalia* complex, *Pterosiphonia*	0.954	10	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Ulva/Monostroma/Ulvaria* complex, *Fucus, Pilayella, Halosaccion, Mazzaella/Mastocarpus* complex, *Neorhodomela/Odonthalia* complex, *Palmaria, Pterosiphonia,* upright corallines	0.955	5	*Ulva/Monostroma/Ulvaria* complex, *Alaria, Fucus, Neorhodomela/Odonthalia* complex, *Porphyra*
low	0.957	14	*Ulva/Monostroma/Ulvaria* complex, *Elachista, Fucus, Leathesia, Melanosiphon, Ralfsia, Cryptosiphonia, Mazzaella/Mastocarpus* complex, *Neorhodomela/Odonthalia* complex, *Phycodrys, Pterosiphonia, Ptilota, Tokidadendron,* upright corallines	0.955	9	*Ulva/Monostroma/Ulvaria* complex, *Alaria, Fucus, Laminaria, Scytosiphon, Mazzaella/Mastocarpus* complex, *Neorhodomela/Odonthalia* complex, *Palmaria, Porphyra*	0.955	5	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Alaria, Fucus, Neorhodomela/Odonthalia* complex, *Pterosiphonia*
1m	0.953	6	*Alaria, Costaria, Laminaria, Constantinea, Neoptilota,* upright corallines	0.957	6	*Ulva/Monostroma/Ulvaria* complex, *Alaria, Hedophyllum, Neoptilota, Neorhodomela/Odonthalia* complex, *Palmaria*	0.955	7	*Acrosiphonia/Cladophora/Rhizoclonium* complex, *Ulva/Monostroma/Ulvaria* complex, *Alaria, Desmarestia, Laminaria, Neorhodomela/Odonthalia* complex, *Pterosiphonia*
5m	0.973	5	*Agarum, Laminaria, Constantinea, Neoptilota,* upright corallines	0.958	6	*Agarum, Laminaria, Callophyllis, Constantinea, Neoptilota, Palmaria*	0.956	6	*Codium, Agarum, Desmarestia, Laminaria, Pleurophycus, Sparlingia*
10m	0.968	4	*Agarum, Laminaria, Ptilota,* upright corallines	0.954	5	*Agarum, Desmarestia, Laminaria, Constantinea, Membranoptera*	0.976	3	*Agarum, Desmarestia, Laminaria*
15m	0.972	2	*Agarum, Laminaria*	0.972	4	*Agarum, Neoptilota, Palmaria, Pterosiphonia*	0.963	3	*Agarum, Desmarestia, Laminaria*

Appendix 14. Summary list of monitoring and measuring units for intertidal and subtidal rocky substrate communities.

Stratum	Major group	Monitoring units	Measuring unit
Intertidal	Invertebrates	Barnacles	% cover
high – 1m		Mussels	% cover
		Limpets	> 1cm, abundance
		Chitons	> 1cm, abundance
		Gastropods	> 1cm, abundance
		Tubeworms	% cover
		Seastars	> 1cm, abundance, swath counts
		Urchins	> 1cm, abundance
		Crabs	> 1cm, abundance
		Hermit crabs	> 1cm, abundance
		Anemones	> 1cm, abundance, swath counts
		other sessile invertebrates	% cover
	Others	Bare rock/Open substrate	% cover
		Encrusting corallines	% cover
		Upright corallines	% cover
Subtidal	Invertebrates	Limpets	> 1cm, abundance
5-20m		Chitons	> 1cm, abundance
		Gastropods	> 1cm, abundance
		Tubeworms	% cover
		Seastars	> 1cm, abundance, swath counts
		Urchins	> 1cm, abundance, swath counts
		Crabs	> 1cm, abundance
		Hermit crabs	> 1cm, abundance
		Bryozoans	% cover
		Ascideans	% cover, abundance for solitary
		Other encrusting or sessile invertebrates	% cover
	Vertebrates	Rockfish	Swath counts
		Greenlings	Swath counts
		Cod	Swath counts
	Others	Bare rock or other substrate	% cover
		Encrusting corallines	% cover
		Upright corallines	% cover