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# Initial Evaluation of Community Structure in Goose Barnacle (*Pollicipes polymerus*) and Sea Mussel (*Mytilus californianus*) Beds off the West Coast of Vancouver Island, British Columbia

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## ABSTRACT

Goose barnacles (*Pollicipes polymerus* Sowerby, 1833) have been harvested off the west coast of Vancouver Island since 1985. However, following rejection of approval to establish a sea mussel (*Mytilus californianus*) fishery because analysis indicated that harvesting this species would likely have significant negative ecological impacts, attention was directed to the possible effects of the existing commercial goose barnacle fishery. Since the ecological role of this species was also structural and its fishery implications had not previously been thoroughly investigated, the commercial goose barnacle fishery was closed in May, 1999, until appropriate evaluation studies could be done. Such studies were initiated in 2000, with objectives to: 1) evaluate the ecological role of goose barnacles in the exposed rocky intertidal; 2) to conduct goose barnacle biomass estimates in limited areas; and 3) to make management recommendations from an ecological perspective on how a commercial goose barnacle fishery, if reopened, should proceed. Here, we present initial results from our analysis of goose barnacle/sea mussel community structure and initial ecological observations of how experienced fishers harvest goose barnacles.

Species diversity within the exposed rocky intertidal zone is complex and is correlated with matrix thickness (the combined layer of living animals, dead shells and associated debris). Following screening with a 1.0 mm sieve, 142 species were identified in our samples. Species predominating numerically (>1000 individuals/species collected, 85% of all individuals found) in the samples were *Mytilus californianus, Cirolana harfordi, Petrolisthes cinctipes, Corophium sp., Hyale sp., Lacuna vincta, Pollicipes polymerus, Semibalanus cariosus, Cucumaria pseudocurata, and Lottia alveus, respectively*. Species observed consisted of: gastropods (40%); marine arthropods (20%); annelids (16%); echinoderms (7%); molluscs (5%); cnidarians (3%); unknowns (4%); insects, chordates, and sipunculas (5%). Sea mussels and goose barnacles predominated at an intertidal elevation of 2 to 4 m.

Experienced fishers typically harvest fist-sized “colonies” of goose barnacles from a sea mussel or acorn barnacle matrix, prying each colony off with a long flat steel bar. This harvest method produces divot holes in the mussel matrix layer or patches of bare rock in acorn barnacle areas. Three months after harvesting, the holes created in sea mussel areas had largely filled in through realignment of nearby sea mussels. Bare rock was still evident in acorn barnacle areas. Reduced community biomass at areas intensively harvested, anecdotally reported to be due to the actions of inexperienced harvesters in previous year(s), was visible at most sites.

**RÉSUMÉ**

Examen préliminaire de la structure communautaire des bancs de pouce-pied (*Pollicipes polymerus*) et de moules californiennes (*Mytilus californianus*) au large de la côte ouest de l'île de Vancouver, en Colombie-Britannique. Les débuts de la pêche du pouce-pied (*Pollicipes polymerus* Sowerby, 1833) au large de la côte ouest de l'île de Vancouver remontent à 1985. Cependant, la proposition de mettre sur pied une pêche de la moule californienne (*Mytilus californianus*) ayant été refusée en raison des impacts écologiques néfastes que, selon l'analyse, la récolte de cette espèce aurait probablement eus, on s'est intéressé aux effets possibles de l'actuelle pêche commerciale du pouce-pied. Comme le pouce-pied joue un rôle dans la structure de l'écosystème et que les répercussions de la pêche de cette espèce n'ont pas été étudiées de façon approfondie, la pêche commerciale du pouce-pied a été fermée en mai 1999, jusqu'à ce que des évaluations appropriées puissent être faites. Ces études, amorcées en 2000, avaient les objectifs suivants: 1) évaluer le rôle écologique du pouce-pied dans la zone intertidale rocheuse exposée; 2) estimer la biomasse du pouce-pied dans des zones restreintes; et 3) faire des recommandations de gestion d'un point de vue écologique sur la façon dont la pêche commerciale du pouce-pied devrait se dérouler si elle était rouverte. Nous présentons dans ce document les premiers résultats de notre analyse de la structure des communautés de pouce-pied/moules carliforniennes, ainsi que nos premières observations écologiques sur la façon dont des pêcheurs expérimentés récoltent le pouce-pied.

La diversité spécifique dans la zone intertidale rocheuse exposée est complexe et est corrélée avec l'épaisseur de la matrice (couche constituée d'animaux vivants, de coquilles et de débris connexes). Après avoir tamisé nos échantillons avec un crible à mailles de 1,0 mm, nous avons identifié 142 espèces. Les espèces les plus abondantes (>1000 individus/espèce recueillie, 85 % de l'ensemble des individus trouvés) dans les échantillons étaient par ordre décroissant : *Mytilus californianus*, *Cirolana harfordi*, *Petrolisthes cinctipes*, *Corophium* sp., *Hyale* sp., *Lacuna vincta*, *Pollicipes polymerus*, *Semibalanus cariosus*, *Cucumaria pseudocurata* et *Lottia alveus*. Les espèces observées étaient constituées de: gastropodes (40%); d'arthropodes marins (20%); d'annélides (16%); d'échinodermes (7%); de mollusques (5%); de cnidaires (3%); d'espèces inconnues (4%); d'insectes, de cordés et de sipunculiens (5%). La moule californienne et le pouce-pied étaient les plus abondants dans la zone intertidale d'une hauteur de 2 à 4 m.

Les pêcheurs expérimentés pêchent généralement des « colonies » de pouce-pied ayant la taille d'un poing dans une matrice de moules californiennes ou de balanes, en utilisant comme levier une longue barre en acier pour arracher chaque colonie. Cette méthode laisse des trous dans la couche de la matrice de moules ou des endroits de roche dénudée dans les bancs de balanes. Trois mois après la récolte, les trous avaient été largement comblés en raison de la redistribution des moules californiennes à proximité. Par contre, on voyait encore de la roche dénudée dans les bancs de balanes. La diminution de la biomasse de la communauté dans les secteurs de pêche intensive, que l'on attribuait anecdotiquement aux actions de pêcheurs inexpérimentés dans les années antérieures, était évidente dans la plupart des secteurs.

## INTRODUCTION

The gooseneck barnacle, *Pollicipes polymerus*, is abundant along the foreshores of British Columbia to Baja, California on exposed or semi-exposed rocky coasts. First Nations have long since used goose barnacles as a food source, and continue to use them today for food, social and ceremonial purposes, such as the Mother's Day harvest. Commercially, harvesting occurred sporadically until 1985, and continuously until 1999. The fishery was open-access with no size limits or annual total allowable catch (Lauzier 1999a). In 1988, 11 companies purchased goose barnacles, with a record total of 467 licenses issued to harvesters. Landings peaked that year at 53.5 t.

Harvesters typically remove fist-sized colonies of harvestable sized barnacles. A harvestable sized goose barnacle typically has a rostral-carinal (RC) length of 15 to 30 mm, peduncle length between 20 to 80 mm, and a volume of 5 to 25 ml (Figure 1). Harvesters utilise a long flat steel bar (sharpened car leaf spring with a handle) to pry barnacle clumps from sea mussel (*Mytilus californianus*) or acorn barnacle (*Balanus sp.*) substrates. Goose barnacles are then carefully removed from these species to minimise peduncle wounding, as bleeding animals have to be discarded as they are not marketable. The primary markets for goose barnacles are Spain, Portugal, and France, where it is considered a food delicacy. The main market of British Columbian goose barnacles, which are a substitute for European product, is the Barcelona area of Spain.

Stock status, habitat region, and the availability of exploitable populations of goose barnacles are not currently known, but are currently under investigation (R. Lauzier, DFO, pers. comm.). The west coast of Vancouver Island has been traditionally harvested by both commercial and First Nations harvesters. Due to its data-limited nature and unknown ecological impacts, the commercial fishery was closed on May 31, 1999 (Lauzier 1999b).

The biology of goose barnacles has been previously described by Lauzier (1999) and Jamieson et al. (1999a). In general, goose barnacles are found attached to each other, rocks, mussels, and acorn barnacles where wave action is strong. Goose barnacles often occur as distinct rosette-shaped aggregations that are typically 20 to 40 cm in diameter (Hoffman 1989). Rosettes are often formed with the older individuals in the centre surrounded by progressively smaller individuals. Juveniles are often found attached to the peduncle of adults, as cyprid larvae have a high preference for adult peduncles as a substrate (Lewis 1975). As attached juveniles mature they increase in size and gradually move down towards the base substrate and form a rosette cluster.

The elevation range of goose barnacles above chart datum is determined by wave action, physiological limitations to air exposure, competition with mussels, and predation within the subtidal zone. The upper elevation range has been found as high as one meter above the highest water level, due to wave splash and as shallow as the subtidal zone (Austin 1987). However, in most cases barnacles generally reside within the mid-littorial zone along the main belt of *Balanus glandula* (approximately 2.0 m to 3.0 m above chart datum). Goose barnacles are also closely associated with and often attached to *M. californianus*, which creates a matrix (a combined layer of living animals, dead shells and associated debris) with a complex community structure (a diverse community of algae, invertebrates, and fish). Community structure is a function of species diversity in these habitats and both physical and ecological processes. The community structure is high in species diversity and is a function of matrix thickness. The matrix also provides shelter and habitat for other species. According to Yamada and Peters (1988), the matrix may contain at least 300 other species of invertebrates.

The living sea mussels composing the matrix may consist of various ages and may range from a monolayer of small mussels to several complex layers of larger individuals. As the layers develop and matrix thickness increases, an increase in species richness also occurs, which in turn decreases with an increase in elevation (see Jamieson et al. 1999). The upper intertidal level of predation of goose barnacles is mostly limited by the exposure tolerances of marine predators. In the lower mussel/barnacle zone, the purple seastar, *Pisaster ochraceus,* is the primary predator and its upper habitat range coincides with the average lower barnacle range. Within the mid-upper barnacle zone, predatory snails (*Nucella spp*.) and sea gulls (*Larus glaucescens*) are the primary predators (Lauzier 1999a). According to Bernard (1988), predators of *P. polymerus* in order of significance are purple starfish (*Pisaster ochraceus*), muricid snails (*Nucella emarginata* and *N. lamellosa*), and small pagurid crabs. Bernard (1988) also reported that several polychaete species were predatory on newly settled goose barnacles.

In addition to predation, goose barnacles and sea mussels may be impacted by seasonal storm events, which may create gaps in the mussel matrix. Small gaps or holes in the matrix may be filled through the relatively rapid realignment of nearby sea mussels depending on intertidal elevation and slope. Larger gaps require more time to fill in due to the need for greater lateral sea mussel movement. In areas where bare rock is exposed, successional recruitment of species on the rock surface may occur. Goose barnacles adhering to bare rock are not harvestable as peduncle damage occurs in their removal.

The recruitment rate of goose barnacles was reviewed by Jamieson et. al. (1999); observed resettlement of goose barnacles in experimental harvested areas in less exposed Barkley Sound locations had not occurred within a seven-year period (Austin, 1992).

Here, we describe the ecosystem monitoring conducted prior to and during experimental goose barnacle fishing in the fall, 2000, and analyse the data obtained. Recommendations as to future ecosystem studies and fishing development are provided.

# METHODS

## ECOSYSTEM ASSESSMENT

The primary focus of the first year's sampling in the ecosystem assessment was to determine general intertidal community structure (species presence, relative abundances, and species diversity) within the goose barnacle intertidal distribution range throughout various commercially harvested locations along the west coast of Vancouver Island. We hypothesised that variability in community structure would be high and would depend on such factors as islet location (outer locations versus inner more sheltered sites), sample site exposure (lee or windward perspective), matrix thickness, and elevation above chart datum.

### FIELD PROCEDURES

Samples were collected in two general locations (Figure 2) on the outer coast along the central west coast of Vancouver Island: 1) Ucluelet (Amphitrite Point) (Figure 3); and 2) islets off Clayoquot Sound (Tofino Area): Lennard Island, Islet #2, Islet #3, Nob Rock, and Nob Rock II (Figure 4). Sampling locations were those used in the stock assessment surveys, and were chosen based on both harvestability and accessibility. Each site except Amphitrite Point was stratified into two representative areas based on *Mytilus/Pollicipes* bed exposure: windward (exposed) or leeward (sheltered) (Appendix A).

Amphitrite Point was surveyed on June 23, 2000, to determine sampling logistics. This site was chosen primarily for its accessibility by land and was subsequently observed to contain limited harvestable barnacles by the participating commercial harvester, Trevor Hamilton, Canadian Goose Barnacle Harvesters Co-op. Harvesting does not normally occur in this area as it does not contain a large quantity of easily accessible marketable barnacles, relative to the outer reefs and islets in more exposed areas. Therefore, data collected from this site was unique in both its collection protocol and its representativity of a typical harvest site. These data were thus not used in analyses with data obtained from the other sites assessed.

The Amphitrite Point site sampled, bearing $182^O$ from the Amphitrite lighthouse, consisted of two beds with similar windward exposure. Four samples were chosen ad hoc from each bed at various elevations and slope gradients. Each sample (visually estimated at about 1400 $cm^2$ in size) was harvested down to bare substrate. All matrix and biota present at each site were collected and placed into a large clear plastic bag. The samples were transported to the Pacific Biological Station (PBS) in Nanaimo where Department of Fisheries and Oceans (DFO) staff members and Philip Lambert, Invertebrates Curator, Royal BC Museum, randomly chose four sub-samples for identification of soft-bodied invertebrates. Soft invertebrates obtained from each sub-sample were preserved in a 3.9% formalin solution and the remaining contents were frozen for later sorting.

On July 3 and 4, 2000, off Tofino, two sets of two samples each were to be collected from each of ten islets, for a total of 40 sample sites. However, due to time restraints and logistics, only five islets were sampled, for a total of 21 sample sites (one additional sample was collected at Lennard Island). The five islets sampled were deemed to be those most productive for barnacles by participating local commercial harvester, Joe David, West Coast Gooseneck's Association, and were referenced by GPS. Four to five sample sites were selected ad hoc on each islet near the middle of the *Mytilus/Pollicipes* intertidal height spatial distribution range in areas typical of harvestable product. Each sample collected was 900 $cm^2$ in area (determined with a measured plastic quadrat frame) and was harvested down to bare substrate, with the removal of all biota within the quadrat as previously conducted at Amphitrite Point. Sample sites were photographed and referenced via triangulation. In areas where convenient reference points were not obvious, a bright orange permanent marine spray was used to mark each reference point. However, upon revisiting sites in May and June of 2001, no evidence of marine spray paint was visible.

At each site, the number of larger, more mobile species (e.g., *Pisaster sp.*) and marine flora that were nearby and which might possibly influence the biological community at the sites sampled, but which were unlikely to be sampled by the above protocol (e.g., tide pools and crevices), were recorded. Such organisms are also part of the intertidal ecosystem and would be potentially impacted by goose barnacle harvesting. Observations were mostly made within a 10 m band of longshore width, centred around the quadrate, which when multiplied by the length (lower to upper part of the barnacle zone) of the intertidal zone, allows calculation of an estimated number per unit area, or density. However, in some case, such as due to a rising tide, this was not possible, and so the area of the observable sea mussel bed was measured.

Soft-bodies species in one sample from each stratum on each islet were immediately removed and preserved on the day of collection, with the remaining material, and other samples, then frozen for later sorting in Nanaimo. Soft-bodied species were preserved in a 3.9% formalin solution for later identification. In total, 29 quadrats were collected from both Amphitrite Point and islets off Tofino.

<u>LABORATORY PROCEDURES</u>

Samples were thawed, the larger organisms removed and then the remaining material was screened to three different size fractions (>1.0 mm, 0.5-1.0 mm and 0.5-0.3 mm). Animals greater than 1.0 mm were examined in this study; the remaining size fractions were preserved in 70% isopropanol for possible future analyses. Larger mussels, *Mytilus californianus*, approximately ≥ 2 cm, were set aside for detailed morphometric measurements. Epizoans on mussels. such as the thatched barnacle (*Semibalanus cariosus),* acorn barnacle (*Balanus nubilis),* bryozoan species and the goose barnacle, had their attachment location noted, and their measurments and/or weight recorded.

For the first sample, all mussels ≥ 3 cm were measured for length and drained soft body wet weight. The rostral-carinal (RC) length (mm), whole weight (g), and volume (via water displacement, ml) of each goose barnacle was also determined. Other species, such as thatched barnacle, acorn barnacle, and bryozoans, were measured as to diameter or area of coverage, recorded to the nearest tenth of a millimetre. However, due to the time-consuming nature of this protocol, it was not followed for the remaining samples. With these, only the first fifty goose barnacles encountered in each sample were measured for both wet weight and volume. Length, diameter, and or area of coverage, where appropriate, were measured for all other species.

Representatives of all species (≥1.0 mm) sorted out through sieving were preserved in 70% isopropanol and labelled to create a reference collection.

## ANALYTICAL PROCEDURES

For each site, estimates of species diversity, species evenness, and species richness were calculated using Shannon's index of species diversity, Simpson's index of dominance, and Hurlbert's (1971) index for species richness, summarised from Michael (1980), Diamond and Case (1986), and Green (1979):

Species Diversity Index (H'): Shannon's Index of Diversity

$$H' = \sum_i \frac{n_i}{N} \ln \frac{n_i}{N}$$

where $n_i$ is the number of individuals in the $i^{th}$ species, and N is the total number of individuals collected.

The species diversity index is often used in impact assessments. It is a weighted measure that takes into account the relative quantities of the *s* species (*i*= 1,…,s). The larger the number of species (richness) and the more equitably distributed (evenness) the numbers of individuals among the species, the greater the species diversity. The index is only applicable on random samples drawn from a large community in which the total number of species is known. Therefore, in investigating species diversity, species richness and evenness should always by measured in addition to the composite measure, H'.

Species Evenness: Simpson's (1949) Index of Dominance

$$D = 1 - S1 = 1 - \sum_i \frac{n_i(n_i - 1)}{N(N-1)}$$

where SI equals the evenness or equitability of distributions of individuals, $n_i$ is the number of individuals in the $i^{th}$ species, and N is the total number of individuals collected.

Species evenness attempts to quantify the sample’s unequal species representation against a hypothetical community in which all species are equally common (most communities contain a few dominant and many uncommon species). Evenness can be estimated by the ratio of observed heterogeneity to maximum possible heterogeneity, when all species have the same number of individuals. Without a calculation of evenness, the diversity index on its own may be misinterpreted, as it does not take into account that a community with a few, evenly represented species can give the same diversity index as one with many, unevenly represented species. The contribution of each species to this index is proportional to the probability of it appearing in a sample of N individuals. Therefore, as N increases, the contribution of rare species increases.

Species Richness: Hurlbert's equation (1971), from Michael (1980):

$$S_R = S - \sum_i \log^{-1}\left[\log(N - n_i)! - \log(N - n_i - N_R!)\right] - \left[\log N! - \log(N - N_R)!\right.$$

where $S_R$ is the number of species expected in a sample of size $N_R$, N is the total number of individuals in the collection and $n_i$ is the number of individuals of the $i^{th}$ species in the total collection.

According to Michael (1980), pollution and other perturbations frequently reduce the number of species in a community, i.e. its species richness, or the number of species in a collection of a given size, or area. This is a statistical method for estimating the number of species expected in a random sample of individuals taken from a collection. It answers the question: *if the sample had consisted of n individuals (n<N), what number of species(s) would likely have been seen?* It permits a comparison of species richness among several communities sampled with different levels of intensity.

There has been some scepticism of the ability of Shannon's Index of Diversity alone to monitor impact in assessments. Therefore, by using the above indices in conjunction with other data analyses, such as multivariate analyses and indicator-species approaches one may reflect on the relative opportunism of the species assemblage (Michael 1980). Multivariate techniques that would be applicable include numerical classification (i.e. cluster analysis) and ordination (i.e. principal component analysis (PCA) or factor analysis). However, these analyses are not conducted here, both due to the additional, and unavailable, resources required and because while relevant, this study is not intended to be a detailed statistical study of the details of this intertidal community. Rather, it attempts to generally characterise the differences associated with different features of the community, data which may influence the design of later, more detailed studies of the impacts of specific known perturbations to the community. Thus, only the three indices described above are presented here.

ECOLOGICAL IMPACT ASSESSMENT

a) Site Impact

Efforts to investigate the ecological impact of goose barnacle fishing were conducted simultaneously with the Stock Assessment Division's biomass survey and an experimental fishery, conducted between Sept 13 - Dec 13, 2000, in the Ucluelet, Tofino, and Kyuquot areas. Survey sites chosen to examine the recruitment/recovery rate impacts of significant harvests were determined from each area's harvest potential and the estimated time required to harvest the entire site or a portion there of. Biomass estimates were conducted at only selected site locations. Photographs and location descriptions of harvest sites were taken for future reference and to define the harvest boundaries for later harvesting by fishers. Subsequent harvests were only conducted within the surveyed portion of the islets and continued until harvesters decided on the basis of product availability to move harvesting activities to another location. Presumably, this was when catch-per-unit-effort reached some minimal value.

To determine the ecological impact of a "significant" goose barnacle removal, i.e. one which was visible and subjectively large enough to have an impact, each specific location was referenced, where feasible, via triangulation to a predominate feature. In the Tofino region only, experimental flagging of impact sites was attempted using a large metal "needle" and highly visible yellow polypropylene rope, with the rope "sewn" into the mussel matrix. For both the Tofino and Kyuquot regions, each marked harvest site was photographed for future reference and documented. Photographs included one general site view and another looking directing down upon the site with a 30 cm ruler placed along one side. The depth and diameter of each labelled impacted site was recorded.

b) Barnacle Discards

During the harvest cycles from each islet, each harvester's catch was randomly sampled. Harvesters were asked to separate their catches into two bags (marketable sized barnacles and discarded material). Each of the bags were tagged by product type, sample location and harvester. On returning to port, marketable barnacle bags were weighed (in bulk) and counted for total number of individuals before the product was returned to the harvester. Bags containing discarded material were sorted into three size fractions, based on visual observation and utilising procedures used in the goose barnacle stock assessment biomass protocol (R. Lauzier, DFO, pers. comm.). Each size fraction was weighed collectively and the individuals then counted. The representative RC length (mm), peduncle length (mm), and weight (g) from up to five representative individuals from each size fraction were measured using digital callipers (Table 1).

## RESULTS

### ECOSYSTEM ASSESSMENT

A total of 142 species ≥1.0 mm were encountered (Appendix B). Numbers of the dominant species found and their average densities over the 21 islet sites are in Table 2. Table 3 gives the number and density by site of *Pisaster ochraceus*, the only large mobile predator observed. Gastropods represented approximately 40% of the species present in the reference collection compiled, marine arthropods 20%, and annelids 16%. The remaining 24% of the species observed consisted of echinoderms (7%), molluscs (5%), cnidarians (3%), unknowns (4%), and insects, chordates, and sipunculas (1% relatively, Figure 11). Many species were abundant within all twenty-nine sites. These species included *Pachycheles sp., Petrolisthes sp., Amphissa sp., Balanus glandula, Bryozoan sp*., *Cirolana harfordi*, *Cucumaria pseudocurata, Jassa falcata, Lottia sp., Margarites sp., Mytilus californianus, Pollicipes polymerus, and Semibalanus cariosus.* However, many of these species comprised a relatively small percentage of each quadrat's biomass despite their high abundance (Table 4). Species frequency varied significantly between all sites, likely due to several factors: the general location (Ucluelet area (Barkley Sound) vs. Tofino area (Clayoquot Sound), exposure (outer remote islets vs. inner, more sheltered islets), wave action (windward vs. leeward sites), thickness/age of mussel matrix, underlying substrate, or combinations of the above factors.

The number of mussels present in a sample was not significantly correlated with goose barnacle number (Figure 5). Average matrix thickness was directly correlated to average mussel size but not with goose barnacle rostral-carinal (RC) length (Figure 6).

With goose barnacles, peduncle length and RC length vary, depending on site, intertidal height, and especially exposure to wave surge (Bernard, 1988). There is a direct relationship between goose barnacle peduncle length and wet weight ($p = 0.89$) (Figure 7). Goose barnacle morphometric measurements were moderately correlated to matrix thickness (wet weight, $p = 0.38$; volume, $p = 0.44$; and length, $p = 0.36$) (Figure 8).

Exposed (windward) sites had sea mussels averaging 46.3 mm (SD = 14.4) in length, goose barnacles averaging 24.0 mm (SD =3.0) in RC length, and the number of individuals of all species averaging 1996 (SD = 981) (Figure 9; Tables 5, 6). Leeward sites had smaller mussels (average length = 39.9 mm, SD = 10.8), similar goose barnacle sizes (RC length = 24.0 mm, SD = 2.4), and fewer individuals of all species (mean = 1392, SD = 689) (Figure 10; Tables 5, 6).

Species diversity, species evenness and species richness indices for each site are in Table 6. With an increase in matrix thickness, species diversity and the total number of individuals present of all species increased (Figure 12). The total number of individuals present of all species and species diversity were slightly higher on windward sites than on leeward sites and generally decreased with increasing elevation on windward sites (Figures 13, 14; Table 6).

Regressions of each of the above indices versus average matrix thickness were calculated at all 29 sites. Species evenness was inversely proportional and most strongly related ($R^2$=0.48) with matrix thickness. Species diversity was directly related to matrix thickness ($R^2$=0.44), while species richness showed little correlation ($R^2$=0.13, Figure 15). Analysis of the indices with relation to intertidal elevation showed no meaningful correlation (Figure 16). This is probably due to community zonation in the intertidal area, and a linear relationship between species diversity, species richness or species evenness and tidal height was not expected.

Variability between wave exposure and species indices was investigated to determine if community structure in windward sites differed significantly from that in leeward sites. A stronger relationship between species evenness and matrix thickness was evident within the leeward sites (mean = 0.29 ± 0.088, $R^2$=0.69) than within the windward sites (mean = 0.18 ± 0.045, $R^2$=0.043). Average species richness for leeward sites was slightly higher (mean = 1.23 ± 0.39) than for windward sites (mean = 0.79 ± 0.16). Species diversity in the windward sites ranged from 1.14 to 2.81(mean = 2.25±0.16) and in the leeward sites from 1.36to 2.33(mean = 1.83±0.22), indicating that species diversity was significantly (1% level) higher on the windward, exposed sites than on the leeward, more sheltered sites.

## DISCUSSION

Harvesters preferentially harvest on windward areas because more harvestable goose barnacles are located there, and such locations are thus likely to be most affected by harvesters. The larger islets of those investigated, such as Lennard Islet, Food Islet, Father Charles and Starlight Reef, might be particularly affected, since because they have larger goose barnacle biomasses, they are likely to experience the most fishing. Because windward sites have a higher species diversity, increased effort there may have a more noticeable ecosystem impact, and this may in some manner, negatively or positively, influence the successful and timely recovery of harvest sites.

In contrast, smaller islets, such as Islets #2 and #3, Skykes Reef, and Four Rocks, are subject to a more fairly homogeneous wave exposure, as waves go right over them. This tends to result in similar abundant barnacle distributions on all sides. If large enough to have a harvestable goose barnacle population, this means that the potential impact of fishing at these locations might be more extensive as a proportion of total area, than would occur on larger islets.

Some sites, particularly on Starlight Reef, had harvested areas approximately 2 by 5 m where most attached animals had been removed, speculated to have occurred in May, 1999 (Lyndon Clark, Ucluelet West Coast Gooseneck's Association, pers. comm.). However, the exact dates these sites were impacted are undocumented. The recruitment of harvestable goose barnacles depends on the prior establishment of "matrix" builders such as mussels, acorn, or thatched barnacles. Harvests that involve the removal of the entire matrix layer over a specified size, likely greater than 400 $cm^2$ but still to be determined, probably extend the time required for harvestable barnacles to be re-established. After an estimated one year at the larger 2 by 5 m barnacle removal sites observed on Starlight Reef, there was little evidence of barnacle recruitment (S. Dixon, pers. obs.).

During the biomass surveys, 400 $cm^2$ quadrats were sampled to the bare rock for total goose barnacle count and weights. None of these sampled quadrats could be found in a resurvey of Starlight Reef in May 2001. One mechanism of recovery commonly seen with perturbations of about 400 $cm^2$ was realignment and a sloughing inwards of the mussel matrix to fill the cavity created by harvesting. This is believed to occur relatively soon after creation of a small “hole” in the mussel matrix.

In the experimental harvest denoted here, most harvesters worked on a mussel substrate and created small holes, which we term divots, in the matrix by selectively removing small clumps of barnacles, each about 15 to 20 cm in diameter, or 120 to 210 $cm^2$. There was also very little evidence of harvesting activities from the previous year seen during the resurvey of Starlight Reef in May 2001. During the last experimental harvest of the 2000 season, it was observed most of the significant sites that have been tagged, especially those on Food Island, had filled in with mussels and were subsequently difficult to locate. In May and June 2001, the majority of those reobserved tagged sites had filled in with mussels and showed no evidence of previous harvest activities. At one “significant harvest” site that had been tagged by sewing yellow polyester line into the matrix, the line was still visible and the surrounding matrix was still in the process of expanding to fill in the divot hole left by harvesting. The divot removal type of harvesting thus seems to have little long-term effect on overall community structure.

Skykes Reef was thoroughly and aggressively harvested throughout the experimental harvest, and relatively large patches (areas of approximately two $m^2$) of exposed bare rock resulted. It would seem desirable to monitor these sites over the next few years for future community recovery and barnacle recruitment.

There may be a certain size of impact, i.e. area of bare rock exposure, above which goose barnacle recovery may not occur or is prolonged. This is dependent on matrix composition (sea mussels or acorn barnacles) and perhaps to a lesser extent on exposure and specific location. Older acorn barnacle matrices appear to naturally slough off after many of the barnacles have died, presumably from natural longevity, and so goose barnacles on them would naturally be lost. Such sites could conceivably be harvested more extensively, but this needs further study so that guidelines as to when this is indeed acceptable can be determined.

At some locations, such as Four Rocks in Ucluelet, many goose barnacles had relatively long necks, with the barnacles attached deep in the matrix. Goose barnacles with long necks are presently unmarketable due to their increased water retention (and proportional decrease in barnacle meat) and less palatable texture. The climax species, *M. californianus*, has been previously reported (Lauzier 1999a) to displace goose barnacles over time (competitive exclusion). Anecdotal reports are that long-necked barnacles and larger mussels have been intentionally removed and discarded by harvesters to allow other goose barnacles to become established (Lyndon Clarke, Ucluelet West Coast Gooseneck's Association, pers. comm.). There was also the suggestion that smaller subsurface goose barnacles may rapidly grow upward to take advantage of the surface space made available through the harvest removal of large, matrix surface-reaching goose barnacles.

## RECOMMENDATIONS

1. This study was conducted in previously harvested locations that have not been exploited for goose barnacles within the past few years. As damage to the biological matrix underlying harvestable goose barnacles may occur both naturally and anthropogenically, destruction of this habitat from both causes over time needs to be documented and quantified over time. This will require longer term monitoring of the effects of fishing activity at impact sites over time.

2. As a precautionary approach, anthropogenic disruption of the habitat matrix by fishing should be minimized. The ecosystem should be managed to maintain the general integrity of the mussel matrix and of other dependent species. Determining the acceptable areal extent of perturbation of matrix characteristics is an important first step in the development of a Harvesting Code of Conduct for practice by fishers. Subsequent monitoring to examine the effectiveness and implementation level of such a Code will be required because of the observed impacts of previous unregulated fishing on benthic community structure.

3. The location and characteristics of individual islets should be assessed to determine the specific underlying substrates or matrices. Most damage to date was observed during the experimental harvest in areas with an acorn barnacle matrix. Islets with acorn substrate should be more closely monitored for matrix damage in possible future harvesting and should be managed particularly conservatively.

4. Recruitment rates of goose barnacles should be measured at locations marked during the 2000 experimental harvest. Further harvesting at the 2000 experimental harvest sites should not be permitted until biomass estimates have been reassessed and recovery and recruitment rates documented. Assessments of recruitment rate on harvested areas will require a multi-year study.

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Table 1: Field procedure summaries of the biomass and experimental harvest protocols:

| Biomass Survey Protocol | Experimental Harvest Protocol |
|---|---|
| 2 or more transects per bed/site | Random sample of harvest collection, 4 samples per harvester per site, n=16 per site. |
| 12 biomass counts per transect | Per sample, 2 measurements to be taken:<br>1. average total weight of harvestable product<br>2. total count of harvestable product (each individual regardless of size) |
| 3 biomass samples per transect, sort into three size fractions (small ,medium ,large) measurements to be taken:<br>1. average total weight<br>2. total count (each individual regardless of size) | From the random samples chosen above, discarded material should be sorted into three size fractions (small, medium, large) and measured for:<br>1. average total weight<br>2. total count (each individual regardless of size) |
| Representative samples of each size fraction n=5, set aside for measurement of RC, and peduncle lengths and weight. | Representative samples of each size fraction n=5, set aside for measurement of RC, peduncle lengths and weight. |
| | After the marketable material has been returned to the harvesters, the counted and weighed discard material from each harvester's collection, as each harvester sorts his total daily harvest, is recorded. |

Table 2: Number (> 10) of all species that were observed and their average densities over the 21 islet sites.

| Species | Number | Density per m$^2$ |
|---|---|---|
| *Mytilus californianus* | 16181 | 8561 |
| *Cirolana harfordi* | 8487 | 4490 |
| *Petrolisthes cinctipes* | 7372 | 3900 |
| *Corophium sp.* | 3397 | 1797 |
| *Hyale sp.* | 3235 | 1711 |
| *Lacuna vincta* | 2854 | 1510 |
| *Pollicipes polymerus* | 1736 | 919 |
| *Semibalanus cariosus* | 1437 | 760 |
| *Cucumaria pseudocurata* | 1306 | 691 |
| *Lottia alveus* | 1192 | 631 |
| *Bryozoan sp.* | 930 | 492 |
| *Tectura paleacea* | 768 | 406 |
| *Margarites helicinus* | 642 | 340 |
| *Alia carinata* | 619 | 328 |
| *Nucella canaliculata* | 402 | 212 |
| *Lottia pelta or alveus* | 378 | 200 |
| *Lottia pelta* | 314 | 166 |
| *Lottia digitatis* | 271 | 143 |
| *Lacuna sp.* | 235 | 124 |
| *Phascolosoma agassizii* | 187 | 99 |
| *Pachycheles rudis* | 176 | 93 |
| *Nucella emarginata* | 173 | 92 |
| *Amphissa columbiana* | 171 | 90 |
| *Lottia sp.* | 168 | 89 |
| *Anthopleura xanthogrammica or artemisa* | 163 | 86 |
| *Balanus glandula* | 155 | 82 |
| *Lirularia lirulata* | 135 | 71 |
| *Acmaea mitra* | 116 | 61 |
| *Nereis zonata* | 104 | 55 |
| *Colus sp.* | 101 | 53 |
| *Lottia strigatella* | 98 | 52 |
| *Nuticola sp.* | 85 | 45 |
| *Halosydna brevisetosa* | 80 | 42 |
| *Mya truncata* | 75 | 40 |
| *Oediganathus inermis* | 67 | 36 |
| *Amphissa versicolor* | 66 | 35 |
| *Amphissa sp.* | 61 | 32 |
| *Leptasterias sp.* | 61 | 32 |
| *Leptasterias sp.* | 59 | 31 |
| *Ianiropsis sp.* | 55 | 29 |
| *Lottia sp.* | 55 | 29 |
| *Eulima randolphi* | 54 | 29 |
| *Tachyrlychus lacteolus* | 50 | 26 |
| *Ophiopholis aculeata* | 49 | 26 |
| *Leptasteria sp.* | 43 | 23 |
| *Ocenebra interfossa* | 43 | 23 |
| *Pinnotheres spp.* | 38 | 20 |
| *Dynamenella sheareri* | 35 | 19 |
| *Nucella lima* | 34 | 18 |
| *Cirratulus sp.* | 32 | 17 |
| *Cheilonereis cyclurus* | 31 | 16 |
| *Amphioplus strongyloplax* | 30 | 16 |
| *Corophium sp.* | 27 | 14 |
| *Lacuna sp.* | 27 | 14 |
| *Polychaeta sp.* | 24 | 13 |
| *Fabia subquadrata* | 21 | 11 |
| *Dogwinkle Egg Sacs* | 20 | 11 |
| *Ocenebra lurida* | 20 | 11 |
| *Protothac staminea* | 20 | 11 |
| *Megaluropus sp.* | 19 | 10 |
| *Mopolia ciliata* | 18 | 10 |
| *Balanus nubilis* | 17 | 9 |
| *Apodichthys flavidus* | 16 | 8 |
| *Nereis vexillosa* | 16 | 8 |
| *Tectura person* | 16 | 8 |
| *Chorila longipes* | 13 | 7 |
| *Leptasterias sp.* | 13 | 7 |
| *Pachycheles pubescens* | 13 | 7 |
| *Jassa sp.* | 12 | 6 |

| | | | | | |
|---|---|---|---|---|---|
| *Bittium attenuatum* | 11 | 6 | | | |
| *Leptolanan vesculata* | 11 | 6 | **Total of all animals** | | |
| *Katharina tunicata* | 10 | 5 | **found >10 species** | **55343** | **29,282** |
| *Tachyrhynchus lacteolus* | 10 | 5 | | | |

Table 3: Sites with large mobile species (only *Pisaster ochraceus* was observed) and the average density by site. Where the estimated number was greater than a number, that minimum number was used in the density calculation.

| Site | Intertidal length (m) | Observed *Pisaster* | Estimated number per $m^2$ |
|---|---|---|---|
| 9C | 142.5 | 11 | .08 |
| 9E | 26.1 | 1 | .04 |
| 10A | 57.6 | 1 | .02 |
| 10B | 190.0 | >100 | .53 |
| 10C | 59.0 | 20 | .34 |
| 10D | 67.0 | 1 | .01 |
| 11A | 50.0 | >50 | 1.0 |
| 11B | 38.0 | >50 | 1.32 |
| 12A | 135.0 | >50 | .37 |
| 12B | 38.0 | 4 | .11 |
| 13A | 353.0 | 5 | .01 |
| 13B | 247.0 | 5 | .02 |
| 13C | 240.0 | >100 | .42 |
| 13D | 350.0 | 5 | .01 |
| **mean** | | | **.31** |
| **SD** | | | **.41** |

Table 4: A. The total number of individuals present, B. The average weight of each dominant species per site, and C. The percent biomass of overall dominate species for each community structure habitat sample site.

A.

| | | Total Number of Individuals | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ranked Height (m)(above chart datum) | Matrix Depth (cm) | *Mytilus californianus* | *Pollicipes polymerus* | *Balanus glandula* | *Apodichthys flavidus* | *Cirolana harfordi* | *Cucumaria pseudocurata* | *Petrolisthes cinctipes* | *Euphasid spp.* | *Amphissa spp* | *Semibalanus cariosus* | *Amphipod spp.* | *Lottia alveus* |
| 1.894 | n/a | 633 | 87 | 16 | 0 | 692 | 0 | 13 | 460 | 15 | 14 | 150 | 41 |
| 1.953 | 30 | 388 | 62 | 0 | 5 | 616 | 1 | 475 | 1099 | 40 | 29 | 420 | 4 |
| 1.980 | 13 | 418 | 21 | 0 | 0 | 209 | 201 | 145 | 3 | 2 | 121 | 100 | 44 |
| 2.020 | 28 | 277 | 35 | 0 | 0 | 309 | 78 | 184 | 4 | 29 | 74 | 59 | 2 |
| 2.174 | 25 | 476 | 360 | 80 | 0 | 266 | 0 | 73 | 308 | 3 | 11 | 142 | 28 |
| 2.244 | 20 | 769 | 54 | 6 | 2 | 1037 | 0 | 626 | 308 | 35 | 27 | 336 | 65 |
| 2.295 | 7 | 521 | 13 | 1 | 0 | 2 | 2 | 12 | 0 | 0 | 0 | 16 | 36 |
| 2.306 | 11 | 296 | 13 | 1 | 0 | 6 | 19 | 91 | 0 | 2 | 67 | 0 | 13 |
| 2.342 | 8 | 610 | 37 | 0 | 0 | 168 | 3 | 503 | 0 | 1 | 76 | 25 | 12 |
| 2.344 | 12 | 1290 | 13 | 2 | 0 | 366 | 1 | 639 | 7 | 13 | 19 | 48 | 49 |
| 2.437 | 17 | 543 | 11 | 0 | 0 | 35 | 71 | 428 | 2 | 1 | 42 | 3 | 57 |
| 2.520 | 16 | 308 | 37 | 0 | 0 | 168 | 28 | 347 | 39 | 3 | 154 | 7 | 4 |
| 2.574 | 20 | 575 | 28 | 1 | 2 | 604 | 2 | 668 | 329 | 52 | 16 | 191 | 36 |
| 2.628 | 22 | 438 | 35 | 0 | 0 | 273 | 92 | 0 | 5 | 11 | 101 | 70 | 90 |
| 2.683 | 30 | 594 | 82 | 2 | 0 | 471 | 2 | 603 | 25 | 13 | 43 | 304 | 0 |
| 2.751 | 5.5 | 1373 | 13 | 1 | 0 | 227 | 16 | 732 | 0 | 0 | 69 | 0 | 0 |
| 2.824 | 11 | 257 | 26 | 3 | 0 | 78 | 66 | 39 | 0 | 0 | 75 | 6 | 0 |
| 2.894 | 8 | 628 | 203 | 4 | 1 | 454 | 0 | 7 | 198 | 11 | 101 | 164 | 80 |
| 2.908 | 6 | 541 | 23 | 1 | 0 | 2 | 6 | 50 | 0 | 0 | 5 | 0 | 0 |
| 3.024 | 11 | 965 | 168 | 23 | 0 | 168 | 38 | 420 | 0 | 10 | 39 | 7 | 32 |
| 3.234 | 17 | 387 | 122 | 3 | 1 | 405 | 0 | 131 | 484 | 54 | 29 | 573 | 85 |
| 3.264 | 7 | 1079 | 21 | 0 | 0 | 37 | 42 | 46 | 0 | 0 | 27 | 0 | 0 |
| 3.280 | 17 | 513 | 27 | 0 | 1 | 396 | 8 | 325 | 35 | 23 | 83 | 149 | 80 |
| 3.350 | 20 | 264 | 7 | 0 | 0 | 201 | 138 | 131 | 3 | 8 | 69 | 81 | 74 |
| 3.560 | 12 | 230 | 46 | 0 | 0 | 184 | 0 | 69 | 0 | 7 | 3 | 25 | 8 |
| 3.804 | 12 | 496 | 92 | 3 | 0 | 191 | 68 | 157 | 7 | 3 | 69 | 12 | 178 |
| 3.900 | 13 | 526 | 34 | 3 | 1 | 324 | 325 | 96 | 0 | 0 | 23 | 52 | 12 |
| 4.184 | 28 | 511 | 30 | 3 | 3 | 496 | 1 | 73 | 81 | 110 | 18 | 285 | 130 |
| 5.128 | 20 | 275 | 36 | 2 | 0 | 102 | 98 | 127 | 0 | 0 | 33 | 10 | 6 |
| | Total | 16181 | 1736 | 155 | 16 | 8487 | 1306 | 7210 | 3397 | 446 | 1437 | 3235 | 1166 |

Table 4 continued…

B.

| Ranked Height (m)(above chart datum) | Matrix Depth (cm) | Biomass of Dominate Species (g) *Mytilus californianus* | *Pollicipes polymerus* | *Balanus glandula* | *Apodichthys flavidus* | *Cirolana harfordi* | *Cucumaria pseudocurata* | *Petrolisthes cinctipes* | *Euphasid spp.* | *Amphissa spp* | *Semibalanus cariosus* | *Amphipod spp.* | *Lottia alveus* | Total Biomass of Dominate Species (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.894 | n/a | 8514 | 321 | 14 | 0 | 135 | 0 | 6 | 0 | 1 | 21 | 0 | 7 | 9019 |
| 1.953 | 30 | 5219 | 229 | 0 | 27 | 120 | 0 | 229 | 0 | 2 | 43 | 0 | 1 | 5870 |
| 1.980 | 13 | 5622 | 78 | 0 | 0 | 41 | 44 | 70 | 0 | 0 | 181 | 0 | 8 | 6044 |
| 2.020 | 28 | 3726 | 129 | 0 | 0 | 60 | 17 | 89 | 0 | 2 | 111 | 0 | 0 | 4134 |
| 2.174 | 25 | 6402 | 1330 | 68 | 0 | 52 | 0 | 35 | 0 | 0 | 16 | 0 | 5 | 7909 |
| 2.244 | 20 | 10343 | 199 | 5 | 11 | 202 | 0 | 302 | 0 | 2 | 40 | 0 | 12 | 11116 |
| 2.295 | 7 | 7007 | 48 | 1 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 6 | 7069 |
| 2.306 | 11 | 3981 | 48 | 1 | 0 | 1 | 4 | 44 | 0 | 0 | 100 | 0 | 2 | 4182 |
| 2.342 | 8 | 8205 | 137 | 0 | 0 | 33 | 1 | 242 | 0 | 0 | 114 | 0 | 2 | 8733 |
| 2.344 | 12 | 17351 | 48 | 2 | 0 | 71 | 0 | 308 | 0 | 1 | 28 | 0 | 9 | 17818 |
| 2.437 | 17 | 7303 | 41 | 0 | 0 | 7 | 16 | 206 | 0 | 0 | 63 | 0 | 10 | 7646 |
| 2.520 | 16 | 4143 | 137 | 0 | 0 | 33 | 6 | 167 | 0 | 0 | 231 | 0 | 1 | 4717 |
| 2.574 | 20 | 7734 | 103 | 1 | 11 | 117 | 0 | 322 | 0 | 3 | 24 | 0 | 6 | 8322 |
| 2.628 | 22 | 5891 | 129 | 0 | 0 | 53 | 20 | 0 | 0 | 1 | 151 | 0 | 16 | 6262 |
| 2.683 | 30 | 7989 | 303 | 2 | 0 | 92 | 0 | 291 | 0 | 1 | 64 | 0 | 0 | 8742 |
| 2.751 | 5.5 | 18467 | 48 | 1 | 0 | 44 | 4 | 353 | 0 | 0 | 103 | 0 | 0 | 19020 |
| 2.824 | 11 | 3457 | 96 | 3 | 0 | 15 | 15 | 19 | 0 | 0 | 112 | 0 | 0 | 3716 |
| 2.894 | 8 | 8447 | 750 | 3 | 5 | 88 | 0 | 3 | 0 | 1 | 151 | 0 | 14 | 9463 |
| 2.908 | 6 | 7276 | 85 | 1 | 0 | 0 | 1 | 24 | 0 | 0 | 7 | 0 | 0 | 7396 |
| 3.024 | 11 | 12979 | 621 | 20 | 0 | 33 | 8 | 202 | 0 | 1 | 58 | 0 | 6 | 13928 |
| 3.234 | 17 | 5205 | 451 | 3 | 5 | 79 | 0 | 63 | 0 | 3 | 43 | 0 | 15 | 5867 |
| 3.264 | 7 | 14513 | 78 | 0 | 0 | 7 | 9 | 22 | 0 | 0 | 40 | 0 | 0 | 14669 |
| 3.280 | 17 | 6900 | 100 | 0 | 5 | 77 | 2 | 157 | 0 | 1 | 124 | 0 | 14 | 7380 |
| 3.350 | 20 | 3551 | 26 | 0 | 0 | 39 | 30 | 63 | 0 | 0 | 103 | 0 | 13 | 3826 |
| 3.560 | 12 | 3094 | 170 | 0 | 0 | 36 | 0 | 33 | 0 | 0 | 4 | 0 | 1 | 3339 |
| 3.804 | 12 | 6671 | 340 | 3 | 0 | 37 | 15 | 76 | 0 | 0 | 103 | 0 | 32 | 7277 |
| 3.900 | 13 | 7075 | 126 | 3 | 5 | 63 | 72 | 46 | 0 | 0 | 34 | 0 | 2 | 7426 |
| 4.184 | 28 | 6873 | 111 | 3 | 16 | 96 | 0 | 35 | 0 | 6 | 27 | 0 | 23 | 7191 |
| 5.128 | 20 | 3699 | 133 | 2 | 0 | 20 | 22 | 61 | 0 | 0 | 49 | 0 | 1 | 3987 |

Table 4 continued…

C.

| Ranked Height (m)(above chart datum) | Matrix Depth (cm) | Percent Biomass of Dominate Species (g) *Mytilus californianus* | *Pollicipes polymerus* | *Balanus glandula* | *Apodichthys flavidus* | *Cirolana harfordi* | *Cucumaria pseudocurata* | *Petrolisthes cinctipes* | *Euphasid spp.* | *Amphissa spp* | *Semibalanus cariosus* | *Amphipod spp.* | *Lottia alveus* | Percent Biomass of Dominate Species (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.894 | n/a | 94 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 1.953 | 30 | 89 | 4 | 0 | 0 | 2 | 0 | 4 | 0 | 0 | 1 | 0 | 0 | 100 |
| 1.980 | 13 | 93 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 3 | 0 | 0 | 100 |
| 2.020 | 28 | 90 | 3 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 3 | 0 | 0 | 100 |
| 2.174 | 25 | 81 | 17 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 2.244 | 20 | 93 | 2 | 0 | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 100 |
| 2.295 | 7 | 99 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 2.306 | 11 | 95 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 100 |
| 2.342 | 8 | 94 | 2 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 100 |
| 2.344 | 12 | 97 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 100 |
| 2.437 | 17 | 96 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 100 |
| 2.520 | 16 | 88 | 3 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 5 | 0 | 0 | 100 |
| 2.574 | 20 | 93 | 1 | 0 | 0 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 100 |
| 2.628 | 22 | 94 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 100 |
| 2.683 | 30 | 91 | 3 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 100 |
| 2.751 | 5.5 | 97 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 100 |
| 2.824 | 11 | 93 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 100 |
| 2.894 | 8 | 89 | 8 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 100 |
| 2.908 | 6 | 98 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 3.024 | 11 | 93 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 100 |
| 3.234 | 17 | 89 | 8 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 100 |
| 3.264 | 7 | 99 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 3.280 | 17 | 93 | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 100 |
| 3.350 | 20 | 93 | 1 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 3 | 0 | 0 | 100 |
| 3.560 | 12 | 93 | 5 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 100 |
| 3.804 | 12 | 92 | 5 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 100 |
| 3.900 | 13 | 95 | 2 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 100 |
| 4.184 | 28 | 96 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| 5.128 | 20 | 93 | 3 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 100 |

Table 5: Average size distribution of A. *Mytilus californianus* and B. *Pollicipes polymerus* by degree of exposure at the Tofino and Ucluelet sites (excluding Amphitrite Point).

A. *Mytilus californianus* - Windward Sites

| Site | Total Number Counted | Individuals >10.00mm | Average Length (mm) | Standard Deviation | Max | Min | 95 % Confidence interval |
|---|---|---|---|---|---|---|---|
| 9C | 388 | 219 | 65.76 | 31.43 | 165.50 | 13.03 | 4.16 |
| 9D | 1079 | 791 | 25.14 | 14.97 | 84.70 | 10.18 | 1.04 |
| 9E | 1373 | 1071 | 24.38 | 15.79 | 93.63 | 10.03 | 0.95 |
| 10A | 418 | 290 | 41.38 | 27.98 | 125.10 | 10.10 | 3.22 |
| 10B | 308 | 252 | 47.81 | 29.62 | 128.37 | 10.79 | 3.66 |
| 11C | 257 | 229 | 33.74 | 20.16 | 103.23 | 10.06 | 2.61 |
| 11D | 277 | 159 | 63.10 | 37.55 | 125.06 | 11.23 | 5.84 |
| 12C | 511 | 287 | 59.08 | 29.38 | 135.05 | 10.00 | 3.40 |
| 12D | 594 | 340 | 58.96 | 36.72 | 169.30 | 10.75 | 3.90 |
| 13A | 264 | 180 | 48.46 | 35.10 | 135.90 | 10.06 | 5.13 |
| 13B | 175 | 157 | 50.01 | 31.36 | 118.56 | 10.00 | 4.91 |

*Mytilus californianus* - Leeward Sites

| Site | Total Number Counted | Individuals >10.00mm | Average Length (mm) | Standard Deviation | Max | Min | 95% Confidence interval |
|---|---|---|---|---|---|---|---|
| 9A | 610 | 508 | 31.99 | 20.76 | 105.90 | 10.51 | 1.81 |
| 9B | 1290 | 854 | 31.93 | 18.62 | 93.89 | 10.17 | 1.25 |
| 10C | 543 | 460 | 32.62 | 16.69 | 90.90 | 10.59 | 1.53 |
| 10D | 541 | 366 | 29.86 | 11.69 | 68.53 | 10.28 | 1.20 |
| 11A | 296 | 265 | 35.28 | 19.62 | 94.20 | 10.21 | 2.36 |
| 11B | 521 | 397 | 27.13 | 12.29 | 70.20 | 10.13 | 1.21 |
| 12A | 526 | 440 | 33.26 | 19.92 | 125.19 | 10.24 | 1.86 |
| 12B | 230 | 211 | 56.28 | 28.48 | 185.95 | 10.44 | 3.84 |
| 13C | 513 | 405 | 50.11 | 30.58 | 152.16 | 10.03 | 2.98 |
| 13D | 438 | 273 | 46.00 | 29.93 | 145.27 | 10.76 | 3.55 |

Table 5 continued…

A. *Pollicipes polymerus* - Windward Sites

| Site | Total Number Counted | Average RC Length (mm) | Standard Deviation | Max | Min | 95% Confidence interval |
|---|---|---|---|---|---|---|
| 9C | 62 | 18.28 | 8.64 | 28.00 | 3.60 | 2.15 |
| 9D | 21 | 23.66 | 2.41 | 28.60 | 18.40 | 1.03 |
| 9E | 13 | 20.21 | 2.51 | 25.23 | 15.66 | 1.37 |
| 10A | 21 | 17.29 | 8.27 | 26.30 | 4.50 | 3.54 |
| 10B | 37 | 22.17 | 3.53 | 28.10 | 14.10 | 1.14 |
| 11C | 26 | 25.56 | 5.74 | 40.12 | 17.13 | 2.21 |
| 11D | 35 | 22.99 | 5.60 | 30.38 | 7.41 | 1.86 |
| 12C | 30 | 29.58 | 3.72 | 36.03 | 20.60 | 1.33 |
| 12D | 82 | 26.52 | 3.14 | 31.79 | 17.20 | 0.68 |
| 13A | 7 | 26.19 | 1.84 | 29.90 | 24.10 | 1.36 |
| 13B | 36 | 25.30 | 4.32 | 32.38 | 16.35 | 1.41 |

*Pollicipes polymerus* - Leeward Sites

| Site | Total Number Counted | Average RC Length (mm) | Standard Deviation | Max | Min | 95 % Confidence interval |
|---|---|---|---|---|---|---|
| 9A | 37 | 20.26 | 2.69 | 24.90 | 15.10 | 0.87 |
| 9B | 13 | 22.49 | 1.87 | 25.60 | 20.16 | 1.02 |
| 10C | 11 | 23.94 | 4.26 | 29.70 | 17.70 | 2.52 |
| 10D | 23 | 25.87 | 2.48 | 28.89 | 17.15 | 1.01 |
| 11A | 13 | 26.73 | 2.36 | 31.50 | 23.75 | 1.28 |
| 11B | 13 | 19.72 | 4.87 | 25.50 | 9.60 | 2.65 |
| 12A | 34 | 23.82 | 3.24 | 31.97 | 16.72 | 1.09 |
| 12B | 46 | 26.68 | 2.88 | 31.72 | 15.74 | 0.83 |
| 13C | 27 | 24.38 | 3.40 | 31.92 | 17.89 | 1.28 |
| 13D | 35 | 24.80 | 4.59 | 31.50 | 12.20 | 1.52 |

Table 6: Species evenness, richness, and diversity indices per site by height above chart datum (m)

Windward Sites:

| Ranked Height (m) above chart datum | Matrix thickness (cm) | Number of Species | Number of Individuals | Evenness Index (Simpson's Index of Dominance) | Richness Index (Hurlbert 1971) | Shannon Species Diversity Index |
|---|---|---|---|---|---|---|
| 1.894 | n/a | 47 | 2484 | 0.18 | 0.79 | 2.20 |
| 1.953 | 30 | 46 | 3868 | 0.15 | 0.42 | 2.26 |
| 1.980 | 13 | 35 | 1666 | 0.12 | 0.74 | 2.50 |
| 2.020 | 28 | 52 | 1520 | 0.11 | 1.49 | 2.69 |
| 2.174 | 25 | 51 | 2059 | 0.13 | 1.30 | 2.43 |
| 2.244 | 20 | 44 | 3636 | 0.17 | 0.37 | 2.17 |
| 2.520 | 16 | 28 | 1352 | 0.15 | 0.78 | 2.24 |
| 2.574 | 20 | 40 | 2833 | 0.16 | 0.61 | 2.18 |
| 2.683 | 30 | 41 | 3201 | 0.13 | 0.46 | 2.39 |
| 2.751 | 5.5 | 28 | 2677 | 0.35 | 0.53 | 1.44 |
| 2.824 | 11 | 24 | 700 | 0.18 | 1.32 | 2.18 |
| 2.894 | 8 | 36 | 2093 | 0.17 | 0.75 | 2.17 |
| 3.024 | 11 | 47 | 2383 | 0.22 | 0.60 | 2.17 |
| 3.234 | 17 | 71 | 3147 | 0.10 | 0.91 | 2.81 |
| 3.264 | 7 | 30 | 1510 | 0.52 | 0.72 | 1.41 |
| 3.350 | 20 | 31 | 1367 | 0.098 | 0.59 | 2.62 |
| 3.804 | 12 | 47 | 1565 | 0.15 | 1.40 | 2.42 |
| 4.184 | 28 | 46 | 2861 | 0.15 | 0.57 | 2.35 |
| 5.128 | 20 | 19 | 774 | 0.19 | 0.65 | 2.03 |
| **AVERAGE ± 95% CI** | **18** | **40** | **1996** | **0.18 ±.045** | **0.79 ±0.16** | **2.25 ±0.16** |

Table 6 continued…

Leeward Sites:

| Ranked Height (m) above chart datum | Matrix thickness (cm) | Number of Species | Number of Individuals | Evenness Index (Simpson's Index of Dominance) | Richness Index (Hurlbert 1971) | Shannon Species Diversity Index |
|---|---|---|---|---|---|---|
| 2.295 | 7 | 26 | 749 | 0.50 | 1.87 | 1.36 |
| 2.306 | 11 | 21 | 559 | 0.33 | 2.29 | 1.62 |
| 2.342 | 8 | 29 | 1741 | 0.22 | 0.64 | 1.93 |
| 2.344 | 12 | 41 | 2847 | 0.28 | 0.59 | 1.83 |
| 2.437 | 17 | 31 | 1398 | 0.25 | 1.05 | 1.87 |
| 2.628 | 22 | 31 | 1419 | 0.16 | 0.63 | 2.33 |
| 2.908 | 6 | 23 | 729 | 0.56 | 1.59 | 1.18 |
| 3.280 | 17 | 33 | 1916 | 0.16 | 0.73 | 2.18 |
| 3.560 | 12 | 24 | 648 | 0.23 | 1.82 | 1.91 |
| 3.900 | 13 | 36 | 1646 | 0.19 | 1.05 | 2.10 |
| **AVERAGE** | **12.5** | **30** | **1392** | **0.29** | **1.23** | **1.83** |
| **± 95% CI** | | | | **±0.088** | **±0.39** | **±0.22** |

## FIGURE CAPTIONS

Figure 1: Diagram demonstrating the goose barnacle peduncle and rostral-carinal (RC) length.

Figure 2: Overall goose barnacle habitat assessment study region in Clayoquot and Barkley Sound, west coast of Vancouver Island, British Columbia.

Figure 3: Location of one ecosystem assessment site at Amphitrite Point and the four experimental harvest sites in Ucluelet. The four experimental harvest sites were Food Island, Starlight Reef, Skykes Reef, and Four Rocks.

Figure 4: Location of the five ecosystem assessment sites and two experimental harvest sites in Tofino, Clayoquot Sound. Five ecosystem assessment sites were Lennard Rock, Islet #2, Islet #3, Nob Rock, and Nob Rock II. The two experimental harvest sites were Father Charles and Nob Rock.

Figure 5: The number of *Mytilus californianus* greater than 10-mm present versus the total number of *Pollicipes polymerus* present per community structure sampling site. No correlation ($R^2$= 0.0009) was observed between the number of sea mussels and the number the number of goose barnacles present.

Figure 6: The average matrix thickness (cm) versus the average lengths of *Mytilus californianus* (mm) and *Pollicipes polymerus* (rostral-carinal (RC)) per sample site. A moderate correlation ($R^2$= 0.6712) was observed to occur between sea mussel length and average matrix thickness. However, no correlation ($R^2$= 0.0449) was found it exist for goose barnacle size and average matrix thickness.

Figure 7: The average peduncle length (mm) versus the average wet weight (g) of goose barnacles collected throughout the 29 sites (Amphitrite Point data included in analysis). A strong correlation was observed ($p = 0.89$, $R^2 = 0.79$).

Figure 8: Goose barnacle morphometric measurements versus average matrix thickness (cm). A moderate correlation was observed for all three parameters: wet weight $p = 0.38$, $R^2 = 0.14$; volume $p = 0.44$, $R^2 = 0.19$; and length $p = 0.36$, $R^2 = 0.13$.

Figure 9: The average size distribution and number of *Mytilus californianus* and *Pollicipes polymerus* present versus elevation above chart datum (m) for windward sites (excluding Amphitrite Point). Amphitrite Point was not included in analyses due to the larger quadrats used.

Figure 10: The average size distribution and number of *Mytilus californianus* and *Pollicipes polymerus* present versus elevation above chart datum (m) for leeward sites.

Figure 11: Representative phyla present in species reference collection based on the number of individuals present.

Figure 12: The total number of individuals present for all species (A) and Shannon's index of species diversity (B) versus the average matrix thickness (cm) for both windward (excluding Amphitrite Point) and leeward sites.

Figure 13: The total number of individuals for all species (A) present and Shannon's index of species diversity (B) for windward sites with height above chart datum, excluding Amphitrite Point. Figure C represents the relationship between species diversity and the total number of individuals for all species present.

Figure 14: The total number of individuals of all species (A) present and Shannon's index of species diversity (B) for leeward sites plotted against height above chart datum, excluding Amphitrite Point. Figure C represents the relationship between species diversity and the total number of individuals for all species present.

Figure 15: Species evenness, richness, and diversity indices versus average matrix thickness for all sites including Amphitrite Point. Indices used are a function of the total number of individuals present. Therefore, Amphitrite Point sites were included in this analysis.

Figure 16: Species evenness, richness, and diversity indices versus height above chart datum (m) for all sites including Amphitrite Point. Indices used are a function of the total number of individuals present Therefore, Amphitrite Point sites were included in this analysis.

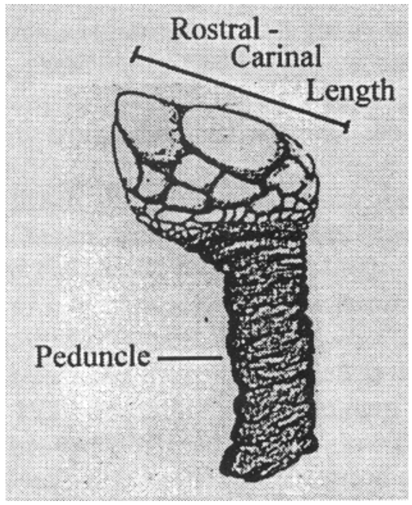



Figure 1

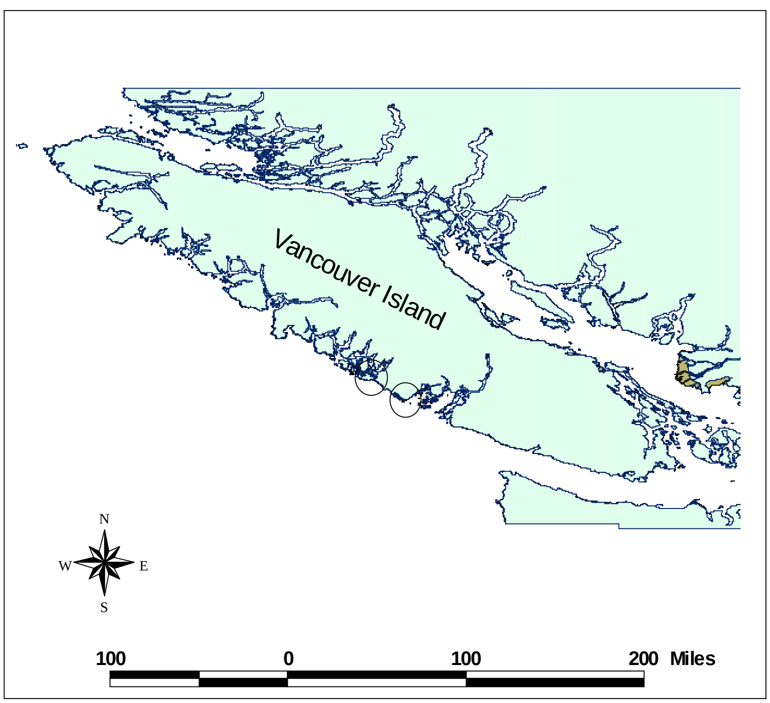



Figure 2

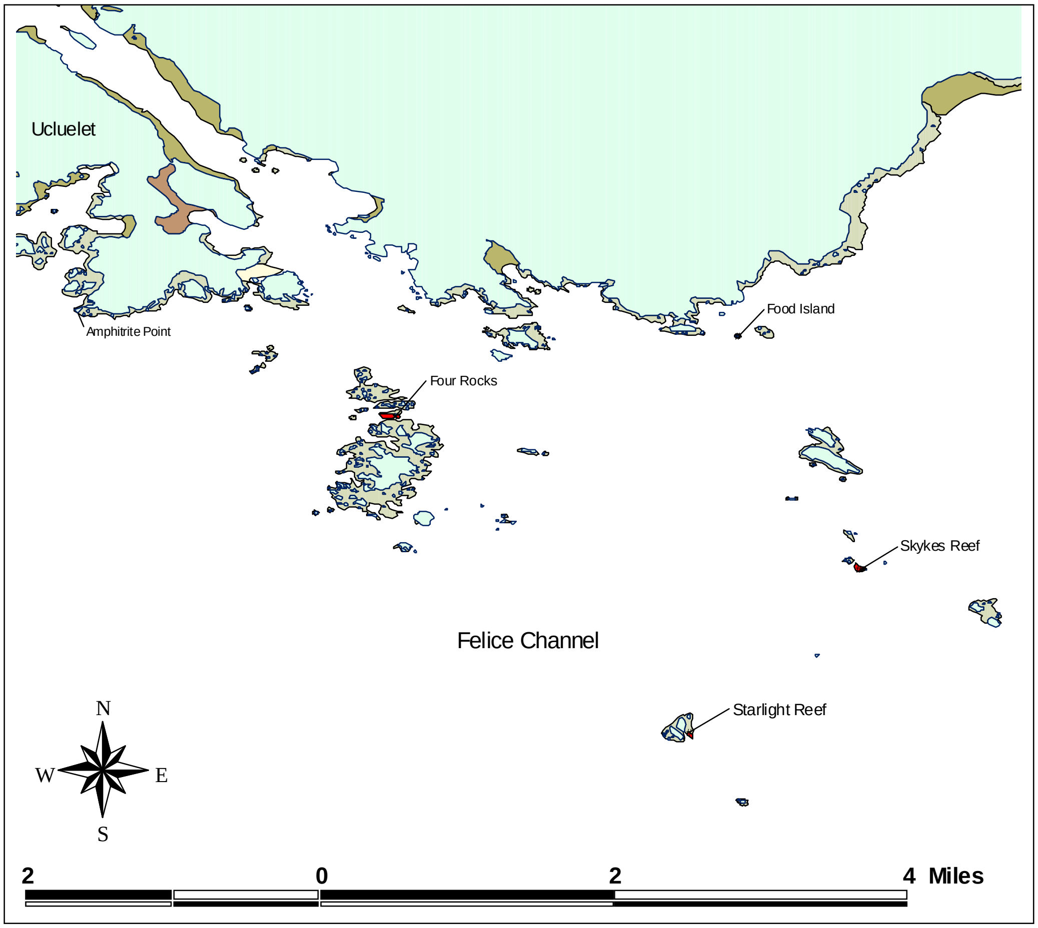

Ucluelet
Amphitrite Point
Food Island
Four Rocks
Skykes Reef
Felice Channel
Starlight Reef
N
W
E
S
2
0
2
4 Miles

Figure 3

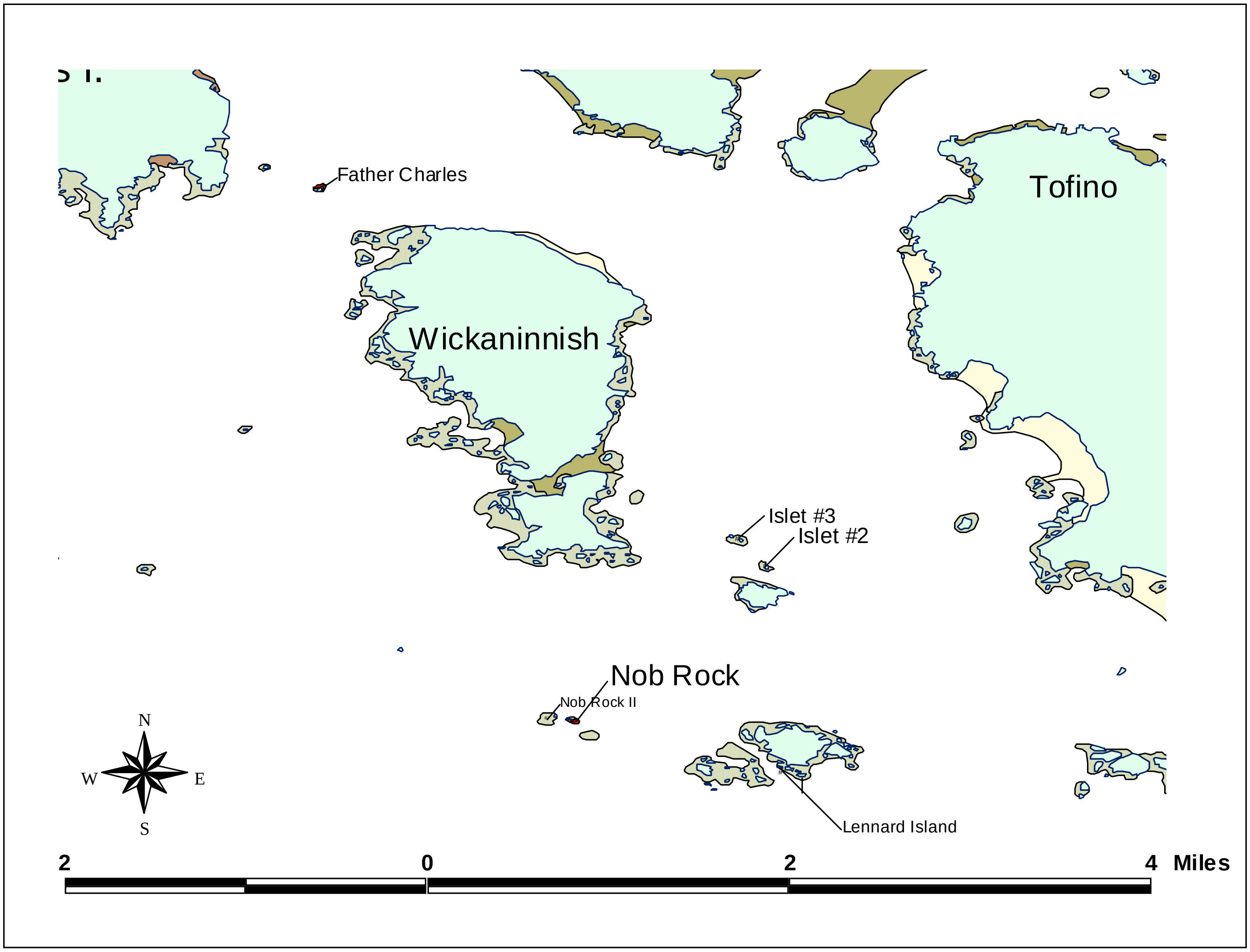
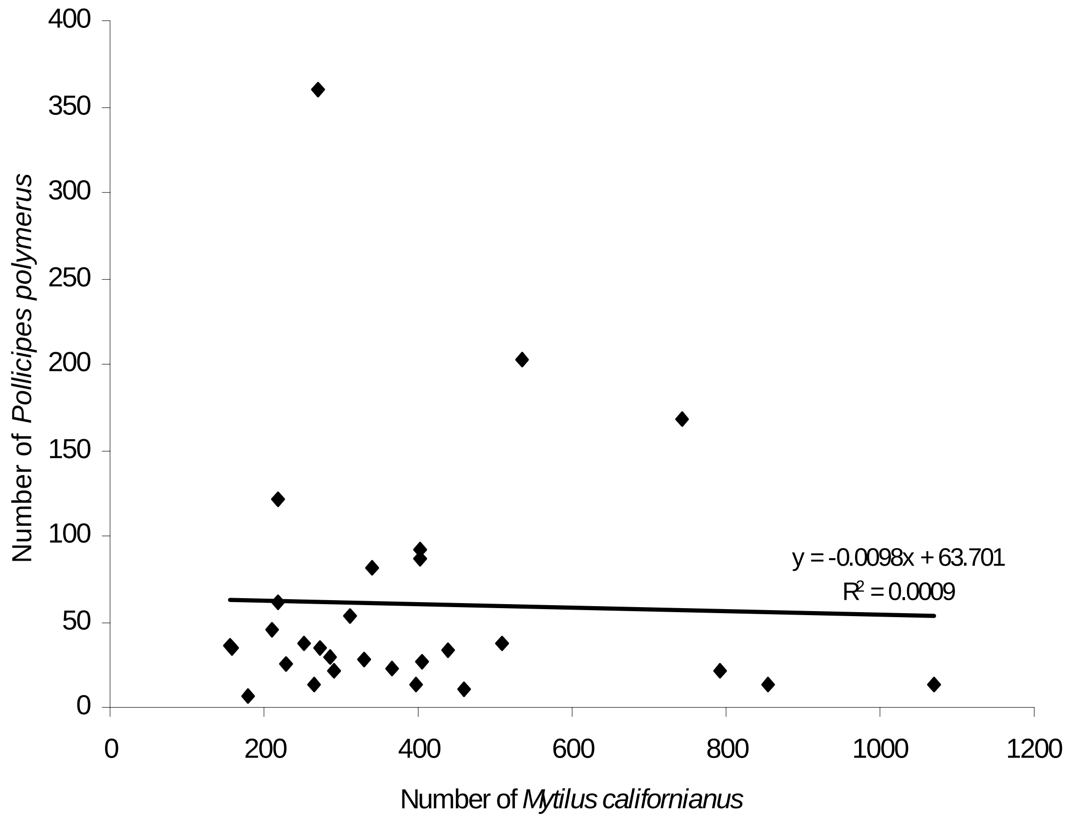

Father Charles
Tofino
Wickaninnish
Islet #3
Islet #2
Nob Rock
Nob Rock II
N
W
E
S
Lennard Island
2
0
2
4 Miles

Figure 4



400
350
300
250
200
150
100
50
0
Number of Pollicipes polymerus
y = -0.0098x + 63.701
R2 = 0.0009
0
200
400
600
800
1000
1200
Number of Mytilus californianus


Figure 5

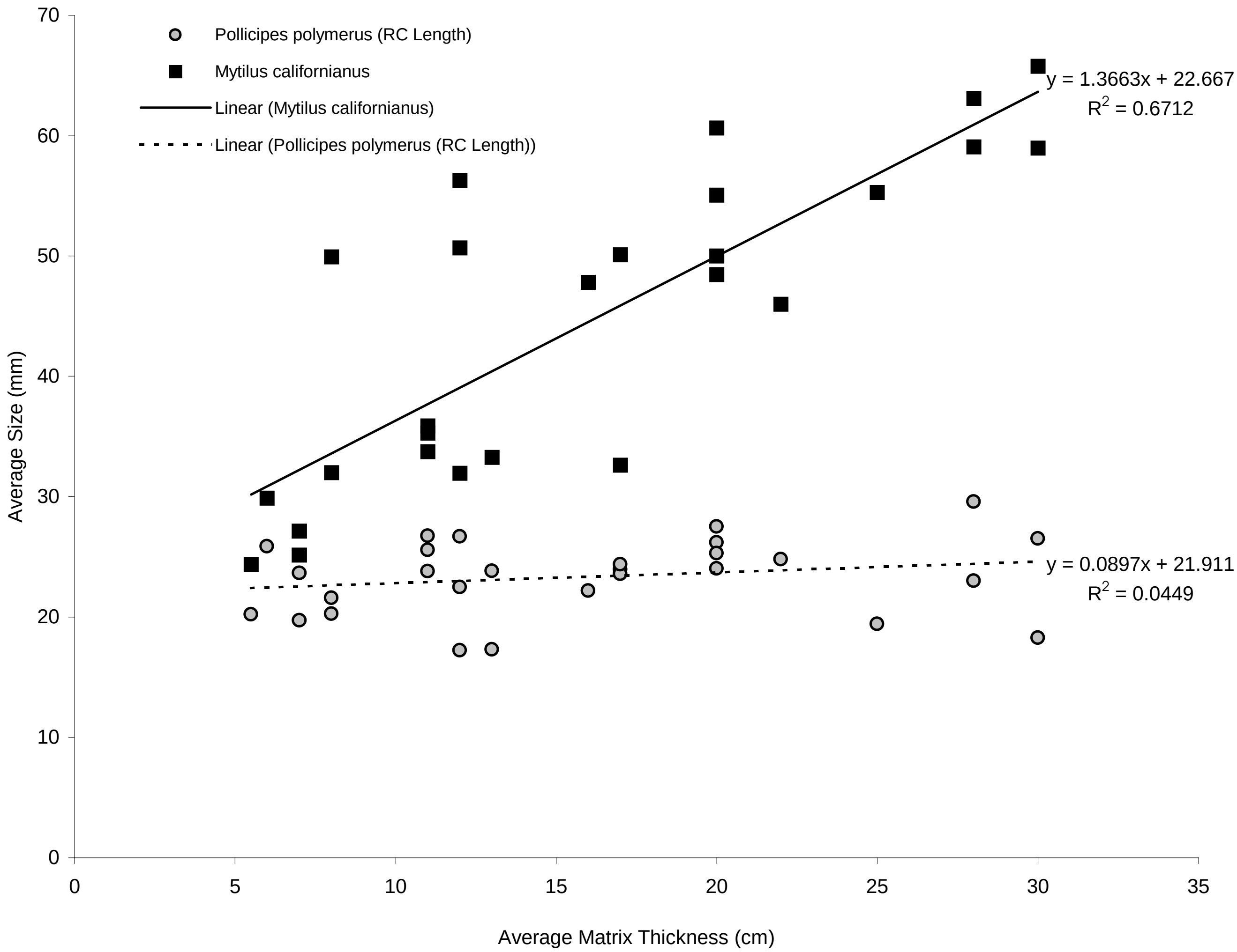

Pollicipes polymerus (RC Length)
Mytilus californianus
Linear (Mytilus californianus)
Linear (Pollicipes polymerus (RC Length))
y = 1.3663x + 22.667
R2 = 0.6712
y = 0.0897x + 21.911
R2 = 0.0449
Average Size (mm)
Average Matrix Thickness (cm)
0
10
20
30
40
50
60
70
0
5
10
15
20
25
30
35

Figure 6

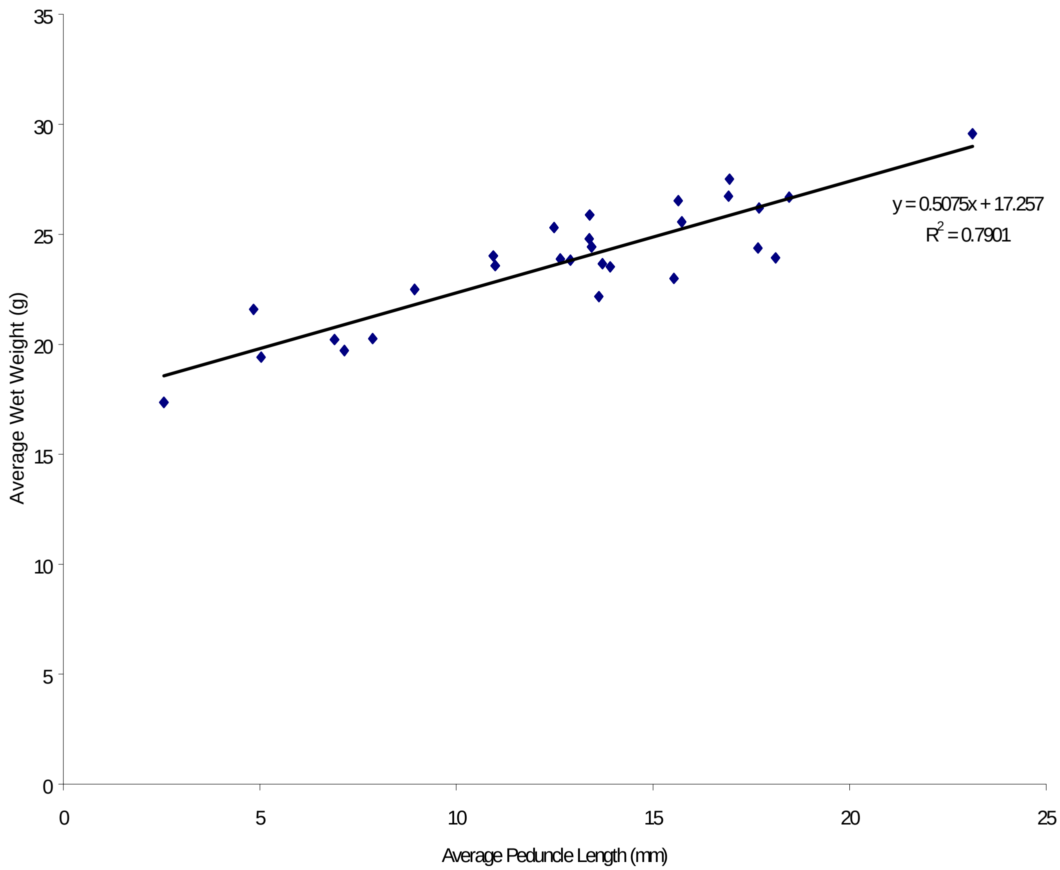
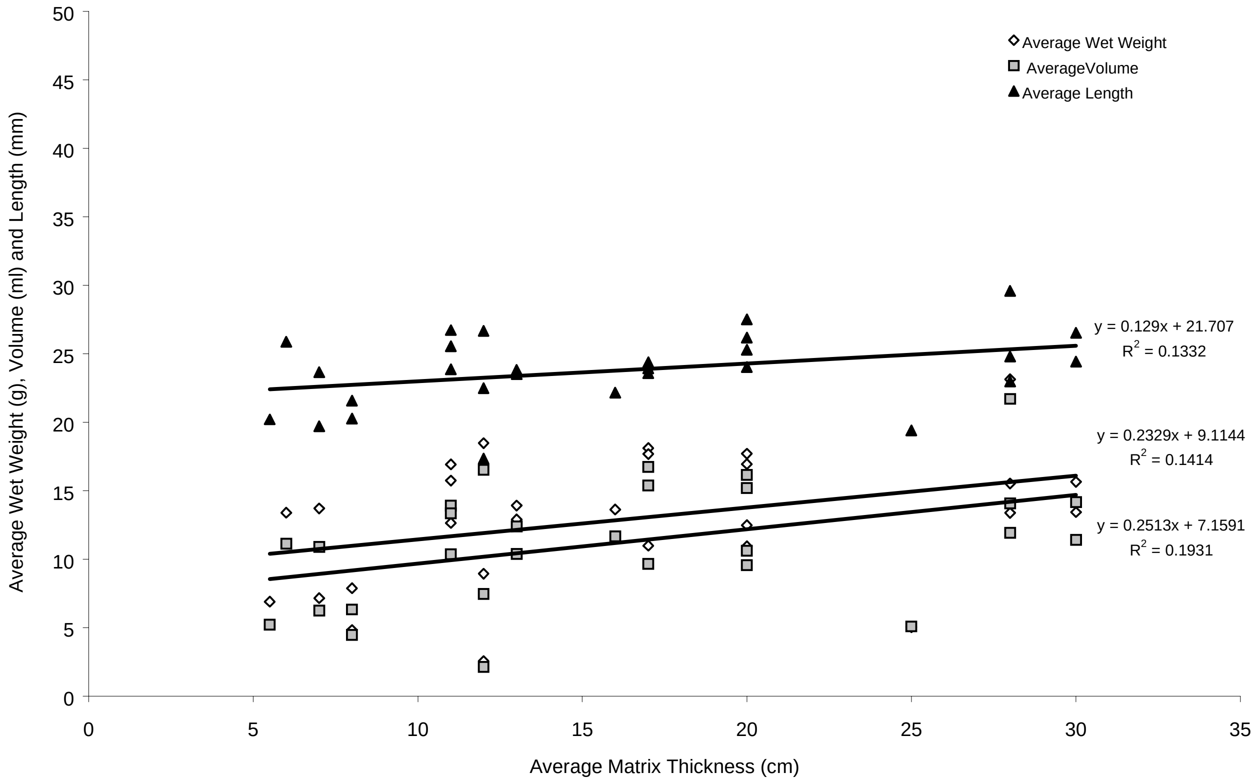

35
30
25
20
15
10
5
0
Average Wet Weight (g)
0
5
10
15
20
25
Average Peduncle Length (mm)
y = 0.5075x + 17.257
R2 = 0.7901

Figure 7



Average Wet Weight
AverageVolume
Average Length
y = 0.129x + 21.707
R2 = 0.1332
y = 0.2329x + 9.1144
R2 = 0.1414
y = 0.2513x + 7.1591
R2 = 0.1931
Average Wet Weight (g), Volume (ml) and Length (mm)
Average Matrix Thickness (cm)
0
5
10
15
20
25
30
35
40
45
50


Figure 8

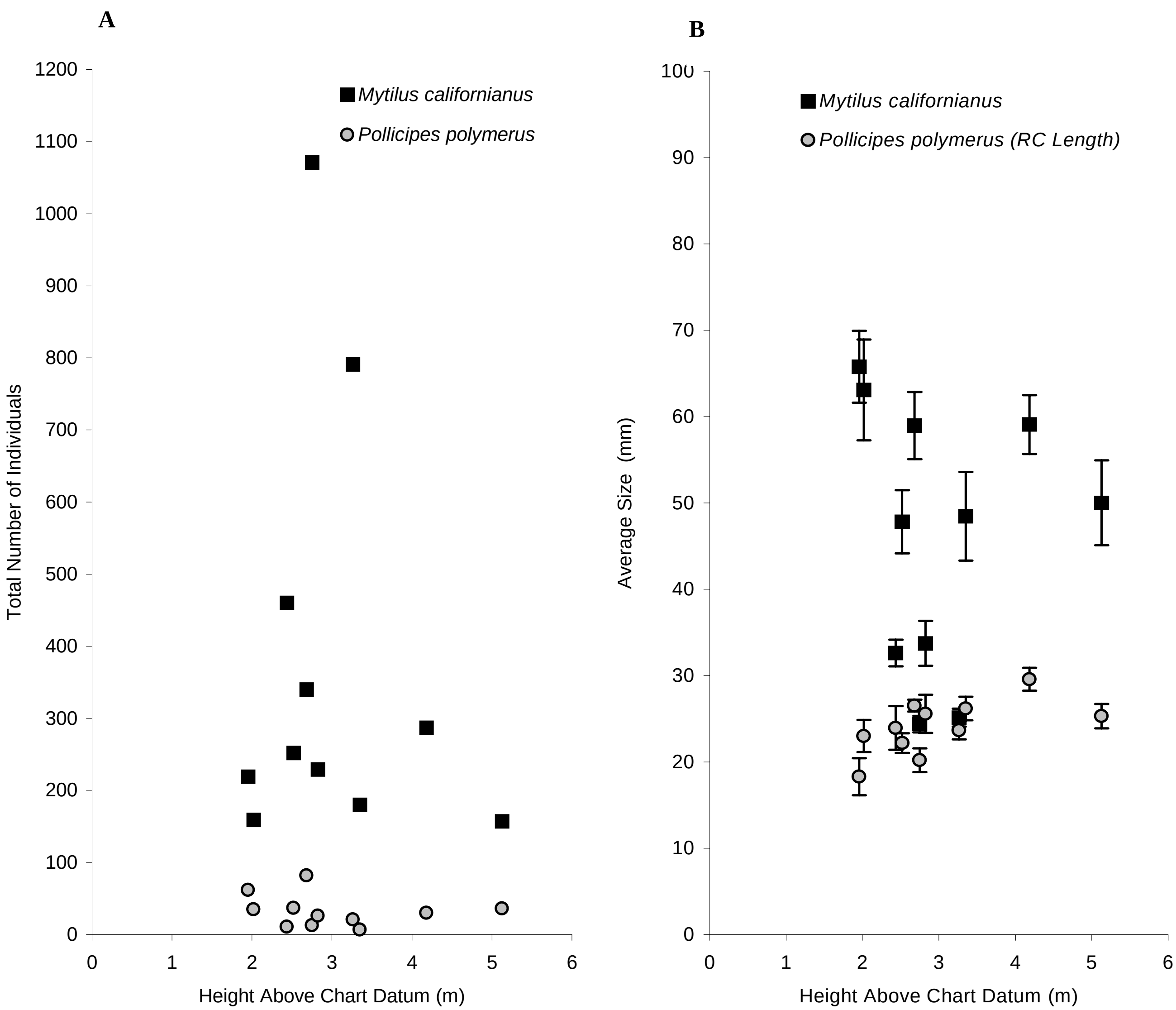
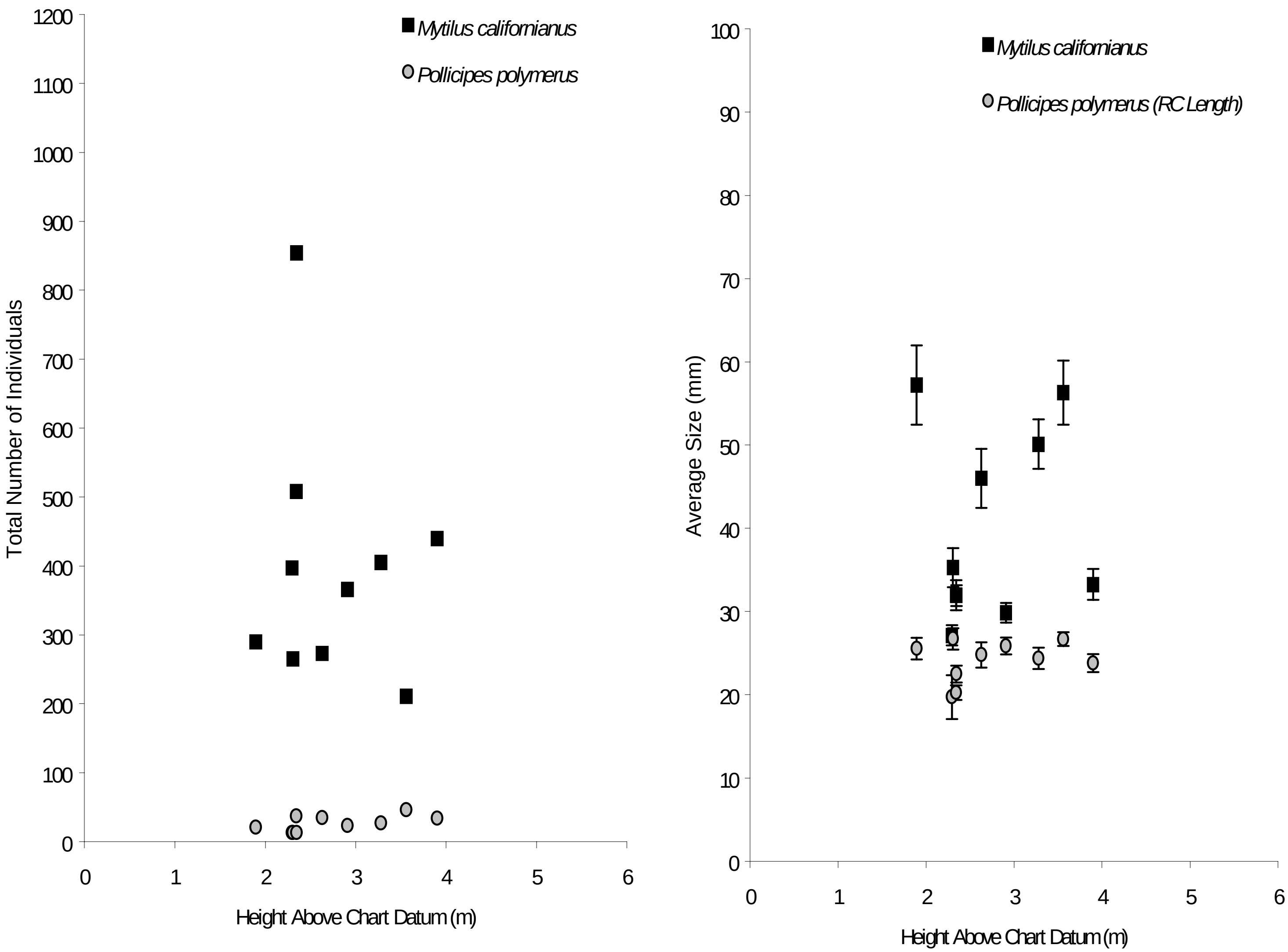

A
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Total Number of Individuals
Mytilus californianus
Pollicipes polymerus
0
1
2
3
4
5
6
Height Above Chart Datum (m)
B
100
90
80
70
60
50
40
30
20
10
0
Average Size (mm)
Mytilus californianus
Pollicipes polymerus (RC Length)
0
1
2
3
4
5
6
Height Above Chart Datum (m)

Figure 9

A

B



Mytilus californianus
Pollicipes polymerus
Total Number of Individuals
Height Above Chart Datum (m)
Mytilus californianus
Pollicipes polymerus (RC Length)
Average Size (mm)
Height Above Chart Datum (m)


Figure 10

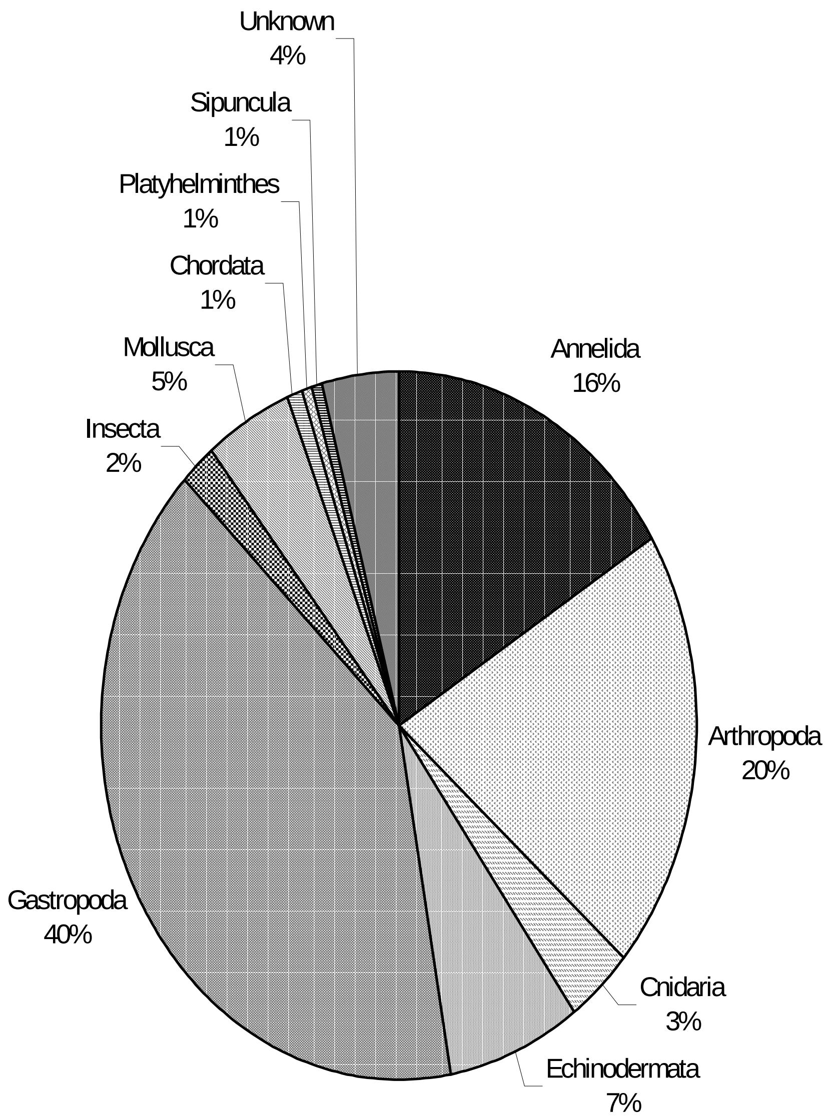

Unknown
4%
Sipuncula
1%
Platyhelminthes
1%
Chordata
1%
Mollusca
5%
Insecta
2%
Annelida
16%
Arthropoda
20%
Gastropoda
40%
Cnidaria
3%
Echinodermata
7%

Figure 11

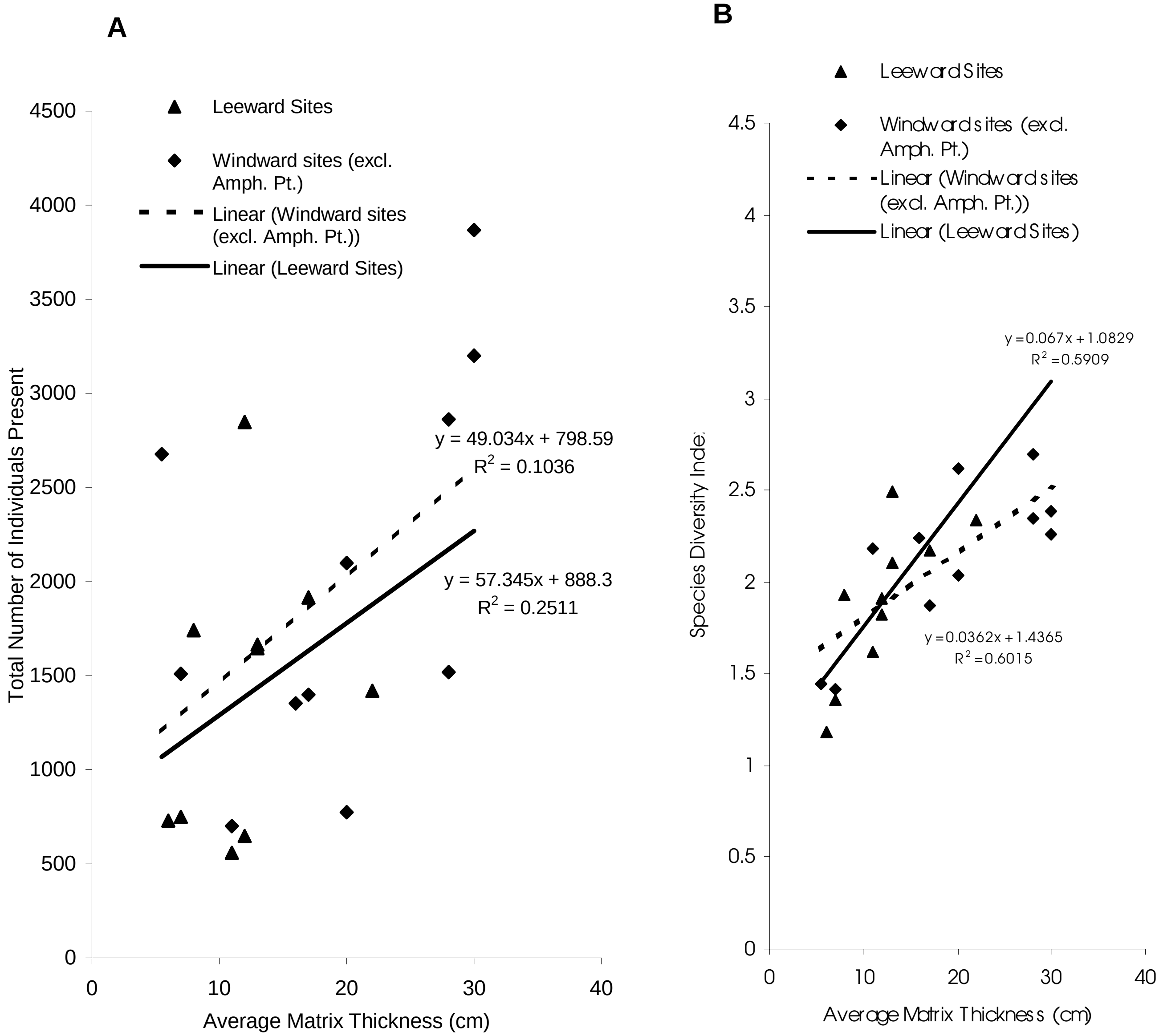

A
Leeward Sites
Windward sites (excl. Amph. Pt.)
Linear (Windward sites (excl. Amph. Pt.))
Linear (Leeward Sites)
Total Number of Individuals Present
y = 49.034x + 798.59
R2 = 0.1036
y = 57.345x + 888.3
R2 = 0.2511
Average Matrix Thickness (cm)
B
Leeward Sites
Windward sites (excl. Amph. Pt.)
Linear (Windward sites (excl. Amph. Pt.))
Linear (Leeward Sites)
Species Diversity Inde:
y = 0.067x + 1.0829
R2 = 0.5909
y = 0.0362x + 1.4365
R2 = 0.6015
Average Matrix Thickness (cm)

Figure 12

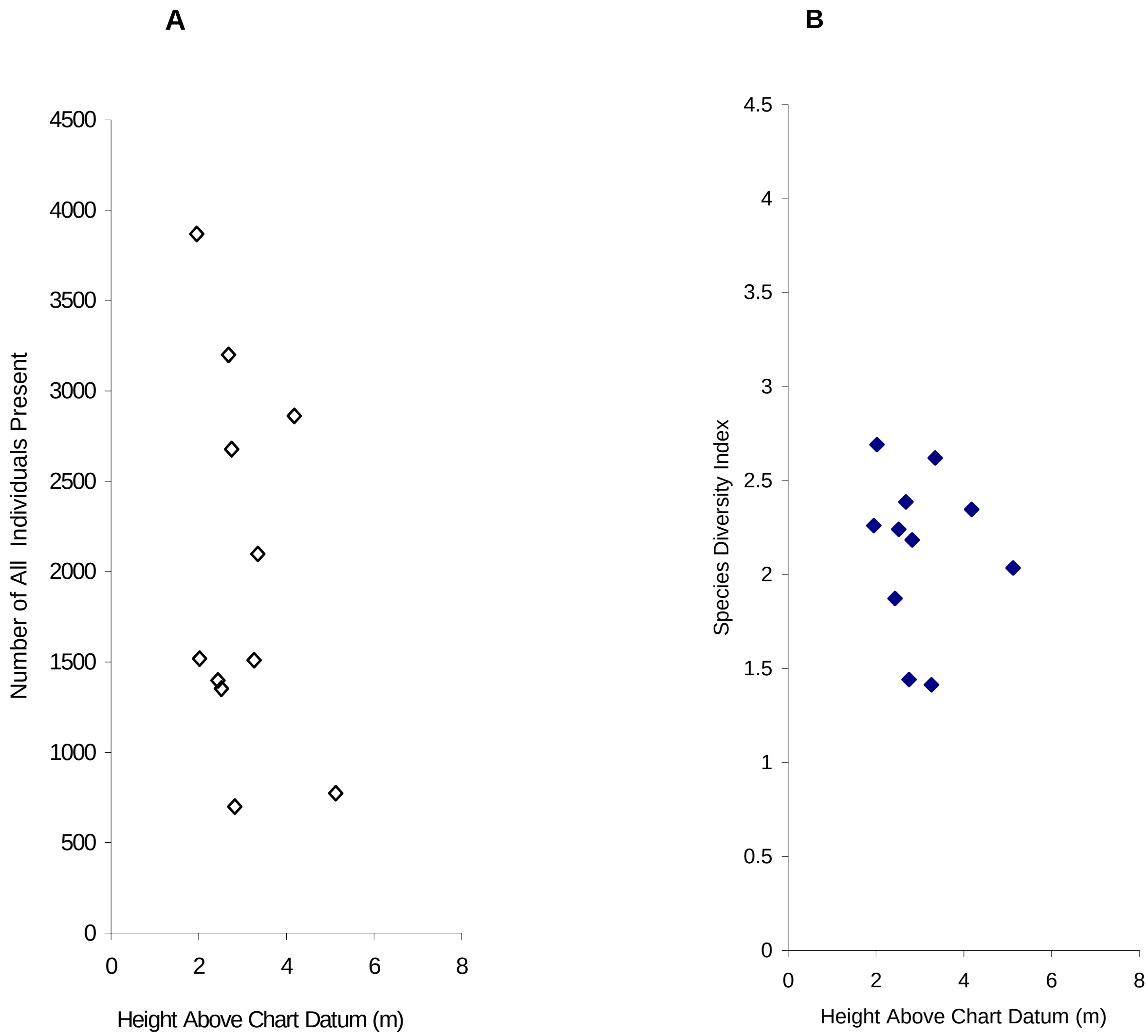
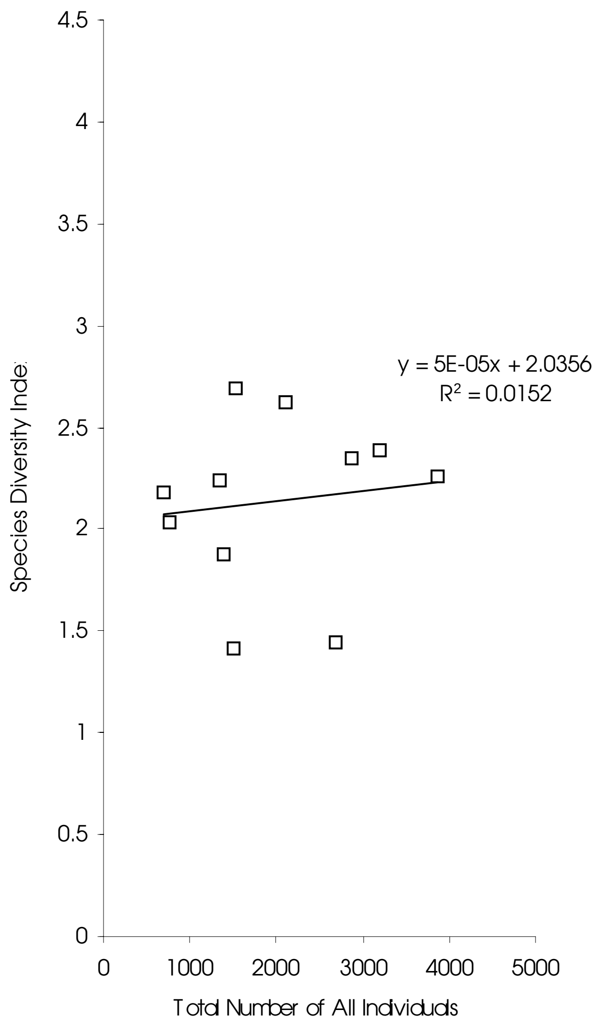



Figure 13 A and B

**C**



y = 5E-05x + 2.0356
R² = 0.0152
Species Diversity Inde
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1000
2000
3000
4000
5000
Total Number of All Individuals


Figure 13 C

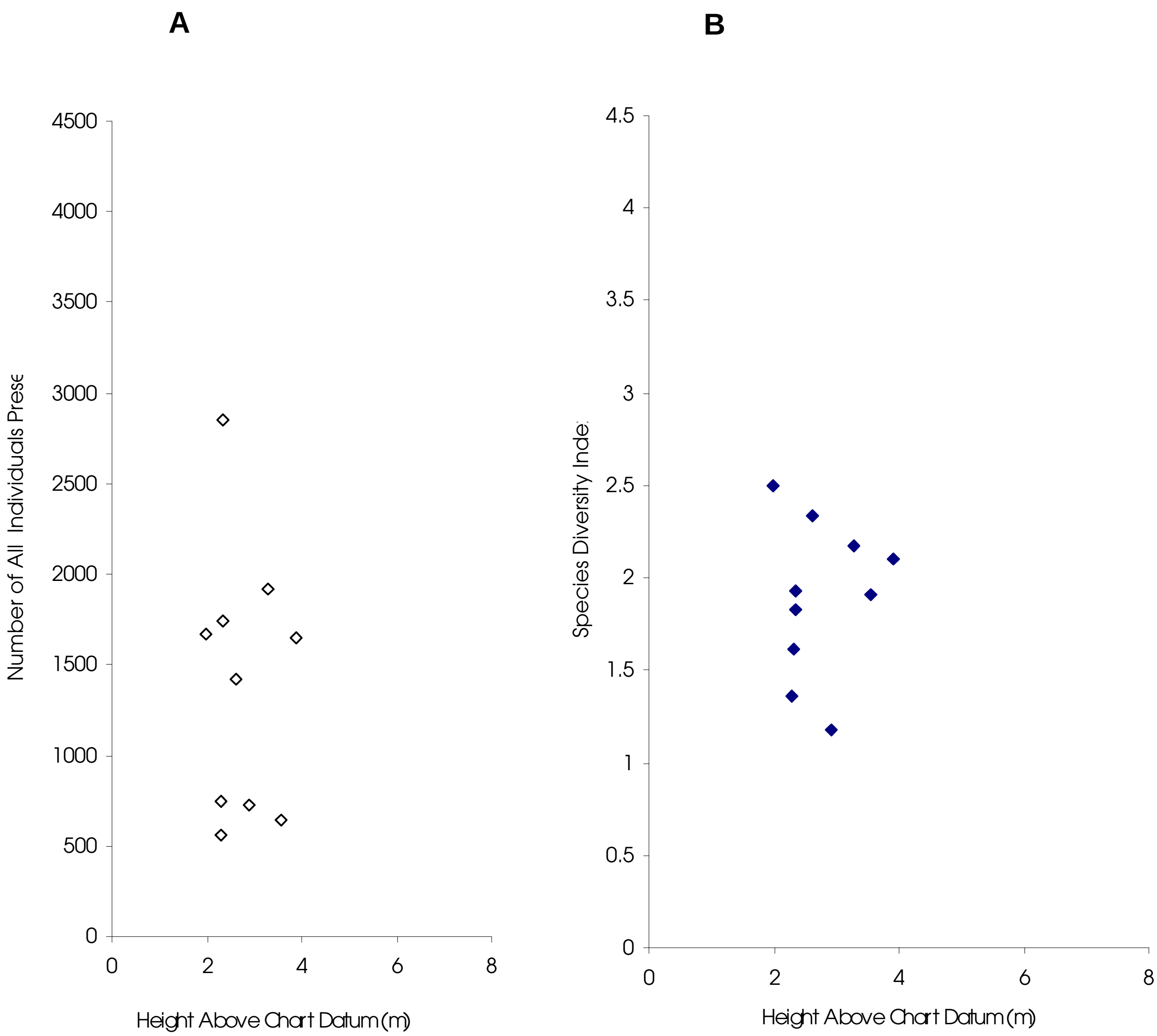



Figure 14 A and B

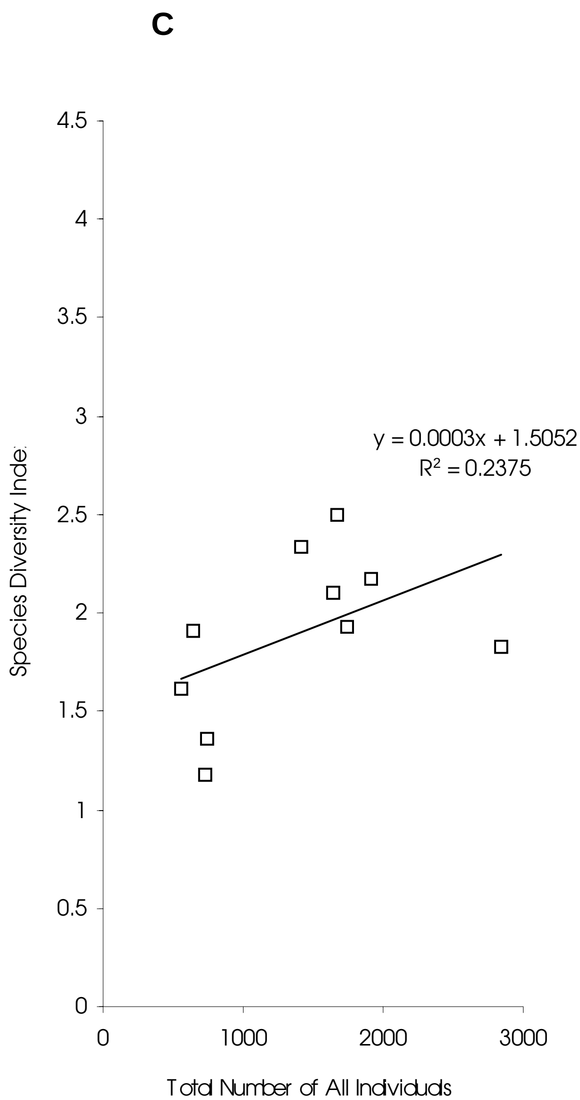
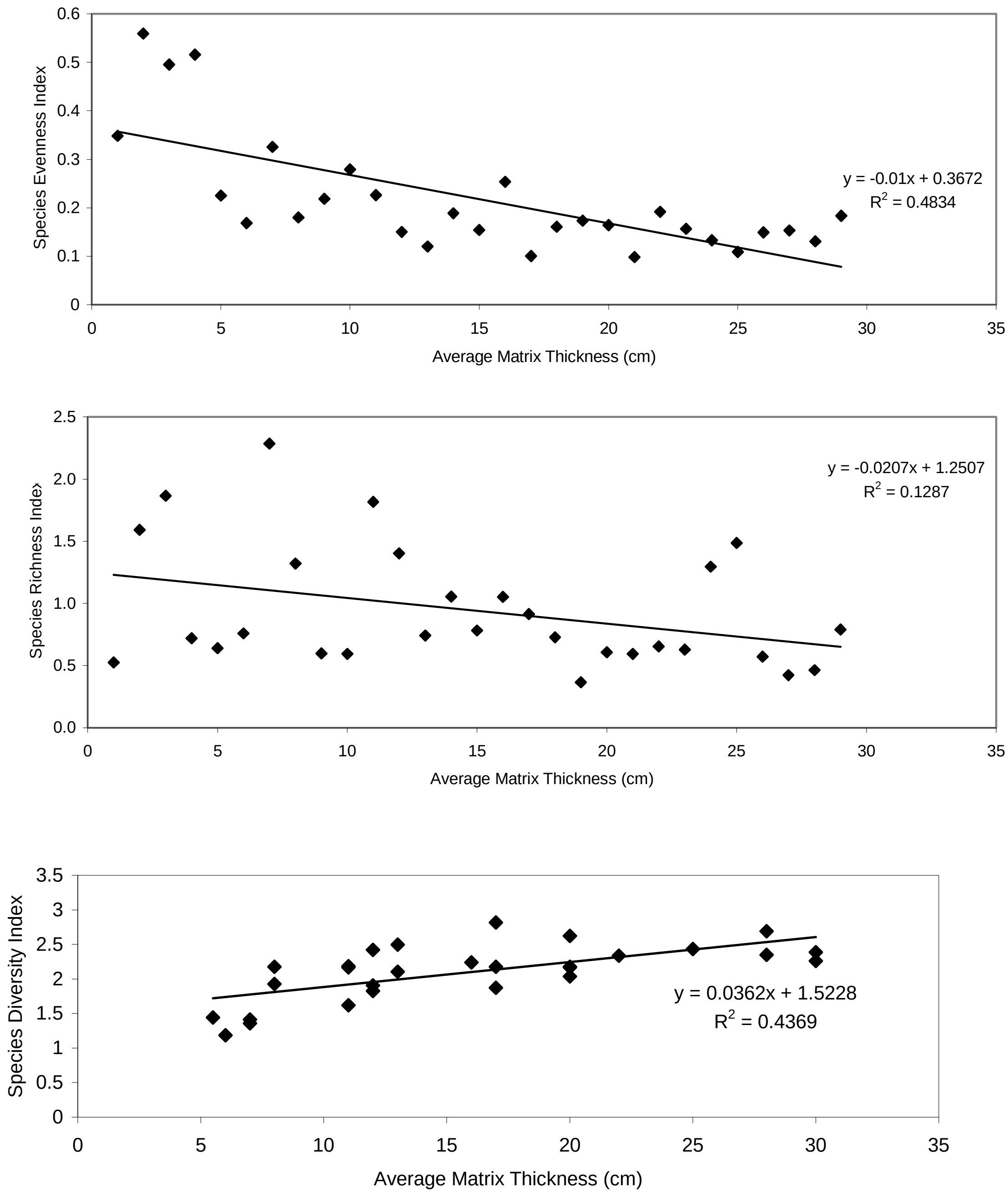
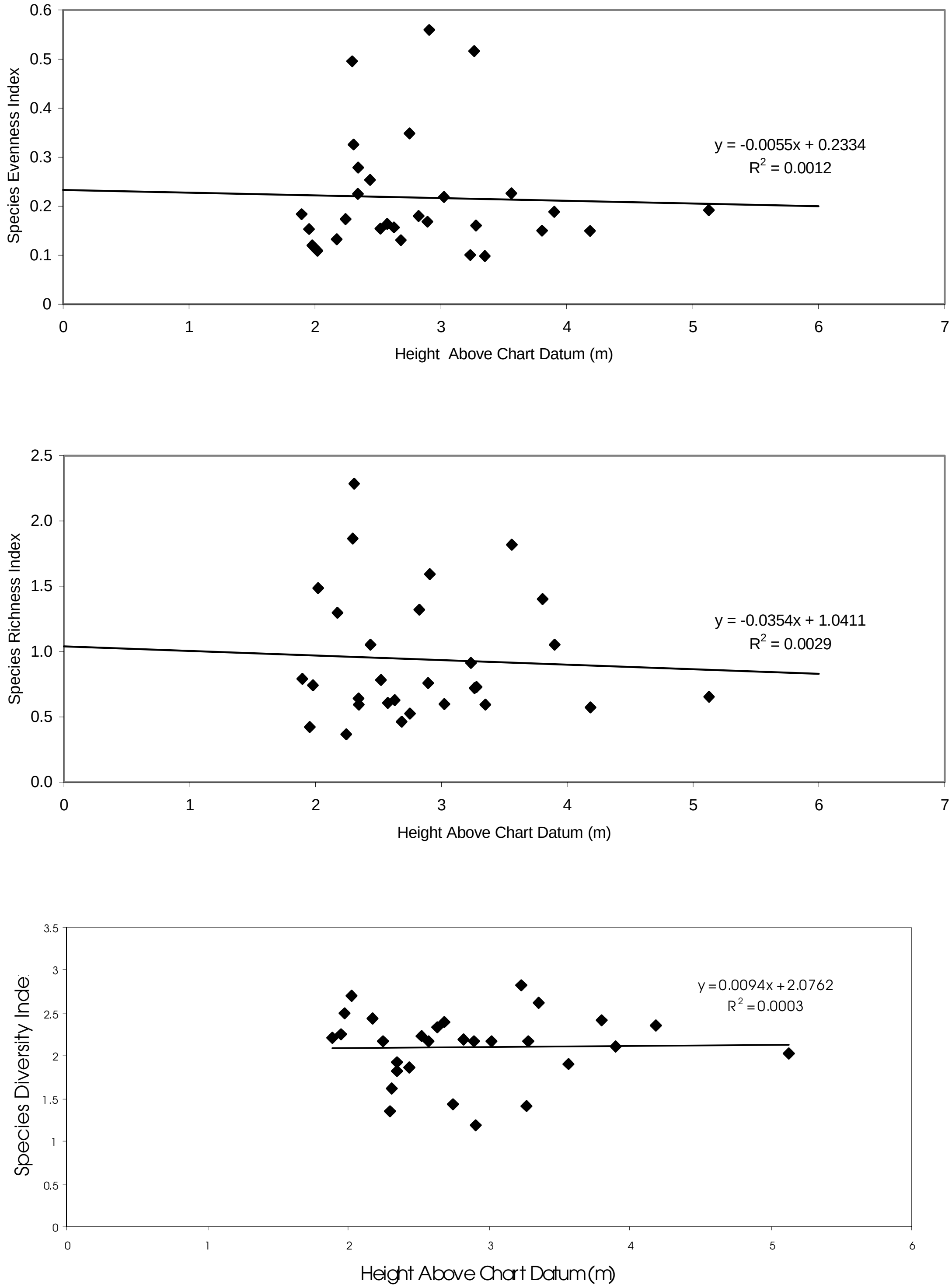

C
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Species Diversity Inde:
y = 0.0003x + 1.5052
R² = 0.2375
0
1000
2000
3000
Total Number of All Individuals

Figure 14 C



Species Evenness Index
y = -0.01x + 0.3672
R2 = 0.4834
Average Matrix Thickness (cm)
Species Richness Index
y = -0.0207x + 1.2507
R2 = 0.1287
Average Matrix Thickness (cm)
Species Diversity Index
y = 0.0362x + 1.5228
R2 = 0.4369
Average Matrix Thickness (cm)


Figure 15



Species Evenness Index
y = -0.0055x + 0.2334
R2 = 0.0012
Height Above Chart Datum (m)
Species Richness Index
y = -0.0354x + 1.0411
R2 = 0.0029
Height Above Chart Datum (m)
Species Diversity Inde
y = 0.0094x + 2.0762
R2 = 0.0003
Height Above Chart Datum (m)


Figure 16

# APPENDIX A: SITE DESCRIPTIONS

Refer to Figures 2, 3 and 4 for locations (Elevations recorded above chart datum (m))

| | | |
|---|---|---|
| Site 1A<br>Amphitrite<br>Point;<br>Windward | Elevation: | 3.804-m |
| | Quadrate size: | 1400-$cm^2$ |
| | Average Depth of Quadrate: | 12.0-cm |
| | Bearing to Lighthouse: | 2.0$^o$ |
| | Bearing to Green Buoy: | 98.0 $^o$ |
| | Bearing to Red Buoy: | 194.0 $^o$ |
| | Bearing to Pathway: | 14.0 $^o$ |
| | General Observations: | Site located in the upper mussel/barnacle zone. |
| Site 2A<br>Amphitrite<br>Point;<br>Windward | Elevation: | 3.234-m |
| | Quadrate size: | 1400-$cm^2$ |
| | Average Depth of Quadrate: | 17.0-cm |
| | Bearing to Lighthouse: | 4.0 $^o$ |
| | Bearing to Green Buoy: | 93.0 $^o$ |
| | Bearing to Red Buoy: | 193.0 $^o$ |
| | Bearing to Pathway: | N/A |
| | General Observations: | Site located in the lower mussel/ barnacle zone.<br>Distance relative to 1A: 7.8-m @ 192.0 $^o$ |
| Site 3A<br>Amphitrite<br>Point;<br>Windward | Elevation: | 2.894-m |
| | Quadrate size: | 1400-$cm^2$ |
| | Average Depth of Quadrate: | 8.0-cm |
| | Bearing to Lighthouse: | 4.0 $^o$ |
| | Bearing to Green Buoy: | 100.0 $^o$ |
| | Bearing to Red Buoy: | 197.0 $^o$ |

| | | |
|---|---|---|
| | Bearing to Pathway: | N/A |
| | General Observations: | Site located in the low to mid mussel/barnacle zone west of a cluster of *Postelsia palmaeformis* (sea palm) kelp.<br>Distance relative to 1A: 6.25-m @ 224.0$^o$ |
| Site 4A Amphitrite Point; Windward | Elevation: | 1.894-m |
| | Quadrate size: | 1400-cm$^2$ |
| | Average Depth of Quadrate: | (not obtained) |
| | Bearing to Lighthouse: | 8.0 $^o$ |
| | Bearing to Green Buoy: | 95.0 $^o$ |
| | Bearing to Red Buoy: | 194.0 $^o$ |
| | Bearing to Pathway: | N/A |
| | General Observations: | Site located on the vertical slope<br>Site abundant in *Alaria spp*. and *Postelsia palmaeformis.*<br>Distance relative to 1A: 7.30-m @ 215.0$^o$ |
| Site 5B Amphitrite Point; Windward | Elevation: | 2.174-m |
| | Quadrate size: | 1400-cm$^2$ |
| | Average Depth of Quadrate: | 25.0-cm |
| | Bearing to Lighthouse: | 18.0 $^o$ |
| | Bearing to Red Buoy: | 192 .0 $^o$ |
| | Bearing to right corner of station house | 23.0 $^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Large tidal pool/crevice upslope of site. Tide pool/crevice abundant in *Alaria spp., Phyllospadix scouleri* and *Anthopleura xanthogrammica.*<br>Distance relative to 7B: 9.7-m @ 160.0$^o$ |
| Site 6B Amphitrite Point; Windward | Elevation: | 2.574-m |
| | Quadrate size: | 1400-cm$^2$ |
| | Average Depth of Quadrate: | 20-cm |
| | Bearing to Lighthouse: | 20.0 $^o$ |
| | Bearing to Red Buoy: | 196.0 $^o$ |

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| | Bearing to right corner of station house | 24.0 $^{o}$ |
| | General Observations: | Site located in the lower mussel/barnacle zone.<br>0.4-m above site 5B.<br>Large tidal pool/crevice upslope of site. Tide pool/crevice abundant in *Alaria spp.*, *Phyllospadix scouleri* and *Anthopleura xanthogrammica.*<br>Distance relative to 7B: 11.5-m @ 170.0$^{o}$ |
| Site 7B<br>Amphitrite Point;<br>Windward | Elevation: | 3.024-m |
| | Quadrate size: | 1400-cm$^{2}$ |
| | Average Depth of Quadrate: | 11.0-cm |
| | Bearing to Lighthouse: | 23.0 $^{o}$ |
| | Bearing to Red Buoy: | 193.0 $^{o}$ |
| | Bearing to right corner of station house | 27.0 $^{o}$ |
| | General Observations: | Site located in the upper mussel/barnacle zone.<br>Distance relative to site 1A: 32.3-m @ 121.0$^{o}$ |
| Site 8B<br>Amphitrite Point;<br>Windward | Elevation: | 2.244-m |
| | Quadrate size: | 1400-cm$^{2}$ |
| | Average Depth of Quadrate: | 20.0-cm |
| | Bearing to Lighthouse: | 21.0 $^{o}$ |
| | Bearing to Red Buoy: | 192.0 $^{o}$ |
| | Bearing to right corner of station house | 28.0 $^{o}$ |
| | General Observations: | Site located in the lower mussel/barnacle zone.<br>Site surrounded by *Alaria spp*.<br>Distance relative to 7B 12.35-m @ 218.0$^{o}$ |
| Site 9A<br>Lennard Island;<br>Leeward | Elevation: | 2.342-m |
| | Quadrate size: | 900-cm$^{2}$ |
| | Average Depth of Quadrate: | 8.0-cm |
| | Slope of Substrate: | 20.0$^{o}$ |
| | Bearing to shoreline: | 294.0$^{o}$ |
| | Bearing to Lighthouse: | 32.0$^{o}$ |
| | Bearing to reference point #1 (high point): | 11.4-m @ 92.0$^{o}$ |
| | Bearing to reference point #2 (flat peak to the west) | 10.9-m @ 165.0$^{o}$ |
| | General Observations: | Site in the mid mussel/barnacle zone. |

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| | | *Egregia menziesii* (Feather Boa Kelp) and *Phyllospadix scouleri* (Surfgrass) abundant in the lower intertidal zone. Upper intertidal zone, abundant in *Fucus distichus*.<br>Bed length and width: 37.3-m x 27.3-m<br>Reference points #1 and #2 both spray painted with orange dye. |
| Site 9B<br>Lennard Island;<br>Leeward | Elevation: | 2.344-m |
| | Quadrate size: | 900-$cm^2$ |
| | Average Depth of Quadrate: | 12.0-cm |
| | Slope of Substrate: | 22.0$^o$ |
| | Bearing to shoreline: | 240.0$^o$ |
| | Bearing to Lighthouse: | 23.0$^o$ |
| | Bearing to reference point #2 (flat peak to the west) | 6.65-m @ 349.0$^o$ |
| | Bearing to reference point #3 (high point): | 7.05-m @ 95.0$^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone between large crevice and large tide pool.<br>Bed length and width: 12.7-m x 9.7-m.<br>Reference points #2 and #3 both spray painted with orange dye. |
| Site 9C<br>Lennard Island;<br>Windward | Elevation: | 1.953-m |
| | Quadrate size: | 900-$cm^2$ |
| | Average Depth of Quadrate: | 30.0-cm |
| | Slope of Substrate: | Approx. 30.0 $^o$ |
| | Bearing to shoreline: | 126.0$^o$ |
| | Bearing to Lighthouse: | 334.0$^o$ |
| | Bearing to reference point #4: | 33.0-m @ 340$^o$ |
| | Bearing to reference point #5: | 19.7-m @ 208.0$^o$ |
| | General Observations: | Site located in the low mussel/barnacle zone.<br>Upslope large tide pool present with approx. 30% *Anthopleura xanthogrammica.*<br>11 *Pisaster ochraceus* observed in the region.<br>A 2-inch sea cucumber species and one gunnel species was observed.<br>Bed length and width: 9.5-m x 15.0-m |
| Site 9D<br>Lennard Island;<br>Windward | Elevation: | 3.264-m |

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| | Quadrate size: | 900-cm$^2$ |
| | Average Depth of Quadrate: | 7.0-cm |
| | Slope of Substrate: | 0.0$^o$ |
| | Bearing to shoreline: | 130.0$^o$ |
| | Bearing to Lighthouse: | 329.0$^o$ |
| | Bearing to reference point #5 (highest point in area): | 3.65-m @ 11.0$^o$ |
| | Bearing to reference point #6 (second highest point in area): | 10.35-m @ 278.0$^o$ |
| | General Observations: | Site located in the upper mussel/barnacle zone.<br>Site approximately 10.0-m NW from 9C<br>No *Pisaster ochraceus* observed in the region.<br>Bed length and width: 39.0-m x 17.8-m |
| Site 9E<br>Lennard Island;<br>Windward | Elevation: | 2.751-m |
| | Quadrate size: | 900-cm$^2$ |
| | Average Depth of Quadrate: | 5.5-cm |
| | Slope of Substrate: | 35.0$^o$ |
| | Bearing to shoreline: | 22.0$^o$ |
| | Bearing to Lighthouse: | 327.0$^o$ |
| | Bearing to reference point #5 (highest point in area): | 12.0-m @ 150.0$^o$ |
| | Bearing to reference point #6 (second highest point in area): | 11.4-m @ 225.0$^o$ |
| | General Observations: | Site middle of mussel/barnacle zone near large crevice.<br>Three *Pisaster ochraceus* observed in the region.<br>Bed length and width: 4.5-m x 5.8-m. |
| Site 10A<br>Islet #2;<br>Windward | Elevation: | 1.980-m |
| | Quadrate size: | 900-cm$^2$ |
| | Average Depth of Quadrate: | 13.0-cm |
| | Slope of Substrate: | 28.0$^o$ |
| | Bearing to shoreline: | 228.0$^o$ |
| | Bearing to reference point #7 (sprayed onto visible bedrock): | 5.85-m @ 70.0$^o$ |
| | Bearing to reference point #8 (sprayed onto visible bedrock): | 8.20-m @ 106.0$^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>One *Pisaster ochraceus* observed in the region.<br>Bed length and width: 9.6-m x 6.0-m |

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| Site 10B<br>Islet #2;<br>Windward | Elevation: | 2.520-m |
| | Quadrate size: | 900-cm$^2$ |
| | Average Depth of Quadrate: | 16.0-cm |
| | Slope of Substrate: | -10.0$^o$ (away from surf) |
| | Bearing to shoreline: | 259.0$^o$ |
| | Bearing to reference point #7 (sprayed onto visible bedrock): | 11.2-m @ 136.0$^o$ |
| | Bearing to reference point #9 (sprayed onto visible bedrock): | 15.4-m @ 17.0$^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Large tide pool upslope from sample site.<br>Greater than 100 *Pisaster ochraceus* observed in the region.<br>Bed width: 19.0-m |
| Site 10C<br>Islet #2;<br>Leeward | Elevation: | 2.437-m |
| | Quadrate size: | 900-cm$^2$ |
| | Average Depth of Quadrate: | 17.0-cm |
| | Slope of Substrate: | 35.0$^o$ |
| | Bearing to shoreline: | 356.0$^o$ |
| | Bearing to reference point #9 (sprayed onto visible bedrock): | 19.2-m @ 211.0$^o$ |
| | Bearing to reference point #10 (sprayed onto visible bedrock): | 11.6-m @ 170.0$^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Approximately 20 *Pisaster ochraceus* observed in this region.<br>Bed width: 5.9-m |
| Site 10D<br>Islet #2;<br>Leeward | Elevation: | 2.908-m |
| | Quadrate size: | 900-cm$^2$ |
| | Average Depth of Quadrate: | 6.0-cm |
| | Slope of Substrate: | 5.0$^o$ |
| | Bearing to shoreline: | 60.0$^o$ |
| | Bearing to reference point #10 (sprayed onto visible bedrock): | 11.5-m @ 232.0$^o$ |
| | Bearing to reference point #11 (sprayed onto | 6.1-m @ 283.0$^o$ |

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| | visible bedrock): | |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>One *Pisaster ochraceus* observed in this region.<br>Bed width: 6.7-m |
| Site 11A<br>Islet #3;<br>Leeward Site | Elevation: | 2.306-m |
| | Quadrate size: | 900-$cm^2$ |
| | Average Depth of Quadrate: | 11.0-cm |
| | Slope of Substrate: | 20.0$^o$ |
| | Bearing to shoreline: | 36.0$^o$ |
| | Bearing to reference point #12 (sprayed onto visible bedrock): | 13.6-m @ 230.0$^o$ |
| | Bearing to reference point #13 (sprayed onto visible bedrock): | 8.85-m @ 247.0$^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Greater than 50 *Pisaster ochraceus* observed in this region.<br>Bed width: 5.0-m |
| Site 11B<br>Islet #3;<br>Leeward | Elevation: | 2.295-m |
| | Quadrate size: | 900-$cm^2$ |
| | Average Depth of Quadrate: | 7.0-cm |
| | Slope of Substrate: | 12.0$^o$ |
| | Bearing to shoreline: | 4.0$^o$ |
| | Bearing to reference point #13 (sprayed onto visible bedrock): | 8.6-m @ 186.0$^o$ |
| | Bearing to reference point #14 (sprayed onto visible bedrock): | 17.5-m @ 230.0$^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Greater than 50 *Pisaster ochraceus* observed in this region.<br>Bed width: 3.8-m |
| Site 11C<br>Islet #3;<br>Windward | Elevation: | 2.824-m |
| | Quadrate size: | 900-$cm^2$ |

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| | Average Depth of Quadrate: | 11.0-cm |
| | Slope of Substrate: | 25.0$^o$ |
| | Bearing to shoreline: | 194.0$^o$ |
| | Bearing to reference point #12 (sprayed onto visible bedrock): | 26.8-m @ 46.0$^o$ |
| | Bearing to reference point #14 (sprayed onto visible bedrock): | 22.8-m @ 20.0$^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Large tide pool upslope of site.<br>No *Pisaster ochraceus* observed in this region.<br>Bed width: 5.0-m |
| Site 11D<br>Islet #3;<br>Windward | Elevation: | 2.020-m |
| | Quadrate size: | 900-cm$^2$ |
| | Average Depth of Quadrate: | 28.0-cm |
| | Slope of Substrate: | N/A |
| | Bearing to shoreline: | 183.0$^o$ |
| | Bearing to reference point #12 (sprayed onto visible bedrock): | 22.7-m @ 19.0$^o$ |
| | Bearing to reference point #14 (sprayed onto visible bedrock): | 22.4-m @ 0.0$^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Tide was coming in too rapidly and this site quickly became a safety hazard, therefore some data was not obtainable.<br>Slope of substrate was not determined do to the extensive depth of quadrate and incoming tide.<br>No *Pisaster ochraceus* observed in this region.<br>Bed width: not obtainable. |
| Site 12A<br>Nob Rock;<br>Leeward | Elevation: | 3.900-m |
| | Quadrate size: | 900-cm$^2$ |
| | Average Depth of Quadrate: | 13.0-cm |
| | Slope of Substrate: | 15.0$^o$ |
| | Bearing to shoreline: | 24.0$^o$ |
| | Bearing to Lennard Lighthouse: | 109.0$^o$ |
| | Bearing to reference point #15 (Inner most point of Southern crevice, relative to islet): | 12.5-m @ 234.0$^o$ |
| | Bearing to reference point #16 (Inner most point of Eastern crevice, relative to islet): | 25.9-m @ 282.0$^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Fifty or more *Pisaster ochraceus* observed in this region.<br>Bed width: 13.5-m |

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| Site 12B<br>Nob Rock;<br>Leeward | Elevation: | 3.560-m |
| | Quadrate size: | 900-$cm^2$ |
| | Average Depth of Quadrate: | 12.0-cm |
| | Slope of Substrate: | 15.0$^o$ |
| | Bearing to shoreline: | 17.0$^o$ |
| | Bearing to Lennard Lighthouse: | 108.0$^o$ |
| | Bearing to reference point #15 (Inner most point of Southern crevice, relative to islet): | 22.7-m @ 19.0$^o$ |
| | Reference point #16B (large tide pool): | Adjacent to sample site. |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Four *Pisaster ochraceus* observed in this region.<br>Large tide pool with numerous (>100) *Anthopleura xanthogrammica* present.<br>Bed width: 17.8-m |
| Site 12C<br>Nob Rock;<br>Windward | Elevation: | 4.184-m |
| | Quadrate size: | 900-$cm^2$ |
| | Average Depth of Quadrate: | 28.0-cm |
| | Slope of Substrate: | 35.0$^o$ |
| | Bearing to shoreline: | 222.0$^o$ |
| | Bearing to Lennard Lighthouse: | 107.0$^o$ |
| | Bearing to reference point #15 (Inner most point of Southern crevice, relative to islet): | 23.5-m @ 90.0$^o$ |
| | Reference point #16 (Inner most point of Eastern crevice, relative to islet): | 24.3-m @ 32.0$^o$ |
| | General Observations: | Site located in the lower mussel/barnacle zone.<br>No *Pisaster ochraceus* observed in this region. However, very abundant in various kelp species.<br>Gunnel species collected during sampling.<br>Bed width: 15.3-m |
| Site 12D<br>Nob Rock;<br>Windward | Elevation: | 2.683-m |
| | Quadrate size: | 900-$cm^2$ |
| | Average Depth of Quadrate: | 30.0-cm |
| | Slope of Substrate: | 0.0$^o$ |
| | Bearing to shoreline: | 234.0$^o$ |
| | Bearing to Lennard Lighthouse: | 110.0$^o$ |
| | Bearing to reference point #15 (Inner most point of Southern crevice, relative to islet): | 29.6-m @ 98.0$^o$ |
| | Reference point #16 (Inner most point of Eastern crevice, relative to islet): | 23.2-m @ 48.0$^o$ |

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| | General Observations: | Site located in the lower mussel/barnacle zone.<br>No *Pisaster ochraceus* observed in this region. However, very abundant in various kelp species.<br>Bed width: 16.3-m |
| Site 13A<br>Nob Rock II;<br>Windward | Elevation: | 3.350-m |
| | Quadrate size: | 900-cm$^2$ |
| | Average Depth of Quadrate: | 20.0-cm |
| | Slope of Substrate: | -25.0$^o$ away from the surf |
| | Bearing to shoreline: | 187.0$^o$ |
| | Bearing to reference point #17: | 25.8-m @ 104.0$^o$ |
| | Reference point #18: | 21.7-m @ 70.0$^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Site near large crevice along the west side of the islet.<br>Five *Pisaster ochraceus*, one *Strongylocentrotus purpuratus* and few *Anthopleura xanthogrammica* were observed in this region.<br>Bed width: 35.3-m |
| Site 13B<br>Nob Rock II;<br>Windward | Elevation: | 5.128-m |
| | Quadrate size: | 900-cm$^2$ |
| | Average Depth of Quadrate: | 20.0-cm |
| | Slope of Substrate: | 45.0$^o$ |
| | Bearing to shoreline: | 191.0$^o$ |
| | Bearing to reference point #17: | 32.8-m @ 108.0$^o$ |
| | Reference point #18: | 27.5-m @ 74.0$^o$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Site along the west side of the large crevice along the windward side of the islet.<br>Five *Pisaster ochraceus* and a few *Anthopleura xanthogrammica* observed in this region. Abundant in *Nereocystis luetkeana* (Bull Kelp) and *Endocladia muricata* (Sea Moss/Nail Brush).<br>Bed width: 24.7-m |
| Site 13C<br>Nob Rock II;<br>Leeward | Elevation: | 3.280-m |
| | Quadrate size: | 900-cm$^2$ |
| | Average Depth of Quadrate: | 17.0-cm |
| | Slope of Substrate: | 50.0$^o$ |

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| | Bearing to shoreline: | 17.0$^{o}$ |
| | Bearing to reference point #17: | 39.7-m @ 132.0$^{o}$ |
| | Reference point #18: | 27.3-m @ 121.0$^{o}$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Site along the leeward side of islet near large crevice (or bay).<br>Abundant, greater than 100, *Pisaster ochraceus*, and<br>*Nereocystis luetkeana* (Bull Kelp)<br>Bed width:  24.0-m |
| Site 13D<br>Nob Rock II;<br>Leeward | Elevation: | 2.628-m |
| | Quadrate size: | 900-cm$^{2}$ |
| | Average Depth of Quadrate: | 22.0-cm |
| | Slope of Substrate: | 30.0$^{o}$ away from the surf |
| | Bearing to shoreline: | 14.0$^{o}$ |
| | Bearing to reference point #17: | 35.1-m @ 160.0$^{o}$ |
| | Reference point #18: | 20.0-m @ 152.0$^{o}$ |
| | General Observations: | Site located in the mid mussel/barnacle zone.<br>Site on rocky outcrop close to point #18.<br>Sandy rich sediment present.<br>Five *Pisaster ochraceus* observed.<br>Bed width:  approx. 35.0-m |

## APPENDIX B: VERIFIED LIST OF REFERENCE COLLECTION SPECIES

| Phylum, Subphylum or Class | Species Name | Common Name |
|---|---|---|
| Cnidaria | Anthopleura sp. | Anemone |
| Cnidaria | Anthopleura xanthogrammica | Giant Green Anemone |
| Cnidaria | Cnidopus ritteri | White Anemone |
| Cnidaria | Cribrinopsis fernaldi | Anemone |
| Cnidaria | Unknown | Anemone |
| Platyhelminthes | Leptoplana vesiculata | Flatworm |
| Annelida | Cheilonereis cyclurus | Segmented worm |
| Annelida | Cirratulus sp. | Cirratulidae |
| Annelida | Dysoponetus pygmaeus Levinsen | Polychaeta |
| Annelida | Halosydna brevisetosa | Eighteen Scaleworm |
| Annelida | Unknown ppllychaet | Polychaeta |
| Annelida | Nephtys sp. | Segmented worm |
| Annelida | Nereis sp. | Segmented worm |
| Annelida | Nereis vexillosa | Large Mussel Worm |
| Annelida | Nereis zonata | Segmented Worm |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Polychaeta sp. | Polychaeta |
| Annelida | Syllidae sp. | Possibly Exogene |
| Sipuncula | Phascolosoma agassizii | Agassiz's Peanut Worm |
| Arthropoda, Cheliceriformes | Pycnogonum stearnsi | Sea Spider |
| Arthropoda, Insecta | Unknown | Insect |
| Arthropoda, Insecta | Unknown | Insect |
| Arthropoda, Insecta | Unknown | Sea Spider/mite |
| Arthropoda, Crustacea, Maxillopoda | Pollicipes polymerus | Gooseneck Barnacle |
| Arthropoda, Crustacea, Maxillopoda | Balanus glandula/crenatus | Acorn Barnacle |
| Arthropoda, Crustacea, Maxillopoda | Balanus hesperius | Barnacle |
| Arthropoda, Crustacea, Maxillopoda | Balanus nubilis | Giant Acorn Barnacle |
| Arthropoda, Crustacea, Maxillopoda | Coronula sp. | Barnacle |

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| Arthropoda, Crustacea, Maxillopoda | Cancer productus | Red Rock Crab |
| Arthropoda, Crustacea, Maxillopoda | Chorila longipes | Kelp Crab |
| Arthropoda, Crustacea, Maxillopoda | Semibalanus cariosus | Thatched Barnacle |
| Arthropoda, Crustacea, Malacostraca | Cirolana harfordi | Harford's Greedy Isopod |
| Arthropoda, Crustacea, Malacostraca | Corophium sp. | Amphipod |
| Arthropoda, Crustacea, Malacostraca | Cymadusa uncinata | Amphipod |
| Arthropoda, Crustacea, Malacostraca | Dynamenella sheareri | |
| Arthropoda, Crustacea, Malacostraca | Fabia subquadrata | Pinnotheridae "Pea" crab |
| Arthropoda, Crustacea, Malacostraca | Hyale sp. | Amphipod |
| Arthropoda, Crustacea, Malacostraca | Ianiropsis sp. | Isopod |
| Arthropoda, Crustacea, Malacostraca | Idotea sp (fewkesi ?) | Isopod |
| Arthropoda, Crustacea, Malacostraca | Jassa sp. | Amphipod |
| Arthropoda, Crustacea, Malacostraca | Unknown | Juvenile crab |
| Arthropoda, Crustacea, Malacostraca | Megaluropus sp. | Amphipod |
| Arthropoda, Crustacea, Malacostraca | Oediganathus inermis | Hapalogaster Crab |
| Arthropoda, Crustacea, Malacostraca | Pachycheles pubescens | Thick-clawed Porcelain Crab |
| Arthropoda, Crustacea, Malacostraca | Pachycheles rudis | Thick-clawed Porcelain Crab |
| Arthropoda, Crustacea, Malacostraca | Pagurus sp. | Hermit crab |
| Arthropoda, Crustacea, Malacostraca | Petrolisthes cinctipes | Flat Porcelain Crab |
| Arthropoda, Crustacea, Malacostraca | Pinnotheres sp. | "Pea" or commensal crab |
| Arthropoda, Crustacea, Malacostraca | Pugettia producta | Shield-backed Kelp Crab |
| Arthropoda, Crustacea, Malacostraca | Pugettia richii | Kelp Crab |
| Mollusca, Gastropoda | Alia carinata | Joseph's Coat Amphissa |
| Mollusca, Gastropoda | Amphissa columbiana | Wrinkled Amphissa |
| Mollusca, Gastropoda | Amphissa reticulata | Amphissa |
| Mollusca, Gastropoda | Amphissa sp. | Amphissa |
| Mollusca, Gastropoda | Amphissa versicolor | Amphissa |
| Mollusca, Gastropoda | Bittium attenuatum | Slender Bittium |
| Mollusca, Gastropoda | Bittium eschrichtii | Threaded Bittium |
| Mollusca, Gastropoda | Bittium munitum | Bittium |
| Mollusca, Gastropoda | Bittium sp. | Hornsnail |
| Mollusca, Gastropoda | Calliostoma ligatum | Blue Top-shell |
| Mollusca, Gastropoda | Calyptracea fastigiata | White Cup & Saucer Snail |
| Mollusca, Gastropoda | Colus sp. | |
| Mollusca, Gastropoda | Eulima randolphi | Eulimidae |
| Mollusca, Gastropoda | Eulima randolphi/Odostomi sp. | Eulimidae |
| Mollusca, Gastropoda | Lacuna sp | Chink Snail |
| Mollusca, Gastropoda | Lacuna sp. | Chink Snail |
| Mollusca, Gastropoda | Lacuna variegata | Variable Lacuna |
| Mollusca, Gastropoda | Lacuna vincta | Common Northern Chink Shell |
| Mollusca, Gastropoda | Lirularia lirulata | Pearly Topsnail |
| Mollusca, Gastropoda | Littorina keenae | Eroded Periwinkle |
| Mollusca, Gastropoda | Littorina scutulata | Checkered Periwinkle |
| Mollusca, Gastropoda | Littorina sp. | Periwinkle |
| Mollusca, Gastropoda | Lottia alveus | Limpet |
| Mollusca, Gastropoda | Lottia asmi | Black Limpet |
| Mollusca, Gastropoda | Lottia digitatis | Finger Limpet |

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| Mollusca, Gastropoda | Lottia ocharacea | Limpet |
| Mollusca, Gastropoda | Lottia pelta | Limpet |
| Mollusca, Gastropoda | Lottia strigatella | Limpet |
| Mollusca, Gastropoda | Unknown | Limpet |
| Mollusca, Gastropoda | Niveotectura funiculata | Limpet |
| Mollusca, Gastropoda | Tectura (Notoacmaea) scutum | Plate Limpet |
| Mollusca, Gastropoda | Tectura paleacea | Limpet |
| Mollusca, Gastropoda | Tectura persona | Mask Limpet |
| Mollusca, Gastropoda | Tectura scutum | Plate Limpet |
| Mollusca, Gastropoda | Acmaea mitra Eschscholtz | Whitecap Limpet |
| Mollusca, Gastropoda | Lottia strigatella or painei | Limpet |
| Mollusca, Gastropoda | Margarites helicinus | Smooth Margarite |
| Mollusca, Gastropoda | Margarites puppillus | Puppet Margarite |
| Mollusca, Gastropoda | Margarites rhodia or pupillus | Margarite |
| Mollusca, Gastropoda | Katharina tunicata | Black Katy Chiton |
| Mollusca, Gastropoda | Lepidozona mertensii | Merten's Chiton |
| Mollusca, Gastropoda | Lepidozona sp. | Chiton |
| Mollusca, Gastropoda | Mopalia muscosa | Mossy Chiton |
| Mollusca, Gastropoda | Mopalia porifera | Chiton |
| Mollusca, Gastropoda | Mopalia sp. | Chiton |
| Mollusca, Gastropoda | Mopalia sp. (spectabilis?) | Chiton |
| Mollusca, Gastropoda | Placiphorella velata | Veiled Chiton |
| Mollusca, Gastropoda | Mopolia ciliata | Hairy Chitin |
| Mollusca, Gastropoda | Nucella canaliculata | Channeled Doqwinkle |
| Mollusca, Gastropoda | Nucella | Dogwinkle egg sacs |
| Mollusca, Gastropoda | Nucella emarginata | Striped Dogwinkle |
| Mollusca, Gastropoda | Nucella lima | File Dogwinkle |
| Mollusca, Gastropoda | Ocenebra interfossa | Carpenter's Dwarf Triton |
| Mollusca, Gastropoda | Ocenebra japonica | Dwarf Triton |
| Mollusca, Gastropoda | Ocenebra lurida | Carpenter's Dwarf Triton |
| Mollusca, Gastropoda | Ocenebra sp. | Dwarf Triton |
| Mollusca, Gastropoda | Solariella obscura | Solariella |
| Mollusca, Gastropoda | Tachyrlychus lacteolus | |
| Mollusca, Gastropoda | Tegula funebralis | Black Top-Shell |
| Mollusca, Gastropoda | Tegula pulligo | Dusty Turban |
| Mollusca, Gastropoda | Tegula sp. | Tegula |
| Mollusca, Gastropoda | Unknown | Snail |
| Mollusca, Bivalvia | Chlamys hastata | Spiny Scallop |
| Mollusca, Bivalvia | Hiatella arcticaarticapacifica) | Arctic hhiatella |
| Mollusca, Bivalvia | Mya truncata or saxicavase | Clam |
| Mollusca, Bivalvia | Mytilus californianus | California Mussel |
| Mollusca, Bivalvia | Nutricola sp. | Clam species (Dwarf Venus?) |
| Mollusca, Bivalvia | Protothaca staminea | Venerid clam |
| Mollusca, Bivalvia | Protothaca | Venerid clam |
| Ectoprocta | Bryozoan sp. | Moss animals |
| Echinodermata | Amphioplus stronglyloplax | Brittle Star |
| Echinodermata | Cucumaria fallax | Sea Cucumber |
| Echinodermata | Cucumaria pseudocurata | Black Sea Cucumber |

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| Echinodermata | Eupentacta quinquesemita | White Sea Cucumber |
| Echinodermata | Henricia sp. | Sea Star |
| Echinodermata | Leptasterias hexactis | Six-Ray Sea Star |
| Echinodermata | Leptasterias hexactis | Six-Ray Sea Star (Juvenile) |
| Echinodermata | Ophiopholis aculeata | Daisy Brittle Sea Star |
| Echinodermata | Pisaster brevispinus | Pink Sea Star |
| Echinodermata | Strongylocentrotus droebachiensis | Green Sea Urchin |
| Echinodermata | Strongylocentrotus pallidus | Pale Sea Urchin |
| Echinodermata | Strongylocentrotus purpuratus | Purple Sea Urchin |
| Chordata | Apodichthys flavidus | Gunnel |
| Unknown | Larval stage unknown | |
| Unknown | Unknown | White spherical ball |
| Unknown | Unknown | |
| Unknown | Unknown | Inchworm like |
| Unknown | Unknown | Gelatinous substance |
| Unknown | Unknown | Scaleworm casting? |