Newport Coast and Laguna Beach ASBS Intertidal Monitoring Study

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1.0 INTRODUCTION

Areas of special biological significance (ASBS) have been identified throughout California shorelines to provide protection for areas that provide habitat to valuable biological resources. Impacts to intertidal and subtidal habitats include sedimentation, scouring, contamination, and dilution of the saline water via dry weather flows and wet weather flows. Additional types of intertidal disturbance include direct harvesting, scavenging, trampling, and collecting of organisms by humans. The Newport Coast and Laguna Beach ASBS Protection and Restoration Program was designed to assess the magnitude and extent of multiple types of anthropogenic impacts to these areas and to create a baseline dataset for the intertidal zone. By monitoring the intertidal community over time, changes to the community due to further impacts or effective recovery can be assessed, and decisions on mitigating actions can be made.

The Newport Coast and Laguna Beach ASBS Protection and Restoration Program (Grant Agreement No. 05-230-550-0) approach involves five elements: study/investigation/monitoring, evaluation/assessment, planning, implementation, and renovation. For this program, the cities of Newport Beach and Laguna Beach have undertaken several studies to identify and quantify impacts to the ASBS. These studies include intertidal public use surveys, an intertidal monitoring survey, a mussel bioaccumulation study, a kelp toxicity study, and an experimental restoration program for the rockweed (*Silvetia compressa*). The results of these studies will be used to develop an implementation strategy that will be documented in the Integrated Coastal Watershed Management Plan (ICWMP). When implementation programs are complete, effectiveness assessments will be conducted to ensure the approach is on target and allows for changes under an adaptive management policy. Finally, the renovation program will re-introduce native species to restore and enhance the ASBS.

This report details the intertidal monitoring surveys conducted at locations within the Newport Coast and Laguna Beach ASBS.

1.1 Study Locations

Data were collected within the Newport Coast and Heisler Park ASBS to identify the presence, abundance, and distributions of species regularly monitored at rocky intertidal sites (e.g., Shaws Cove, Crystal Cove, Treasure Island, and Dana Point) as part of the Minerals Management Service (MMS) program and as part of California's Critical Coastal Area (CCA) long-term monitoring program. For this study, three sites were selected within the intertidal zone of the Newport Coast and Heisler Park ASBS. The sites were located in the rocky intertidal zones at Little Corona Del Mar (Buck Gully), Morning Canyon, and Heisler Park (Figure 1).

As with other long-term monitoring programs, biannual surveys were conducted, one during summer and one during winter. The comparable data collected as part of the proposed monitoring program may help to identify species-specific restoration or recovery goals for Newport and Irvine ASBS through the use of correlative analyses and temporal trend analyses. The initial sampling events, along with historical and comparable reference location data, provide the basis to aid in the determination of magnitude and extent of multiple types of anthropogenic impacts and to create a baseline in which to monitor change over time as a result of ASBS impacts or recovery actions.

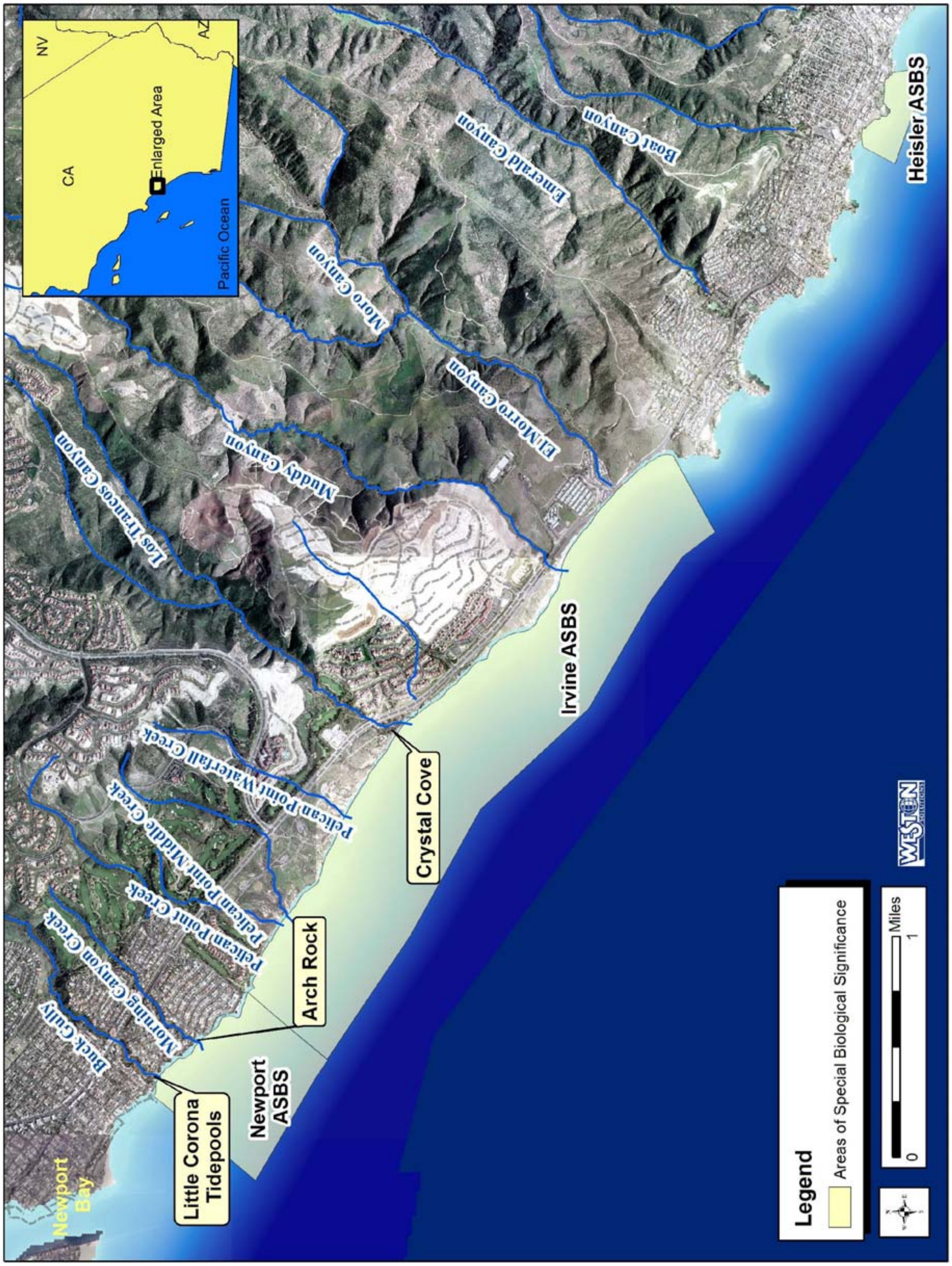

Figure 1. Newport Coast Showing Study Sites and Areas of Special Biological Significance

2.0 SAMPLING METHODS

2.1 Intertidal Monitoring Surveys

The Baseline Intertidal Monitoring Survey was designed to help to determine which current anthropogenic activities may be deleterious to species present in ASBS as well as to create a base-line dataset from which to monitor restoration efforts and future impacts. The Baseline Intertidal Monitoring Survey identifies the presence, abundance and distributions of species by conducting initial biannual surveys along permanent transect lines. The transect lines are stratified by habitat type and tidal level following methods comparable to other long-term monitoring programs. This baseline survey will be used to develop a comprehensive Intertidal Monitoring Program within the ASBS.

The Newport Coast and Laguna Beach ASBS Intertidal Monitoring Survey was designed to be consistent with methods currently used in other long-term monitoring programs (e.g., MMS intertidal marine program (http://www.marine.gov)) (Engle, et al. 2005).

2.1.1 Sampling Frequency

Two monitoring surveys were performed during the 2007 monitoring year. The first event took place in January–February 2007, and the second event occurred in July–August 2007. The surveys were scheduled to coincide with the occurrence of spring tides to ensure the greatest length of time was available in which to sample the exposed intertidal zone. Approximately four hours were available to conduct each of the monitoring surveys during low tide. During each survey, several different monitoring designs were employed. The monitoring designs included line-transect points, point-contact plots, photoplots, and band transects.

2.1.2 Sampling Locations

Intertidal species distribution and abundance data were collected along transect lines stratified by habitat type and tidal level. The transect lines were oriented across the reef, perpendicular to the alongshore axis of the beach, and surveys were conducted from the lower to upper intertidal zone along each transect. Point contacts, quadrats, and searches were implemented following standardized MMS methods for Orange County sites. To assess impacts from urban runoff, transects were aligned upcoast and downcoast of the mouths of Buck Gully and Morning Canyon and in close proximity to storm drain outfalls at Heisler Park.

All sampling locations within the Newport Coast ASBS (e.g., line-transect points, point-contact plots, photoplots, and band transects at Buck Gully and Morning Canyon) were marked using stainless-steel bolt markers drilled and epoxied into the rock substrate. Sampling locations within the Laguna Beach ASBS (Heisler Park) were marked using the marine epoxy, Z-spar. Because it was essential that the line-transect points, point-contact plots, photoplots and band transects were laid out in an identical manner during each survey, the locations of each bolt and epoxy marker were recorded using WAAS-enabled global positioning system (GPS). The length and diameter of the bolts used were dependent upon the hardness of the rock surface. During each visit, bolts and epoxy site markers were cleaned of fouling organisms to enhance visual identification of the site markers in subsequent sampling events. In instances where bolts were not visible, metal detectors were used to locate site markers.

2.1.3 Line Transects

Three transect lines were extended perpendicular to the alongshore axis of the beach (Figure 2). The seaward starting point for each transect was located at the 0 ft mean lower low water (MLLW) mark. Once the first transect was in place, the two remaining transects were placed parallel approximately 20 m upcoast and 20 m downcoast of the initial transect, again with the seaward terminus at the 0 ft MLLW mark. Suitable locations for the installation of permanent bolt markers dictated to some degree where transects were placed. The positions of all three transects were used to establish the locations at which the other sampling techniques were carried out. Data were recorded using the point-contact method, described below, at 20-cm intervals along the entire length of the transect. All animals, algae, and plants that fell immediately under the point contacts were scored as well as any underlying organisms. Only organisms easily visible to the eye were scored.

2.1.3.1 Point-Intercept Transect Protocol

The point-intercept transect protocol was adapted from the unified monitoring protocols developed by MMS. Permanent point-intercept transects were employed to monitor the cover of three target species: *Phyllospadix scouleri/torreyi, Egregia menziezii*, and red algae (turf algae, including articulated corallines and other red algae). Transects were established at sites with sufficient cover of the target species for monitoring.

Scoring Cover on Point-Intercept Transects
The cover of target species, as well as secondary core and optional species/taxa/substrates, was sampled by scoring point-intercepts along permanent 30-m to 50-m transects. Transects were marked at both ends and in the center with stainless-steel bolts or epoxy markers. Each transect was sampled by scoring occurrences under 100 points uniformly distributed at 20-cm intervals along a meter tape laid out along the transect. Rules for scoring were as follows. Each point along the transect meter tape was located and scored as one of 24 categories of core species, higher taxa, or substrates. Only the topmost (visible) layer attached to the substrate (i.e., not an obvious epibiont) was scored, except surfgrass (*Phyllospadix scouleri/torreyi*) is also scored separately when it is covered by another non-epibiont species. For example, if *Egregia* drapes across articulated corallines, it is left in place and scored as the top-layer species. Definitions for the lumped taxa and substrate categories will be provided in the monitoring plan. The monitoring group can opt to score transects in greater taxonomic detail; however, finer-scaled data must be lumped to fit the core categories for entry into the MMS database unless optional species have been formally registered with the database, requiring a commitment to consistently score the species (if present) in all surveys.

Phyllospadix was scored in either of two categories: *Phyllospadix* Overstory or *Phyllospadix* Understory. Thus surfgrass was documented even when it was covered by another species. Total transect coverage was greater than 100% whenever understory surfgrass was scored. Since any amount >100% cover represents understory surfgrass only, compatibility with previous MMS top-layer-only scoring was maintained. Scoring other understory species, though possible in the field, would have been tedious and impractical (especially when transects are periodically awash) given personnel and time constraints. Dead barnacle tests, dead mollusk shells, and other non-living substrates that were not rock, sand, or tar were scored as other substrates. Epoxy corner markers and bolts were scored as rock. When present under a point along the transect, sand was scored whenever the sand cover is 2 cm or greater; otherwise, rock or the underlying core species is scored.

2.1.4 Quadrat Plots

In addition to the transect line point-contact sampling, fixed-plot sampling was also performed in accordance with the unified monitoring protocols developed by MMS. Fixed-plot sampling involved quantifying animal and vegetative organisms found within the confines of a quadrat placed upon the designated sampling location (Figure 3). Epoxy or bolt markers indicating the placement of the quadrat ensured that sample locations remained static throughout the study. The quadrat locations at Buck Gully and Morning Canyon were arranged such that a total of six quadrats were aligned along the 0 ft MLLW elevation (two per transect). For each transect, one fixed-plot quadrat was located on the transect at the 0 ft MLLW, and one was located approximately 5 m upcoast of the transect at 0 ft MLLW. The remaining twelve quadrat locations were situated in a similar arrangement (i.e., two aligned along a midtidal elevation on each transect (one on the transect and one approximately 5 m downcoast of the transect) and two aligned along an upper intertidal elevation on each transect (one on the transect and one approximately 5 m upcoast of the transect)). At Heisler Park, quadrat locations were located only along the transect. As a result, Heisler Park had three quadrat locations per transect (one at the 0 ft MLLW elevation, one at the midtidal elevation, and one at the upper intertidal elevation), whereas Buck Gully and Morning Canyon each had six quadrat locations per transect (two at each elevation).

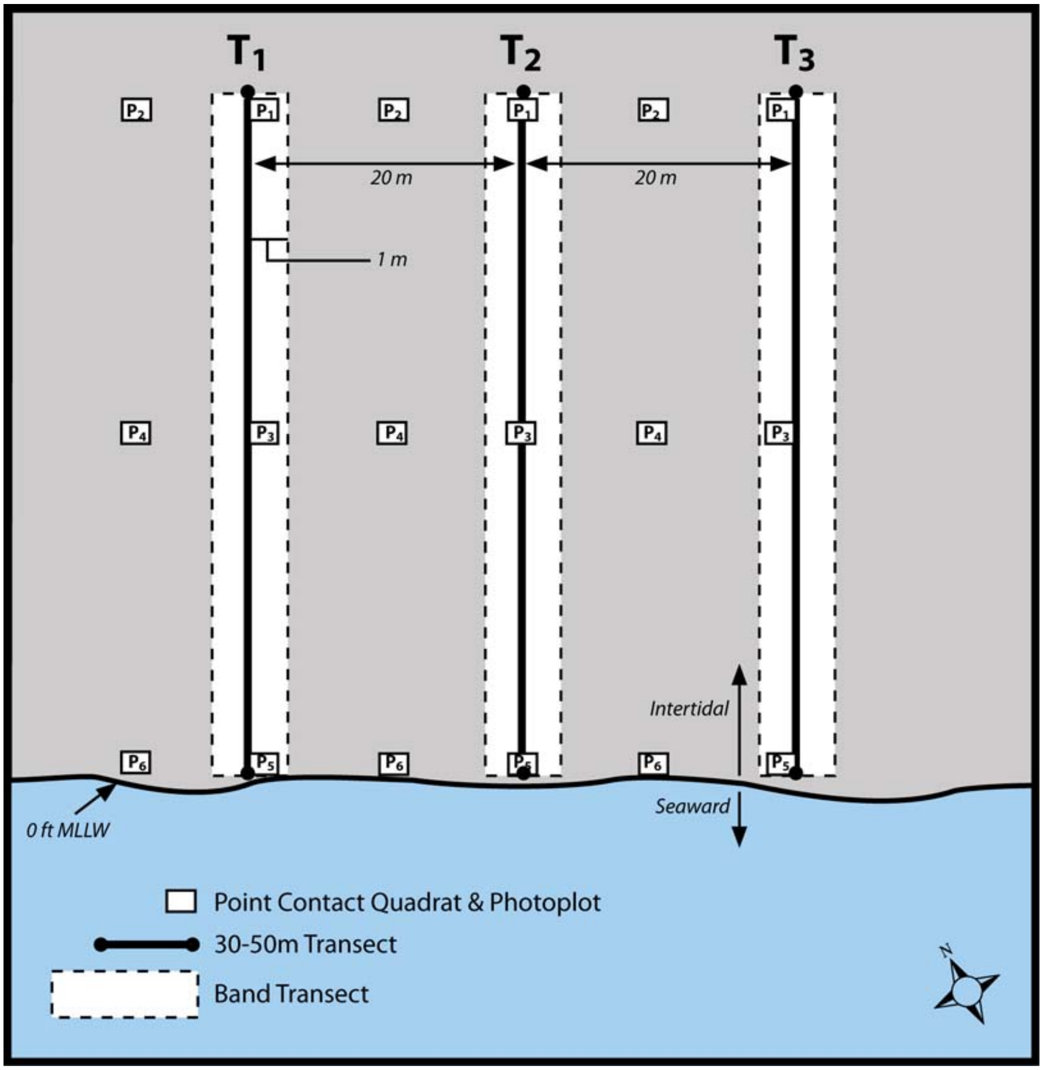

Figure 2. Diagram of Intertidal Monitoring Survey Design Showing Transect Lines, Photoplot and Point-Contact Quadrats, and Band Transects

The scoring quadrats were made of sturdy PVC with dimensions of 50 cm by 75 cm (0.375 m^2) for the inside area. The quadrats were divided into ten sections both horizontally and vertically using metal wire permanently attached to the perimeter. This provided a gridded area from which to easily observe the substrate. The monofilament grid consisted of 100 evenly spaced intersecting points. Each of the intersecting points was scored as described below in the quadrat plots protocol (Section 2.1.4.1). A team of field biologists was used to record the quadrat data; one biologist called out the grid line coordinates and the corresponding species or substrate that was identified below the intersection point while another biologist recorded the data onto field data sheets (Figure 3). Information from field data sheets was later transferred into an Excel spreadsheet for use in analyses.

Fixed plots were chosen over randomly selected plots for the purpose of reducing the variability inherent in analysis of randomly chosen plots and for budgetary reasons. The high heterogeneity of intertidal assemblages would require a significantly larger amount of replicate plots to be monitored at each project site if randomly chosen plots were used in each seasonal survey. For the purposes of this study, a fixed-plot study design was deemed to be best suited for detecting temporal changes in species abundances.

Figure 3. Fixed-Plot Sampling at Heisler Park

2.1.4.1 Quadrat Plots Protocol

The quadrat plot protocol was adapted from the unified monitoring protocols developed by MMS. The cover of target species as well as core and optional species (including higher taxa and substrates) was surveyed by sampling permanent 50 cm by 75 cm (0.375 m^2) plots per target species. Plots were scored in the field using a collapsible 50 cm by 75 cm frame divided by 10 evenly spaced wire lines. With the frame over the plot, a narrow steel rod was placed across each wire in sequence (using predetermined slots) to create ten intersection points per string, making 100 points total under which organisms were identified and recorded.

Scoring Quadrat Plots

At each of the 100 points within the photoplot, species were identified to the lowest reasonable taxonomic level. Layering was not scored separately, so the total percent cover was constrained to 100%. The top-most (visible) layer attached to the substrate was always scored. This rule applied regardless of the target or core species involved. The rule was formulated to work consistently for scoring from photos, supplemented when possible with rough plot sketches and brief notes. The top-most rule eliminates much of the uncertainty of trying to determine what lies below the upper layer and does not bias for or against target species. It should be noted, however, that this method will underestimate target species cover whenever the target species is covered by another species (e.g., by rockweeds or any plant whose attachment lies outside the plot). Though desirable, scoring cover of understory target species was too complex and time consuming to fall within the scope of the monitoring protocol. Fortunately, layering was not a major issue. Sedentary motile invertebrates occurring under a point were scored as one of the following core categories: *Lottia gigantea*, limpet, chiton, *Pisaster ochraceus*, or other invertebrate. If an un-removed active motile invertebrate occurred under a point, it was scored with what was likely underneath, if possible; otherwise, it was scored as unidentified (it was not scored as other invertebrate). Bleached crustose corallines (appearing white) were scored as crustose corallines, not rock. Because bleached crustose corallines may still be alive, they were assumed to be live and scored as such. Obviously dead barnacle tests, dead mollusk shells, and other non-living substrates that were not rock, sand, or tar were scored as other substrates. Epoxy corner markers and bolts were scored as rock. When sand was present under a point, if the observer could positively identify what was under the sand, then the underlying core species or rock was scored; otherwise, sand was scored. This means that sand was scored whenever sand thickness was greater than just a thin layer with patches of rock or some core species showing through.

2.1.5 Data Documentation

All information pertinent to field activities was recorded on a series of field sampling log forms maintained in a notebook. Data sheet entries were made using water-resistant ink and were recorded in accordance with field data protocols described in the Quality Assurance Project Plan (QAPP). During each sampling event, the field supervisor recorded the time, station coordinates, transect identification, type of sample method performed, field personnel, weather conditions, and other relevant field information. All data were geo-referenced using a hand-held GPS and were compiled to incorporate maps, photos, standard data, notes, and observations specific to each sampling episode.

2.1.5.1 Monitored Species

Intertidal target species were selected for long-term monitoring. As defined by MMS, target species in rocky intertidal habitats dominate particular zones or biotic assemblages. The criteria used for selecting target species included the following:

- Species that are ecologically important in structuring intertidal communities.
- Species that are competitive dominants or major predators.
- Species that are abundant, conspicuous, or large.
- Species whose presence provides numerous microhabitats for other organisms.
- Species that are slow growing and long lived.
- Species that have interesting distributions along California coasts.
- Species found throughout California shores.
- Species characteristic of discrete intertidal heights.
- Species that are rare, unique, or found only in a particular intertidal habitat.
- Species approaching their biogeographic limits in California.
- Species that have been well studied, with extensive literature available.
- Species of special human interest.
- Species vulnerable and/or sensitive to human impacts, especially from oil spills.
- Species with special legal status.
- Introduced or invasive species.
- Species harvested by sport or commercial activities.
- Practical species for long-term monitoring.
- Readily identifiable species.
- Sessile or sedentary species of reasonable size.
- Non-cryptic species.
- Species located high enough in the intertidal zone to permit sufficient time to sample.

The target species for the Newport Coast and Heisler Park Intertidal Monitoring Study include those species listed on Table 1. The list of targeted species included both regularly monitored species in the MMS program as well as additional species recommended for aid in the identification of certain anthropogenic impacts resulting from activities, such as trampling, scavenging, harvesting, and collecting. Species sensitive to water quality contamination and sedimentation were also included.

Table 1. Baseline Intertidal Monitoring Surveys Species List

Species		Types of Impacts: Increased Sedimentation	Chemical Contamination Toxicity	Scavenging	Harvesting (food or bait)	Collecting (scientific or aquaria)	Trampling
Gastropods	*Haliotis cracherodii*	Increased density and decreased suitable habitat of mobile organisms due to emigration from zones of sedimentation	Reduction in sensitive species, settlement, and bioaccumulation of contaminants.	?	Yes	No	No
	Lottia gigantea			No		No	No
	Tegula gallina/aureotincta			No		No	No
	Tegula funebralis			No	No	No	No
	Norrissia norrissii			?	Yes	Yes	No
	Astraea undosa			No			No
	Littorina spp			?	No	No	No
	Megathura crenulata			No	Yes	No	No
Chitons	*Stenoplax conspicua*			No		No	No
	Mopalia spp			No	No	Yes	No
Sea stars	*Pisaster ochracheous*			Yes	No	No	No
Sea urchins	*Stongylocentrotus purpuratus*				No	?	No
	Strongylocentrotus franciscanus				Yes	?	No
Anemones	*Anthopleura elegantissima/solia*	Decreased density and increased suitable habitat of mobile organisms due to immigration to new sediment free zones		No	No	Yes	No
	Anthopleura xanthogrammica			No	No	Yes	No
Barnacles	*Pollicipes polymerus*			No	Yes	No	Yes
	Tetraclita squamosa rubescens			No	No	No	No
	Chthamalus dalli/fissus/ Balanus glandula			No	No	No	Yes
Bivalves	*Mytilus californianus*			No	Yes	No	No
Polychaeta	*Phragmatapoma cementarium*			No	No	Yes	Yes
Boa kelp	*Egregia menziesii*			Yes	Yes	No	
Rock weed	*Hesperophycus californicus*			No		No	
	Silvetia compressa			No	No	No	
Turf weed	*Endocladia muricata*			No	No	No	
Surfgrass	*Phyllospadix scourleri/torreyi*			No	No	No	No
Sea lettuce	*Ulva sp*		?	No	Yes	No	Yes

Black = Regularly monitored as part of the MMS program at most sites

Red = Additional species recommended as part of the ASBS to aid in the identification of specific anthropogenic impacts

? = unknown

2.1.6 Photoplots

Each of the 18 fixed-plot quadrats at Buck Gully and Morning Canyon and each of the nine fixed-plot quadrats at Heisler Park were photographed as photoplots using a digital camera at a minimum resolution of 5.0 megapixels during the winter survey (Figure 4). One edge of each of the additional photoplots was positioned at 0 m, 25 m, and 50 m on each of the three transect lines. Digital photoplots were taken to allow for post-processing confirmation of organism densities within the quadrats.

A digital camera capable of a minimum resolution of 5.0 megapixel was used with or without a waterproof housing. A single or double strobe configuration was used to illuminate the plots at night and to eliminate shadows during daylight sampling. A quadrapod apparatus was used to support the camera at a constant height and orientation to ensure consistent framing of each plot. The quadrapod, constructed of PVC pipe, consisted of a bottom photoplot-sized frame (50 cm by 75 cm internal dimensions) connected to a smaller camera frame by four poles. The lens of the camera was aligned to provide coverage of the entire plot. The quadrapod was placed over each plot in a consistent orientation, typically with the permanent plot number marker in the upper left corner. The plot number (along with site, date, and target species) was written or otherwise set up on the quadrapod such that it was recorded by the plot photo. Resulting images needed to be of sufficient quality to consistently recognize target and core species when scoring. Unattached drift plants (e.g., giant kelp blades), large motile invertebrates that were not scored in photoplots (e.g., *Aplysia*; record count if doing motile invertebrate protocol), invertebrate debris (e.g., lobster exoskeleton or loose mollusk shell), or flotsam (e.g., driftwood) were removed prior to photographing plots. Large or abundant top-layer active motile invertebrates (including *Aplysia*, *Lithopoma*, *Tegula*, predatory snails, and hermit crabs) were removed from photoplots prior to photo/scoring if their presence significantly blocked scoring of topmost sessile cover layer. Otherwise, plot photos were taken as is without moving live organisms. For each consecutive photograph, the target species, plot number, and plot-specific notes were recorded.

Figure 4. Example of Photoplot from Buck Gully Taken on January 30, 2007

2.1.7 Band Transects

Data from six band transects were recorded at each site. The band transects were situated along 1-m-wide swaths on either side of, and parallel to, each transect, perpendicular to the shoreline (Figure 2). Only the large targeted macroinvertebrates *Lottia gigantea* and *Haliotis spp.* were recorded in the band transects. Band transects were used for large and/or rare species that may not have sufficient densities in smaller, fixed plots. Band transects were searched for the presence of *Lottia gigantea* and *Haliotis spp.* for ten minutes. Sizes of each organism were recorded on field data sheets using graduated calipers accurate to 1 mm.

2.1.8 Field Log and Site Reconnaissance Protocol

During each site monitoring survey, observations of general physical and biological conditions were completed. Additional site-wide categorization of species abundance, appearance, and recruitment were completed whenever time permitted. These observations, along with the habitat overview photographs, provided valuable perspective on site dynamics that aided interpretation of data from the fixed plots and transects.

Field log information and site reconnaissance characterization were recorded on a two-page field log data form. Field log data required by the MMS database included site, date, survey time, low tide time and height, and names of survey participants**.** Physical data that were also recorded included weather and sea conditions (swell/surge, wind, rain, recent rain, and water temperature), substratum changes (sediment level, scour, and rock movement), and the presence of debris/pollutants (plant wrack, driftwood, shells, dead animals, trash, and oil/tar). Relevant biological features that were recorded included site-wide presence of birds, marine mammals, or humans; and abundance, appearance, and recruitment of target species (primary emphasis) and other core species (secondary consideration). To facilitate standardization and data management, many data entries were restricted to specific category codes (i.e.., low, med, and high). Additional information was also written as notes. All data entry blanks on the field log were filled in with a code, actual value, notes, or a dashed line indicating no data.

3.0 RESULTS

3.1 Point Intercept Transect Study

Figure 5. Point Intercept Transect Survey

Winter and summer point-contact transect surveys were performed at each of the three sampling sites (Morning Canyon, Heisler Park, and Buck Gulley) to determine if differences among intertidal biological communities were evident between sites and to contribute to a baseline dataset against which future monitoring surveys can be compared. Data were recorded at 20-cm intervals along the length of the 30–50 m transect lines using the point intercept method, described in Section 2.3.1 and shown on Figure 5. Results of species abundance data from point-contact transect surveys is provided on Table 2. Species abundance at each site was a mean of the species located along each transect. A list of species detected along transect lines at each site is provided in Appendix A.

Transect data from the intertidal survey performed during June 2007 indicate crustose coralline algae and *Phyllospadix sp*. were more prevalent at Morning Canyon than at either Buck Gully or Heisler Park, whereas *Egregia menziesii*, a fleshy algae, was more prevalent at Buck Gully than at Heisler Park or Morning Canyon. *Silvetia compressa* was detected at Morning Canyon during both summer and winter surveys but was not detected at either Buck Gully or Heisler Park. Abundances of the mussel, *Mytilus californianus*, were highest at Buck Gully.

Winter transect data indicate *Egregia menziesii*, crustose coralline algae, and the category other brown algae was highest at Buck Gully. Articulated coralline algae, which was not detected in the summer transect survey, was found across all sites during the winter survey, though it was most prevalent at Morning Canyon and Heisler Park. Surf grass was not observed at Buck Gully but was detected along all three transects at both Morning Canyon and Heisler Park. In addition to *Silvetia compressa*, species that were detected along winter transects at only Morning Canyon included the sea urchin (*Stronglylocentrotus purpuratus*), the sand castle worm (*Phragmatopoma californica*), the kelp (*Macrocystis pyrifera*), and other limpets and other barnacles. Red turf algae was detected at only Heisler Park during the winter survey while the category other invertebrates was detected only at Buck Gully.

Table 2. Species Abundance along Point-Contact Transects Located along Three Sites in Newport Coast Area of Special Biological Significance

Group	Species	Summer						Winter					
		Buck Gully		Heisler Park		Morning Canyon		Buck Gully		Heisler Park		Morning Canyon	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Algae	Articulated coralline			7.0				3.3	0.6	25.7	3.5	26.3	8.5
	Colpomenia sp	2.0		3.0		2.7	1.5						
	Crustose coralline	23.0	7.0	22.0	1.0	46.0	9.8	20.0	4.2	3.0		5.5	2.1
	Egregia menziesii	19.0		11.7	10.1	12.7	8.0	18.0		5.5	0.7	3.3	0.6
	Eisenia arborea			29.0								1.0	
	Other Brown algae	22.7	35.8	14.7	14.8	3.5	3.5	39.3	39.3	13.7	7.1	25.3	7.2
	Other Green algae	2.7	2.1	6.0	4.0	8.0	9.9	1.7	1.2	5.7	8.1	4.0	0.0
	Other Red algae	6.0	7.1	8.3	3.5	7.3	4.0	1.0		6.5	0.7	1.0	0.0
	Red turf	4.5	0.7	8.0		1.3	0.6			4.5	2.1		
	Sargassum muticum					1.0				4.0	2.8	1.0	
	Silvetia compressa					5.5	3.5					5.0	4.2
	Ulva/Enteromorpha	1.0											
Surf grass	Phyllospadix sp.			30.0	22.3	7.0				38.0	17.5	23.0	31.1
Invertebrates	Anthropleura elegantissa/sola	5.0	4.0	3.7	1.5	5.0		3.0	1.0	8.7	2.1	1.0	
	Barnacles	5.0	0.0	2.0	1.4	2.0		12.0	8.5	2.0	1.4	16.0	
	Lottia gigantean	1.0	0.0	2.0	1.4	3.0				1.0		1.0	
	Mytilus californianus	21.3	24.0	28.0		15.3	12.7	25.3	28.6	17.5	19.1	16.3	25.7
	Other Barnacles											1.0	
	Other Invertebrates	1.0				3.0		3.0	1.0				
	Other Limpets											2.0	
	Phragmatopoma californica											1.0	
	Stronglyocentrotus purpuratus					6.0						1.0	
Substrate	Other substrate			1.0	0.0	1.0		1.5	0.7	2.3	1.5	12.7	13.2
	Rock	60.0	31.0	21.7	11.6	61.3	7.6	55.0	25.0	24.3	10.4	63.3	21.4
	Sand	1.0	0.0	14.5	4.9	18.0		3.0	2.8	15.3	11.7	3.5	2.1
	Shell rubble	3.5	3.5			5.5	6.4						
	Tar	3.0	1.4			5.3	2.5					2.0	1.4

S.D. = Standard Deviation

Exposed rock was highest at Buck Gully and Morning Canyon across both summer and winter seasons than at Heisler Park. In contrast, Heisler Park had substantially more sand substrate during both seasonal surveys than either Buck Gully or Morning Canyon. Seasonal effects were observed for shell rubble, which was observed during the summer survey at Buck Gully and Morning Canyon but was not observed at any of the sites during the winter survey. Visual differences between the intertidal habitat at Morning Canyon versus at Buck Gully and Heisler Park are more dramatic than might be expected from examining the transect data.

3.1.1 Photoplots

Each of the fixed-plot quadrats were photographed as photoplots using a digital camera at a minimum resolution of 5.0 megapixels during the winter sampling event. Eighteen photoplots were recorded at Morning Canyon and Buck Gully in accordance with the sampling design described in Section 2.1, whereas nine photoplots were recorded at Heisler Park. Because permission for permanent bolt placement within the intertidal zone was not granted within Heisler Park, only nine quadrat plots, and hence nine photoplots, were recorded (three along each transect) at this site. Digital photoplots were taken to allow for post-processing confirmation of organism densities within the quadrats and are provided within Appendix B. Due to time and budget constraints, digital photoplots were not taken during the summer survey. Species identifications were recorded in the field during both winter and summer surveys.

3.1.2 Quadrat Plots

The cover of target species as well as core and optional species and substrates were calculated by sampling permanent 50 by 75 cm (0.375 m²) plots located along transects at each of the three sites. Additionally, plots located adjacent to transects at Morning Canyon and Buck Gully were also scored. In total, 18 plots were scored at both Buck Gully and Morning Canyon, whereas nine plots were scored at Heisler Park. Raw data results of percent coverage within quadrat plots are provided in Appendix A. A summary of the percent coverage of major species groupings in quadrat plots surveyed during the winter and summer is shown on Figure 6 and Figure 7, respectively.

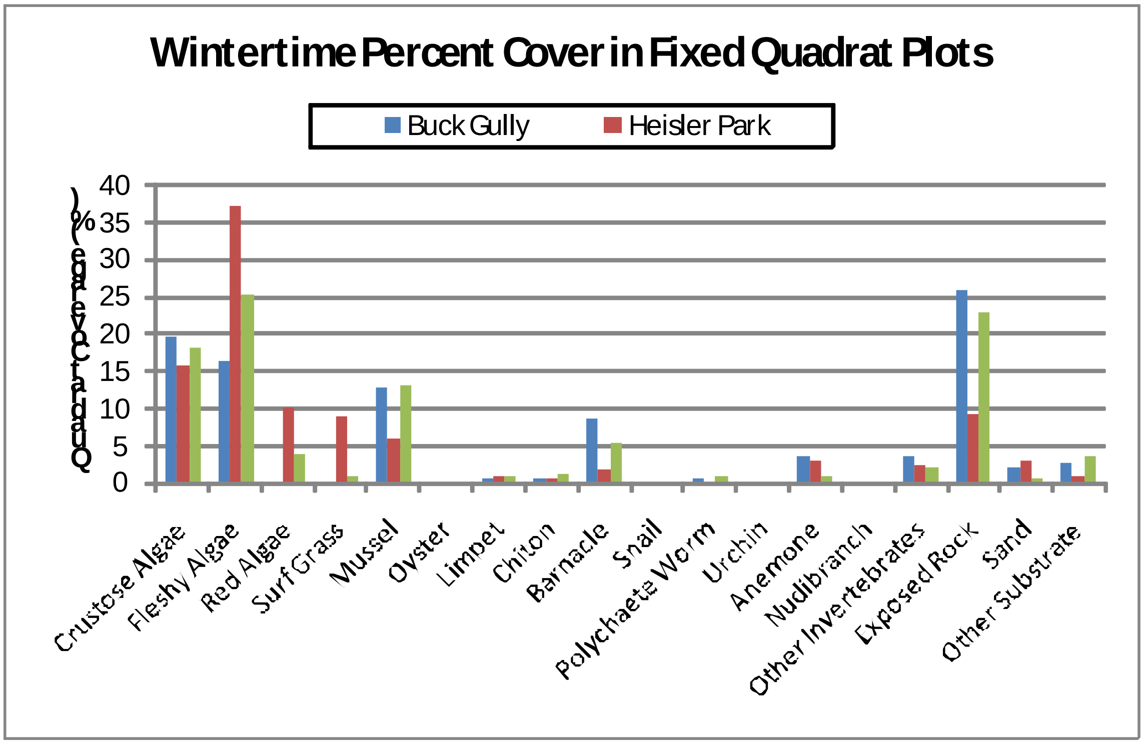

Figure 6. Summary of Percent Coverage in Quadrat Plots Surveyed in January 2007

3.1.2.1 Community Structure – Winter

The intertidal community at Buck Gully was characterized by similar ratios of articulated coralline algae (19.7%) and fleshy algae (16.6%) during the winter survey. California mussels were the dominant fauna, constituting 13.1% cover within the fixed quadrats, followed by barnacles (8.8% cover), the anemone *Anthopluera elegantissima* (3.9%), and other invertebrates (3.8%). Exposed rock accounted for 26.1% of the total cover at Buck Gully during the winter, whereas sand and other substrate accounted for 2.3% and 2.8% of the cover, respectively. Chitons, limpets, polychaete worms, and non-coralline red algae each constituted less than 1% cover. No surf grass or rock weed was observed at Buck Gully.

Heisler Park's intertidal community structure during the winter survey had substantially more fleshy algae (37.4%) than coralline algae (15.8%) or non-coralline red algae (10.1%). Surf grass accounted for 9% of the total coverage at Heisler Park. Mussels, anemones, other invertebrates, and barnacles were the dominant winter fauna observed within the quadrats. Exposed rock accounted for 9.4% cover, whereas sand and other substrate accounted for 2.9% and 0.9% cover, respectively.

Mussels and barnacles were the dominant winter invertebrates observed in Morning Canyon quadrats. Mussels and barnacles comprised 13.1% and 5.5% of the total cover, respectively, whereas chitons comprised 1.1% of the total cover. All other invertebrates accounted for less than 5% of the total winter coverage at Morning Canyon. Fleshy algae, exposed rock, and coralline algae had the site's largest coverages (25.4%, 23.1%, and 18.2% of the total coverage, respectively).

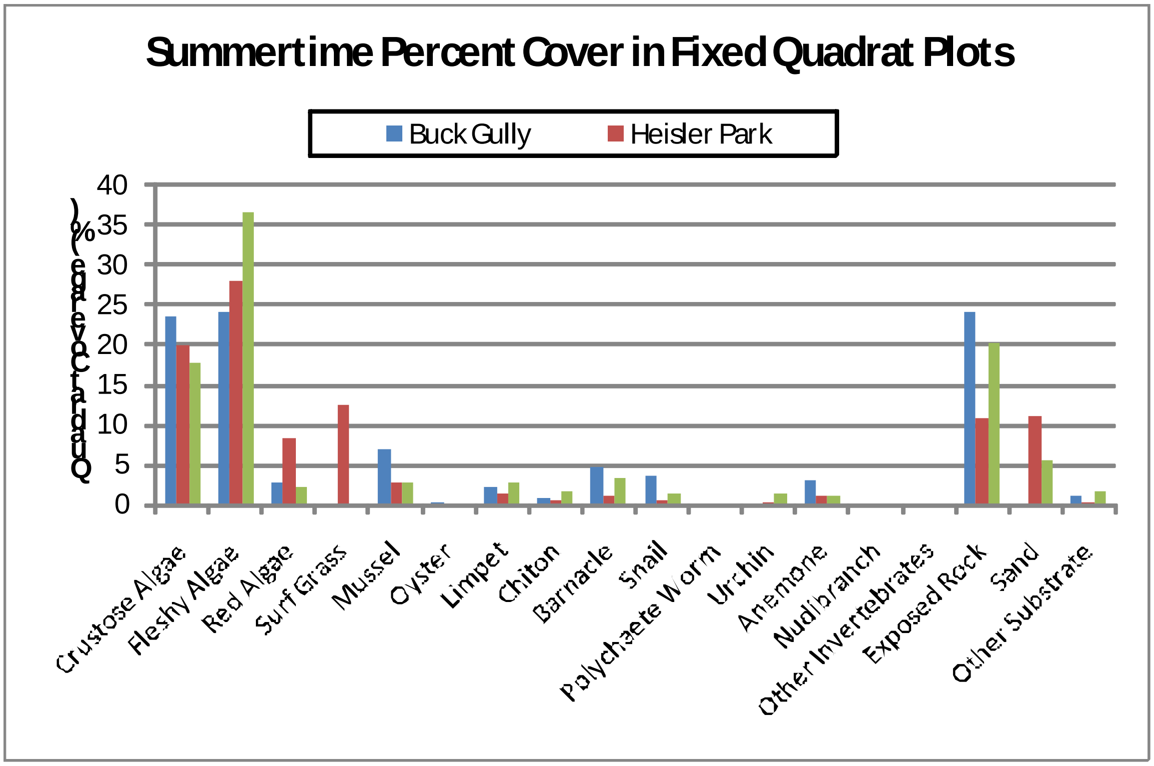

Figure 7. Summary of Percent Coverage in Quadrat Plots Surveyed in July 2007

3.1.2.2 Community Structure – Summer

The intertidal community at Buck Gully was characterized by nearly equal ratios of articulated coralline algae (23.7%), fleshy algae (24.2%), and exposed rock (24.2%) during the summer. California mussels were the dominant fauna, constituting 7.1% cover within the fixed quadrats, followed by barnacles (4.8%), snails (3.7%), the anemone *Anthopluera elegantissima* (3.1%), and limpets (2.2%). Oysters, chitons, polychaete worms, and sea urchins each constituted less than 1% cover. No surf grass, rock weed, or sand was observed within the quadrats at Buck Gully.

Heisler Park's summertime intertidal community structure had a slightly lower percent of articulated coralline algae (20%) and a slightly higher percentage of fleshy algae (28.1%) than Buck Gully. Heisler Park, however, had a substantially higher percentage of surf grass, sand, and red algae than Buck Gully (12.6%, 11.2%, and 8.3%, respectively, versus 0%, 0%, and 2.9%, respectively, at Buck Gully). The invertebrate community at Heisler Park was comprised primarily of California mussels (2.9%), limpets (1.6%), anemones (1.2%), and barnacles

(1.1%).All other invertebrate species each accounted for less than 1% cover. Of the three sites surveyed, Heisler Park had the lowest percentage of exposed rock within the quadrats.

Morning Canyon had the highest percentage of fleshy algae (36% cover) among the three sites during the summer. The rock weed, *Silvetia compressa*, which was found only at Morning Canyon, constituted 5.8% of the total coverage. Articulated coralline algae coverage (17.7%) was lower at Morning Canyon than at either Buck Gully or Heisler Park. Invertebrates at Morning Canyon constituted a total of 13.6% of the coverage, with barnacles comprising the highest percent coverage (3.4%), followed by mussels (2.8%), limpets (2.8%), chitons (1.7%), snails (1.4%), and sea urchins (1.4%). Exposed rock constituted 20.3% of the cover, whereas sand and other substrates constituted 5.6% and 1.7%, respectively.

3.1.2.3 Site-Specific Seasonal Changes

Moderate seasonal differences were evident within each of the surveyed intertidal communities (Table 3 and Table 4). During Buck Gully's summer survey, coralline algae coverage at fixed quadrat locations increased slightly from an average of 19.7% cover to an average of 23.7% cover, whereas fleshy algae coverage increased by 7.6% coverage and exposed rock decreased by 1.9% coverage. Summer mussel and barnacle coverage at Buck Gully declined by 54% compared with winter coverage. In contrast, snails, which were not observed during the winter survey, constituted 3.7% of the total cover during summer.

At Morning Canyon, the percentage of coralline algae remained nearly the same across both summer and winter surveys, whereas fleshy algae increased from 25.4% cover in winter to 36.7% cover in summer. The increase in fleshy algae coverage was due primarily to recruitment of *Egregia menziesii* (2.4% cover in winter versus 15.5% cover in summer). Mussel coverage dramatically decreased from the winter survey to the summer survey, whereas barnacle coverage decreased only slightly. Sand coverage increased from 0.6% cover in winter to 5.6% cover in summer, whereas exposed rock coverage decreased slightly in summer, likely as a result *E. menziesii* recruitment.

At Heisler Park, coverage of coralline algae increased by 4.2% from the winter to the summer survey, whereas fleshy algae decreased by 9.3%. The decrease in fleshy algae can be largely attributed to two species, *Endocladia muricata* and *Ulva/Enteromorpha spp*. *Endocladia muricata* comprised 15.6% of the cover during winter but was not observed during the summer survey, whereas *Ulva/Enteromorpha* decreased from an average of 11.9% cover in winter to 6.8% cover in summer. Mussel coverage decreased from 5.9% in winter to 2.9% in summer, whereas surf grass increased from 9% cover to 12.6% cover.

Table 3. Percent Coverage of Wintertime Species and Substrates Observed in Quadrat Monitoring

Common Name	Species	Winter Survey								
		Buck Gully			Heisler Park			Morning Canyon		
		Transect Total			Transect Total			Transect Total		
		1	2	3	1	2	3	1	2	3
Crustose algae	Articulated coralline	12.3	5.2	10.3	10.7	14.3	21.0	21.0	11.0	20.5
	Crustose coralline	14.7	10.8	5.8	0.3	0.0	1.0	0.3	0.0	1.7
Fleshy algae	*Eisenia arborea*	0.0	0.3	0.0	0.0	0.0	2.0	0.0	0.0	0.0
	Endocladia muricata	6.3	0.0	0.0	21.7	11.7	12.7	14.7	7.3	11.7
	Sargassum muticum	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0
	Silvetia compressa	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.7	12.7
	Ulva or *Enteromorpha*	1.2	0.5	2.8	12.7	12.0	11.0	4.7	4.3	5.2
	Egregia menziesii	6.3	1.2	0.0	4.3	1.3	18.7	3.5	0.0	3.8
	Other brown algae	12.7	13.7	4.3	1.0	0.7	0.3	1.2	0.3	5.5
	Other green algae	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Red algae	Red algal turf	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.0
	Other red algae	0.5	0.0	0.0	4.7	23.3	2.3	0.2	0.3	11.0
Surf grass	*Phyllospadix sp.*	0.0	0.0	0.0	20.7	0.0	6.3	0.0	0.0	2.5
Mussel	*Mytilus californica*	13.2	22.2	4.0	0.0	12.3	5.3	1.7	37.0	0.7
Limpet	Other limpets	0.5	0.5	0.5	1.0	1.0	0.0	1.2	0.2	1.0
	Lottia giantea	0.0	0.7	0.7	0.0	0.7	0.0	0.2	0.0	0.2
Chiton	Chitons	0.7	1.0	1.0	1.7	0.3	0.0	1.5	1.3	0.3
Barnacle	*Chthalmus* or *Balanus sp.*	0.5	3.7	18.0	0.0	3.0	0.0	0.0	13.5	3.0
	Tetraclita rubescens	0.8	1.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
	Pollicipes polymerus	0.0	1.8	0.0	0.0	2.0	0.0	0.0	0.0	0.0
Anemone	*Anthopluera elegantissima*	0.5	10.3	1.0	1.3	2.3	5.3	0.8	0.2	1.3
Worm	*Phragmatopoma californica*	1.3	0.8	0.0	0.0	0.0	0.0	2.3	0.2	0.0
Other invertebrates	Other invertebrates	4.2	2.3	5.0	1.0	1.0	5.0	1.7	3.0	1.8
Substrate	Exposed rock	17.0	17.5	43.8	8.0	14.0	6.3	40.8	13.0	15.5
	Sand	7.0	0.0	0.0	8.7	0.0	0.0	0.0	0.0	1.7
	Other substrate	0.2	6.2	2.0	0.0	0.0	2.7	3.2	7.5	0.0

Table 4. Percent Coverage of Wintertime Species and Substrates Observed in Quadrat Monitoring

Common Name	Species	Summer Survey								
		Buck Gully			Heisler Park			Morning Canyon		
		Transect Total			Transect Total			Transect Total		
		1	2	3	1	2	3	1	2	3
Crustose algae	Articulated coralline	31.8	23.3	16.0	12.3	25.7	21.7	23.3	13.7	16.2
	Crustose coralline	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Fleshy algae	*Egregia menziesii*	24.3	2.0	0.0	9.3	12.3	4.7	7.7	6.7	32.2
	Sargassum muticum	1.0	0.3	0.5	1.3	1.0	1.7	1.2	0.0	0.5
	Silvetia compressa	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.7	15.7
	Ulva or *Enteromorpha*	10.5	3.8	2.2	3.7	6.7	10.0	3.3	17.8	3.7
	Other brown algae	12.2	6.2	7.0	5.0	9.3	14.7	5.0	6.0	0.2
	Codium setchellii	0.2	0.5	0.3	0.0	0.0	0.0	0.8	0.0	1.2
	Colpomenia sp.	1.0	0.2	0.5	0.0	0.0	0.3	0.2	3.5	0.0
	Ralfisia pacifica	0.0	0.0	0.0	2.3	0.0	2.0	0.0	2.7	0.0
	Iridaea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
Red algae	Red algal turf	2.3	4.3	2.0	10.7	11.0	3.3	3.2	0.0	4.0
Surf grass	*Phyllospadix sp.*	0.0	0.0	0.0	16.3	0.0	21.3	0.0	0.0	0.0
Mussel	*Mytilus californica*	7.5	10.3	3.3	0.0	7.7	1.0	0.3	6.3	1.7
Oyster	*Chama sp.*	0.2	1.2	0.2	0.0	0.0	0.0	0.0	0.2	0.2
Limpet	*Collisella digitalis*	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0
	Collisella limatula	0.0	0.7	1.0	0.3	1.3	0.3	2.5	1.2	0.7
	Collisella scabra	0.0	1.7	0.7	0.0	1.0	0.3	1.0	0.0	1.3
	Acmea strigatella	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fissurella volcano	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.7	0.0
	Lottia giantea	0.0	1.3	0.5	0.0	1.0	0.3	0.0	0.5	0.2
Chiton	*Mopalia muscosa*	0.0	0.0	0.2	0.7	0.0	0.3	0.2	0.0	0.2
	Nuttallina californica	0.5	1.3	0.3	0.7	0.0	0.0	2.5	1.3	0.8
Barnacle	*Balanus glandula*	0.2	3.3	4.0	0.0	1.3	0.0	0.0	7.7	1.0
	Cthamalus fisus	0.3	0.5	3.2	0.0	0.0	0.0	0.0	1.0	0.5
	Tetraclita rubescens	0.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pollicipes polymerus	0.0	1.7	0.0	0.0	2.0	0.0	0.0	0.0	0.0
Snail	*Acanthina spirata*	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.2
	Littorina scutulata	0.0	0.3	8.7	0.0	1.0	0.0	0.0	0.7	0.2
	Tegula eisini	0.3	1.3	0.2	0.0	0.0	1.0	1.2	1.7	0.2
	Megastraea undosa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
	Serpulorbis squamigerus	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0
Hermit crab	*Paguridae sp.*	0.3	2.0	0.2	0.0	0.0	0.0	0.8	1.7	0.0
Sea urchin	*Strongylocentrotus pupuratus*	0.0	0.3	0.0	0.0	0.0	1.0	0.8	3.3	0.0
Anemone	*Anthopluera elegantissima*	0.2	7.7	1.5	0.3	0.7	2.7	2.0	0.8	1.0
Nudibranch	*Doriopsilla albopunctata*	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Substrate	ROCK	4.8	21.2	46.5	3.0	18.0	11.3	24.0	18.3	18.5
	Sand	0.0	0.0	0.0	33.3	0.0	0.3	16.7	0.0	0.0
	Other substrate	1.7	1.5	0.7	0.0	0.0	1.0	1.7	20.0	0.0

Intertidal invertebrate community data observed in seasonal fixed-quadrat surveys were analyzed for the following community measures: number of species, abundance, Shannon-Wiener diversity index, Margalef diversity index, evenness, and dominance index. Analyses were normalized to account for an unequal number of plots among the three sites. Because Buck Gully and Morning Canyon had twice the number of quadrat locations as Heisler Park, species observed in the two quadrat locations within a given intertidal zone (i.e., quadrat locations P_1 and P_2, P_3 and P_4, and P_5 and P_6) along a given transect were averaged.

3.1.2.4 Invertebrate Taxa Richness

The number of invertebrate species observed across all plots within a given site during summer and winter surveys is shown on Figure 8. The total number of invertebrate species observed among the three sites was not substantially different during the winter survey. Shannon-Wiener diversity index values during the winter survey ranged from 1.38 at Morning Canyon to 1.69 at Buck Gully, whereas dominance values ranged from two organisms at Morning Canyon to three organisms at Buck Gully and Heisler Park.

Seasonal differences in the number of invertebrate species observed were evident. Across each of the three sites, a substantially greater number of invertebrate species was observed during the summer than during the winter. During the summer survey, no significant differences were observed between the invertebrate species counts at Buck Gully and Morning Canyon. The summer total invertebrate species count at Heisler Park (13), however, was lower than the invertebrate species counts at Buck Gully (19) and Morning Canyon (18). The Shannon-Wiener diversity index values increased during the summer survey, ranging from 2.18 at Heisler Park to 2.43 at Buck Gully. Similarly, dominance was higher during the summer than during the winter. Summer invertebrate dominance ranged from six species at Buck Gully and Heisler Park to seven species at Morning Canyon.

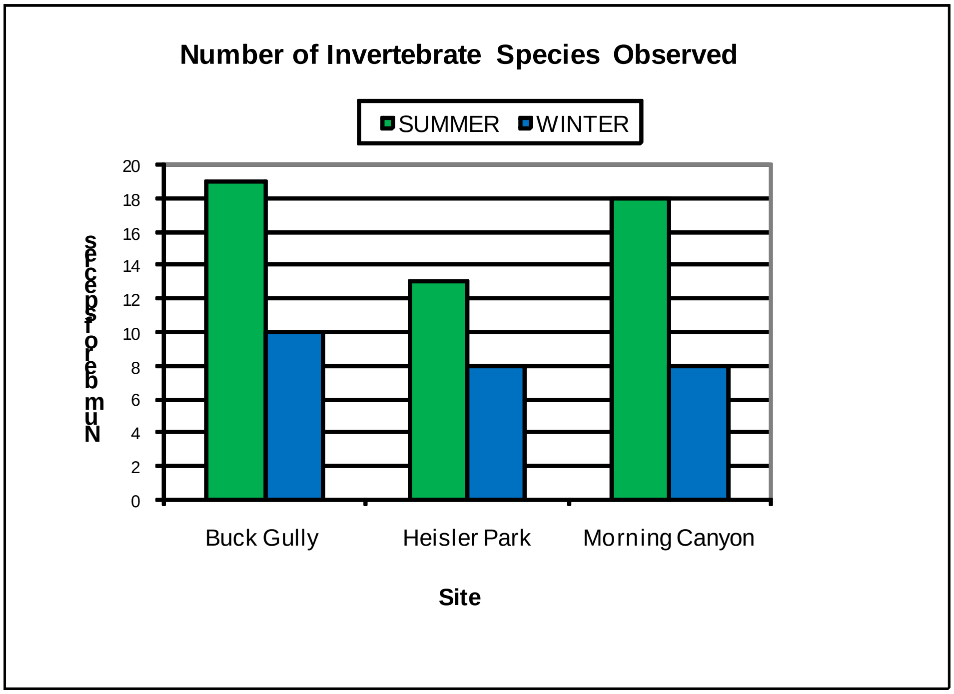

Figure 8. Invertebrate Species Observed across All Plots during Summer and Winter Surveys

3.1.2.5 Invertebrate Abundance

While invertebrate species diversity was greater across each of the sites during the summer than during the winter, the total invertebrate abundance across the three sites was highest during the winter (Figure 9). Buck Gully had the highest invertebrate abundance observed among the three sites during both summer and winter seasons. The prevalence of mussels and barnacles along quadrat locations at Buck Gully was mostly responsible for the site's relatively high invertebrate count in comparison to Morning Canyon and Heisler Park.

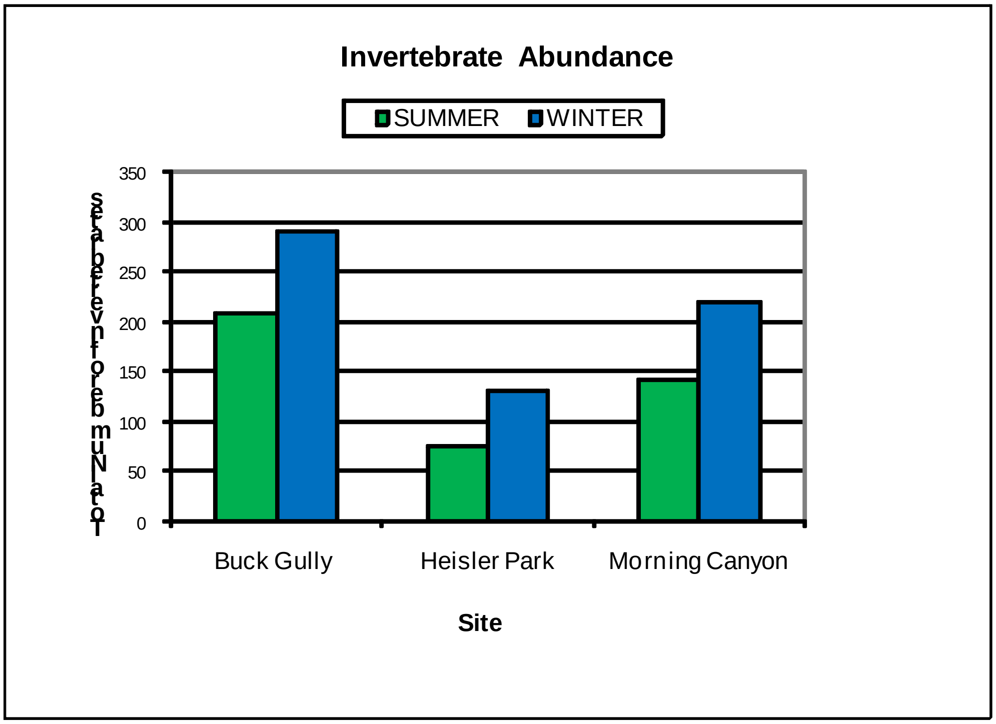

Figure 9. Invertebrate Abundance Observed across All Plots during Summer and Winter Surveys

3.1.3 Band Transects

Band transects were performed at each of the three sites during summer and winter surveys to identify abundance of large and/or rare motile invertebrate species. Previous studies have linked size class distributions of the owl limpet (*Lottia gigantea*) to the degree to which intertidal zones have undergone disturbance by human trampling. It has been demonstrated that tide pool harvesters are typically size selective and preferentially extract the largest limpets from intertidal zones (Ghazanshahi et al., 1983; Pombo and Escofet, 1996). As a result, intertidal zones that receive higher amounts of tide pool traffic generally have owl limpet populations that are comprised of smaller size classes than less frequented areas.

A search of six band transects at each of the sites was performed for owl limpets (*Lottia gigantea*) and abalone species (*Haliotis sp*.). The presence and size of these target species can be indicative of the relative level of scavenging that occurs among the sites. Although the band transect search included a search for abalone species, none were found. *L. gigantea*, however, were observed in each of the three sites during both seasonal surveys, though abundances were low. *L. gigantea* were analyzed using a two-way unbalanced analyis of variance (ANOVA) for size class and site.

Abundance and average size results of *L. gigantea* are presented in Table 5. Graphical results of size class distributions of *L. gigantea* at each of the three study locations are provided on Figure

10. During summer, the *L. gigantea* size class ranged from 20 cm to 41 cm at Buck Gully, whereas at Morning Canyon, it ranged from 20 cm to 60 cm, and at Heisler Park, it ranged from 29 cm to 65 cm. During the winter, the size ranged from 16 cm to 41 cm at Buck Gully while at Morning Canyon it ranged from 20 cm to 60 cm and at Heisler Park it ranged from 15 cm to 41 cm. During the summer, *L. gigantea* were significantly larger at Heisler Park and at Morning Canyon than at Buck Gully. Size differences among *L. gigantea* at Heisler Park and Morning Canyon were not significant.

Table 5. Summary of Summer and Winter *L. gigantea* Counts, Average Size, and Statistical Difference between Sites

Season	Site	Total Count	Average Limpet Size (mm)	Standard Deviation	Statistical Difference between Sites
Summer	Buck Gully	27	30	4.2	HP, MC
	Heisler Park	20	40.3	10.4	BG
	Morning Canyon	7	46.4	14.5	BG
Winter	Buck Gully	71	28.6	5.6	HP
	Heisler Park	29	37.9	9.4	BG, MC
	Morning Canyon	8	24.1	10.6	HP

A total of 27 *L. gigantea* were observed at Buck Gully during the summer survey versus counts of 20 and seven at Heisler Park and Morning Canyon, respectively. Substantial recruitment occurred between the summer and winter surveys at Buck Gully. Winter counts of *L. gigantea* increased from 27 to 71 individuals at Buck Gully, whereas at Morning Canyon, the count increased by only one and at Heisler Park the count increased by nine. Statistical analyses indicate that *L. gigantea* were significantly larger in size at Heisler Park during the winter than at Morning Canyon or Buck Gully. No statistical size differences were detected among *L. gigantea* size classes at Morning Canyon and Buck Gully.

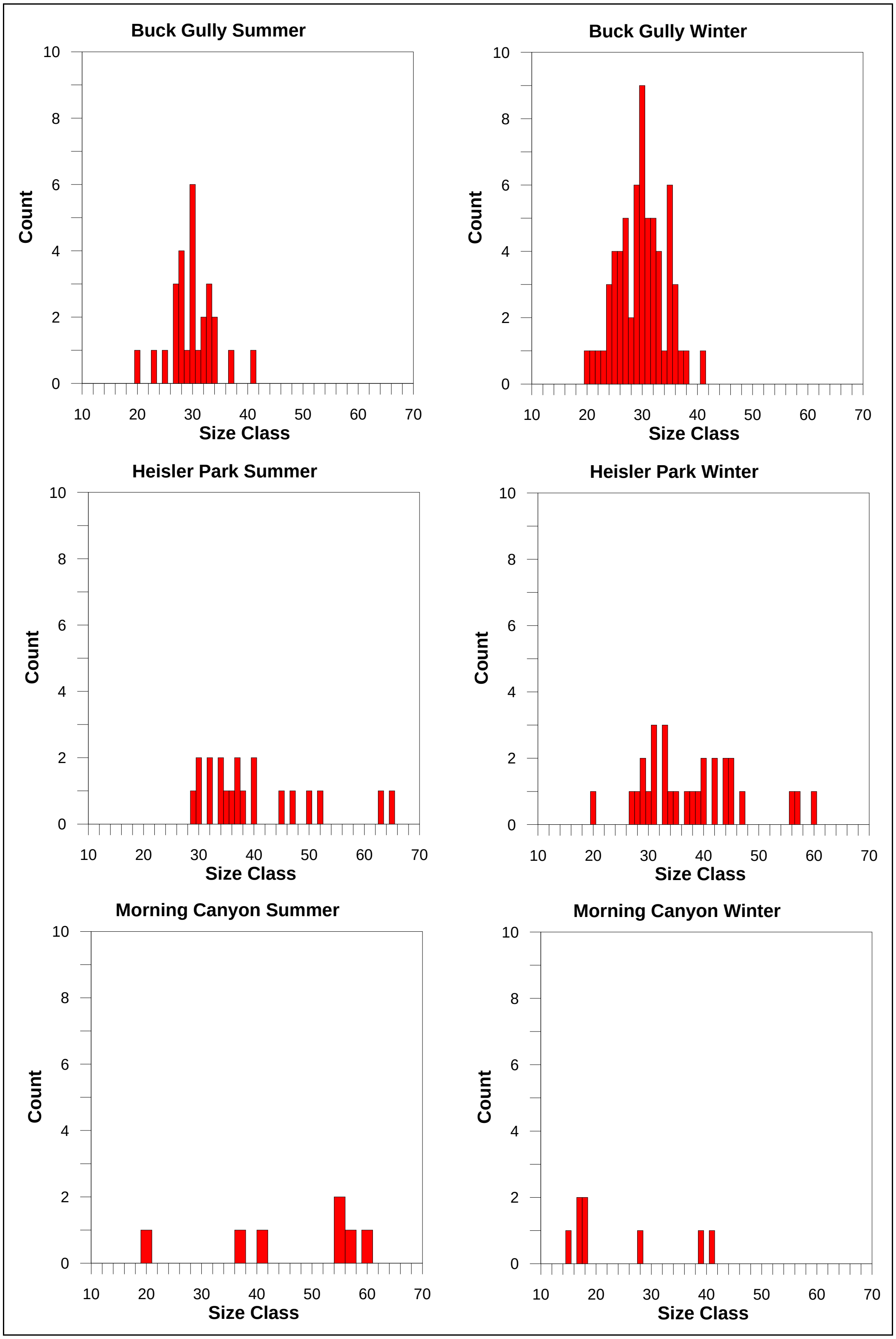

Figure 10. Seasonal Size Class Distributions of *Lottia gigantean* across Three Newport Coast Areas of Special Biological Significance Sites

3.1.4 Indicator Species

Indicator species, or target species, are species or species groups specifically chosen for long-term monitoring. They are known to dominate particular zones or biotic assemblages in rocky intertidal habitats but may be greatly reduced or extremely abundant as a result of disturbance or lack of disturbance. The selected indicator species discussed below (*Lottia gigantea*, *Silvetia compressa*, *Ulva/Enteromorpha sp*.) and exposed rock were selected in this study to assess the effects of scavenging, trampling, and water quality nutrient levels across the three study sites.

Table 6. Expected Impacts from Selected Indicator Species

Indicator Species	Expected Impact	Disturbance Mechanism	References
Lottia gigantea	Collecting/scavenging will cause a decrease in limpet size.	Collecting	Zedler, 1978; Pombo and Escofet, 1996
Silvetia compressa	Trampling will cause a decrease in cover.	Trampling	Brosnan and Crumrine, 1994
Ulva/Enteromorpha sp.	High nutrient levels will cause an increase in cover. Trampling will cause a decrease in cover.	Nutrient loading, Trampling	Bally and Griffiths, 1989

Lottia gigantea **(Owl Limpet)**

L. gigantea size class and abundance results are discussed in Section 3.1.3. Based on the public use portion of this study as well as other studies, the intertidal areas at Buck Gully and Heisler Park would be expected to experience the greatest impacts from scavenging activities and, thus, should contain owl limpet populations with a smaller average shell length than the population residing at the less frequented intidal zone at Morning Canyon. Although owl limpet data collected in this study showed a seasonal effect among the sites (shell lengths were larger in summer; population size was greater in winter), data were inconclusive with respect to large limpet size correllating to low public use. In the summer survey, owl limpets at Morning Canyon were not significantly larger than those observed at Heisler Park, but were significantly larger than those observed at Buck Gully. During winter, owl limpets at Morning Canyon were not significantly larger than those observed at Buck Gully, but were significantly larger than those observed at Heisler Park.

Figure 11. *Lottia gigantea* in the Rocky Intertidal Zone

Silvetia compressa **(Rockweed)**

Figure 12. *Silvetia compressa* Growing Amid Rocks at Morning Canyon

Cover of *Silvetia compressa* has been linked to trampling in several studies. *S. compressa* is a fleshy algae which is typically found in the upper intertidal zone along the Southern California coastline. These algae, which may be exposed to air at low tide, provide shelter to barnacles, shore crabs, tubeworms, snails, and other intertidal organisms. While *S. compressa* may be abundant at sites which receive little trampling, in high public use areas that experience frequent trampling, *S. compressa* coverage would be expected to be low or nonexistent. In this study, Morning Canyon was the only site where *S. compressa* was observed, representing approximately 5% coverage within quadrat locations and along point-contact transects in Morning Canyon. Although the presence of *S. compressa* did not appear to represent a substantial amount of total coverage in the fixed-quadrat and point-contact datasets, field observations indicate that it may constitute the dominant flora within the upper intertidal zone at Morning Canyon and at other similarly protected coves in the area.

Ulva/Enteromorpha sp. **(Sea Lettuce)**

Figure 13. Exposed Algae in the Genera *Ulva* and *Enteromorpha*

The distribution of *Ulva/Enteromorpha* is typically limited by available nitrogen. Due to its high nitrogen requirements, intertidal areas that contain high densities of *Ulva/Enteromorpha* are generally indicative of areas with enhanced nutrient levels resulting from anthropogenic inputs. *Ulva/Enteromorpha* is also typically more prevalent in semi-protected, lower energy environments. In this study, *Ulva/Enteromorpha* coverage was highest during the summer survey along Transect 1 at Buck Gully, Transect 2 at Morning Canyon, and Transect 2 at Heisler Park. Transect 1 at Buck Gully was directly aligned to the mouth of Buck Gully, whereas Transect 2 at Morning Canyon was directly aligned to the mouth of Morning Canyon. At Heisler Park, although each of the transects was aligned to a storm drain outfall, the storm drain aligned with Transect 2 was the only storm drain thought to have a nearly constant flow, according to the field notes. During the winter survey, *Ulva/Enteromorpha* coverage was considerably lower at the mouths of Buck Gully (Transect 1) and Morning Canyon

(Transect 2), whereas at Heisler Park, coverage increased slightly to nearly uniform densities across all transects.

Community Indices

Dendogram cluster analyses from fixed-quadrat data collected during each seasonal survey were produced to examine if distinct clustering of intertidal species or quadrat locations was evident. Since cluster analysis will identify similarities among quadrat locations and species groupings, quadrat locations comprised of similar species should group together. Results of the cluster analysis for Winter 2007 data are shown on Figure 14, and results of the cluster analysis for Summer 2007 data are shown on Figure 15.

Cluster analysis results indicate that there does not appear to be significant clustering of species into unique associations or communities from either summer or winter surveys. Although some clustering of lower intertidal quadrats (P3 quadrats) occurs in the summer data, the distributions of species overlap to such a degree that unique, persistent groups were generally not discernable. A multi-dimensional scaling (MDS) plot, employing a square root transformation of all fixed-quadrat data, was also generated to determine if clustering of sites was significant (Figure 16). The MDS graph indicates that differences among fixed quadrat plots across the three sites do not appear to be significant.

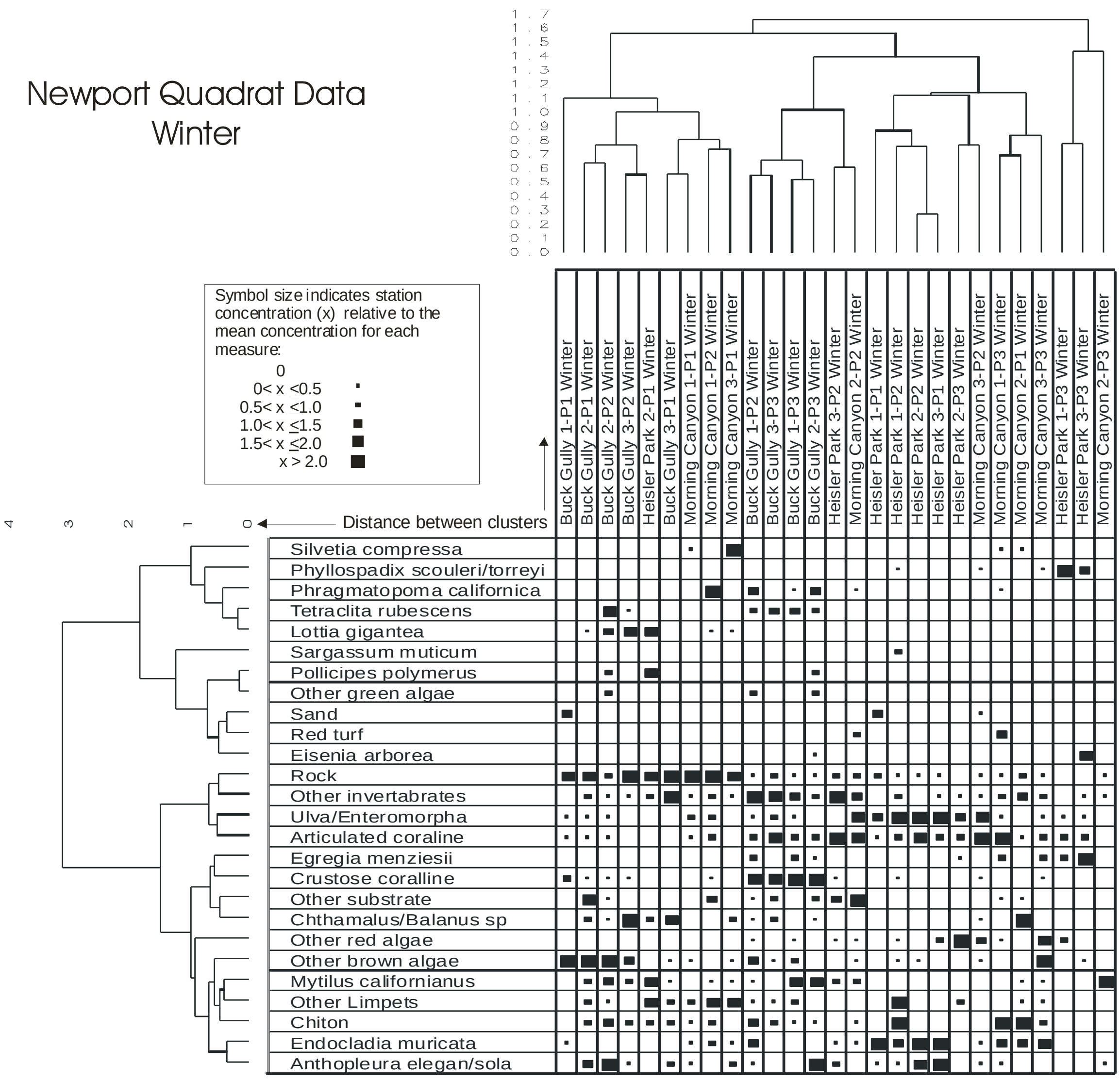

Figure 14. Cluster Analysis of Fixed-Quadrat Data Collected in January and February 2007

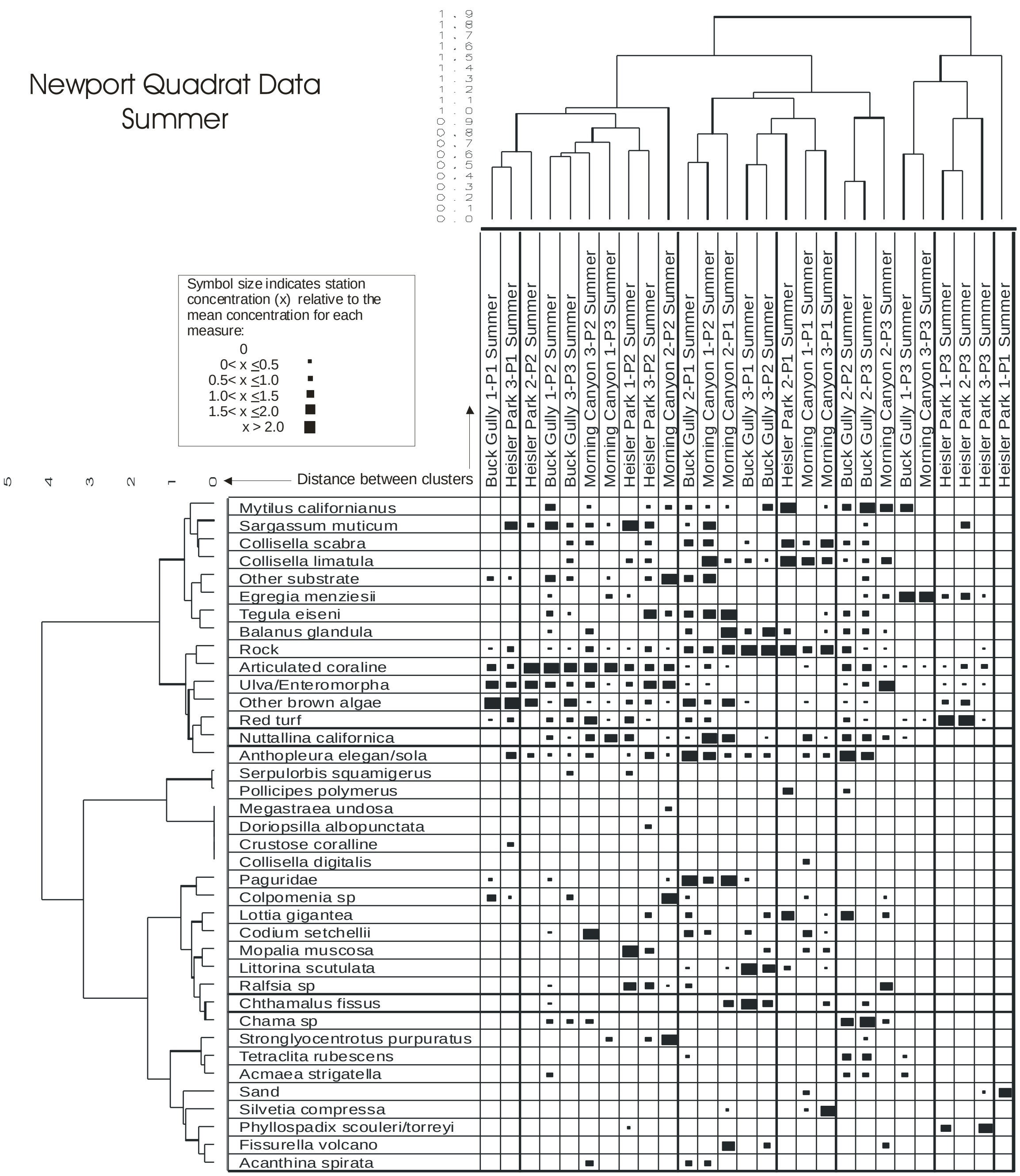

Figure 15. Cluster Analysis of Fixed-Quadrat Data Collected in January and February 2007

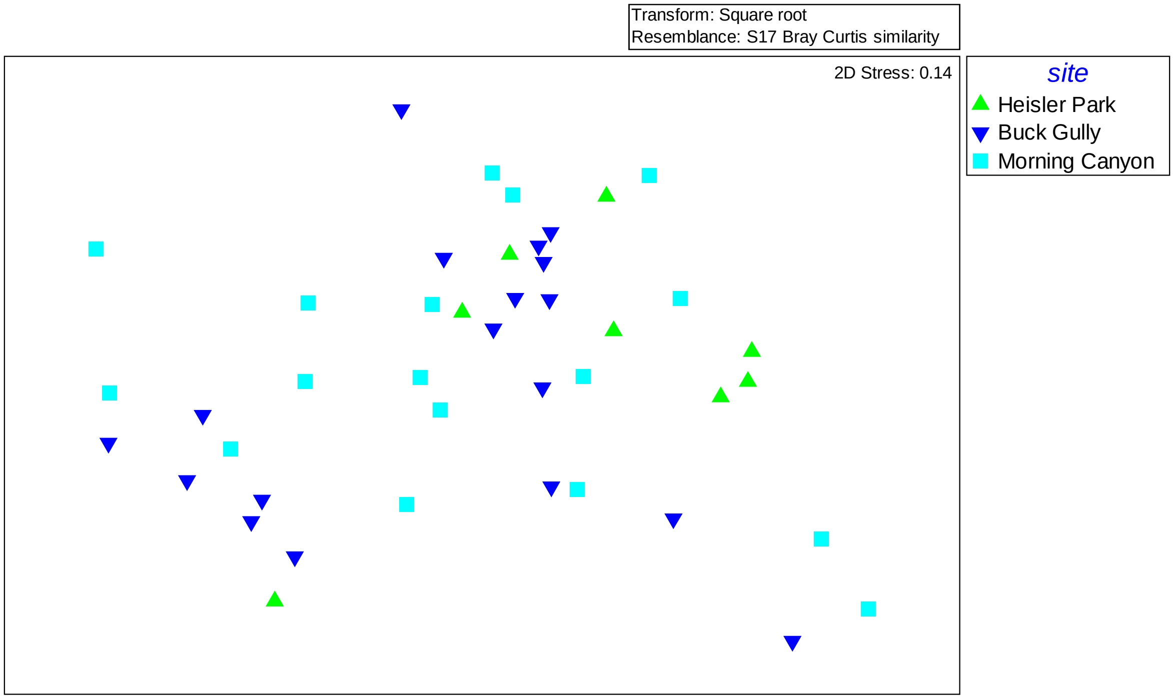

Figure 16. Multi-Dimensional Plot of Fixed-Quadrat Data

4.0 DISCUSSION

Chronic human impacts have affected each of the intertidal communities within this study to some degree, making it difficult to discern subtle differences in community structure between sites amid typical high degrees of natural seasonal and spatial variability. Due to extensive public use of the rocky intertidal shoreline within Orange County, no true reference sites were known to exist within the vicinity of the study area. As a result, a weight-of-evidence approach was used to compare impacts between high-use sites (Buck Gully and Heisler Park) and a low-use site (Morning Canyon).

Point-contact transect data indicated that although season variability existed within sites, species densities and species richness between high-use sites and low-use sites were generally not substantially different. Two target species, however, were found exclusively at Morning Canyon during both summer and winter surveys and, thus, were negatively associated with the number of yearly tidepool visitors. The rockweed, *Silvetia compressa*, and the sea urchin, *Strongylocentrotus purpuratus*, were observed, albeit in relatively low densities, along the Morning Canyon transects. *S. compressa* constituted approximately 5% of the total coverage in both summer and winter transects, whereas *S. purpuratus* constituted 6% of the coverage in summer and 1% of the coverage in winter at Morning Canyon. Because the thalli of *S. compressa* are easily damaged, *Silvetia* is susceptible to trampling (Vesco and Gillard, 1980) and recovery from disturbance is believed to be long. It is therefore of interest that no *S. compressa* was observed along transects at either of the high-use sites. This alga appeared to be ubiquitous in the upper intertidal zone along all semi-protected, low-use to moderate-use coves located within approximately one mile of Buck Gully. Similarly, *S. purpuratus* would be expected to be found in lower densities and smaller sizes at high-use sites as a result of handling and collecting. It should also be noted that observations made during the summer survey noted that the *S. compressa* beds at Morning Canyon appeared to be significantly thinner than they had been during the winter survey.

Fixed quadrat plot data also indicated strong seasonality among several intertidal species, such as *Endocladia muricata,* which was not observed during the summer survey but comprised greater than 11% and 15% cover during the winter survey at Buck Gully and Morning Canyon, respectively. Similarly, *Egregia menziesii* had substantially lower abundance during the winter at Buck Gully and Morning Canyon than during the summer. In general, invertebrate species diversity was higher during the summer than during the winter across all sights while invertebrate abundance was highest during the winter. Invertebrate dominance in winter ranged between two to three organisms at across all sights, whereas during the summer, dominance ranged from six to seven organisms across all sights. Several species were found at only one site; however, these species typically had extremely low abundances and were unlikely indicative of site-specific impacts. As with the point-contact transect data, Morning Canyon was the only site where *Silvetia compressa* was observed. This is believed to be correlated to reduced trampling at

Morning Canyon relative to Buck Gully and Heisler Park. Aside from the presence of *S. compressa*, however, species abundance and diversity at the low-use site was not significantly different than at the high-use sites. Cluster analysis and multi-dimensional plot analysis indicated that little to no substantial clustering of plots occurs with the data collected from fixed-quadrat plots across all sites.

Band transect data examined *L. gigantea* size differential among the three sites. Previous studies have shown that preferential collecting and scavenging activities by humans is correlated to *L. gigantea* populations with smaller shell lengths (Pombo and Escofet, 1996). In this study, it was assumed that Morning Canyon, which receives substantially fewer annual visitors than either Buck Gully or Heisler Park, would have a *L. gigantea* population containing significantly larger individuals. Statistical analysis of the winter data determined that Heisler Park owl limpets were significantly larger than owl limpets at both Buck Gully and Morning Canyon. Conversely, during summer, Morning Canyon and Heisler Park owl limpets were statistically larger than Buck Gully owl limpets. Although there may be a subtle difference in owl limpet size at Morning Canyon, due to the low abundances observed (only seven and eight owl limpets were measured in Morning Canyon band transects during summer and winter, respectively), *L. gigantea* size differences among the high-use sites and the low-use sites remains largely speculative and is at this point, still inconclusive.

An important goal of this study was to provide baseline data for future long-term monitoring of these same study locations. In this way, change in intertidal community structure can be documented and assessed over time so informed management decisions can be made regarding impacts to the Newport Coast and Laguna Beach ASBS. This study has shown that subtle differences in intertidal community structure among high-use sites and low-use sites may be difficult to determine statistically from a relatively small dataset without a true reference site. Each of the rocky intertidal communities surveyed in this study is likely under a constant state of disturbance from multiple fronts. Additional monitoring studies performed at these same locations could provide useful insights into how each location responds to specific anthropogenic impacts, such as trampling, scavenging, urban runoff, storm water runoff, and cross contamination from Newport Harbor.

5.0 REFERENCES

Bally, R. & C. L. Griffiths. 1989. *Effects of human trampling on an exposed rocky shore*. International Journal of Environmental Studies, 34: 115–125.

Brosnan, D. M. and L.L. Crumrine. 1994. *Effects of Human Trampling on Marine Rocky Shore Communities*, J. Exper. Marine Biol. Ecol. **177**, 79 97.

Engle, J.M. 2005. *Unified Monitoring Protocols for the Multi-Agency Rocky Intertidal Network* (update). OCS Study MMS 0501.

Ghazanshahi, J., T.D. Huchel, and J.S. Devinny. 1983. *Alteration of Southern California Rocky Shore Ecosystems by Public Recreational Use. In* Journal of Environmental Management. 16:379–394.

Pombo, O.A. and A. Escofet. 1996. *Effect of Exploitation on the Limpet* Lottia gigantea*: A Field Study in Baja California (Mexico) and California (USA)*. Pacific Science. 50(4):393–403.

Vesco, L.L. and R. Gillard. 1980. *Recovery of Benthic Marine Populations along the Pacific Coast of the United States Following Man-Made and Natural Disturbances Including Pertinent Life History Information*. U.S. Department of the Interior, Bureau of Land Management Service, POCS Reference Paper No. 53-4.

Zedler, J.B. 1978. *Public Use Effects in the Cabrillo National Monument Intertidal Zone*. Project Report of the U.S. Dept. of Interior National Park Service. 52 pp.