INVENTORY OF INTERTIDAL AND SHALLOW SUBTIDAL MARINE INVERTEBRATES AT KALAUPAPA NATIONAL HISTORIC PARK MOLOKA'I, HAWAI'I

Hawaii Biological Survey

Final Report

January 2006

COVER PHOTOS

Tide pool area at Ka Laemau on northwestern tip of Kalaupapa Peninsula.
Inset, the intertidal anemone *Cladactella manni* (Verrill, 1899).
(Cover Design: D. Preston, Photos by: S. Godwin)

FINAL REPORT
INVENTORY OF INTERTIDAL AND SHALLOW SUBTIDAL MARINE INVERTEBRATES AT KALAUPAPA NATIONAL HISTORIC PARK

Prepared for:
U.S. Department of the Interior
National Park Service
Pacific Islands Coral Reef Program
Pacific Cooperative Studies Unit
3190 Maile Way, St John 410
Honolulu, Hawaii 96822

Prepared by:
Scott Godwin and Holly Bolick
Hawaii Biological Survey
Bishop Museum
1525 Bernice St
Honolulu, Hawaii 96817

January 2006
Contribution No. 2006-003 to the Hawaii Biological Survey

ISSN -1085-455X

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In September 2004 a project designated as KALA-00013 under National Park Service (NPS) permit KALA-2004-SCI-0004 was begun as a collaborative effort with the Pacific Cooperative Studies Unit, University of Hawai'i Manoa, The National Park Service (NPS), Pacific Islands Coral Reef Program, and the Bishop Museum in Honolulu, Hawaii which focused on the intertidal and supralittoral habitats of Kalaupapa National Historic Park (KALA). The principal goal of this project was to collect both qualitative and quantitative site-specific information focusing on a species inventory of marine invertebrates associated with intertidal and supralittoral coastal habitats of KALA. The intent of the inventory work and methods entail acquisition of species inventory data that will contribute to the subsequent development of an integrated and comprehensive long-term marine monitoring program. Additionally, an archived and catalogued collection of 507 lots of marine invertebrates containing roughly 1548 specimens was created with organisms from this project. This collection was deposited with KALA as an addition to existing cultural and natural history material.

A total of 12 sites were surveyed, with both quantitative monitoring and species inventory methodologies. The species inventory yielded 306 species, with 284 native, 14 endemic, 9 introduced, and 3 cryptogenic species. In addition, there were 2 new records for the Hawaiian Archipelago, and 3 new species records. Two of the new species records have been previously recorded for the Hawaiian Archipelago but one was a newly described species. An archive of both *in situ* and laboratory images of common species was created and deposited with NPS staff at KALA.

Introduction

The intertidal zone in Hawai‘i is created by horizontal faces of ancient lava flows at various stages of erosion. These flows have formed benches that are at or just above mean tide level, which are the basis of the variety of habitats associated with shorelines in the Main Hawaiian Islands. These habitats include sea cliffs, sea-level basalt shorelines, calcareous solution and water-leveled benches (Kay, 1979). The supra-littoral beach zone associated with these habitats is also quite varied, and is represented by single or combined substrates. These substrates are boulder/cobble, calcareous and basaltic rubble, and various sand types. The variety of intertidal and supralitorral habitat contains cryptic species assemblages that have attracted little attention historically by researchers in Hawai‘i but have always been of great cultural importance.

The land under control of the Kalaupapa National Historic Park (KALA) comprises 1093 hectares of shallow nearshore marine habitat with associated shorelines that have all of the previously mentioned intertidal and supralittoral habitat and substrates. The geographic isolation and access restrictions to this area have allowed it to remain basically unaltered. It is therefore an excellent site to expand the knowledge of species assemblages and vertical partitioning of habitat by marine invertebrate organisms in the Hawaiian intertidal and supralittoral zones.

In September 2004, a project designated as KALA-00013 under National Park Service (NPS) permit KALA-2004-SCI-0004 was begun as a collaborative effort with the Pacific Cooperative Studies Unit, University of Hawai’i Manoa, The National Park Service (NPS) Pacific Islands Coral Reef Program, and the Bishop Museum in Honolulu, Hawai‘i which focused on the intertidal and supralittoral habitats of KALA. The principal goal of this project was to collect both qualitative and quantitative site-specific information focusing on a species inventory of marine invertebrates associated with intertidal and supralittoral coastal habitats of KALA. The intent of the inventory work and methods entail acquisition of species inventory data that will contribute to the subsequent development of an integrated and comprehensive long-term marine monitoring program.

Proposed Project Components and Deliverables

The proposed products of these efforts were: *****(1) a 90% presence-absence species inventory, including a species list with relative abundance data, in an agreed upon digital format denoting native, endemic, alien/invasive, and cryptogenic taxa, that will be used by KALA staff to populate spatial (GIS) or relational databases. (2) digital photographs with sufficient resolution to identify macroinvertebrates, done in conjunction with KALA staff during field work. (3) training of KALA staff during field work. (4) a final PCSU/CESU and BPBM jointly published report that briefly summarizes findings. Also, (5) a comprehensive set of voucher specimens accessioned and catalogued using NPS collections management policy and regulations and deposited with the museum curator at KALA.

*** This is a guideline based on National Park Service initiatives and was deemed unrealistic for the reasons of inadequate taxonomic resolution for many organisms and too short of a time period for the project.**

Deliverables Produced

Final Report including:

? Site data that includes habitat descriptions such as habitat and substrate types and GPS position

? Complete inventory data including; species, taxonomic authorship (authority of taxon name), status (i.e.; alien, native…), relative abundance, and distribution presented for each site surveyed. To include (with caveats):

<u>Phylum Porifera</u> Due to complications with the taxonomy of this group most identifications will be tentative or not to species.

<u>Phylum Cnidaria</u>

<u>Phylum Nemertea</u>

<u>Phylum Annelida</u>

<u>Phylum Sipuncula</u>

<u>Phylum Mollusca</u>

<u>Phylum Arthropoda</u> (not to include subphylum Uniramia or class Arachnida)

<u>Phylum Ectoprocta</u>

<u>Phylum Echinodermata</u>

<u>Phylum Chordata</u> (Ascidiacea only): Due to the complications with the taxonomy of the Family Didemnidae in this phylum, some of the members of this group can only be tentatively identified.

Additional products:

? Digital photo catalog on CD

? Archived and catalogued collection of 507 lots of specimens of marine invertebrates, with database

Methodology

Field Component

A total of 12 sites were chosen and surveyed during the course of the project. These sites encompassed the representative range of all nearshore marine habitat types present to a maximum depth of 1.5 meters, and took into consideration any criteria set forth by the National Park Service (NPS) during an initial site trip.

STANDARD SITE SURVEYS

Surveys were based on two basic activities, species inventory and quantitative survey, which took place either as joint exercises or individually. Table 1.1 provides the metadata for each site, which includes the activity conducted. The specifics of these activities are:

Species Inventory:

1) Transect Inventory – Species are recorded along a 2 meter belt transect that was used for quantitative enumeration. This serves as a point to record and collect species but also to define species distribution and habitat type.

2) Roving Collections – The collection of the representative fauna strictly for species inventory. This activity ranged throughout the site from a water depth of 1 meter to the extent of the supralittoral zone. This was accomplished by shore wading, roving swims, and searching the supralittoral zone to collect qualitative data or samples for common, rare, or cryptic organisms and to survey any additional habitats present at the site, (e.g.; sand, pavement, undersides of cobbles, small boulders and rubble).

Quantitative Survey:

1) Transect Survey – A transect line is stretched from the low tide mark to the extent of the supralittoral zone. A $0.125m^2$ quadrat is placed at pre-set intervals and all organisms are enumerated.

SURVEY SCENARIO

An initial site visit was conducted for the purpose of reviewing the habitat types around the coastline of Kalaupapa Peninsula, and what requirements for access existed. A decision was made to follow the existing plan for sites used for prior intertidal research (Bird *pers. comm.*; Minton & Carnevale, 2004). The only deviation from these previous plans was to designate sites specifically for collection of organisms.

Field activities were planned around the greatest low tide periods that occurred in the hours between 6:00 AM and noon with ranges between 0.1 and -0.3 feet. This allowed field activities during the morning hours and sample processing and data entry in the afternoon. Occasionally sites were visited during evening low tides to collect particular organisms more active during this period.

Quantitative surveys were the first activity conducted at a site and were then followed by field collections. Transect tapes were laid out perpendicular to the shoreline from the low tide mark to the beginning of the vegetation zone, or out to a maximum of 60 meters (whichever was applicable). Two individuals conducted quadrat counts, while another recorded GPS coordinates, photographed the site, and conducted the transect inventory. Once quantitative surveys were complete the roving collection of errant and sessile marine invertebrates took place. In some cases, sites were chosen to conduct roving collections exclusively (See Table 1.1). In conjunction with the roving collections and transect inventory, *in situ* photos of organisms were taken. Specialized collections of rubble, dead coral, and algae for symbiotic organisms or substrate-specific inhabitants were done during the roving collection step. These samples were processed in the following ways:

1) Rubble is placed in a dilute formalin bath to dislodge small mobile invertebrates, which are removed by a 0.5 mm sieve. Large pieces of rubble are broken apart with chisels and examined for the purpose of collecting any sessile fauna.

2) Algae and other substrate are washed with either dilute formalin or under running fresh water to collect epibionts, which are collected on a 0.5 mm sieve.

All collected organisms were sorted by higher taxonomic and morphotype level in an on-site field lab at KALA. Specimens were preserved with methods appropriate to the specific taxonomic group. Porifera, molluscs, crustaceans, and echinoderms were preserved in 75% ethanol or frozen, and soft-bodied organisms (cnidaria, sea slugs, and urochordates) preserved in 10% formalin. Individual specimens and the samples mentioned above are temporarily stored in clear plastic samples bags for transport back to Bishop Museum. These specimens are then transferred to glass storage containers for short term storage during the taxonomy phase.

Laboratory Analysis and Voucher Collections

All collected material was brought back to the Bishop Museum for further analysis. The analysis at Bishop Museum involved the use of recent taxonomic literature to make identifications. Problematic groups were sent on loan to recognized experts for positive identification. The loan process was monitored by both the Bishop Museum registrar and Invertebrate Zoology collections manager until the specimens were returned.

All organisms identified during the above process were first entered into a phylogentically ordered inventory list. The list contains current genus and species, taxonomic authority, and status (i.e.; native, endemic, non-native, new record….etc). Additionally, a site inventory for each species was produced.

NATURAL HISTORY COLLECTIONS FOR KALA

In collaboration with the NPS museum curator at KALA, an archival process was set in place during the course of species identifications. A NPS accession number for all material collected under the permit was assigned and a string of catalogue numbers was provided for individual specimens. Once identification of a specimen was confirmed, it was assigned a catalogue number, and a label (with all pertinent information) is printed on archival paper with a standard laser printer. The specimen and label was sealed in a glass container and suspended in 75% ethanol. This material and an accompanying collections inventory were then deposited with the KALA museum curator.

Results

A total of 12 sites were surveyed during the course of the project and Table 1.1 shows the breakdown of activities, as well as site designations, geographic names, and UTM coordinates (NAD 83, UTM Zone 4N). A map of the Kalaupapa Peninsula depicting the locations of each site is shown in Figure 1.1 and descriptions of the sites are in the following section. The results of the quantitative survey will be presented first and will be followed by the results of the species inventory.

Site Descriptions

The following section has field descriptions with specific highlights. Data presented in following sections will cover more specific topics such as species distributions and relative abundance, which are not covered in the site descriptions.

Site	Locality	UTM-N	UTM-E	Comments
4	Piko'one	2343829.42	708988.26	Quantitative Survey
5	Puwah	2344305.11	709237.90	Quantitative Survey
6	Kahili	2346757.45	710096.55	Quantitative Survey, Species Inventory
7	Ka Laemau	2347143.39	710176.33	Quantitative Survey, Species Inventory
16	Mormon Pond	2342852.37	713419.70	Quantitative Survey
20	Church Pasture	2343090.14	713344.71	Quantitative Survey, Species Inventory
21	Carpenters Beach	2344725.96	709198.16	Quantitative Survey
22	Dock	2344473.76	709216.56	Species Inventory
23	Papaloa Beach	2344859.0	709362.0	Quantitative Survey
24	Lighthouse	2346614.0	711613.0	Quantitative Survey
25	Old Lady Cave	2345055.0	712539.0	Quantitative Survey, Species Inventory
26	Ka Laemilo Point	2345785.6	709347.2	Species Inventory

Table 1.1. Site designations, UTM coordinates, and activities.

KALA-04, Piko‘one

A narrow basaltic bench with sparse tide pools and a narrow band of boulders fronting a steep hillside. At low tide, the exposed area between the vegetation zone and the low tide mark was 30 meters. The boulder habitat was roughly 12 meters wide and a zone defined by the presence of *Littoraria pintado* began 5.6 meters from the vegetation zone within the boulder habitat. This site is washed heavily by waves at high tide and is reported to be inundated by sand during certain periods of the year. The common species at this site: *Littoraria pintado*, *Nodilittorina hawaiensis*, and *Nerita picea* were located from low intertidal to low supralittoral zones. The upper supralittoral zone was devoid of species except for crabs of the genus *Pachygrapsus*.

KALA-05, Puwah

A finger of basalt extending roughly 40 meters from a 10 meter wide boulder shoreline. A steep sloping relief characterizes the southern side of the finger, while the northern side is bordered by a shallow bench that is exposed at low tide. This shallow bench was characterized by extensive tide pools and contained numerous corals, mollusks, and echinoderms. The quantitative survey of this site took place from the seaward tip along the spine of the finger to the extent of the boulder habitat. This basalt finger is inundated during high tide and receives harsh pounding from waves during the winter months. Typical low intertidal species, such as opihi and the urchins *Colobocentrotus* and *Echinometra* were present on the seaward and southern edge. The gastropods *Littoraria pintado*, *Nodilittorina hawaiensis*, *Nerita picea* and *Peasiella tantilla* were common on upper exposed areas, while *Morula uva, Drupa ricina* and *Serpulorbis variabilis* were common on lower wave-washed areas.

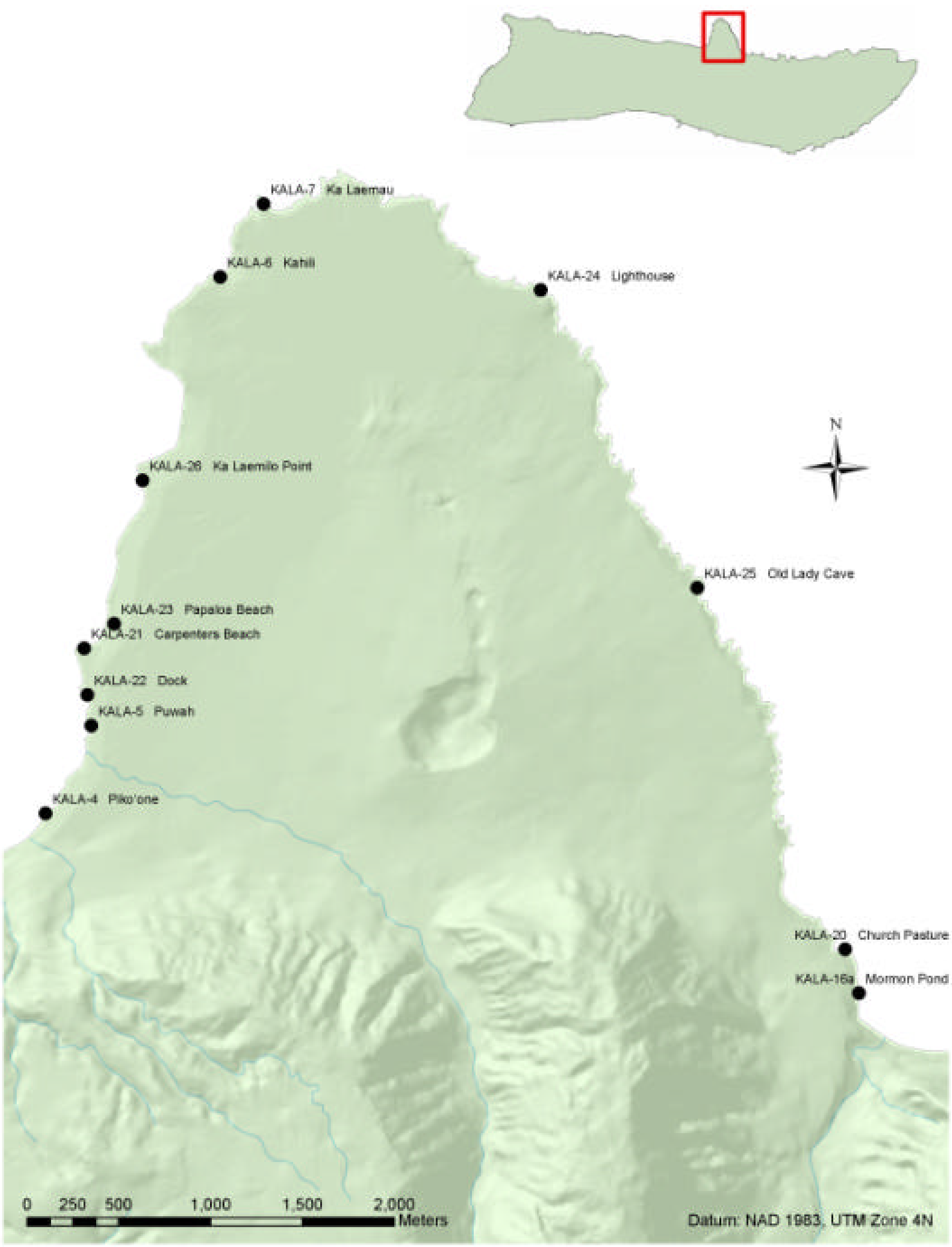


Figure 1.1. Kalaupapa Peninsula and location of project survey sites. Map produced by: M. McShane

KALA-06, Kahili

An extensive intertidal area characterized by boulders, shallow sand/cobble areas, and basalt pavement in conjunction with a broad sand beach. At low tide an extensive area is covered by water less than 0.5 meters deep which has unconsolidated rubble, sand, and basalt pavement. This zone was characterized by numerous holothuroid and echinoid echinoderms, and the gastropod *Hipponix imbricatus* was extremely abundant. Also at low tide, a zone running for roughly 30 meters from the sand beach that contained shallow sand pits and tide pools is exposed. The site is also protected from extreme wave action through most of the year by a subtidal boulder field on the extreme seaward edge. The quantitative transect at this site began at the edge of the sand beach and ran for 40 meters seaward. Extensive species inventory sampling was conducted at this site, and a new species of holothuroid from the genus *Stichopus* was obtained during this activity (see description and photo, p. 24).

KALA-07, Ka Leamau

Ka Leamau Point is at the extreme seaward edge of an extensive lava flow north of KALA-06. The point is characterized by a high wall that drops sharply to a moderate relief basalt bench that runs roughly 100 meters east to a boulder field that spans 200-300 meters and terminates at a sand beach. A transect was run across an extensive tide pool area for the quantitative survey and therefore, is not directly comparable to other sites. The common species that were captured by quantitative enumeration were *Nodilittorina hawaiensis* and *Nerita picea*. A new species of holothuroid from the genus *Holothuria* was recorded from this site (see description and photo, p. 23).

KALA-16, Mormon Pond

This site was composed entirely of boulder habitat roughly 10 meters in width at low tide. The site is battered by strong wave action during the winter months and is quite representative of the southern-most end of the east side of the peninsula. The zone from the low tide mark to 5 meters was characterized by opihi (*Cellana exarata*), *Nerita picea*, and *Littoraria pintado*, while the zone up to 10 meters had the majority of species. The gastropods *Littoraria pintado*, *Nodilittorina hawaiensis* and *Melampus castaneus*, and shore crabs of the genus *Pachygrapsus* and *Cyclograpsus* were recorded in this zone.

KALA-20, Church Pasture

A broad expanse of basalt bench existed at this site, which contained numerous tide pools. The basaltic bench in this area was up to 100 meters in width at some spots. A location was chosen to survey that was 60 meters from low tide mark to the vegetation zone. The first 10 meters of the transect was dominated by the gastropod *Serpulorbis variabilis* and the hermit crab *Calcinus seurati*. The remaining 50 meters contained the gastropod *Littoraria pintado* up to the vegetation zone. Three shore crab species were recorded in the high intertidal and supralittoral zones. These were *Pachygrapsus* and *Geograpsus* in the high intertidal and *Sesarma* and *Cyclograpsus* in the supralittoral zone. The isopod *Ligia* was noted in both these zones as well. Vegetation zone was dominated by ironwood trees and the pine needle litter associated with this species.

KALA-21, Carpenter's Beach

Low basalt bench with sand and cobble beach and high volume of pine needles from ironwood trees. The site chosen to survey was 35 meters in width from the low tide mark to the vegetation zone and contained poorly developed tide pools. The low intertidal had the gastropods *Cellana exarata*, *Cellana sandwicensis*, *Serpulorbis variabilis*, and *Nerita picea*, and the cnidarians *Palythoa caesia* and *Aiptasia pulchella*. Individuals of the gastropod *Littoraria pintado* began appearing 10 meters from the low tide mark and were found up to the vegetation zone. Three shore crab species were recorded: *Grapsus tenuicrustatus* was present in the low and middle intertidal zone, while *Pachygrapus* and *Cyclograpsus* were found in the supralittoral zone.

KALA-22, Dock

This site was a combination of man-made sea wall, large rip-rap boulders, and associated shallow subtidal sand habitat that was surveyed for species inventory only. Numerous opihi were present in the boulder habitat from high intertidal (*Cellana exarata*) to below the low tide mark (*Cellana sandwicensis* and *Cellana talcosa*). The gastropods *Thais intermedia* and *Purpura aperta* were numerous and the cephalopod *Octopus cyanea* was recorded. The holothuroids *Stichopus horrens* and *Holothuria atra* were present, as were the echinoid echinoderms *Diadema paucispinum*, *Eucidaris metularia*, *Tripneustes gratilla*, and *Echinometra*. The crabs *Grapsus tenuicrustatus* and *Percnon planissimum* were common throughout the boulder habitat.

KALA-23, Papaloa Beach

A drowned reef substrate is located intertidally and represents a unique habitat. A transect 15 meters long was laid from the low tide mark to the edge of this unique substrate. The vegetation zone was located 10 meters beyond this edge and the substrate was all sand within this zone. The only species abundant throughout the drowned reef substrate was the gastropod *Peasiella tantilla*. The gastropods *Littoraria pintado*, *Nodilittorina hawaiensis*, *Nerita picea*, and *Ittibitium* sp. were present in high numbers but were patchy in distribution.

KALA-24, Lighthouse

Extensive basalt shore area southeast of the lighthouse. The distance from the low tide mark to the vegetation zone was well over 200 meters, so the transect was run from the low tide mark out to 50 meters. Moderate relief basalt tide pool habitat extended 40 meters beyond the low tide mark. The majority of species recorded were located in the low intertidal, with the gastropod *Nerita picea* being the most abundant. The only species found commonly through a majority of the site was the gastropod *Littoraria pintado*.

KALA-25, Old Lady's Cave

Low relief basalt bench with a sharp drop-off to the ocean that was located at the base of a cliff. Large boulders bordered the site at the base of the cliff and the transect was run from the edge of the bench to this area. The tide pool system at this site harbored a diverse group of echinoid echinoderms and bivalve and gastropod mollusks.

KALA-26, Ka Laemilo Point

This site encompassed an extensive intertidal and shallow subtidal area on the south side of Ka Laemilo Point. This area was used exclusively for species inventory activities that focused on the collection of specimens. The consolidated and unconsolidated boulder and cobble provided habitat for a variety of organisms and new species of amphipod was identified from the site (see description and photo, pp 24 & 25).

Species Distribution

The following section will graphically show species distribution patterns for some sites quantitatively enumerated during the project. The data is presented by individual site and does not include KALA-22 or KALA-26 since only species inventories were carried out at these sites. Distributions (presence/absence) are charted in 5 meter intervals beginning at the low tide mark (LTM) and the habitat type is recorded at each interval. A set of organisms that were common across most sites were chosen for charting and for use in the later species abundance section. The codes for these species are as follows:

Aip. pulch. = *Aiptasia pulchella*, Cnidaria: Actinaria
Zoanth. = Cnidaria**,** Zoanthidae
Ner. pic. = *Nerita picea,* Mollusca: Gastropoda
Lit. pint. = *Littoraria pintado,* Mollusca: Gastropoda
Nod. haw. = *Nodilittorina hawaiensis,* Mollusca: Gastropoda
Peas. tant. = *Peasiella tantilla,* Mollusca: Gastropoda
Ittibit = *Ittibittium* sp., Mollusca: Gastropoda
Melamp. = *Melampus castaneus*, Mollusca: Gastropoda
Isog. = *Isognomon* sp., Mollusca: Bivalvia
Cell. exart. = *Cellana exarata*, Mollusca: Gastropoda
Cell. sand. = *Cellana sandwicensis*, Mollusca: Gastropoda
Calc. seurat. = *Calcinus seurati,* Arthropoda: Crustacea
Pachy. = *Pachygrapsus sp.*, Arthropoda: Crustacea
Cyclo. = *Cyclograpsus sp.*, Arthropoda: Crustacea
Grap. = *Grapsus tenuicrustatus,* Arthropoda: Crustacea
Sesarm. = *Sesarma sp.* Arthropoda: Crustacea
Nes. intext. = *Nesochthamalus intertextus* Arthropoda: Crustacea (Barnacle)
Colobo. = *Colobocentrotus atratus,* Echinodermata: Echinoidea
Echino. = *Echinometra sp.*, Echinodermata: Echinoidea
Zoanth = Zoanthid, Cnidaria: Zoanthidea

Codes for habitat types are defined, as follows:

ba = basalt
bo = boulder
co = cobble
s = sand
ca = carbonate
tp = tide pool
v = vegetation

Site 4 - Piko'one		Species															
Interval (m) Beginning at LTM	Habitat	Ner. pic.	Lit. pint.	Nod. haw.	Peas. tant.	Melamp.	Cell. exart	Cell. sand.	Calc. serat.	Pachy.	Cyclo.	Grap.	Sesarm.	Nes. intext.	Colobo.	Echino.	Zoanth.
0-5	ba/tp																
5-10	ba/tp																
10-15	ba/bo																
15-20	bo																
20-25	bo																
25-30	bo/v																

Site 5 - Puwah		Species															
Interval (m) Beginning at LTM	Habitat	Ner. pic.	Lit. pint.	Nod. haw.	Peas. tant.	Melamp.	Cell. exart	Cell. sand.	Calc. serat.	Pachy.	Cyclo.	Grap.	Sesarm.	Nes. intext.	Colobo.	Echino.	Zoanth.
0-5	ba/tp																
5-10	ba/tp																
10-15	ba/tp																
15-20	ba/tp																
20-25	ba																
25-30	ba																
30-35	ba/bo																
35-40	bo/co																
40-45	bo																
45-50	bo/v																

Site 6 - Kahili		Species															
Interval (m) Beginning at LTM	Habitat	Ner. pic.	Lit. pint.	Nod. haw.	Peas. tant.	Melamp.	Cell. exart	Cell. sand.	Calc. serat.	Pachy.	Cyclo.	Grap.	Sesarm.	Nes. intext.	Colobo.	Echino.	Zoanth.
0-5	bo/co/s																
5-10	bo/co/s																
10-15	bo/co/s																
15-20	ba/bo/s																
20-25	ba/bo/s																
25-30	ba/bo/s																
30-35	ba/bo/s																
35-40	ba/s																
40-45	ba/s																

Table 1.2. Species distributions for KALA-04, KALA-05, and KALA-06

Site 7 - Ka Laemau		Species															
Interval (m) Beginning at LTM	Habitat	Ner. pic.	Lit. pint.	Nod. haw.	Peas. tant.	Melamp.	Cell. exart	Cell. sand.	Calc. serat.	Pachy.	Cyclo.	Grap.	Sesarm.	Nes. intext.	Colobo.	Echino.	Zoanth.
0-5	ba/tp						X										
5-10	ba/tp	X		X										X			
10-15	ba/tp	X		X										X			
15-20	ba/tp	X		X					X								
20-25	ba/tp			X													
25-30	ba/tp			X													

Site 16 - Mormon Pond		Species															
Interval (m) Beginning at LTM	Habitat	Ner. pic.	Lit. pint.	Nod. haw.	Peas. tant.	Melamp.	Cell. exart	Cell. sand.	Calc. serat.	Pachy.	Cyclo.	Grap.	Sesarm.	Nes. intext.	Colobo.	Echino.	Zoanth.
0-5	bo	X	X				X										
5-10	bo		X	X		X				X	X						

Site 20 - Church Pasture		Species															
Interval (m) Beginning at LTM	Habitat	Ner. pic.	Lit. pint.	Nod. haw.	Peas. tant.	Melamp.	Cell. exart	Cell. sand.	Calc. serat.	Pachy.	Cyclo.	Grap.	Sesarm.	Nes. intext.	Colobo.	Echino.	Zoanth.
0-5	ba/tp	X					X	X	X					X	X		X
5-10	ba/tp			X					X								
10-15	ba/tp		X	X					X								
15-20	ba/tp		X	X					X								
20-25	ba/tp		X	X					X								
25-30	ba/tp		X	X					X								
30-35	ba/tp		X	X					X								
35-40	ba/tp		X	X					X								
40-45	ba		X	X					X								
45-50	ba		X	X					X								
50-55	ba/bo		X							X	X		X				
55-60	ba/bo/v		X			X					X		X				

Site 21 - Carpenter's Bch		Species															
Interval (m) Beginning at LTM	Habitat	Ner. pic.	Lit. pint.	Nod. haw.	Peas. tant.	Melamp.	Cell. exart	Cell. sand.	Calc. serat.	Pachy.	Cyclo.	Grap.	Sesarm.	Nes. intext.	Colobo.	Echino.	Zoanth.
0-5	ba	X		X	X		X	X	X								X
5-10	ba	X		X	X				X			X					
10-15	ba	X	X	X					X			X					
15-20	ba	X	X									X					
20-25	ba	X	X														
25-30	ba		X							X							
30-35	ba/v		X							X	X						

Table 1.3. Species distributions for KALA-07, KALA-16, KALA-20, and KALA-21

Site 23 - Papaloa Beach		Species															
Interval (m) Beginning at LTM	Habitat	Ner. pic.	Lit. pint.	Nod. haw.	Peas. tant.	Melamp.	Cell. exart	Cell. sand.	Calc. serat.	Pachy.	Cyclo.	Grap.	Sesarm.	Nes. intext.	Colobo.	Echino.	Zoanth.
0-5	ca																
5-10	ca/s																
10-15	ca/s																

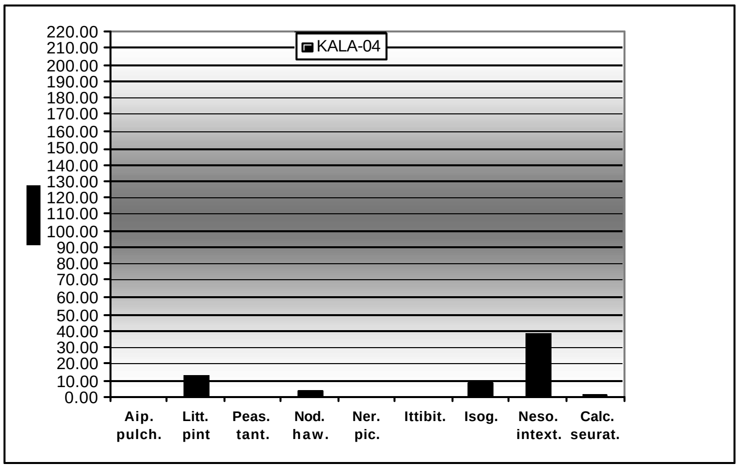
Site 24 - Lighthouse		Species															
Interval (m)	Habitat	Ner. pic.	Lit. pint.	Nod. haw.	Peas. tant.	Melamp.	Cell. exart	Cell. sand.	Calc. serat.	Pachy.	Cyclo.	Grap.	Sesarm.	Nes. intext.	Colobo.	Echino.	Zoanth.
0-5	ba/tp																
5-10	ba/tp																
10-15	ba/tp																
15-20	ba/tp																
20-25	ba/tp																
25-30	ba/tp																
30-35	ba/tp																
35-40	ba/tp																
40-45	ba																
45-50	ba																

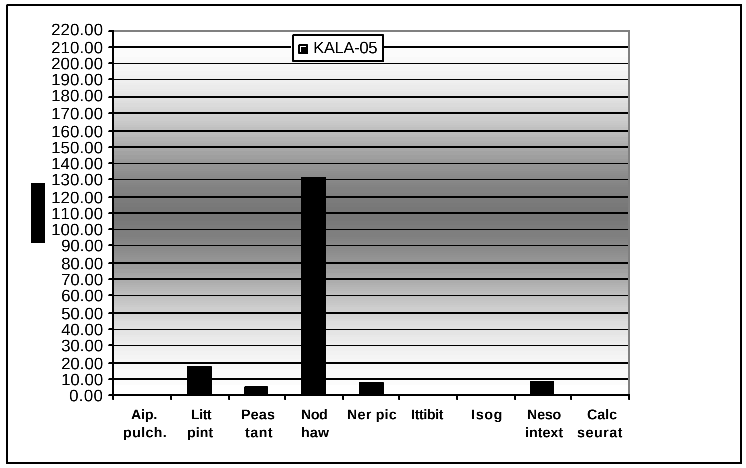
Site 25 - Old Lady's Cave		Species															
Interval (m)	Habitat	Ner. pic.	Lit. pint.	Nod. haw.	Peas. tant.	Melamp.	Cell. exart	Cell. sand.	Calc. serat.	Pachy.	Cyclo.	Grap.	Sesarm.	Nes. intext.	Colobo.	Echino.	Zoanth.
0-5	ba/tp																
5-10	ba/tp																
10-15	ba/tp																
15-20	ba/tp																
20-25	ba/tp																
25-30	ba/tp																
30-35	ba/tp																
35-40	ba/tp																
40-45	ba/tp																
45-50	ba/bo																

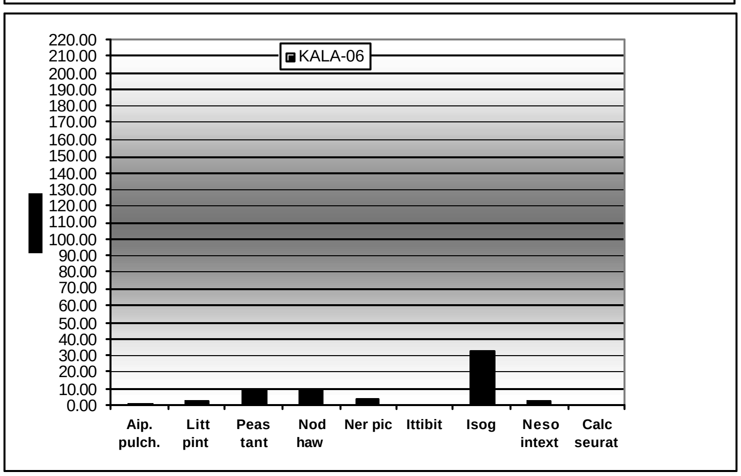
Table 1.4. Species distributions for KALA-23, KALA-24, and KALA-25

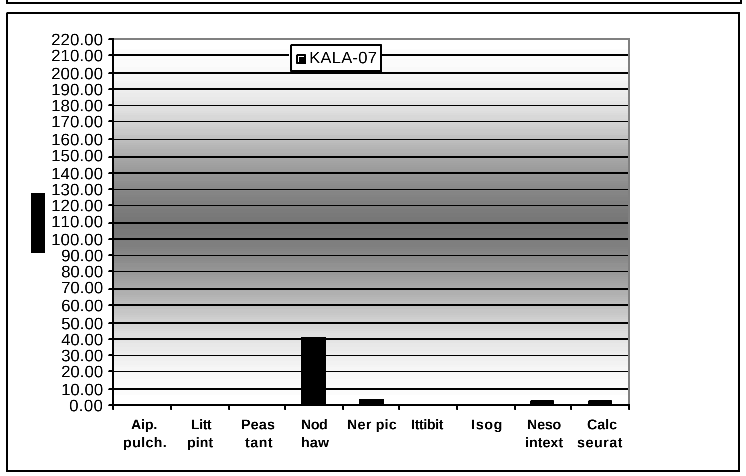
Species Abundance

The relative abundance of organisms enumerated during quantitative surveys will be reported in this section. As with any transect/quadrat methodology, the full suite of organisms present at any site is not fully represented. The species picked up by the transect enumeration should be considered a subset of representative fauna associated with intertidal habitats of the Kalaupapa Peninsula. The list of species reported in this section represents sessile and mobile fauna enumerated at two or more quantitative survey sites. Obviously, very active mobile fauna such as grapsid shore crabs are not included due to the inability to include them in quadrats.



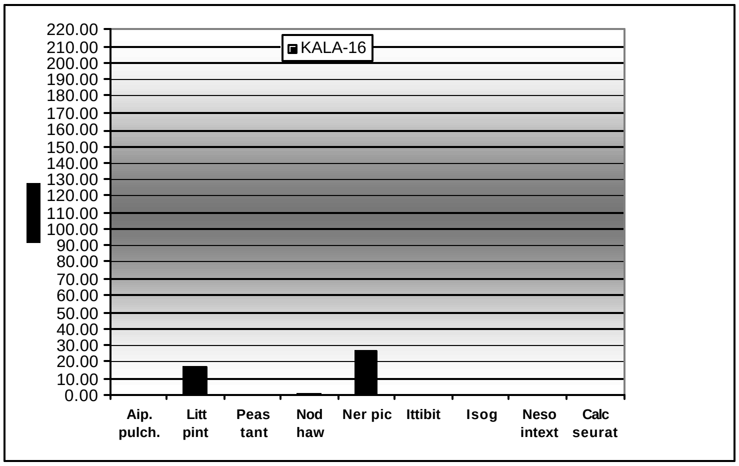


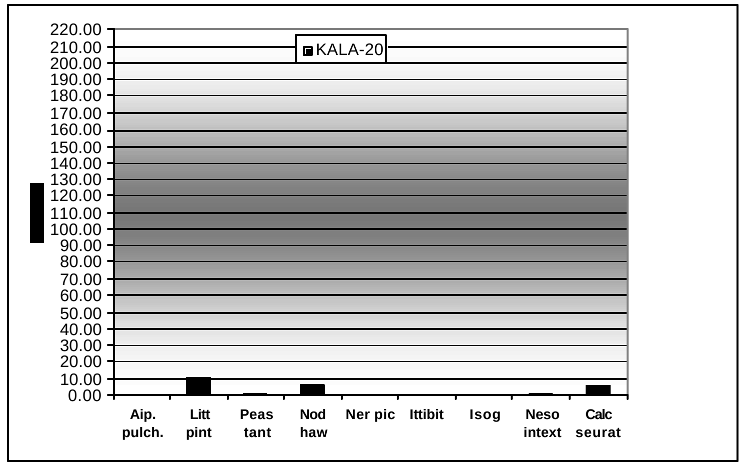


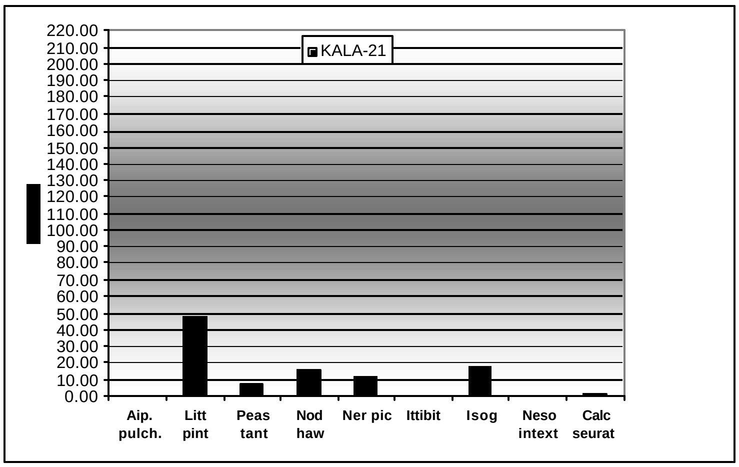


	KALA-04	KALA-05	KALA-06	KALA-07
Aip. pulch.	0.00	0.00	0.40	0.00
Litt. pint	13.13	17.81	2.20	0.00
Peas. tant.	0.00	5.42	9.80	0.00
Nod. haw.	4.10	131.61	9.00	40.73
Ner. pic.	0.21	8.00	4.00	2.91
Ittibit.	0.00	0.00	0.00	0.00
Isog.	8.62	0.00	32.60	0.00
Neso. intext.	38.56	8.26	2.20	2.18
Calc. seurat.	1.23	0.52	0.00	2.18

Table 1.5. Relative abundance of taxa (Avg#/m^2) for KALA-04, KALA-05, KALA-06 and KALA-07

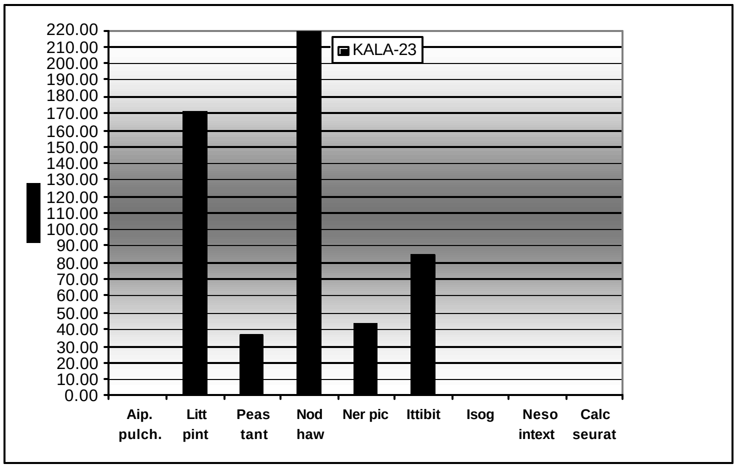


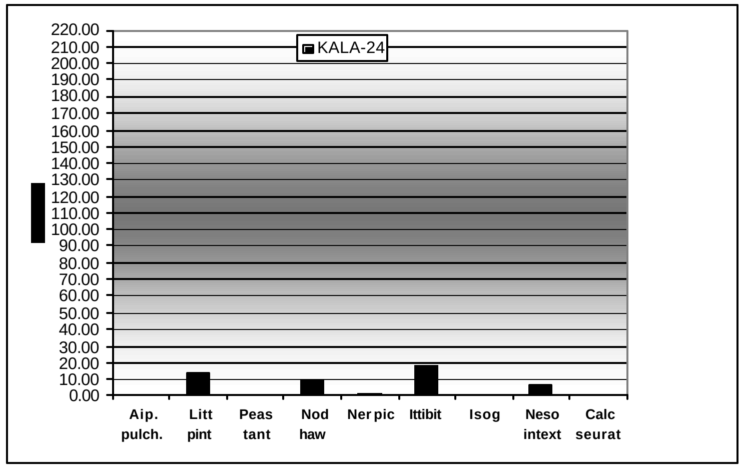


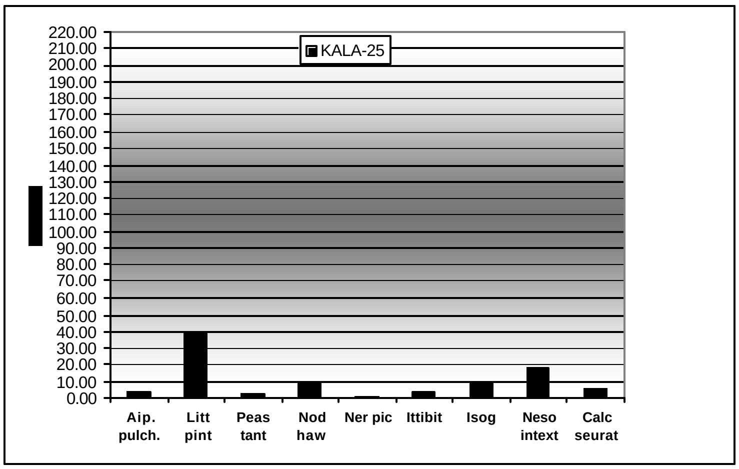


	KALA-16	KALA-20	KALA-21
Aip. pulch.	0.00	0.00	0.00
Litt. pint	17.00	10.56	48.00
Peas. tant.	0.00	0.64	8.00
Nod. haw.	1.00	6.08	16.00
Ner. pic.	27.00	0.00	11.29
Ittibit.	0.00	0.00	0.00
Isog.	0.00	0.00	17.88
Neso. intext.	0.00	0.96	0.00
Calc. seurat.	0.00	5.44	1.88

Table 1.6. Relative abundance of taxa (Avg#/m^2) for KALA-16, KALA-20, and KALA-21







	KALA-23	KALA-24	KALA-25
Aip. pulch.	0.00	0.00	3.52
Litt. pint	170.77	13.76	39.36
Peas. tant.	36.42	0.64	2.24
Nod. haw.	219.52	9.92	10.24
Ner. pic.	43.53	1.28	0.64
Ittibit.	85.11	18.56	3.52
Isog.	0.00	0.64	8.96
Neso. intext.	0.00	7.04	18.56
Calc. seurat.	0.00	0.32	5.44

Table 1.7. Relative abundance of taxa (Avg#/m^2) for KALA-23, KALA-24, and KALA-25

next page ->