Inventory & Monitoring Program
National Park Service
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PACIFIC ISLAND NETWORK

Section 2: Marine Invertebrates

A Preliminary Survey of the Marine and Intertidal Invertebrates of Kalaupapa National Historical Park (Molokai, Hawaii)

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Executive Summary

Preliminary surveys of marine and intertidal invertebrates were conducted between August 15-20, 2003 at Kalaupapa NHP. This report documents 293 species records, of which 222 are new park records. Because of inclement weather and limitations associated with the techniques employed, this value is believed to represent <33% of the park's actual marine and intertidal invertebrate fauna, which is estimated to be between 1000-1500 species. Kalaupapa's invertebrate fauna is generally typical of other nearshore Hawaiian reefs; it varies from other Hawaiian reefs in the main islands in that it is not heavily exploited by humans. Kalaupapa has exceptional examples of exposed, basalt shoreline, intertidal communities and submerged boulder communities.

Introduction

The legislated boundary of Kalaupapa National Historical Park includes 1093 hectares (2700 acres) of shallow nearshore marine waters. These waters, located along 26.4 km of the north coast of the island of Molokai, are exposed to high wave action for much of the year, resulting in poor coral reef formation. Much of the marine substrate is comprise of large basalt boulders/benches covered with isolated coral heads and interspersed with patches of sand. Some reef development is found along the western side of the Kalaupapa Peninsula, where the land blocks swells and waves generated by tradewinds.

Because of the park's isolation from a large population source and the enforcement of the resident Hansen's disease patient (patients) rules, the marine resources are not exploited. The patients developed and the National Park Service enforces a strict set of rules for visitors and for the use of natural resources. Visitors of residents may only fish with poles. They are not to take opihi. Visitors may not take any marine life on behalf of patient and employee residents or exercise their privileges. In order to protect marine life, residents may not have more than six visitors at one time. Any violations of the Kalaupapa fishing policy or State of Hawaii fish and game laws will result in the visitor being declared unwelcomed and banned from future visits to Kalaupapa. Relative to fishing pressure elsewhere in Hawaii, there are only a few of Kalaupapa's permanent residents that routinely harvest marine resources for themselves, patients, and kokua (helpers of the patients). The exportation of marine resources is discouraged. Harvesting for commercial purposed is not allowed within the park. For this reason, the marine resources within the park are expected to be abundant, diverse and to contain individuals of large size. This nearshore marine community may be one of the few in the Main Hawaiian Islands that has not been significantly altered by human activity.

Until recently, the marine resources within Kalaupapa NHP have received little attention from the National Park Service (NPS) and have not been adequately inventoried. Since 2000, the NPS has embarked upon an ambitious program to inventory the natural resources within parks. This report documents a preliminary inventory of the marine and intertidal invertebrates of Kalaupapa NHP conducted August 15-20, 2003, with additional intertidal work completed in the summer of 2004. It is intended to be a first step in meeting the agency's goal of obtaining a comprehensive inventory (90% of the species) of the natural resources within the park.

Site Descriptions

A total of 14 sites around Kalaupapa peninsula were surveyed for this report (Figure 1). The six sites surveyed using SCUBA were restricted to the more sheltered western side of peninsula. Corresponding intertidal sites were also surveyed for many of the dive sites. Additional intertidal surveys were made, including four sites on the exposed eastern side of the peninsula (Ka Leamau, Lae Hoolehua, Mormon Pond/Church Pasture and Kauwo). General site information, including GPS locations, survey methods and dates visited, has been summarized in Appendix 1. Detailed habitat descriptions for each site are provided below. Photos of the survey sites are available in Appendix 5.

Piko'one Bench (Photo 1)

The habitat at this site consists of a low bench surrounded by large boulder areas on either side. The bench extends outward approximately 30 m from the vegetation line and is wave washed at high tide. Shallow tide pools are found throughout. Transect 4 is located directly on this low bench. When visited in the fall of 2003, this area had had been inundated with sand, filling the tidepools. By the spring of 2004, the sand had been flushed out. The boulder areas surrounding this bench extend no more than 10 meters from the vegetation line. Transect 4L is located in a small boulder field just south of the low bench.

Piko'one (Photo 2)

Divers entered the water off the old Slaughterhouse and swam along the reef edge that extends in a north-south direction along the west side of Kalaupapa peninsula. To the north of this site (i.e. Carpenter Beach), the reef edge was better developed. At this site, along southwestern section of the peninsula, the reef edge formation and the 10 m terrace disintegrate, leaving a meandering 3 m undercut ledge, fissured with narrow crevices. The reef flat, about 3 m deep at this site, was filled with large deep holes along its margin. Instead of a rocky terrace at 10 m, the ledge abutted an expansive sand flat at about 8-10 m.

Puwah Bench (Photo 3)

This portion of coastline also varies between bench and boulder sections. Transects are located due west of the Kalaupapa Natural Resource Division Offices. Transect 5 is located in the section of coastline that contains boulders with an average diameter of approximately 0.5 m. The transect runs through a large (2 m diameter) boulder that sits out of the water on calm days. Transect 5L is located on a low bench just north of the boulders. The bench has a large tide pool in its center. Smaller tide pools are scattered throughout the area. The bench itself has an even lower ledge along its perimeter that is exposed only at low tide.

Puwah (Photo 4)

This survey site was approximately 100 m off the Natural Resources Management building. Near the reef edge, this site was similar to Carpenter Beach, but with more topographic relief. Where Carpenter Beach was a single mostly linear wall, Puwah was not linear and had cuts into the wall and also had several "mesa" like features extending up from the 10 m terrace. Detailed geological features were evident; several lava flows formed squared off, box like boulders and the separate lava layers were visible. Away from the wall, the bottom gently sloped to about 14 m. Boulders lined the slope, creating a fairly heterogeneous landscape eventually giving way to an extensive sand flat between 13-15 m. Sand was fine grained and had many "snail trails" in it, but most trains were old and turned up few live specimens. However, the presence of extensive trails suggests an abundant sand fauna.

Carpenter Bench (Photo 5)

This tidepool survey was made directly adjacent to Carpenter Beach and was inshore of the Carpenter Beach dive site. Tidepools were located on a low basalt bench extending approximately 75 m out from shore. The pools were poorly developed and were present predominately at the seaward edge of the bench. Ocean conditions were calm, but the tide was not ideal for this work and limited the effectiveness of the visual surveys.

Carpenter (Photos 6 and 7)

This dive site was located directly off Carpenter Beach. Divers entered the ocean through a cut in the basalt boulders lining the beach of a small cove, and, once in the water, headed out a shallow channel until the water was approximate 3 m deep. The bottom was composed predominately of encrusted basalt boulders. A submerged reef edge existed about 25 meters off shore and drop quickly from 5 meters to 10 meters to a terrace that extended out from shore. The terrace as comprised primarily of basalt substrate colonized by sporadic heads of Pocillopora meandrina and Porites lobata.

Carpenter North (Photo 8)

This survey dive originated at the buoy off Carpenter Point. While situated only a 0.25 to 0.5 kilometer north of the Carpenter survey site, this site varied from the previous in that it had no defined reef edge. The 5 m reef flat gave way to a boulder field that gently sloped to approximately 15 m. The field continued to slope deeper but this dive was restricted to 15 m depth. Boulders were large (SUV-sized) and jumbled, creating pockets and small "caves" that trapped sand and cobble. Fish were extremely abundant and large. Pocillopora meandrina dominated the substratum.

Papaloa (Photo 9)

In shallow water, this site was very similar to Ka Laemilo, but with more relief; some holes in the reef top were 2 m deep. The first half of the survey dive was spent in approximately 5 m of water. Eventually reaching the reef edge, divers descended to 10 m. The deeper area of this site was similar to Carpenter Beach. The terrace at 10 m had good relief with many boulder outcrops. Boulders had numerous Pocillopora colonies on them. Like Ka Laemilo, three species of Pocillopora (P. meandrina complex, P. damicornis and P. edouxi) were present as well as Porites lobata and P. flabbalata.

Ka Laemilo Point (Photo 10)

This survey dive started about 100 m north of the shipwreck in 5 m of water. Divers swam south to the wreck before turning in toward shore. The bottom was basalt, had relatively low relief and was encrusted with Pocillopora colonies. Turf algae and other assorted fuzz covered much of the substrate. Tunicates and sponges were also common under rocks, more so that at Carpenter Beach. Up to three species of Pocillopora (perhaps P. meandrina complex, P. damicornis and P. edouxi) are believed to be present. Porites lobata, and P. flabbalata were also observed at this site.

Kahili (Photo 11)

Little time was spent at this site because the tidal conditions were not ideal for survey work. This site, comprised of a basalt bench scattered with numerous small boulders, had poorly developed tide pools. At the time of the survey, most pools were submerged and unsurveyable. The primary reason for visiting this site was because the Kalaupapa Natural Resources staff had collected what appears to be specimen of Cellana melanostoma at this location. This limpet species is generally restricted to the Northwest Hawaiian Islands, and is rarely found in the main eight.

Lae Hoolehua (Photo 12)

This site had extensive well-developed tide pools formed along a basalt bench covered with small boulders. Tidal and weather conditions were not ideal for surveying this area and only a few beach-washed specimens were collected from this site.

Ka Leamau (Photo 13)

This area is a large mid-level basalt bench that drops along its seaward edge to a low bench. This bench, covered with Turbinaria algae is exposed during low tides on calm days. Transect 7 was situated such that its start point was atop the mid-level bench and descended the "wall" to the low bench. The wall was covered with cracks that sheltered intertidal organisms.

Mormon Pond to Church Pasture (Photo 14)

This stretch of Kalaupapa coastline is a low- to mid-level basalt bench with well-developed tidepools. The bench was up to 100m wide and bordered an exposed shoreline. Pools ranged in size from small to extensive and varied in water exchange, depth, and invertebrate species composition. Some pools were hypersaline, containing visible salt crystals along the perimeter and on the bottom. Pools varied in their percent cover and species of algae. Surf was high, restricting access to the seaward pools and bench edge.

Kauwo (Photo 15)

This area is a cobble beach located just east of Waileia Valley, with stones varying in size from 0.5 to 1 m in diameter. During times of high surf, these cobbles appear to move, and have formed a large "berm" near the landward edge of the beach. This beach receives heavy tradewind swell that compromised the surveying of the lower intertidal section of the transect.

Methodology

Review of Park Inventories

On August 20, 2003 time was spent reviewing staff inventories and doing spot walks along the coast and examining beach drift. The park inventory, compiled by the park's Natural Resources Staff, was reviewed to ascertain its accuracy. A checklist and a photo database were examined. With few exceptions, the inventory appeared accurate and is included in this report for completeness.

Taxonomic References

A variety of resources were used to assist with identifications. While numerous specialized resources were used, three works specific to Hawaii were particular useful for identifying the common marine macro-invertebrates; these included: Hoover (1998), Kay (1979), and Eldredge and Delany (1977). A complete list of references used to identify invertebrates is included at the end of this report.

Subtidal Surveys

Weather conditions restricted all in-water surveys to the western side of Kalaupapa Peninsula, where conditions were safe enough to allow diving and snorkeling. High surf and the lack of safe shore entry and exit points precluded any in-water survey work east of Ka Laemilo (Figure 1). While the intertidal zone was accessible along the entire coastline, this work was restricted to the Peninsula itself; the coastline east of Kalaupapa Peninsula was too isolated to allow for surveys within the short time frame of this project. All in-water surveys were conducted on SCUBA or by snorkel.

SCUBA surveys were conducted at the following sites: Piko'one, Puwah, Carpenter, Carpenter North, Papaloa Beach, and Ka Laemilo (Figure 1). For SCUBA surveys, two divers descended to the target depth and proceeded along the reef margin searching for macro-invertebrates. Invertebrates were field identified when possible. If a positive field identification was not possible, a specimen was collected and returned to the lab for further investigation. If a positive identification was obtained in the lab, the specimen was returned to the ocean alive. Specimens that could not be positively identified in the field or laboratory were preserved using 75% isopropyl alcohol. On each survey dive, rubble and sand samples were collected when available.

Rubble was collected in a bag made of 200 µm plankton mesh and returned to the lab. Rubble was placed in a freshwater bath to dislodge organisms from the rock. Most dislodged organisms sank to the bottom of the bucket. The rubble was then removed from the water, broken apart with a hammer and chisel and visually inspected for any burrowing animals or animals still attached to the substrate surface. Rubble pieces were then rinsed with a hose. All water used for rinsing was passed through a 0.5 mm sieve to collected organism. The rubble wash was preserved with 75% isopropyl alcohol and sent to Bernice P. Bishop Museum for further analysis.

Sand samples were collected by hand and placed in resealable bags. Sand samples were taken at the following three sites: Carpenter, Carpenter North, and Papaloa Beach. At Papaloa Beach, two samples were taken, one at 5 m depth on the reef flat near the reef edge, a second at 10 m from between two large boulders that formed a small "cave." This second sample was taken to search for a suite of micromollusks that frequent cave-like locations in Hawaii. Sand was air-dried and all micromollusks were removed from a 15 cm3 sub-sample using forceps and a dissecting microscope. Species were identified to the lowest possible taxonomic level.

Intertidal Surveys

Intertidal species inventories were conducted using visual surveys at Carpenter Bench, Kahili, Lae Hoolehua, and Mormon Pond/Church Pasture (Figure 1). Tidepools and benches were searched, and ocean conditions permitting, the lower intertidal (characterized by pink crustose coralline algae) was examined. Cobble in tidepools was rolled to search for cryptic animals. All species not identifiable in the field were returned to the lab. If a positive identification was obtained, the specimen was returned to the intertidal alive. Specimens that could not be identified in the field or laboratory were preserved using 75% isopropyl alcohol and were left at the park for future analysis by taxonomic experts.

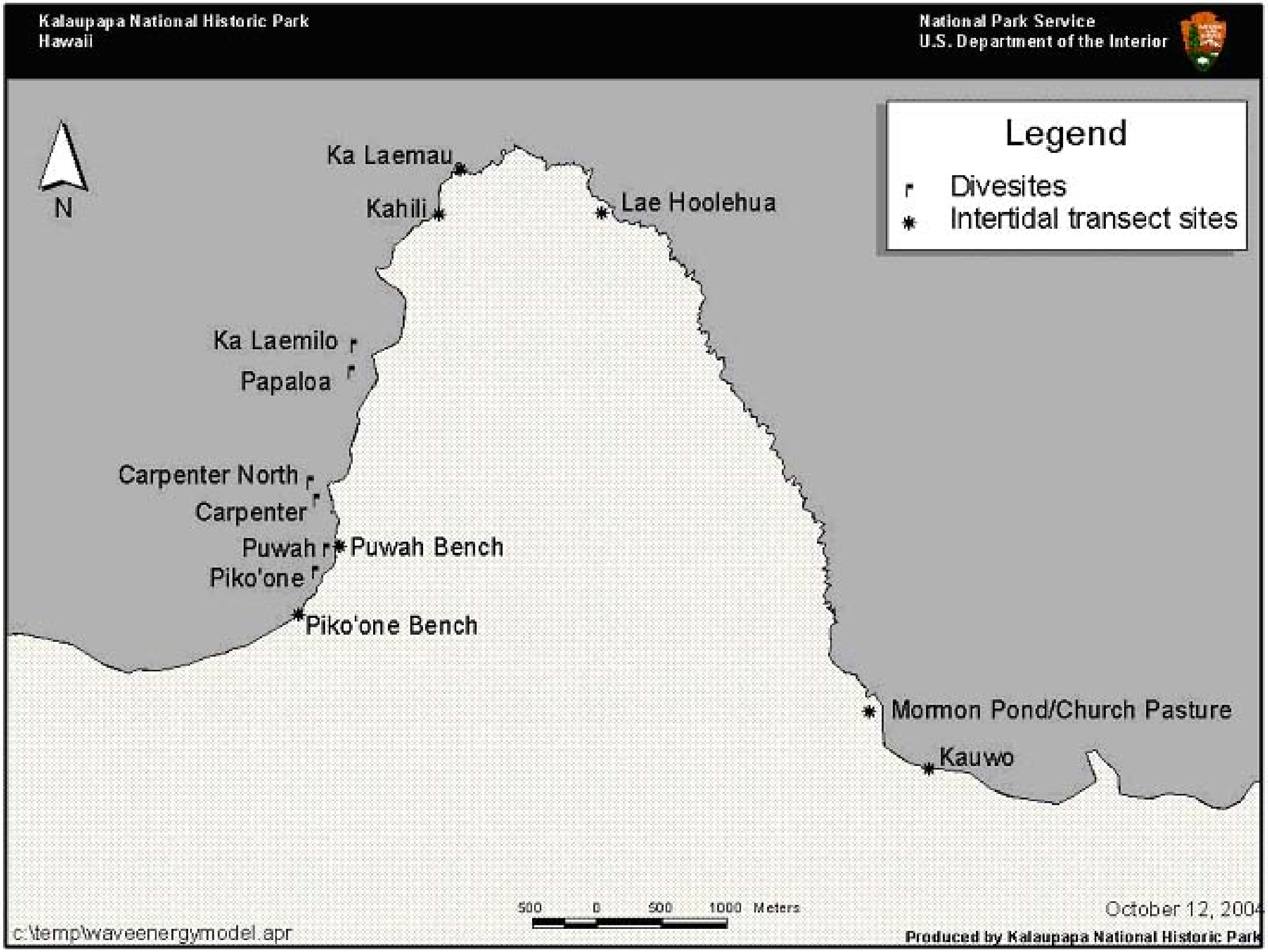

Figure 1. Sites surveyed for the preliminary marine and intertidal invertebrate inventory at Kalaupapa NHP.

Belt transects were conducted at six locations along the shore to obtain baseline quantitative data on intertidal invertebrate densities (Figure 1). Using ArcView GIS 3.2, the park coastline was divided into 18 equivalent sections. Within each of these sections, two points were placed using a random number table. The first point was considered the permanent plot location, while the second was placed as an alternate in the event that the primary site could not be safely surveyed. All points were overlaid on aerial photos that were used in the field to navigate to the location. Once in the field, the area was assessed for safety and a workable zone was measured with a meter tape parallel to shore. A random number was utilized to determine the placement of a permanent marker along the tape, and the start of the transect. From this marker, a 0.6 m wide belt was surveyed perpendicular to shore. Data collection started from the top of the spray zone at the first littorinid individual encountered and continued towards the water, ending when data collection was compromised by surf. Measurements were taken from the permanent marker to the start of the transect, the start of the coralline algal zone, and the end of the transect. Straight length of the transect and its rugosity were also taken. Straight length was measure by pulling the tape taut to measure the linear distance traversed. The tape was then laid flush the substrate and measured. A rugosity index was calculated by dividing the measurement made flush to the substrate by the straight length measurement. Each invertebrate species falling within the belt was identified to the lowest possible taxonomic level and counted. Transects were usually measured around a morning low tide. To date, six transects in four of the eighteen shore segments have been complete, including Piko’one Bench, Puwah Bench, Ka Leamau, and Kauwo.

Limitations of the Survey Methodology

This preliminary inventory was designed to be a rapid assessment of the marine and intertidal invertebrates within the park, and, as such, focused primarily on common macro-invertebrates. While collections were made for more in-depth analysis, many invertebrate groups require specialized taxonomic knowledge to identify and were beyond the scope of this limited project. Other groups of conspicuous macro-invertebrates are poorly studied and present significant taxonomic challenges. These have been treated in a very cursory manner in this report. These include groups such as Porifiera (sponges) Urochordata (tunicates), and Platyhelminthes (flatworms), among others.

Micro-invertebrates, or animals under approximately 1 cm in size, are poorly represented in this inventory yet comprise a very significant proportion of the invertebrate community. These small species probably represent ¾ or more of all Hawaiian invertebrate species. This report does contain a significant number of micro-mollusks collected and identified from sand samples.

The survey methodology is also biased towards slow moving and/or sessile animals, non-cryptic species, diurnal species, and species found on hard substrate. Fast moving animals, such as many crustacean species, were difficult to collect or rarely observed. Species identification often relied on finding dead animals or carapaces from which identifications were made. Different, more invasive methods will be required to adequately inventory these species. For obvious reasons, cryptic species are also under represented in this inventory. Many invertebrates are nocturnal, and surveys conducted during the day seldom encounter these species as they retreat into crevices or sand and cannot be observed or collected. While no quantitative assessment has been done in Hawaiian waters, nocturnal surveys conducted in Guam found twice the number of species compared to diurnal surveys using comparable methods (Minton 1993). Finally, while some soft bottom habitats were investigated in this survey, relatively little time was spent in this habitat and no collections were made for infauna. Some groups (e.g. annelids, sipunclids, etc.) are found almost exclusively within the soft bottom habitat and are therefore poorly represented in this study.

Results

Prior to this survey, previous researchers and park staff identified 71 species of invertebrates, the majority of which were intertidal or tide pool animals. This survey identified an additional 222 species, bringing the current marine invertebrate inventory of Kalaupapa NHP to 293 species (Appendix 2 & 3).

Marine mollusks represented the most speciose group: 189 species (63.9% of the total). This result is not surprising considering the group's well-know systematics, the taxonomic bias of the authors, and the design of the survey methods, which favored slow moving and/or sessile animals. Thirty-seven (12.5%) species of crustaceans and 27 species (9.1%) of echinoderms are also now documented from the park.

While a few groups have had significant progress made in their inventories, most invertebrate groups are still poorly known from the park waters (Table 1). Of the sixteen major groups of invertebrates, it is our opinion that only two of these groups, mollusks and echinoderms, have received more than a cursory examination. For twelve of the sixteen groups, it is estimated that <5% of the species occurring within the park have been identified and no group meets the NPS goal of >90% documented. Given the limited spatial, temporal, and methodological scope of this work, it is estimated that the park contains anywhere from 1000-1500 species of invertebrates and this survey accounts for <33% of this expected invertebrate fauna.

The six intertidal transect lines surveyed a variety of shoreline habitat types (Table 2.). While all transects were conducted on hard substratum, habitat types included boulder and low basalt benches with rugosity varying between nearly flat (1.07) to rugose (4.68). At sites where multiple transects were surveyed, differences in habitat and rugosity were noted, showing high heterogeneity in the geophysical coastal features over a relatively spatial small scale (<35 m).

Twenty-one invertebrate taxa were noted along the six intertidal transects (Table 3 and Appendix 4). Nerita picea was the most common invertebrate, appearing on every transect but one (Transect 7). Also common on the transects were two species of opihi (*Cellana exerata* and *C. sandwicensis*) and an unidentified sea anemone.

Table 1. Total records, new records for this survey, and an estimation of the percent of the inventory completed with this survey for 16 of the major invertebrate taxon.

Taxon	Total Records	New records	Estimated % Complete[1]
Porifera	10	9	2
Placazoa	0	-	1
Cnidarian	19	13	2
Ctenophora	0	-	1
Platyhelminthes	2	2	1
Nemertea	0	-	1
Mollusca	188	153	2-3
Annelida	4	3	1
Sipuncula	0	-	1
Echiura	0	-	1
Arthropoda	37	24	1-2
Brachiopoda	0	-	1
Bryozoa	3	3	1
Hemicordata	0	-	1
Echinodermata	27	12	2-3
Urochordata	3	3	1
Total	293	222	2

[1]Categories: 1=(<5%); 2=5-33%; 3=33-66%; 4=67-95%; 5=(>95%)

Table 2. Characteristics of six intertidal transect lines surveyed for invertebrates.

Site Name	Transect		Length (m)	Area (m^2)	Rugosity	Habitat Description
Piko'one	4	Upper	12.7	7.62	1.07	Low bench
		Lower[1]	-	-	-	-
Piko'one	4L	Upper	4.4	2.64	1.17	Large boulders
		Lower[1]	-	-	-	-
Puwah Bench	5	Upper	1.7	1.02	1.52	Mixed boulders
		Lower	3.8	2.28	1.39	Mixed boulders
Puwah Bench	5L	Upper	0.6	0.37	4.68	Low bench
		Lower	4.7	2.81	1.25	Low bench
Ka Lea Mau	7	Upper	1.5	0.9	2.93	Low bench
		Lower[1]	-	-	-	-
Kauwo	17	Upper	2.6	1.56	-[2]	Small boulders
		Lower[1]	-	-	-	-

[1]Section of transect could not be surveyed because of safety concerns.
[2]Rugosity was not measured on this transect.

Table 3. Invertebrate densities (individuals/m2) along six transects at four locations along the shore of Kalaupapa NHP. Densities were calculated by diving the total number of individuals along the transect (Appendix 2) by the area surveyed.

Transect		Sea anemone	Zoanthid	*Cellana exerata*	*Cellana sandwicensis*	*Cellana talcosa*	*Nerita picea*	*Littoraria pintado*[1]	*Serpulorbis variabilis*	*Drupa sp.*	*Drupa morum*	*Drupa racina*	*Morula granulata*	*Isognomon californicum*	*Nesochthamalus intertextus*	*Calcinius laevimanus*	Unidentified crab	*Grapsus tennicrustatus*	*Colobocentrotus atratus*	*Echinometra oblonga*	*Actinopyga mauritiana*	Unidentified drill
Upper	4	0.7	0.1	-	-	-	0.5	3.3	0.7	-	-	0.3	0.1	2.2	17.1	0.9	0.26	0.13	-	-	-	-
	4L	23.1	-	8.3	1.5	-	7.6	-	-	-	-	-	-	0.4	0.4	-	-	-	-	-	-	1.9
	5	-	-	4.9	-	2.0	196.1	-	1.0	-	-	-	-	-	-	-	-	-	3.0	-	-	-
	5L	2.7	-	37.6	-	-	150.5	-	-	-	-	5.4	-	-	-	13.4	-	-	-	-	-	-
	7	-	-	-	3.3	-	-	55.6	-	-	-	-	-	-	-	-	-	-	1.1	1.1	-	-
	17	-	-	-	-	-	5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	-	-	2.2	9.7	3.1	-	-	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-
	5L	-	-	-	2.1	0.7	-	-	-	0.4	0.4	2.5	-	-	-	-	-	-	-	7.8	0.4	-
	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1]may include some individuals of *Nodilittorina hawaiensis*.

Distributions of the invertebrates across the transects was highly variable. No species occurred on every transect and only five (an unidentified sea anemone, *Cellana exerata*, *C. sandwicensis*, *Nerita picea*, and *Drupa racina*) occurred on three or more transects. While the data is limited, densities of invertebrates appears higher on the upper sections of transects than on lower section and there is also a suggestion of species zonation. More data is needed to confirm this observation.

Discussion

Marine waters around Kalaupapa do not contain classic reefs found along the leeward coastlines of Hawai‘i, but rather reef communities. The substrate is primarily basalt lava flows dotted with coral colonies. Most of the coastline is exposed to seasonal periods of high wave energy, causing substrate scouring and retarding reef development. Regardless, the high rugosity of the bottom promotes a diverse assemblage of coral reef animals. Populations appear to be healthy and intact.

Because of inclement weather, these in-water surveys were confined to the leeward side of Kalaupapa Peninsula, an area of relatively homogenous habitat. The eastern side of the peninsula and the eastern cliffs are certain to contain different habitat types and a different suite of invertebrate species. Any surveys conducted in the future must focus more effort in this area to adequately survey the park’s marine invertebrate fauna.

Kalaupapa contains exceptional examples of intertidal habitat and associated invertebrates. Hawaiian opihi are numerous and large, among the largest observed in the main eight Hawaiian Islands. Both high densities and large individual size are probably related to the lack of an intense fishery within the park. Currently, only residents are legally allowed to collect opihi at Kalaupapa. It appears that the park may also have all four endemic opihi species. This is particularly unusual as *Cellana melanostoma* is generally restricted to the Northwest Hawaiian Islands (Kay 1979). Specimens of *C. melanostoma* were colleted by park staff at Kahili and Kukaiwa’a and sent to Bishop Museum and the University of Hawai‘i for taxonomic confirmation. Based on shell characteristics, the specimen appears to be *C. melanostoma* (R. Kawamoto, pers. comm.), but genetic research on the specimen has raised doubts. The specimen may be an individual *C. exerata* with an unusual shell morphology (C. Bird, pers. comm.). According to Kay (1979), this species is occasionally observed on Kauai, so its potential presence at Kalaupapa is unusual and noteworthy, but not improbable.

Kalaupapa appears to have few introduced species. The introduced barnacle, *Chthalamous proteus* was not observed in the park and did not appear to be present at the time of this survey (validated by barnacle specialist Dr. John Zardus). The park should be aware of the potential for its introduction via the yearly barge, and efforts should be made to reduce the risk. While the impact of this species is currently under study, it appears that it may outcompete native barnacles and exclude them from the shoreline. *Pennaria disticha,* an introduced hydroid is present and abundant at some locations, particularly in the shallow waters off Piko’one. Though not directly observed during this survey, the park staff has observed *P. disticha* at high density in some of the tidepools at Carpenter Bench.

The impact of this introduced hydroid on the marine and intertidal environments is unclear at present.

While the quantitative intertidal data are relatively sparse, they do suggest some spatial trends. Species richness appears to decline moving around the peninsula from Piko'one to Kauwo. This may be associated with wave exposure. Piko'one and Puwah are sheltered from tradewind swells, receiving significant surf primarily in the winter (Figure 2). Kauwo experiences rough weather year round, but particularly in the winter when tradewinds and winter swell combine to generate surf in excess of 6 m. This surf is sufficient to move the large cobble at Kauwo, which may also play a role in it low species richness. A difference may also exist between boulder and bench habitats. Again, data is limited, but bench habitats appear to have higher species diversity. This is not unexpected; given large enough surf, boulders will roll, crushing organisms. Benches, provided they have adequate rugosity, provide a stable, substrate in heavy surf.

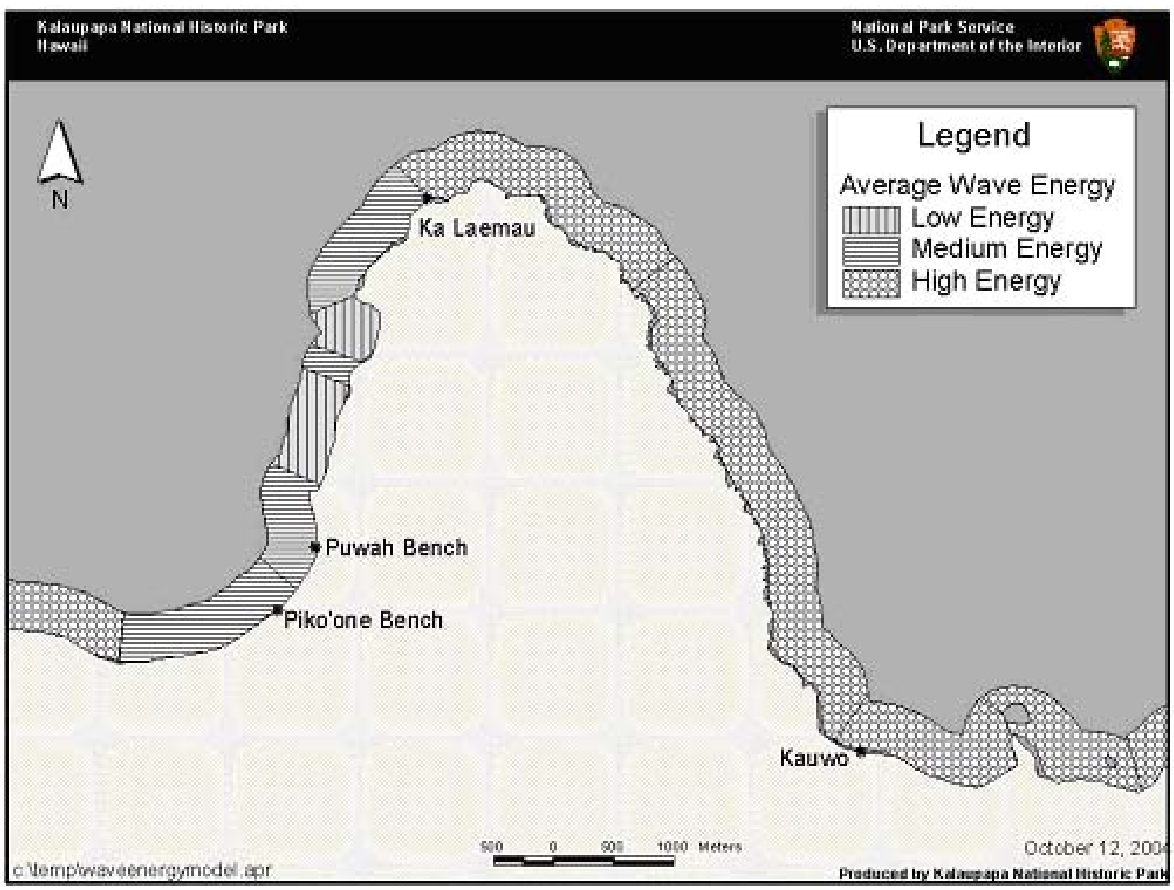

Figure 2. Wave energy along the Kalaupapa coast. Adapted from data collected by Bill Eichenlaub for Kalaupapa NHP.

Future Work

This project represents a preliminary survey of Kalaupapa's marine and intertidal invertebrate fauna and its limited scope leaves considerable work still to be completed. Recommended work for future surveys includes:

- Rapid assessments (comparable to this work) of the eastern side of Kalaupapa peninsula and coast, including sediment, rubble, and algae wash collections.
- Analysis of rubble samples collected during this survey and sent to Bernice P. Bishop Museum.
- A thorough inventory of lower intertidal areas and an intensive survey of the park's exceptional tidepools.
- Targeted surveys for specific taxonomic groups, specifically the worm phyla and arthropods.
- Nocturnal surveys. If in-water work is not possible, small traps should be placed out over night to capture mobile crustaceans and nocturnal mollusks.

Acknowledgements

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Appendix 1. Site name (transect number), coordinates (UTM), survey methodology, and survey date for all sites visited.

Site Name	X_coord	Y_coord	Survey Method	Survey Date
Piko'one Bench (4L)	708511.06686	23443459.51102	Transects	6-23-04
Piko'one Bench (4)	708649.19872	2343498.61651	Transects	6-23-04
Piko'one	709051.66171	2344043.41009	SCUBA	8-20-03
Puwah Bench (5)	709239.77468	2344271.49884	Transects	6-23-04
Puwah Bench (5L)	709235.76270	2344297.57673	Transects	6-23-04
Puwah	709135.66094	2344217.63072	SCUBA	8-18-03
Carpenter Bench	709174.58680	2344703.95515	Visual Survey	8-16-03
Carpenter	709060.99495	2344603.40496	SCUBA	8-15-03
Carpenter North	709011.21763	2344730.95935	SCUBA	8-19-03
Papaloa	709325.43698	2345580.28491	SCUBA	8-18-03
Ka Laemilo	709347.21456	2345785.61637	SCUBA	8-18-03
Kahili	710038.45515	2346835.10166	Visual Survey	8-20-03
Ka Leamau (7)	710164.03535	2347146.58642	Transects	7-30-04
Lae Hoolehua	711188.44550	2346789.70731	Visual Survey	8-19-03
Mormon Pond/ Church Pasture	713383.88162	2342974.19321	Visual Survey	8-16-03
Kauwo (17)	713386.15950	2342971.61623	Transects	9-2-04

Appendix 2. Checklist of marine and intertidal invertebrate species present at Kalaupapa NHP. Listing includes all species previously identified by the park Natural Resources staff and new species added through this study. Species marked with an * were collected from sediment samples.

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
1	Annelida	Eurythoe complanata	(Pallas, 1766)	orange fireworm		X	
2	Annelida	Lomia sp.		-			
3	Annelida	Pherecardia striata	(Kinberg, 1857)	lined fireworm		X	
4	Annelida	Spirobranchus giganteus	(Grube, 1862)	christmas tree worm		X	
5	Bryozoan	Bugula sp.		-		X	
6	Bryozoan	Bugula sp. (neritina?)		brown fan bryozoan	Y	X	introduced
7	Bryozoan	Reteporellina denticulata	(Busk, 1884)	lace bryozoan		X	
8	Cnidarian	Aiptasia pulchella	Carlgren, 1943	glass anemone			
9	Cnidarian	Aiptasia sp.1 (pulchella?)		-		X	
10	Cnidarian	Aiptasia sp.2 (pulchella?)		-		X	
11	Cnidarian	Anthopleura nigrescens	(Verrill, 1928)	dusky anemone			
12	Cnidarian	Balanophyllia sp.		-		X	
13	Cnidarian	Carijoa riisei	Duchassaing & Michelotti, 1860	snowflake coral	Y	X	introduced; native of the Carribean/western Atlantic
14	Cnidarian	Cladactella manni	(Verrill, 1899)	Mann's anemone		X	
15	Cnidarian	Montipora capitata	(Dana, 1846)	rice coral		X	endemic to Hawaii
16	Cnidarian	Montipora flabellata	Studer, 1901	blue rice coral		X	probably endemic to Hawaii
17	Cnidarian	Palythoa sp. (cf. caesia)	Dana, 1848	blue-gray zooanthid			
18	Cnidarian	Pennaria disticha	Goldfuss, 1820	christmas tree hydroid	Y		introduced
19	Cnidarian	Pocillopora damicornis	(Linnaeus, 1758)	lace coral		X	
20	Cnidarian	Pocillopora eydouxi	Milne-Edwards & Haime, 1860	antler coral		X	

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
21	Cnidarian	Pocillopora meandrina	Dana, 1846	cauliflower coral		X	
22	Cnidarian	Porites compressa	Dana, 1846	finger coral		X	probably endemic to Hawaii
23	Cnidarian	Porites lobata	Dana, 1846	lobe coral		X	
24	Cnidarian	Protopalythoa spp.		-			
25	Cnidarian	Tubastraea coccinea	Lesson, 1831	colonial cup coral		X	
26	Cnidarian	Zoanthus spp.		-			
27	Crustacean	Alpheus deuteropus	Hilgendorf 1878	petroglyph shrimp			
28	Crustacean	Alpheus paracrinitus	Miers, 1881	orange banded snapping shrimp		X	
29	Crustacean	Calcinus elegans	(H. Milne Edwards, 1836)	elegant hermit crab		X	
30	Crustacean	Calcinus laevimanus	(Randall, 1839)	left-handed hermit crab			=C. herbstii
31	Crustacean	Calcinus laurentae	Haig & McLaughlin, 1983	Laurent's hermit crab		X	known only from Hawaii
32	Crustacean	Calcinus seurati	Forest, 1951	Seurat's hermit crab		X	
33	Crustacean	Calcinus sp. (haigae?)		-		X	
34	Crustacean	Carpilius maculatus	Linnaeus, 1758	seven-eleven crab			
35	Crustacean	Charybdis erythrodactyla	(Lamark, 1818)	rainbow swimming crab		X	
36	Crustacean	Charybdis hawaiiensis	Edmonson, 1954	Hawaiianm swimming crab		X	
37	Crustacean	Ciliopagurus strigatus	(Herbst, 1804)	cone shell hermit crab		X	=Trizopagurus strigatus
38	Crustacean	Cinetorhynchus sp.		-		X	residing in coral heads
39	Crustacean	Clibanarius zerba	(Dana, 1851)	zebra hermit crab		X	
40	Crustacean	Dardanus sanguinocarpus	Degener, 1925	bloody hermit crab		X	
41	Crustacean	Enopometopus occidentalis	(Randall, 1840)	red reef lobster		X	
42	Crustacean	Euraphia hembeli	(Conrad, 1834)	Hembel's rock barnacle			presence confirmed by barnacle taxonimist (Dr. J. Zardus)
43	Crustacean	Grapsis tenuicrustatus	(Herbst, 1783)	thin-shelled rock crab			
44	Crustacean	Haplocarcinus marsupialis	Stimpson, 1859	coral gall crab		X	
45	Crustacean	Lepas anserifera	Linnaeus, 1767	goose barnacle			

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
46	Crustacean	Nesochthamalus intertextus	(Darwin 1854)	purple rock barncle			presence confirmed by barnacle taxonimist (Dr. J. Zardus)
47	Crustacean	Ocypode paalidula	Jacquinot, 1852	pallid ghost crab			
48	Crustacean	Pachygrapsus plicatus	(H. Milne Edwards, 1837)	pleated rock crab		X	
49	Crustacean	Palaemon debilis	(Dana, 1852)	feeble shrimp			
50	Crustacean	Palaemon pacificus	Stimpson, 1860	tiger shrimp			
51	Crustacean	Panulirus marginatus	(Quoy & Gaimard,1825)	banded spiny lobster			endemic to Hawaii
52	Crustacean	Panulirus penicillatus	(Oliver, 1791)	tufted spiny lobster		X	
53	Crustacean	Parribacus antarcticus	(Lund, 1793)	sculptured slipper lobster		X	
54	Crustacean	Percnon planissimum	(Herbst, 1804)	flat rock crab		X	
55	Crustacean	Plagusia depressa tuberculata	(Lamarck, 1818)	scaly rock crab			
56	Crustacean	Pseudocryptochirus kahe	MaCain & Coles, 1979	Kahe Point crab		X	
57	Crustacean	Pylopaguropsis keijii	McLaughlin & Haig, 1989	Keiji's hermit crab		X	
58	Crustacean	Ranina ranina	(Linnaeus, 1788)	kona crab		X	
59	Crustacean	Saron sp.		-		X	green banded legs: Saron neglectus?
60	Crustacean	Stenopus hispidus	(Oliver, 1812)	banded coralshrimp			
61	Crustacean	Trapezia ferrugunea	Latreille, 1823	rusty guard crab		X	
62	Crustacean	Trapezia intermedia	Miers, 1886	common guard crab		X	
63	Crustacean	Xanthid crab		-		X	maybe Pildius areolatus. Specimen in KALA collection
64	Echinodermata	Actinopyga mauritiania	(Quoy & Gaimard,1833)	white-spotted sea cucumber			
65	Echinodermata	Actinopyga obesa	(Selenka, 1867)	plump sea cucumber		X	
66	Echinodermata	Colobocentrotus atratus	(Linnaeus, 1758)	helmet urchin			
67	Echinodermata	Cyrtechinus verruculatus	(Luetken, 1864)	warty sand urchin		X	
68	Echinodermata	Diadema paucispinum	(A. Agassiz, 1863)	long-spined urchin			
69	Echinodermata	Echinometra oblonga	(de Blainville, 1826)	oblong urchin			

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
70	Echinodermata	Echinometra spp. (mathei complex)		rock-boring urchin			recent research has shown this to be a species complex, not a single species
71	Echinodermata	Echinoneus cyclostomus	Leske, 1778	round-mouthed bean urchin		X	
72	Echinodermata	Echinostrephus aciculatus	A. Agassiz, 1863	needle-spined urchin		X	
73	Echinodermata	Echinothrix calamaris	(Pallas, 1774)	banded urchin			
74	Echinodermata	Echinothrix diadema	(Linnaeus, 1758)	blue-black urchin			
75	Echinodermata	Eucidaris metularia	(Lamark, 1816)	ten-lined urchin		X	
76	Echinodermata	Heterocentrotus mammillatus	(Linnaeus, 1758)	red pencil urchin			
77	Echinodermata	Holothuria atra	Jaeger, 1833	black sea cucumber			
78	Echinodermata	Holothuria impatiens	(Forsskål, 1775)	impatient sea cucumber			
79	Echinodermata	Holothuria pervicax	(Selenka, 1867)	stubborn sea cucumber			
80	Echinodermata	Holothuria whitmaei	Bell, 1887	teated sea cucumber		X	
81	Echinodermata	Lapidodemus semperianum	Selenka, 1867	white sea cucumber			
82	Echinodermata	Ophiocoma brevipes	Peters, 1851	reticulated brittle star		X	
83	Echinodermata	Ophiocoma erinaceus	Müller & Troschel, 1842	spiny brittle star			
84	Echinodermata	Ophiocoma pica	Müller & Troschel, 1842	pied brittle star		X	
85	Echinodermata	Ophionereis sp.		-		X	
86	Echinodermata	Opiodesoma spectabilis	Fisher, 1907	conspicuous sea cucumber			likely a misidentification; probably Euapta godeffroyi
87	Echinodermata	Polyplectana kefersteini	(Selenka, 1867)	Kefersteini's sea cucumber		X	
88	Echinodermata	Rhinobrissus sp.		-		X	
89	Echinodermata	Stichopus horrens	Selenka, 1867	warty sea cucumber			
90	Echinodermata	Tripneustes gratella	(Linnaeus, 1758)	collector urchin		X	
91	Mollusca	Alcyna ocellata*	Hickman & McLean, 1990	-		X	=Thalotia ocellata
92	Mollusca	Alcyna subangulata*	Hickman & McLean, 1990	-		X	=Thalotia subangulata
93	Mollusca	Alvinia isolata*	(Laseron, 1956)	-		X	

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
94	Mollusca	Aplysia juliana	Quoy & Gaimard, 1832	Juliana's sea hare			
95	Mollusca	Arca ventricosa	Lamarck, 1818	ventricose ark shell		X	
96	Mollusca	Atys semistriata	Pease, 1860	-		X	
97	Mollusca	Balcis sp.1		-		X	
98	Mollusca	Balcis sp.2*		-		X	
99	Mollusca	Barbatia diveracata	(Sowerby, 1833)	-		X	
100	Mollusca	Berthelina citrina	(Rüppell & Leuckart, 1831)	orange gumdrop		X	
101	Mollusca	Bittium impendens*	(Hedley, 1899)	-		X	
102	Mollusca	Bivalve*		-		X	small, green with red markings.
103	Mollusca	Bursa granularis	(Röding, 1798)	-			
104	Mollusca	Caecum arcuatum*	de Folin, 1867	-		X	found only in Papaloa cave sand sample
105	Mollusca	Caecum glabella*	A. Adams 1868	-		X	
106	Mollusca	Caecum septimentum*	de Folin, 1867	-		X	=C. arcuatum
107	Mollusca	Carinapex minutissima*	(Garrett, 1873)	-		X	
108	Mollusca	Casmaria erinaceus kalosmodix	(Melvill, 1883)	spiked helmet		X	
109	Mollusca	Cellana exerata	(Reeve, 1854)	blackfoot opihi			endemic to Hawaii
110	Mollusca	Cellana melanostoma	(Pilsbry, 1891)	-			endemic to Hawaii; generally restricted to the NWHI
111	Mollusca	Cellana sandwicensis	(Pease, 1861)	yellowfoot opihi			endemic to Hawaii
112	Mollusca	Cellana talcosa	(Gould, 1846)	giant opihi			endemic to Hawaii
113	Mollusca	Cerithidium perparvulum*	(Watson, 1886)	-		X	
114	Mollusca	Cerithium columna	Sowerby, 1834	-		X	
115	Mollusca	Cerithium eqenum	Gould, 1849	-		X	
116	Mollusca	Cerithium nesioticum	Pilsbry & Vanatta, 1905	-		X	
117	Mollusca	Cerithium zebrum	Kiener, 1841	zebra horn		X	
118	Mollusca	Cerithopsis sp. (arga?)*	Kay, 1979	-		X	

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
119	Mollusca	Ceritium echinatum	Houbrick, 1992	prickly horn		X	
120	Mollusca	Chama iostoma	Conrad, 1837	-		X	
121	Mollusca	Cheilea equestris	(Linnaeus, 1758)	-		X	
122	Mollusca	Chlamys coruscans hawaiiensis	Dall, Bartsch & Rehder, 1938	-		X	
123	Mollusca	Chromodoridinae sp.1		-		X	clear with lacy white pattern on top, red rhinophore tips. ~8 mm.
124	Mollusca	Chromodoridinae sp.2		-		X	green gills, white body with brown speckles. ~2-3 mm.
125	Mollusca	Chromodoris sp.		red spotted			
126	Mollusca	Clavis sp.*		-		X	
127	Mollusca	Clio sp.*		-		X	
128	Mollusca	Codakia punctata	(Linnaeus, 1758)	-		X	dead shell in tidepools
129	Mollusca	Collonista candida*	(Pease 1861)	-		X	=Leptothyra candida
130	Mollusca	Conus abbreviatus	Reeve, 1843	abbreviatred cone		X	
131	Mollusca	Conus ebraeus	Linnaeus, 1758	hebrew cone			
132	Mollusca	Conus flavidus	Lamarck, 1810	yellow cone			
133	Mollusca	Conus leapoardus	(Röding, 1798)	leopard cone		X	
134	Mollusca	Conus litoglyphus	Hwass, 1792	-		X	
135	Mollusca	Conus lividus	Hwass, 1792	spiteful cone		X	
136	Mollusca	Conus pennaceus	Born, 1780	penniform cone		X	
137	Mollusca	Conus pulicarus	Hwass, 1792	flea cone		X	
138	Mollusca	Conus rattus	Hwass, 1792	rat cone		X	
139	Mollusca	Conus striatus	Linnaeus, 1758	striated cone		X	
140	Mollusca	Conus textile	Linnaeus, 1758	textile cone		X	
141	Mollusca	Cosa sp. (waikiki?)*		-		X	found only in Papaloa cave sand sample
142	Mollusca	Ctena bella*	(Conrad, 1837)	-		X	
143	Mollusca	Ctena transversa	Dall, Bartsch & Rehder, 1938	-		X	

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
144	Mollusca	Cyclostremicus emeryi*	(Ladd, 1966)	-		X	found only in Papaloa cave sand sample
145	Mollusca	Cylinchna sp. (pusilla?)*	(Pease, 1860)	-		X	found only in Papaloa cave sand sample
146	Mollusca	Cymatium nicobaricum	(Röding, 1798)	nicobar triton		X	
147	Mollusca	Cymatium sp. (intermedia?)		-		X	
148	Mollusca	Cypraea caputerserpentus	Linnaeus, 1758	snakehead cowry			
149	Mollusca	Cypraea fimbriata	Gmelin, 1791	fringed cowry		X	
150	Mollusca	Cypraea helvola	Linnaeus, 1758	honey cowry		X	
151	Mollusca	Cypraea isabella	Linnaeus, 1758	Isabella's cowry		X	
152	Mollusca	Cypraea maculifera	Schilder, 1932	reticulated cowry			
153	Mollusca	Cypraea mauritana	Linnaeus, 1758	humpback cowry			
154	Mollusca	Cypraea sp. (juv)		-		X	crabbed shell
155	Mollusca	Cypraea sulcidentata	Gray, 1824	groove-tooth cowry		X	endemic to Hawaii
156	Mollusca	Cypraea talpa	Linnaeus, 1758	mole cowry			
157	Mollusca	Cypraea tigris	Linnaeus, 1758	tiger cowry			
158	Mollusca	Cysticus huna*	Kay, 1979	-		X	
159	Mollusca	Daphnella sp.*		-		X	
160	Mollusca	Dendrodoris tuberculosa	(Quoy & Gaimard, 1832)	tuberculous nudibranch			
161	Mollusca	Dendropoma platypus	Morch, 1861	-		X	
162	Mollusca	Dendropoma rhyssoconchia	Hadfield and Kay, 1972	-		X	
163	Mollusca	Diala varia*	A. Adams 1861	-		X	
164	Mollusca	Diniatys dentifer*	(A. Adams, 1850)	-		X	
165	Mollusca	Diodora granifera*	(Reeve, 1850)	-		X	
166	Mollusca	Dolabrifera dolabrifera	(Rang, 1828)	common sea hare			
167	Mollusca	Drupa morum	Röding, 1798	mulberry drupe			
168	Mollusca	Drupa racina	(Linnaeus, 1758)	spotted drupe			
169	Mollusca	Drupella elata	Blainville, 1832	-		X	

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
170	Mollusca	Duplicaria gouldi	(Deshayes, 1859)	Gould's auger		X	=Terebra gouldi
171	Mollusca	Eatoniella sp.*		-		X	
172	Mollusca	Ervilia bisculpta*	(Gould, 1861)	-		X	
173	Mollusca	Euchelus gemmetus	(Gould, 1845	-		X	
174	Mollusca	Fragum mundum*	(Reeve, 1845)	-		X	
175	Mollusca	Gastrochaena cuneformis	Spengler, 1783	-		X	
176	Mollusca	Gastropod*		-		X	
177	Mollusca	Gibbula marmorea*	(Pease, 1861)	-		X	
178	Mollusca	Granula sandwicensis*	(Pease, 1860)	-		X	
179	Mollusca	Granulina vitrea*	(Laseron, 1957)	-		X	
180	Mollusca	Haumea juddi	Dall, Bartsch & Rehder, 1938	Judd's scallop		X	
181	Mollusca	Herviera gliriella*	(Melvill an Standen, 1896)	-		X	
182	Mollusca	Hexabranchus sanguineus	(Rüppel & Leuckart, 1831)	spanish dancer			
183	Mollusca	Hipponix australis	Lamarck, 1819	-		X	=Sabia conica
184	Mollusca	Hipponix imbricatus	Gould, 1846	shingly hoof snail		X	
185	Mollusca	Hydratina amplustre	(Linnaeus, 1758)	swollen bubble shell			
186	Mollusca	Isognomon californicum	(Conrad, 1837)			X	
187	Mollusca	Isognomon perna	Linnaeus, 1767	brown purse shell			
188	Mollusca	Ittibittium parcum*	Houbrick, 1993	-		X	=Bittium parcum
189	Mollusca	Ittibittium zebrum	(Kiener, 1841)	-		X	
190	Mollusca	Joculator sp. (ridicula?)*	(Watson, 1886)	-		X	found only in Papaloa cave sand sample
191	Mollusca	Julia exquista*	Gould, 1862	-		X	
192	Mollusca	Kermia sp.*		-		X	
193	Mollusca	Leptothyra rubricincta*	(Mighels, 1845)	-		X	
194	Mollusca	Leptothyra verruca*	(Gould, 1845)	-		X	
195	Mollusca	Lima sp. (juv)*		-		X	

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
196	Mollusca	Littoraria pintado	(Wood, 1828)	dotted periwinkle			=Littorina pintado
197	Mollusca	Lophocochlias minutissimus*	(Pilsbry, 1921)	-		X	
198	Mollusca	Melampus castaneus	(Muhlfeld, 1816)	-			
199	Mollusca	Merelina granulosa*	(Pease, 1862)	-		X	
200	Mollusca	Merelina wanawana*	Kay, 1979	-		X	
201	Mollusca	Miralda paulbartschi*	Pilsbry, 1918	-		X	
202	Mollusca	Mitra luctuosa	A. Adams1853	-		X	
203	Mollusca	Mitra saltata*	Pease, 1865	-		X	
204	Mollusca	Mitra stictica	(Link, 1807)	punctued miter		X	
205	Mollusca	Mitrella margarita	(Reeve, 1859)	-		X	
206	Mollusca	Mitridae sp.*		-		X	
207	Mollusca	Morula granulata	(Duclos, 1832)	granular drupe			
208	Mollusca	Morula uva	Röding, 1798	grape morula			
209	Mollusca	Nassarius pauperus*	(Linnaeus, 1758)	-		X	
210	Mollusca	Nassarius sp.		-		X	
211	Mollusca	Natica sp.		-		X	egg mass observed in sand
212	Mollusca	Neothais harpa	(Conrad, 1837)	-		X	
213	Mollusca	Nerita picea	(Recluz, 1841)	black nerite			
214	Mollusca	Nerita polita	Linnaeus, 1758	polished nerite			
215	Mollusca	Nodolittorina hawaiensis	(Philippi, 1846)	-		X	=Nodilittorina picta
216	Mollusca	Octopus cyanea	Gray, 1849	day octopus			
217	Mollusca	Octopus ornatus	Gould, 1852	ornate octpus			
218	Mollusca	Odostomia gulicki*	Pilsbry, 1918	-		X	
219	Mollusca	Odostomia oxia*	Watson, 1886	-		X	found only in Papaloa cave sand sample
220	Mollusca	Odostomia sternsiella*	Pilsbry, 1918	-		X	
221	Mollusca	Otopleura mitralis*	A. Adams, 1854	-		X	

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
222	Mollusca	Parashiela beetsi*	(Ladd, 1966)	-		X	
223	Mollusca	Parashiela sp.*		-		X	more verices than P. beetsi
224	Mollusca	Perglytpta reticulata	(Linnaeus, 1758)	-		X	
225	Mollusca	Petaloconchus keenae	Hadfield and Kay, 1972	-		X	
226	Mollusca	Pinctada radiata	(Leach, 1814)	-		X	
227	Mollusca	Plesiotrochus leutus*	(Gould, 1861)	-		X	
228	Mollusca	Pteriolidea Ianthina	(Angas, 1864)	blue dragon nudibranch			
229	Mollusca	Pupa sp.*		-		X	similar to P. pudica, but pink; found only in Papaloa cave sand sample
230	Mollusca	Purpurta aperta	(Blainville, 1832)	-			
231	Mollusca	Pusillina marmorata*	Ponder, 1985	-		X	=Vitricintha marmorata
232	Mollusca	Pyramidelloides miranda*	(A. Adams, 1861)	-		X	
233	Mollusca	Quoyula madreporarum	(Sowerby, 1834)	-		X	
234	Mollusca	Rastodens labiosa*	Kay, 1979	-		X	
235	Mollusca	Rissoella sp. cf confusa confusa*	Ponder and Yoo, 1977	-		X	found only in Papaloa cave sand sample
236	Mollusca	Rissoidae sp.		-		X	has spiral orange band whorls
237	Mollusca	Rissoina ambigua*	(Gould, 1849)	-		X	
238	Mollusca	Rissoina pulchella*	(Brazier, 1977)	-		X	
239	Mollusca	Rissoina sp.*		-		X	
240	Mollusca	Sansonia kennyi*	(Ladd, 1966)	-		X	=Merelina kennyi*
241	Mollusca	Scaliola sp.*		-		X	found only in Papaloa cave sand sample
242	Mollusca	Scaliolia bella*	Adams, 1860	-		X	
243	Mollusca	Schwartziella ephamilla*	Ponder, 1985	-		X	=Rissoina ephamilla
244	Mollusca	Schwartziella triticea	(Pease, 1861)	-		X	
-	Mollusca	Schwartziella triticea*	(Pease, 1861)	-		-	
245	Mollusca	Seminella peasei*	(von Martens & Langkavel, 1871)	-		X	=Seminella virginea; found only in Papaloa cave sand sample

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
246	Mollusca	Sepiodeao		-			
247	Mollusca	Septifer bryanae*	(Pilsbry, 1921)	-		X	
248	Mollusca	Serpulorbis variabilis	Hadfield and Kay, 1972	variable worm snail			
249	Mollusca	Smaragdinellidae		-		X	shell clear with red spotting
250	Mollusca	Spondylous violacescens	Reeve, 1856	-		X	=Spondylous tenebrosus
251	Mollusca	Streblocerus subannulatum*	de Folin, 1879	-		X	
252	Mollusca	Streptopinna saccata	(Linnaeus, 1758)	baggy pen shell		X	
253	Mollusca	Strombus maculatus	Sowerby, 1842	spotted stomb		X	
254	Mollusca	Styliferina goniochila*	(A. Adams, 1860)	-		X	
255	Mollusca	Stylochelis longicauda	(Quoy & Gaimard, 1824)	lined sea hare		X	
256	Mollusca	Synaptocochlea concinna*	(Gould, 1845)	-		X	
257	Mollusca	Trapezium oblonga	(Linnaeus, 1758)	-		X	
258	Mollusca	Tricolia variabilis*	(Pease 1861)	-		X	
259	Mollusca	Triphora peasi*	(Jousseaume, 1884)	-		X	
260	Mollusca	Triphoridae sp.1*		-		X	
261	Mollusca	Triphoridae sp.2*		-		X	
262	Mollusca	Triphoridae sp.3*		-		X	
263	Mollusca	Triphoridae sp.4*		-		X	
264	Mollusca	Triphoridae sp.5*		-		X	
265	Mollusca	Triphoridae sp.6		-		X	
266	Mollusca	Trivia edgari	Shaw, 1909	-		X	
267	Mollusca	Trochus intextus	Kiener, 1850	woven top			
-	Mollusca	Trochus intextus*	Pease, 1861	-		-	
268	Mollusca	Turbo sandwichensis	Pease, 1861	Hawaiian turban			endemic to Hawaii
269	Mollusca	Turbonilla thaanumi*	Pilsbry and Vanatta, 1908	-		X	found only in Papaloa cave sand sample
270	Mollusca	Turridae sp.*		-		X	

	Taxon	Species	Author	Common name	Introduced?	New Record	Notes
271	Mollusca	Vanikoro imbricata*	Pease, 1861	-		X	
272	Mollusca	Vermetid		-		X	
273	Mollusca	Vexillum (Pusia) cancelloroides	(Anton, 1839)	-		X	
274	Mollusca	Vexillum capricornea*	(Hedley, 1907)	-		X	
275	Mollusca	Vexillum interruptum*	(Anton, 1839)	-		X	found only in Papaloa cave sand sample
276	Mollusca	Vexillum sp. (rubrum?)		-		X	
277	Mollusca	Viriola sp.*		-		X	
278	Mollusca	Xenoturris cerithiformis	Powell, 1964	-		X	
279	Platyhelminthes	Pseudocerotidae		-		X	see Hoover (1998), pg. 74 white striped flatworm
280	Platyhelminthes	Pseuodoceros sp.		-		X	black with yellow line on margin
281	Porifera	Chondrosia? chucalla?	de Laubenfels, 1936	wandering sponge		X	
282	Porifera	Leucetta sp1. (solida?)		-		X	
283	Porifera	Leucetta sp2.		-		X	pink
284	Porifera	Lotrochota protea	(de Laubenfels, 1950)	staining sponge			
285	Porifera	Sponge sp1.		-		X	purple
286	Porifera	Sponge sp2.		-		X	blue
287	Porifera	Sponge sp3.		-		X	red
288	Porifera	Sponge sp4.		-		X	orange
289	Porifera	Sponge sp5.		-		X	pink
290	Porifera	Spongia oceania	de Laubenfels, 1950	black reef sponge		X	
291	Urochordata	Ascidea sydneiensis	Stimpson, 1855	yellow-green sea squirt		X	may have been introduced
292	Urochordata	Botryllus sp.		-		X	
293	Urochordata	Herdmania momus	(Savigny, 1816)	Herdman's sea squirt		X	probably introduced

Appendix 3. Checklist of marine and intertidal invertebrate species by survey site. Species marked with an * were collected from sediment sample.

	Taxon	Species	Piko'one Bench (Transect 4L)	Piko'one Bench (Transect 4)	Piko'one	Puwah Bench (Transect 5)	Puwah Bench (Transect 5L)	Puwah	Carpenter Bench	Carpenter	Carpenter North	Papaloa Beach	Ka Laemilo	Kahili	Ka Leamau (Transect 7)	Lae Hoolehua	Mormon Pond/Church Pasture	Kauwo (Transect 17)	Additional observed species	Existing Kalaupapa Records	Introduced?
1	Annelida	Eurythoe complanata			1			1		1											
2	Annelida	Lomia sp.			1					1							1			1	
3	Annelida	Pherecardia striata			1																
4	Annelida	Spirobranchus giganteus			1			1		1	1		1								
5	Bryozoan	Bugula sp.								1											
6	Bryozoan	Bugula sp. (neritina?)									1										Y
7	Bryozoan	Reteporellina denticulata								1											
8	Cnidarian	Aiptasia pulchella																		1	
9	Cnidarian	Aiptasia sp.1 (pulchella?)								1											
10	Cnidarian	Aiptasia sp.2 (pulchella?)															1				
11	Cnidarian	Anthopleura nigrescens																		1	
12	Cnidarian	Balanophyllia sp.																	1		
13	Cnidarian	Carijoa riisei									1										Y
14	Cnidarian	Cladactella manni																	1		
15	Cnidarian	Montipora capitata																	1		

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
16	Cnidarian	Montipora flabellata																	1		
17	Cnidarian	Palythoa sp. (cf. caesia)						1		1		1	1							1	
18	Cnidarian	Pennaria disticha			1															1	Y
19	Cnidarian	Pocillopora damicornis																	1		
20	Cnidarian	Pocillopora eydouxi																	1		
21	Cnidarian	Pocillopora meandrina																	1		
22	Cnidarian	Porites compressa																	1		
23	Cnidarian	Porites lobata																	1		
24	Cnidarian	Protopalythoa spp.																		1	
25	Cnidarian	Tubastraea coccinea																	1		
26	Cnidarian	Zoanthus spp.																		1	
27	Crustacean	Alpheus deuteropus			1			1		1	1		1							1	
28	Crustacean	Alpheus paracrinitus											1								
29	Crustacean	Calcinus elegans										1									
30	Crustacean	Calcinus laevimanus		1			1		1											1	
31	Crustacean	Calcinus laurentae						1													
32	Crustacean	Calcinus seurati							1								1				
33	Crustacean	Calcinus sp. (haigae?)						1													
34	Crustacean	Carpilius maculatus																		1	
35	Crustacean	Charybdis erythrodactyla			1																
36	Crustacean	Charybdis hawaiiensis			1							1									
37	Crustacean	Ciliopagurus strigatus											1								
38	Crustacean	Cinetorhynchus sp.						1													
39	Crustacean	Clibanarius zerba							1								1				

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
40	Crustacean	Dardanus sanguinocarpus										1									
41	Crustacean	Enopometopus occidentalis								1		1									
42	Crustacean	Euraphia hembeli			1															1	
43	Crustacean	Grapsis tenuicrustatus		1					1								1			1	
44	Crustacean	Haplocarcinus marsupialis									1	1									
45	Crustacean	Lepas anserifera																		1	
46	Crustacean	Nesochthamalus intertextus	1	1																1	
47	Crustacean	Ocypode paalidula																		1	
48	Crustacean	Pachygrapsus plicatus															1				
49	Crustacean	Palaemon debilis																		1	
50	Crustacean	Palaemon pacificus																		1	
51	Crustacean	Panulirus marginatus						1												1	
52	Crustacean	Panulirus penicillatus			1																
53	Crustacean	Parribacus antarcticus			1																
54	Crustacean	Percnon planissimum			1																
55	Crustacean	Plagusia depressa tuberculata																		1	
56	Crustacean	Pseudocryptochirus kahe			1			1		1	1	1									
57	Crustacean	Pylopaguropsis keijii											1								
58	Crustacean	Ranina ranina						1													
59	Crustacean	Saron sp.											1								
60	Crustacean	Stenopus hispidus			1												1			1	
61	Crustacean	Trapezia ferrugunea			1						1										
62	Crustacean	Trapezia intermedia						1		1	1		1								
63	Crustacean	Xanthid crab							1												

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
64	Echinodermata	Actinopyga mauritiania			1		1	1				1					1			1	
65	Echinodermata	Actinopyga obesa									1										
66	Echinodermata	Colobocentrotus atratus				1									1		1			1	
67	Echinodermata	Cyrtechinus verruculatus								1											
68	Echinodermata	Diadema paucispinum																		1	
69	Echinodermata	Echinometra oblonga					1	1		1		1	1		1					1	
70	Echinodermata	Echinometra spp. (mathei complex)								1	1	1	1							1	
71	Echinodermata	Echinoneus cyclostomus						1					1								
72	Echinodermata	Echinostrephus aciculatus			1			1		1	1	1	1								
73	Echinodermata	Echinothrix calamaris			1			1		1		1								1	
74	Echinodermata	Echinothrix diadema																		1	
75	Echinodermata	Eucidaris metularia								1	1										
76	Echinodermata	Heterocentrotus mammillatus									1	1	1							1	
77	Echinodermata	Holothuria atra						1				1	1				1			1	
78	Echinodermata	Holothuria impatiens						1			1		1							1	
79	Echinodermata	Holothuria pervicax																		1	
80	Echinodermata	Holothuria whitmaei								1	1		1								
81	Echinodermata	Lapidodemus semperianum																		1	
82	Echinodermata	Ophiocoma brevipes									1										
83	Echinodermata	Ophiocoma erinaceus						1		1	1		1							1	
84	Echinodermata	Ophiocoma pica								1											
85	Echinodermata	Ophionereis sp.								1											
86	Echinodermata	Opiodesoma spectabilis																		1	

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
87	Echinodermata	Polyplectana kefersteini								1	1										
88	Echinodermata	Rhinobrissus sp.									1										
89	Echinodermata	Stichopus horrens																		1	
90	Echinodermata	Tripneustes gratella			1					1											
91	Mollusca	Alcyna ocellata*								1											
92	Mollusca	Alcyna subangulata*										1									
93	Mollusca	Alvinia isolata*									1	1									
94	Mollusca	Aplysia juliana										1					1			1	
95	Mollusca	Arca ventricosa								1	1										
96	Mollusca	Atys semistriata									1										
97	Mollusca	Balcis sp.1								1			1								
98	Mollusca	Balcis sp.2*										1									
99	Mollusca	Barbatia diveracata			1					1	1	1	1								
100	Mollusca	Berthelina citrina								1											
101	Mollusca	Bittium impendens*							1	1	1	1									
102	Mollusca	Bivalve*								1	1	1									
103	Mollusca	Bursa granularis																		1	
104	Mollusca	Caecum arcuatum*										1									
105	Mollusca	Caecum glabella*								1											
106	Mollusca	Caecum septimentum*								1	1	1									
107	Mollusca	Carinapex minutissima*								1	1	1									
108	Mollusca	Casmaria erinaceus kalosmodix						1			1										
109	Mollusca	Cellana exerata	1			1	1		1								1			1	
110	Mollusca	Cellana melanostoma																		1	

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
111	Mollusca	Cellana sandwicensis	1			1	1								1					1	
112	Mollusca	Cellana talcosa				1	1													1	
113	Mollusca	Cerithidium perparvulum*								1		1									
114	Mollusca	Cerithium columna																	1		
115	Mollusca	Cerithium eqenum						1					1				1				
116	Mollusca	Cerithium nesioticum							1	1							1				
117	Mollusca	Cerithium zebrum															1				
118	Mollusca	Cerithopsis sp. (arga?)*								1	1										
119	Mollusca	Ceritium echinatum																	1		
120	Mollusca	Chama iostoma								1											
121	Mollusca	Cheilea equestris									1										
122	Mollusca	Chlamys coruscans hawaiiensis			1					1		1									
123	Mollusca	Chromodoridinae sp.1											1								
124	Mollusca	Chromodoridinae sp.2											1								
125	Mollusca	Chromodoris sp.																		1	
126	Mollusca	Clavis sp.*								1											
127	Mollusca	Clio sp.*									1	1									
128	Mollusca	Codakia punctata							1		1										
129	Mollusca	Collonista candida*								1		1									
130	Mollusca	Conus abbreviatus								1		1									
131	Mollusca	Conus ebraeus																		1	
132	Mollusca	Conus flavidus								1	1	1	1							1	
133	Mollusca	Conus leapoardus										1									
134	Mollusca	Conus litoglyphus									1										

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
135	Mollusca	Conus lividus								1	1		1								
136	Mollusca	Conus pennaceus								1											
137	Mollusca	Conus pulicarus						1													
138	Mollusca	Conus rattus									1										
139	Mollusca	Conus striatus									1										
140	Mollusca	Conus textile								1											
141	Mollusca	Cosa sp. (waikiki?)*										1									
142	Mollusca	Ctena bella*										1									
143	Mollusca	Ctena transversa									1										
144	Mollusca	Cyclostremicus emeryi*										1									
145	Mollusca	Cylinchna sp. (pusilla?)*										1									
146	Mollusca	Cymatium nicobaricum																			
147	Mollusca	Cymatium sp. (intermedia?)											1								
148	Mollusca	Cypraea caputerserpentus								1										1	
149	Mollusca	Cypraea fimbriata						1			1		1								
150	Mollusca	Cypraea helvola						1			1		1								
151	Mollusca	Cypraea isabella											1								
152	Mollusca	Cypraea maculifera			1															1	
153	Mollusca	Cypraea mauritana			1															1	
154	Mollusca	Cypraea sp. (juv)															1				
155	Mollusca	Cypraea sulcidentata											1								
156	Mollusca	Cypraea talpa																		1	
157	Mollusca	Cypraea tigris																		1	
158	Mollusca	Cysticus huna*									1	1									

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
159	Mollusca	Daphnella sp.*									1										
160	Mollusca	Dendrodoris tuberculosa																		1	
161	Mollusca	Dendropoma platypus			1			1				1	1								
162	Mollusca	Dendropoma rhyssoconchia			1																
163	Mollusca	Diala varia*								1	1										
164	Mollusca	Diniatys dentifer*								1		1									
165	Mollusca	Diodora granifera*								1		1									
166	Mollusca	Dolabrifera dolabrifera																		1	
167	Mollusca	Drupa morum					1	1				1								1	
168	Mollusca	Drupa racina		1		1	1		1			1					1			1	
169	Mollusca	Drupella elata									1		1								
170	Mollusca	Duplicaria gouldi						1													
171	Mollusca	Eatoniella sp.*								1											
172	Mollusca	Ervilia bisculpta*								1	1	1									
173	Mollusca	Euchelus gemmetus									1										
174	Mollusca	Fragum mundum*								1		1									
175	Mollusca	Gastrochaena cuneformis			1			1													
176	Mollusca	Gastropod*								1											
177	Mollusca	Gibbula marmorea*								1		1									
178	Mollusca	Granula sandwicensis*								1	1	1									
179	Mollusca	Granulina vitrea*								1	1	1									
180	Mollusca	Haumea juddi			1																
181	Mollusca	Herviera gliriella*									1	1									
182	Mollusca	Hexabranchus sanguineus			1					1	1									1	

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
183	Mollusca	Hipponix australis								1	1										
184	Mollusca	Hipponix imbricatus								1		1									
185	Mollusca	Hydratina amplustre							1											1	
186	Mollusca	Isognomon californicum	1	1																	
187	Mollusca	Isognomon perna							1	1			1							1	
188	Mollusca	Ittibittium parcum*								1	1										
189	Mollusca	Ittibittium zebrum								1											
190	Mollusca	Joculator sp. (ridicula?)*										1									
191	Mollusca	Julia exquista*								1		1									
192	Mollusca	Kermia sp.*									1	1									
193	Mollusca	Leptothyra rubricincta*								1	1	1									
194	Mollusca	Leptothyra verruca*								1		1									
195	Mollusca	Lima sp. (juv)*										1									
196	Mollusca	Littoraria pintado		1					1						1					1	
197	Mollusca	Lophocochlias minutissimus*								1	1	1									
198	Mollusca	Melampus castaneus																		1	
199	Mollusca	Merelina granulosa*								1		1									
200	Mollusca	Merelina wanawana*									1	1									
201	Mollusca	Miralda paulbartschi*									1										
202	Mollusca	Mitra luctuosa									1										
203	Mollusca	Mitra saltata*								1											
204	Mollusca	Mitra stictica										1									
205	Mollusca	Mitrella margarita			1				1								1				
206	Mollusca	Mitridae sp.*									1										

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
207	Mollusca	Morula granulata		1					1											1	
208	Mollusca	Morula uva						1	1				1							1	
209	Mollusca	Nassarius pauperus*									1										
210	Mollusca	Nassarius sp.									1										
211	Mollusca	Natica sp.									1										
212	Mollusca	Neothais harpa																	1		
213	Mollusca	Nerita picea	1	1		1	1		1									1		1	
214	Mollusca	Nerita polita																		1	
215	Mollusca	Nodolittorina hawaiensis																			
216	Mollusca	Octopus cyanea																		1	
217	Mollusca	Octopus ornatus																		1	
218	Mollusca	Odostomia gulicki*									1	1									
219	Mollusca	Odostomia oxia*										1									
220	Mollusca	Odostomia sternsiella*									1										
221	Mollusca	Otopleura mitralis*								1											
222	Mollusca	Parashiela beetsi*								1	1	1									
223	Mollusca	Parashiela sp.*									1	1									
224	Mollusca	Perglytpta reticulata											1								
225	Mollusca	Petaloconchus keenae						1		1	1	1	1								
226	Mollusca	Pinctada radiata						1		1	1	1	1				1				
227	Mollusca	Plesiotrochus leutus*									1	1									
228	Mollusca	Pteriolidea Ianthina								1										1	
229	Mollusca	Pupa sp.*										1									
230	Mollusca	Purpurta aperta																		1	

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
231	Mollusca	Pusillina marmorata*								1	1	1									
232	Mollusca	Pyramidelloides miranda*								1											
233	Mollusca	Quoyula madreporarum								1											
234	Mollusca	Rastodens labiosa*								1	1										
235	Mollusca	Rissoella sp. cf confusa confusa*										1									
236	Mollusca	Rissoidae sp.							1		1	1									
237	Mollusca	Rissoina ambigua*								1	1	1									
238	Mollusca	Rissoina pulchella*								1	1										
239	Mollusca	Rissoina sp.*										1									
240	Mollusca	Sansonia kennyi*								1	1	1									
241	Mollusca	Scaliola sp.*										1									
242	Mollusca	Scaliolia bella*										1									
243	Mollusca	Schwartziella ephamilla*								1	1	1									
244	Mollusca	Schwartziella triticea									1										
-	Mollusca	Schwartziella triticea*								1	1	1									
245	Mollusca	Seminella peasei*										1									
246	Mollusca	Sepiodeao																		1	
247	Mollusca	Septifer bryanae*			1					1		1									
248	Mollusca	Serpulorbis variabilis		1		1			1								1			1	
249	Mollusca	Smaragdinellidae											1								
250	Mollusca	Spondylous violacescens			1			1			1										
251	Mollusca	Streblocerus subannulatum*									1										
252	Mollusca	Streptopinna saccata			1					1		1									
253	Mollusca	Strombus maculatus																	1		

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
254	Mollusca	Styliferina goniochila*								1	1	1									
255	Mollusca	Stylochelis longicauda			1						1		1								
256	Mollusca	Synaptocochlea concinna*								1		1									
257	Mollusca	Trapezium oblonga											1								
258	Mollusca	Tricolia variabilis*								1	1	1									
259	Mollusca	Triphora peasi*									1										
260	Mollusca	Triphoridae sp.1*								1											
261	Mollusca	Triphoridae sp.2*								1											
262	Mollusca	Triphoridae sp.3*										1									
263	Mollusca	Triphoridae sp.4*										1									
264	Mollusca	Triphoridae sp.5*										1									
265	Mollusca	Triphoridae sp.6								1											
266	Mollusca	Trivia edgari						1									1				
267	Mollusca	Trochus intextus							1	1							1			1	
-	Mollusca	Trochus intextus*								1		1									
268	Mollusca	Turbo sandwichensis							1	1	1	1	1				1			1	
269	Mollusca	Turbonilla thaanumi*										1									
270	Mollusca	Turridae sp.*									1	1									
271	Mollusca	Vanikoro imbricata*									1										
272	Mollusca	Vermetid								1		1									
273	Mollusca	Vexillum (Pusia) cancelloroides							1		1										
274	Mollusca	Vexillum capricornea*								1											
275	Mollusca	Vexillum interruptum*										1									
276	Mollusca	Vexillum sp. (rubrum?)									1										

	Taxon	Species	Piko(4L)	Piko(4)	Piko	Puwa(5)	Puwa(5L)	Puwa	CaBe	Carp	CaNo	Papa	KaLa	Kahi	KaLe(7)	LaHo	MoPo	Kauw(17)	Add Obs	Ex Rec	Into?
277	Mollusca	Viriola sp.*								1											
278	Mollusca	Xenoturris cerithiformis									1										
279	Platyhelminthes	Pseudocerotidae											1								
280	Platyhelminthes	Pseuodoceros sp.										1									
281	Porifera	Chondrosia? chucalla?									1	1	1								
282	Porifera	Leucetta sp1. (solida?)			1						1		1								
283	Porifera	Leucetta sp2.									1										
284	Porifera	Lotrochota protea																		1	
285	Porifera	Sponge sp1.			1			1													
286	Porifera	Sponge sp2.						1													
287	Porifera	Sponge sp3.			1																
288	Porifera	Sponge sp4.			1																
289	Porifera	Sponge sp5.			1																
290	Porifera	Spongia oceania			1																
291	Urochordata	Ascidea sydneiensis			1					1			1								
292	Urochordata	Botryllus sp.								1											
293	Urochordata	Herdmania momus			1								1								
	TOTAL		5	9	41	7	9	35	24	88	92	93	45	0	4	0	23	1	14	71	

Appendix 4. Raw counts of invertebrates along six intertidal transect lines at Kalaupapa NHP.

Transect		Sea anemone	Zoanthid	*Cellana exerata*	*Cellana sandwicensis*	*Cellana talcosa*	*Nerita picea*	*Littoraria pintado*[1]	*Serpulorbis variabilis*	*Drupa sp.*	*Drupa morum*	*Drupa racina*	*Morula granulata*	*Isognomon californicum*	*Nesochthamalus intertextus*	*Calcinius laevimanus*	Unidentified crab	*Grapsus tennicrustatus*	*Colobocentrotus atratus*	*Echinometra oblonga*	*Actinopyga mauritiana*	Unidentified drill
Upper	4	5	1	-	-	-	4	25	5	-	-	2	1	17	130	7	2	1	-	-	-	-
	4L	61	-	22	4	-	20	-	-	-	-	-	-	7	1	-	-	-	-	-	-	5
	5	-	-	5	-	2	200[2]	-	1	-	-	-	-	-	-	-	-	-	3	-	-	-
	5L	1	-	14	-	-	56	-	-	-	-	2	-	-	-	5	-	-	-	-	-	-
	7	-	-	-	3	-	-	50	-	-	-	-	-	-	-	-	-	-	1	1	-	-
	17	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	-	-	5	22	7	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
	5L	-	-	-	26	2	-	-	-	1	1	7	-	-	-	-	-	-	-	22	1	-
	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1]may include some individuals of *Nodilittorina hawaiensis.*
[2]Individuals no longer counted after 200

Appendix 5. Photographs of all invertebrate survey sites.

Photo 1. A low basalt bench (foreground) and large boulders (middle left) at Piko'one. Transect 4 was on the bench on the bench in while Transect 4L was in the boulders.

Photo 2. Stripies (*Microcanthus strigatus*) shelter near a small overhang at the base of 3 m ledge at the Piko'one survey site.

Photo 3. Cobble and basalt bench habitat found at the Puwah Bench site. Transect 5 ran through the mixed boulders along the center right side of the photo. Transect 5L ran along the bench in the middle of the photo.

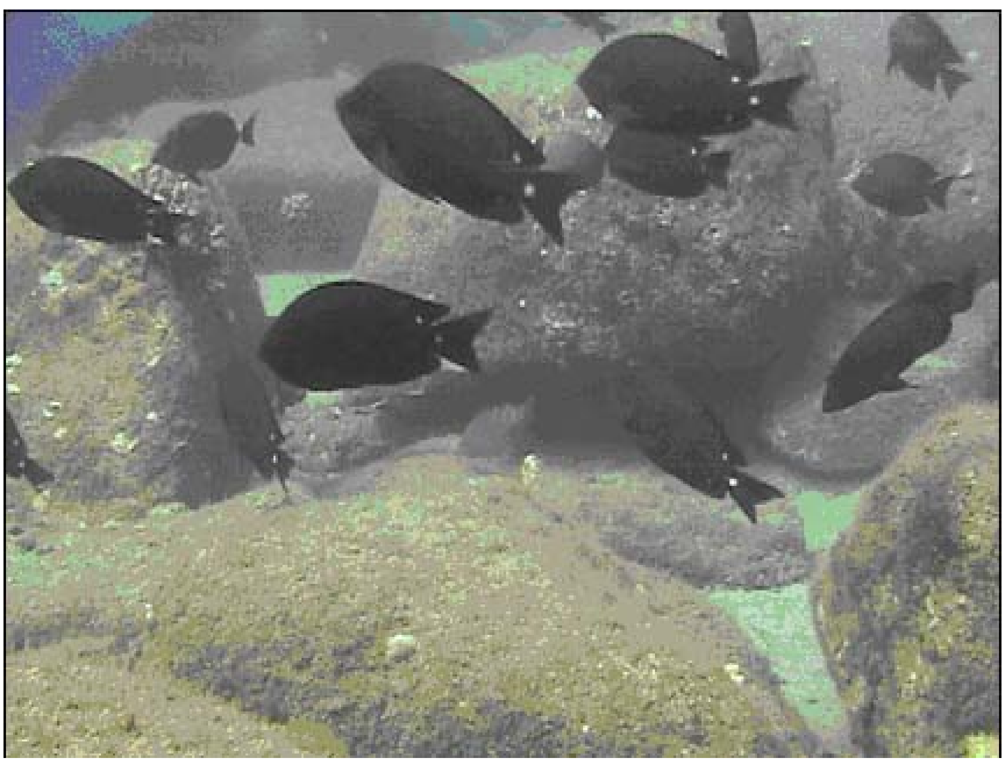
Photo 4. Large basalt boulders, interspersed with sand formed high relief substratum at the Puwah survey site.

Photo 5. The small basalt bench at Carpenter Bench has poorly developed tidepools along its seaward margin.

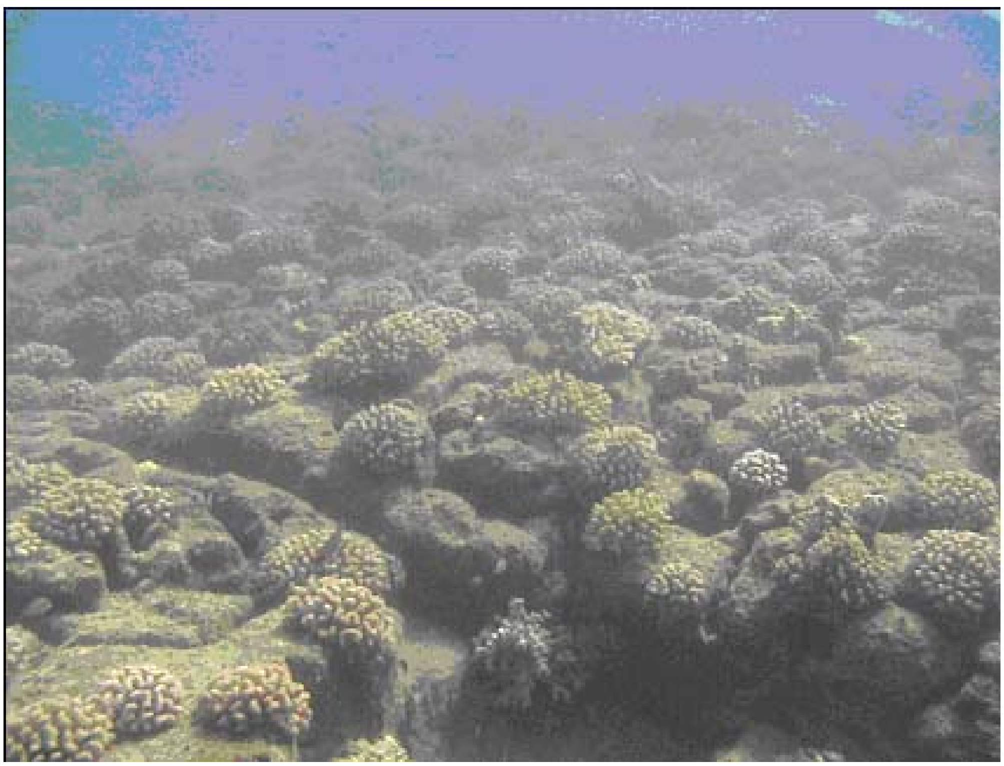

Photo 6. The shallow reef flat at the Carpenter site is comprised of a basalt bench dotted with Pocillopora meandrina coral heads.

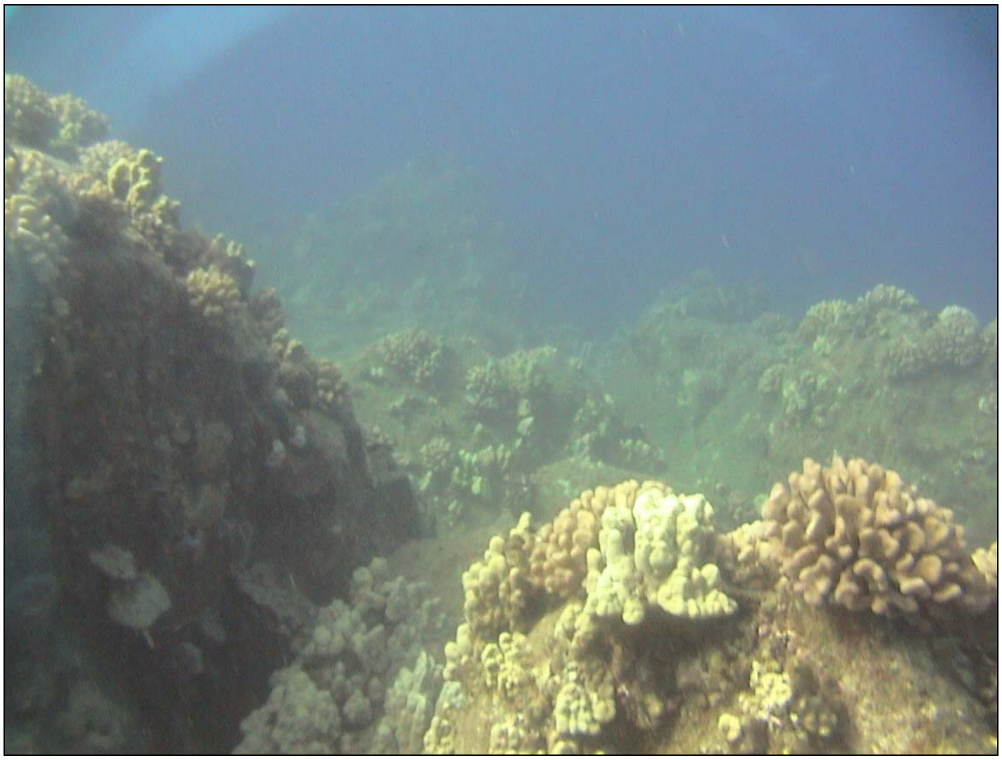

Photo 7. Coral encrusted basalt boulders are the primary substratum at the Carpenter survey site.

Photo 8. Large blocks of basalt formed a heterogeneous substratum for marine invertebrates at Carpenter North.

Photo 9. Basalt boulders sparsely dotted with coral heads line the edge of a large sand patch at the Papaloa Beach survey site.

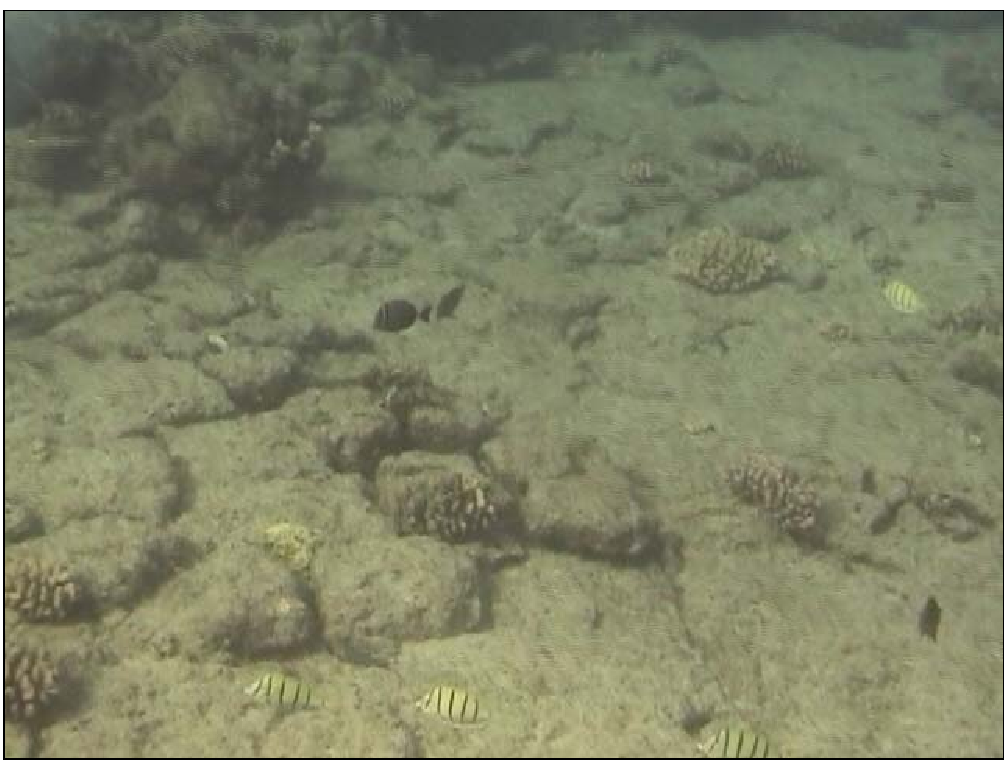

Photo 10. A low relief basalt bottom sparsely dotted with Pocillopora coral heads comprised the primary substratum at the Ka Laemilo survey site.

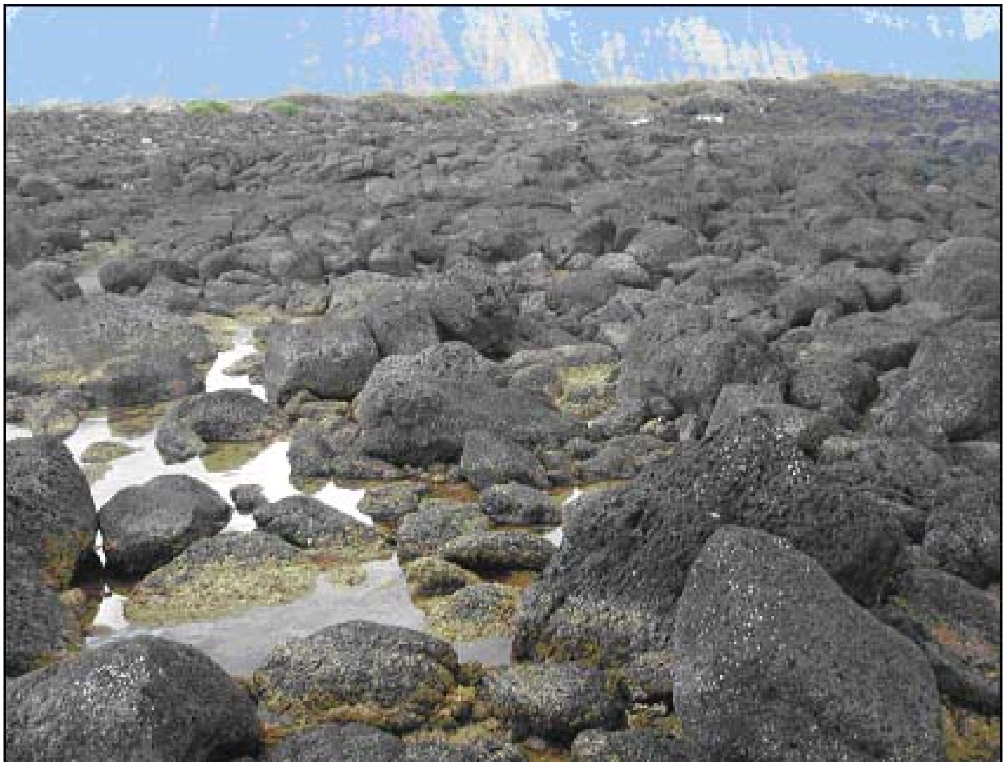
Photo 11. Basalt boulders form the primary substrate at Kahili.

Photo 12. A low bench feature found at Ka Leamau, the site of Transect 7.

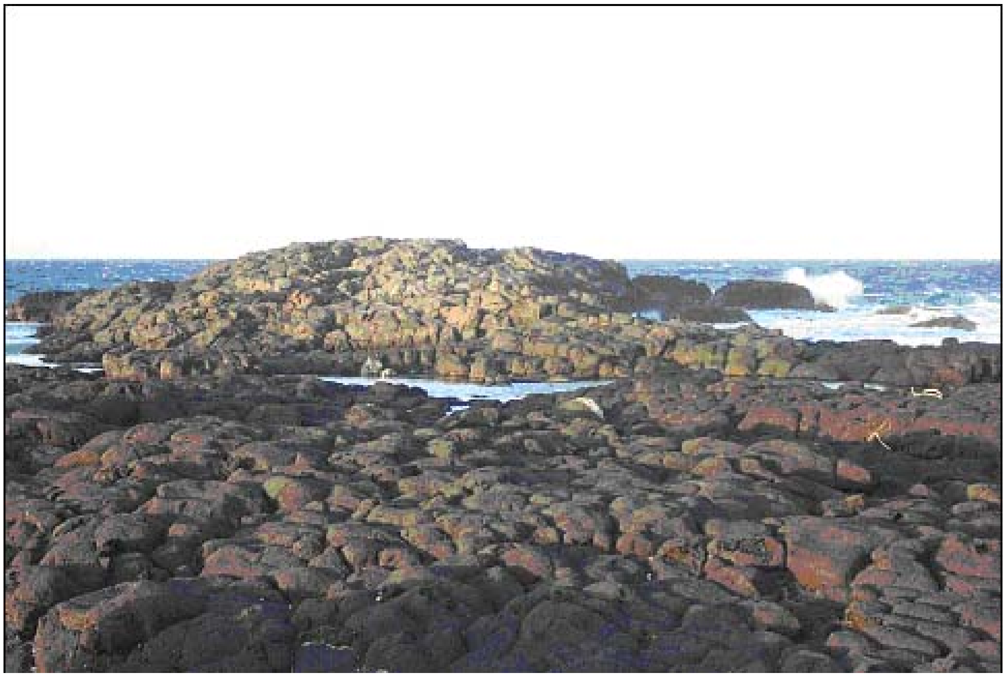

Photo 13. Lae Hoolehua.

Photo 14. Mormon Pond/Church Pasture is an extensive and well-formed basalt bench with numerous tide pools.

Photo 15. Large basalt boulders at Kauwo, the site of Transect 17.