ARTHROPOD INVENTORY AND ASSESSMENT
KAPOLEI HARBORSIDE CENTER SITE
ʻEWA DISTRICT, OʻAHU, HAWAIʻI

October 2006

Prepared for

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II. EXECUTIVE SUMMARY

Kapolei Property Development, LLC is proposing to develop approximately 345 acres of land near Barbers Point, 'Ewa District, O'ahu, Hawai'i for industrial-business uses. The project site is in an industrial area, and comprises land previously used for sugar cane cultivation and coral mining operations.

A survey of arthropods on the Kapolei Harborside Center project site was conducted September 22 through September 29, 2006. Ten sampling methods were used to detect arthropods to ensure a thorough coverage of the existing fauna. Special attention was given to searching for Blackburn's Sphinx moth larvae (*Manduca blackburni*) on tree tobacco (*Nicotiana glauca*), a known host plant that occurs on the site. Special searches were also conducted for *'Ōpae'ula* (*Halocaridina rubra*) in sink holes, and for native snail species, especially in the proposed sinkhole reserve.

One hundred and ninety-five species of insects representing sixteen orders were collected at the site. An additional nineteen species of spiders, three species of other arthropods, and five species of fossilized snail shells were also collected. The most productive sampling methods were aerial netting and foliage beating. Night sampling with UV lights was disappointing, probably due to the time of year of the sampling. Nearly two hundred tree tobacco plants were searched for caterpillars of Blackburn's Sphinx moth and none were found. Despite repeated searching of the one sinkhole found with water, no *'Ōpae'ula* (*Halocaridina rubra*) were found. Fossilized snail shells were found below the litter layer and there was no evidence of extant species.

About thirty-five percent of the arthropod species in Hawai'i are non-indigenous (Nishida 1997). More than ninety percent of the species collected in the Kapolei Harborside Center project site survey were non-indigenous. Many are cosmopolitan, weedy species found throughout the Pacific and the World. The large proportion of non-indigenous species is an indication of the amount of habitat degradation that resulted from the various agricultural and mining operations that have occurred at the site.

The Blackburn's sphinx moth (*Manduca blackburni*) is only listed invertebrate species historically known from O'ahu. While caterpillars of other

species of sphinx moths were observed in May 2006 during the botanical and avian surveys (David and Guinther 2006), no caterpillars or adults of Blackburn's sphinx moth have been observed on the Kapolei Harborside Center project site. This species has not been recorded from the island since the 1940's despite significant efforts to relocate the species on the island (Federal Register 2003). In recent consultation with biologists familiar with this species and with this area, the likelihood that this species is present on the subject property or within the 'Ewa plains area, which has been extensively studied over the past 20-years, is highly unlikely (R. David, pers. com.).

The results of the arthropod survey indicate there are no special concerns or legal constraints related to invertebrate resources in the project area. Although several species of Hawaiian endemic arthropods may occur on the 'Ewa plain, these species are not likely to be abundant in the highly disturbed quarry and dredged spoil disposal areas around Kalaeloa/Barbers Point Harbor or on the former agriculture lands further inland that comprise the Kapolei Harborside Center project site. No invertebrate species listed as endangered, threatened, or that are currently proposed for listing under either federal or State of Hawai'i endangered species statutes are known to exist at the project site (DLNR 1997, Federal Register 1999, 2005).

III. INTRODUCTION

Kapolei Property Development, LLC is proposing to develop approximately 345 acres of land in Honouliuli, 'Ewa District, Kapolei, O'ahu as an industrial business park. The project area was first proposed as an industrial area in the more than 50 years ago. The area was chosen for urban and industrial uses because of its proximity to Kalaeloa/Barbers Point Harbor and the City of Kapolei. The project is consistent with published City and County of Honolulu (the County) and the goals to create more jobs and a Secondary Urban Center in the Kapolei area.

A range of industrial-business uses is proposed at the Kapolei Harborside Center. There will be supporting infrastructure (e.g., roads, storm drain systems, and utilities), a hazardous materials area and an area set aside for preservation.

Historical accounts indicate that prior to contact by Europeans, Hawaiians occupied the *ahupua'a* of Honouliuli. The early inhabitants harvested the marine and estuarine resources at the coast, and the forest resources in the nearby Wai'anae Mountains. They also used the lowlands for wetland cultivation (McDermott et al. 2006).

By the early 1800's the landscape had changed dramatically. Over-harvesting of the sandalwood forest and the introduction of sheep, goats, cattle, and exotic plant species had displaced much of the native vegetation (Cuddihy and Stone 1990). By the late 1800's the area was being used for cattle ranching and sugar cultivation. Since 1995 when sugar cultivation ended different areas of the site have been used for mining limestone, composting green waste, and for a wholesale nursery.

Pacific Analytics, LLC was contracted to conduct an inventory and assessment of the arthropod fauna at the Kapolei Harborside Center site as part of the Environmental Impact Statement process. Pacific Analytics personnel have extensive experience with ecological research, wildlife inventory, monitoring, and consulting. Pacific Analytics personnel have many years of professional experience in tropical and temperate ecosystems.

The intended purpose of this study is to conduct a survey of arthropod residents at the site to determine if there are any resident Federal or State listed endangered, threatened, proposed, or candidate species of arthropods and other invertebrates on the Kapolei Harborside Center site (DLNR 1997, Federal Register 1999, 2005).

A site reconnaissance was conducted on September 21. Sampling of arthropods was approved in a permit obtained from the Department of Land and Natural Resources (DLNR). Sampling began on September 22 and was completed on September 29, 2003.

The nomenclature used in this report follows the Hawaiian Terrestrial Arthropod Checklist, Third Edition (Nishida 1997). Hawaiian and scientific names are italicized.

Species are discussed as being endemic, indigenous, non-indigenous, adventive, and purposely introduced. These terms are defined as:

Endemic – A species native to, or restricted to Hawai'i.

Indigenous – A species native to Hawai'i but that naturally occurs outside of Hawai'i as well.

Non-indigenous – A species not native to Hawai'i.

Adventive – Not native, a species transported into a new habitat by natural means or accidentally by human activity.

Purposely introduced – A species released in Hawai'i for a particular purpose, usually to control a weedy plant or another insect.

IV. PROJECT DESCRIPTION

The Project consists of nine tasks. The tasks were:

Task I) Visual reconnaissance of the site to determine habitats of interest and the special collecting methods that may be deployed.

Task II) Locate and inspect potential hosts plants when found for larval stages of Blackburn's Sphinx Moth and record locality and abundance estimate. Document and voucher with photographs when possible.

Task III) Using an UV light and white sheet, sample for night-flying moths and other taxa. Note occurrences of Blackburn's Sphinx Moth and document and voucher with photographs when possible. Collect specimens for identification.

Task IV) Set pitfall traps in various habitat types present at the site, at least six traps per habitat type, with additional traps if necessary for a thorough survey. Pitfall traps will be open for 5 days. Collect specimens for identification.

Task V) Sample foliage, especially Hawaiian native plant species, using beating sheets and sweep nets for insects. Collect specimens for identification.

Task VI) Sample special habitats that may occur on the site. Collect specimens for identification.

Task VII) Identify and sample sinkholes that contain water that may occur on the site for *'Ōpae'ula* (*Halocaridina rubra*) and land snails. Collect specimens for identification.

Task VIII) Laboratory identification and curation of specimens collected.

Task IX) Preparation of a Final Report of Findings.

V. METHODS

Site Description

The Kapolei Harborside Center project site consists of 345 acres of primarily vacant land in Honouliuli, 'Ewa District, Kapolei, on the Island of O'ahu. It is bound by vacant land, Kalaeloa Boulevard and Kapolei Business Park on the east, Malakole Road and Campbell Industrial Park to the south, Kalaeloa/Barbers Point Harbor and industrial facilities to the west, and a Honolulu Advertiser building and primarily vacant land to the north.

There are several commercial and industrial operations on the project site including a wholesale nursery, a greenwaste collection and composting business, a fill material stockpiling area, a coal conveyor belt, an abandoned coral mining operation, and a sealed .

There are three distinct vegetation zones: 1) the quarry and dredged material tailings, 2) abandoned former sugarcane fields, and 3) *kiawe* (*Prosopis pallida*) and buffelgrass (*Cenchrus ciliaris*) lowland forest and savannah (David and Guinther 2006).

The quarry and dredged material tailings cover most of the western half of the project site. There are extensive areas of calcareous soil and sediment deposits and evidence of seasonal flooding and ponding. The area has patches of weedy non-indigenous vegetation with a concentration of tree tobacco plants (*Nicotiana glauca*) and Russian thistle (*Salsola tragus*).

The abandoned former sugarcane fields on the eastern third of the project site contain ruderal weeds (Char & Associates 1989).

The southern third of the project site is the location of the wholesale nursery and greenwaste collection and composting operations. North of these operations is the *kiawe* lowland forest and savannah. Some of this area has dense growth shrub growth of koa haole (*Leucaena leucocephala*).

There is a concentration of karst sinkholes within an approximately 6 acre fenced reserve on the project site. One of these sinkholes contained water and was search specifically for *'Ōpae'ula* (*Halocaridina rubra*).

There are neither unique floral habitats nor unique avian and mammalian faunal habitats on the project site and a

survey for botanical, avian, and mammalian resources found no threatened endangered, or species endemic to Hawai'i at the site (David and Guinther 2006).

Sampling

Pitfall Traps

Ethylene glycol pitfall traps were used to sample the arthropod ground fauna. Ethylene glycol pitfall traps are cups placed into the ground so that the lip of the cup is level with the substrate. A small amount of ethylene glycol was placed into the trap to kill and preserve specimens that fall into the traps. Ethylene glycol was used because it has a low evaporation rate and because it prevents specimen decomposition during the sampling period. Additionally, it is easily cleaned from the specimens. A 15 cm x 15 cm aluminum cover was placed over the traps and elevated above the ground approximately 15 mm with nails in each corner.

The target of pitfall trapping in this study was ground-active arthropod species. Twenty-two pitfall traps were set at the site, sampling the three vegetation zones with five or more traps per zone. The locations of the pitfall traps are reported in Figure 1. Traps were open for 6 to 7 days, September 22 through September 29.

Yellow Pan Traps

Yellow pan traps were used to sample flying insects attracted to flowers. It has been shown that many small day-active insects are attracted to the color yellow. This trapping method uses small yellow dishes filled with ethylene glycol and the dishes are placed on the ground in conspicuous places. When flying insects land on the surface of the water they rapidly sink and drown. At the end of the collecting period, the solution is strained through a fine sieve and the specimens are retrieved. Yellow pan traps were placed adjacent to each pitfall trap and opened for the same period as they pitfall traps.

Bait Trapping

Meat is a good attractant for some flies, ants, and beetles. They will be attracted to the smell of the rotting meat and come to the trap. The trap consisted of a small plate filled with ethylene glycol with a rock in the center covered with Spam© (Hormel Foods Corporation). The bait traps were open for 4 days, with two traps in each of the 3 vegetation zones. The locations of the bit traps are reported in Figure 1.

Foliage Sampling

Aerial Netting - We spent approximately four hours per day for five days walking transects through

different areas of the project site. The entire site, except for the wholesale nursery and greenwaste composting operation was sampled. Flying insects were captured in aerial nets and placed into killing jars. After the specimens died they were transferred into collecting vials and processed in the laboratory at the end of each day.

Sweep Netting - Grasses, small shrubs and other low-lying vegetation was sampled with a sweep net. The heavy net was brushed along the top of the vegetation or grass, capturing insects. The insects were placed into killing jars, and later into collecting vials for processing.

Foliage Beating -Foliage was sampled using beating sheets. A 0.5 m square sheet was placed under a branch and the stem was struck with a short stick. Arthropods on the foliage were dislodged and fell onto the sheet where they were collected with an aspirator into vials.

Visual Inspection – Plants were visually inspected for arthropods that were not collected by other methods. Tree tobacco plants were especially selected for inspection in an effort to detect any Blackburn's Sphinx moth caterpillars that may be on the site.

Litter Sifting

We turned over rocks and sorted through leaf litter to locate and collect arthropods. We also collected in sinkholes and sifted through the top layer of soil to detect soil-dwelling insects. Arthropods were collected into vials using an aspirator or forceps.

Night Sampling

We used UV lights to attract moths and other nocturnal insects. A cloth sheet was hung on a rope at night with an ultraviolet fluorescent tubes placed at the top of the sheet. As insects were attracted and alighted on the sheet, they were captured in vials. We also tried placing the sheet on the ground with the light suspended a few feet above it to attract a larger variety of insects.

The phases of the moon can influence the attraction of insects to artificial light (Williams et al. 1956). A bright moon may compete with the light source resulting in a reduced catch. The moon was waxing, with approximately 6-8 percent illumination, a phase that during which a large number of nocturnal insects should be flying (Southwood 1984).

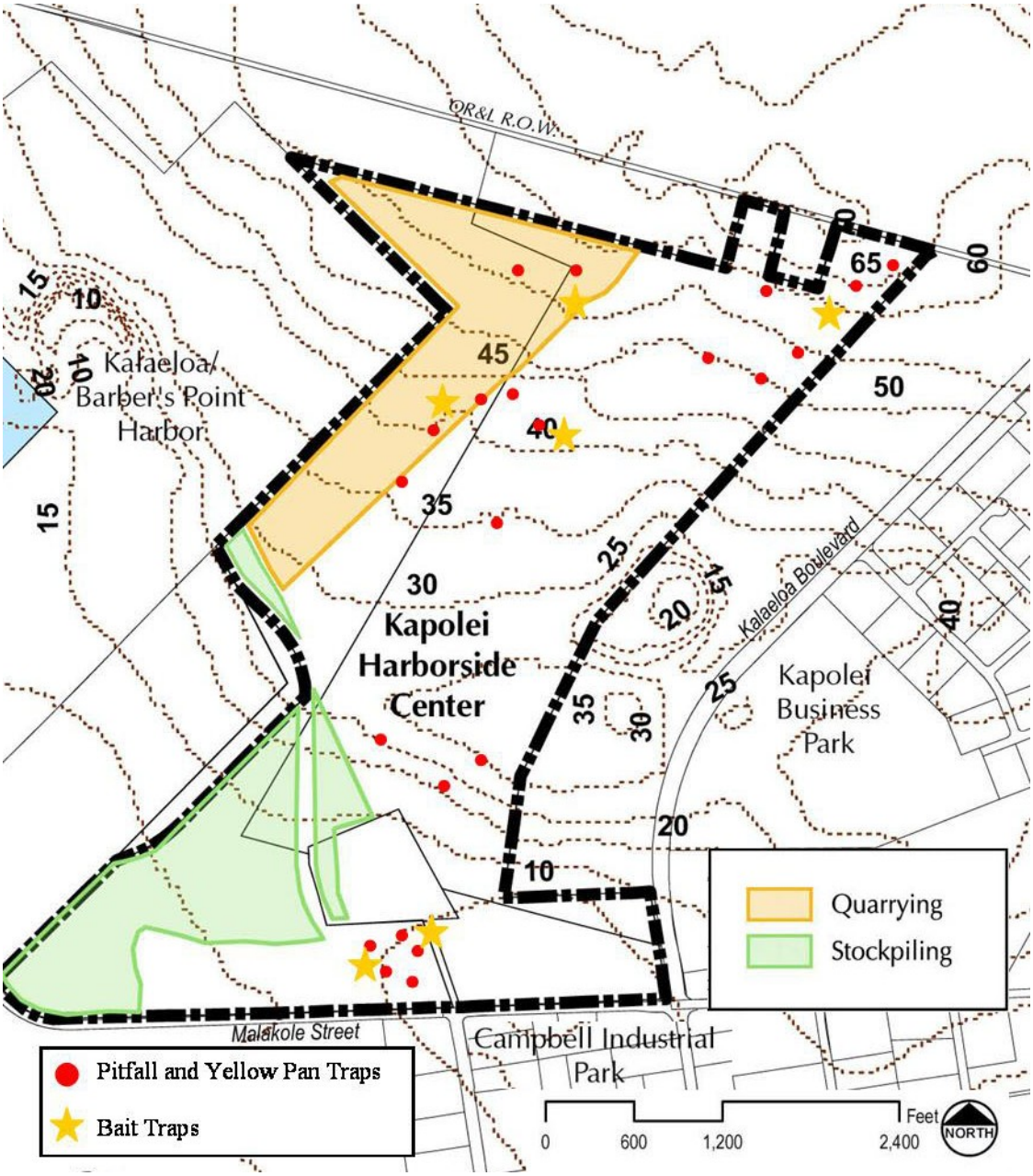

Figure 1. Trap Locations. The locations of Pitfall Traps, Yellow Pan Traps, and Bait Traps

Specimen Curation

The contents of the traps were cleaned in 70% ethyl alcohol and sorted into the morpho-species for identification. Hard-bodied species, such as beetles, true bugs, large flies and wasps were mounted on pins, either by pinning the specimen or by gluing the specimens to paper points. Soft-bodied specimens, such as immature stages, spiders, Collembola, Psyllids, Aphids, small flies and wasps, and centipedes, were stored in vials filled with 70% ethyl alcohol.

Identification

Identification to the species level for all specimens was not feasible in the time frame for this project. Important groups of endemic species, species of concern, and potentially threatening non-indigenous species were given first priority for identification. Other specimens will continue to be identified and the results of those identifications will be reported as an addendum to this report at a later date. Specimens will be deposited in the B.P. Bishop Museum.

Species identification of those specimens identified to genus or species level are unconfirmed and subject to change after comparison to specimens in museums. However, the discussion of the results will not be impacted by changes in species identification because many of the species captured occurred in very low numbers and were not major components of the overall arthropod community.

References for general identification of the specimens included Fauna Hawaiiensis (Sharp (ed) 1899-1913) and the 17 volumes of Insects of Hawai'i (Zimmerman 1948a, 1948b, 1948c, 1948d, 1948e, 1957, 1958a, 1958b, 1978, Hardy 1960, 1964, 1965, 1981, Tentorio 1969, Hardy and Delfinado 1980, Christiansen and Bellinger 1992, Liebherr and Zimmerman 2000, and Daly and Magnacca 2003). Other publications that were useful for general identification included The Insects and Other Invertebrates of Hawaiian Sugar Cane Fields (Williams 1931), Common Insects of Hawai'i (Fullaway and Krauss 1945), Hawaiian Insects and Their Kin (Howarth and Mull 1992), and An Introduction to the Study of Insects Sixth Edition (Borror, Triplehorn, and Johnson 1989).

For specific groups specialized keys were necessary. Keys used to identify Heteroptera included those by Usinger (1936, 1942), Ashlock (1966), and Gagné (1997). Keys used to identify Hymenoptera included Cushman (1944), Watanabe (1958), Townes (1958), Beardsley (1961, 1969, 1976), Yoshimoto and Ishii (1965), and Yoshimoto (1965a, 1965b).

VI. RESULTS AND DISCUSSION

General Observations

One hundred and ninety-five species of insects representing sixteen orders and at least seventy-five families were collected at the site. An additional nineteen species of spiders, three species of other arthropods, and five species of fossilized snail shells were also collected.

The entire site is disturbed by mining, agriculture, and commercial activities, and the vegetation is generally non-indigenous, weedy species. This is reflective of the overall arthropod community which is more than ninety percent non-indigenous. The arthropod fauna in each of the three vegetation zones had a few unique species, but most species were found throughout the site.

Plants that were in bloom attracted pollen and nectar feeders, especially bees and butterflies. Other insects were found feeing on plant juices, under leaves and on stems. Ants were the most abundant insect on the ground.

The most productive sampling methods were aerial netting and foliage beating. Night sampling with UV lights was disappointing, probably due to the time of year of the sampling.

Previous Studies

There have been no previous arthropod surveys at the project site and a search of literature revealed no references for arthropod studies in the Barbers Point vicinity. The nearest, and most complete comparative survey found in the literature was conducted at the Lualualei Naval Magazine 16 km (~10 miles) from the project site (Evenhuis 1997). This one-year study collected 637 species in 23 orders and 120 families.

The Lualualei site had similar vegetation in some areas as that found at the Kapolei Harborside Center site, i.e., land drastically altered by agriculture, cattle grazing, feral animals, and invasive, weedy plants, but also contained large patches of native vegetation that does not occur at the Kapolei Harborside Center site. The species at Lualualei were 21% endemic, and no federally listed species were found. Some rare species were detected in areas of native vegetation (Nishida 1995). None of these rare species were found at the Kapolei Harborside Center site.

Current Study

About thirty-five percent of the arthropod species in Hawai'i are non-indigenous (Nishida 1997). More than ninety percent of the species collected in the Kapolei Harborside Center project site survey were non-indigenous. Many are cosmopolitan, weedy species found throughout the Pacific and the World. The large proportion of non-indigenous species is an indication of the amount of habitat degradation that resulted from the various agricultural and mining operations that have occurred at the site.

The following is a discussion of the arthropods that were detected during the survey of the Kapolei Harborside Center project site.

Class Arachnida

Order Acari
Mites

There are 572 species of Acari (mites) reported in Hawai'i (Nishida 1997). They may be sorted into two major groups, free-living and parasitic. Free-living mites can be further classified into predaceous, phytophagous (plant-feeding), mycophagous (fungi-feeding), saprophagous (feeding on dead tissue), and coprophagous (dung-feeding) forms.

Mites perform important functions in ecosystems. They help breakdown plant litter and implement nutrient recycling. Predaceous mites feed on other arthropods and help to balance their populations.

Their diversity in form, habitat, and behavior make mites difficult to identify taxonomically. One morpho-species of mite was identified from pitfall traps during this study. They were relatively rare, and occurred in only three traps in the quarry and dredged material tailings vegetation zone.

Order Araneae
Spiders

Spiders are abundant arthropods at the Kapolei Harborside Center site. Nineteen species were collected, mostly from vegetation where they prey upon insects.

Class Chilopoda
Centipedes

Centipedes are elongate, flattened arthropods with 15 or more pairs of legs, one pair per body segment. They occur in a variety of habitats, where they feed on spiders and insects.

There are 24 species of centipedes reported in Hawai'i, and eleven from O'ahu. Two specimens of centipedes were collected in this study; both were *Otostigmus scaber* Porat, a non-indigenous species.

Class Insecta

Order Blattodea
Cockroaches

There are nineteen species of cockroaches in Hawai'i, all adventive species. Four species were detected at the Kapolei Harborside Center site.

Order Coleoptera
Beetles

Beetles are the most diverse group of arthropods in Hawai'i. There are 1,983 species of beetles reported in Hawai'i (Nishida 1997). Sixty-two species representing at least seventeen families were found during this study. Only one was identified as endemic to Hawai'i. The other species are adventive or purposely introduced biological control species.

Order Dermaptera
Earwigs

There are twenty-four species of earwigs in Hawai'i, nine that are endemic. Two species of earwigs were captured during this survey, both apparently adventive species of the family Labiidae.

Order Diptera
Flies

Diptera is the second most diverse order of insects in Hawai'i, with 1,449 species representing fifty-seven families. Some of the families, such as Dolichopodidae and Drosophilidae, showed remarkable species radiations and unusual evolutionary developments (Howarth and Mull 1992).

During this study, seventeen species of flies were captured. The most abundant were non-indigenous species of Muscidae (house flies).

Several specimens of Phoridae (hump-backed flies), Drosophilidae (pomace flies, and Sciaridae (dark-winged fungus gnats) were collected. Some of these may be endemic species, but individuals from these families were not abundant in traps or during the visual reconnaissance.

Order Embiidina
Webspinners

Two species of webspinners are known from Hawai'i, both are non-indigenous. One species came to the UV lights during our night sampling.

Order Heteroptera
True Bugs

The order Heteroptera contains 408 species in Hawai'i, 304 of which are endemic. Most species feed on plants, inserting their straw-like mouth parts into the plant to extract the juices. Some species are predaceous. One species, the Wēkiu bug, *Nysius wekiuicola*, has made a remarkable evolutionary modification, adapting to high elevations on Mauna Kea and

feeding on wind-blown insects instead of seeds like its closest relatives.

We detected twenty-three species of true bugs in eight different families. Two are endemic species of the families Miridae and Lygaeidae. Neither of these species is rare.

Order Homoptera
Psyllids, Aphids, and Hoppers

The order Homoptera is another large and diverse group of insects. There are 695 species of Homoptera found in Hawai'i, 386 considered endemic (Nishida 1997). All species feed on plant juices and like the Heteroptera, they use their straw-like mouthparts to feed.

Twelve species of Homoptera were found during this study, two leaf hoppers (family Cicadellidae), and one planthopper (family Cixiidae).

Order Hymenoptera
Bees and Wasps

Bees and wasps are common in Hawai'i. There are 1,270 species that occur in Hawai'i. Of these species, 652 are endemic to Hawai'i and comprise largely small parasitic wasps, mud-daubers, and yellow-faced bees. The yellow-faced bees (family Colletidae) are important pollinators of native plants (Howarth and Mull 1992). Many of the non-indigenous species were purposely released for biological control of agricultural pests.

Another important group of Hymenoptera is the ants (family Formicidae). There are no endemic ants in Hawai'i, but at least forty-four species that now occur here. All were accidentally transported to Hawai'i where they have become a major threat to native arthropods. Four species of worker ants were found during this study, and three species of reproductives. The reproductives were especially abundant during the UV light sampling.

At least forty-four species of Hymenoptera were collected during this study. Many were very small parasitic wasps that are difficult to identify with current keys.

Four species of endemic parasitic wasps of the family Bethylidae were found emerging from seedpods where they were feeding on beetles. Three species of endemic yellow-faced bees (Genus *Hylaeus*) were collected from sourbush (*Pluchia carolinensis*) where they were foraging for nectar.

Order Isoptera
Termites

There are six species of these destructive introduced insects in Hawai'i. Only one species was found during this study, *Crytotermes cynocephalus*.

Order Lepidoptera
Moths and Butterflies

There are 1,148 species of moths and butterflies found in Hawai'i, a majority (1957) of which are endemic. Many of the endemic species are small moths with a wingspan of less than 1 cm (Howarth and Mull 1992).

Endemic Lepidoptera in Hawai'i have made a remarkable feeding adaptation. In most of the World, butterfly and moth larvae are plant feeders. In Hawai'i several species of butterflies and moths have been found to be insectivorous. Larvae of some forest inch worms (family Geometridae) species are ambush predators that blend imperceptibly into their surroundings. Small hairs and nerves on their backs indicate the presence of prey. In a fraction of a second the caterpillar can snap backward and grab its meal with pincer-tipped forelegs.

Five species of butterflies were seen on the Kapolei Harborside Center project site, none of them indigenous to Hawai'i. In addition, three species of macro-moths and fourteen species of micro-moths were captured.

The Blackburn's sphinx moth (*Manduca blackburni*) is only listed invertebrate species historically known from O'ahu. This species has not been recorded from the island since the 1940's despite significant efforts to relocate the species on the island (Federal Register 2003).

While caterpillars of other species of sphinx moths were observed in May 2006 during the botanical and avian surveys (David and Guinther 2006), no caterpillars of Blackburn's sphinx moth have been observed on the Kapolei Harborside Center project site. Nearly two hundred tree tobacco plants were searched for caterpillars of Blackburn's Sphinx moth and none were found.

No adult Blackburn's sphinx moths come to the UV lights during night sampling.

Order Mantodea
Mantids

There are six species of mantids in Hawai'i, all adventive. Two species were found during this study. These species are considered beneficial because they are predators on other insects.

Order Neuroptera
Lacewings

Most of the fifty-eight species of Neuroptera found in Hawai'i are endemic. Two endemic species were found on the Kapolei Harborside Center project site, one green lacewing

(family Chrysopidae) and one brown lacewing (family Hemerobiidae).

Order Odonata
Dragonflies

Nine species of dragonflies are known from Hawai'i, two that are endemic. Five dragonfly species were detected on the Kapolei Harborside Center project, all adventive. They are apparently breeding at temporary ponds or in the drainage ditch. No other sources of water were observed on the site that was capable of sustaining these species.

Order Orthoptera
Grasshoppers and Crickets

More than 275 species of grasshoppers and crickets occur in Hawai'i. Most of the species are endemic crickets, a highly diverse group of Hawaiian insects.

During the survey of the Kapolei Harborside Center project site, two species of grasshoppers, two species of cadydids and two species of crickets were found. All are adventive species.

Order Psocoptera
Psocidss

Psocids are small, soft-bodied insects, less than 6 mm long. Sometimes called barklice, these insects can be found under bark and stones or in dead leaves where they feed on lichens and algae.

Two species of barklice were found on the Kapolei Harborside Center project site.

Order Thysanoptera
Thrips

Thrips are minute, slender-bodies insects 0.5-5 mm in length. They feed on plants, and are especially fond of flowers and buds. Two species of these minute insects were found in this study.

Class Malacostraca

Order Isopoda
Sowbugs and Woodlice

Sowbugs, sometimes called pillbugs, can usually be found under stones, boards, and bark. They are important pests of cultivated crops and can be difficult to control.

There are no confirmed endemic sowbugs among the 20 species known in Hawai'i. One species was found to be particularly abundant on the Kapolei Harborside Center project site.

Special Species Searches

'Ōpae'ula (Halocaridina rubra)

This species lives in underground (hypogeal) environments and in anchialine ponds which have a mix of freshwater and seawater through underground connections to the sea.

They reach 1.5 centimeters (0.5 inch) in length and are herbivores that graze on algal, bacterial, and diatom films growing on rocks and other hard substrates. They can also filter feed in mid-water and at the surface.

Despite repeated searching of the one sinkhole found with water, no 'Ōpae'ula (*Halocaridina rubra*) were found.

Hawaiian Snails

While searching the litter under *Kiawe* (*Prosopis pallida*) trees in the sinkhole reserve a rich deposit of fossilized land snail shells was found below the litter layer. Fossilized snail shells have been known from the karstic 'Ewa Plain at Barbers Point since 1976 (Sinoto 1976). The species diversity of these shells has been studied extensively, most recently being used to document ecological change from human disturbance (Christensen and Kirch 1986, Dye and Tuggle 1998). At least five species of fossilized snail shells were collected in the sinkhole reserve during the current study. There was no evidence of live snails in the area, and there is no reported evidence that land snail species still occur in the vicinity of the Barbers Point.

Summary of the Arthropod Fauna

The arthropods species that were collected during this study would be considered typical of what would be found in lowland, disturbed sites with little or no native vegetation. No species were found that are locally unique to the site. Nor were any species found whose habitat would be threatened by the proposed development at the site

The diversity of the arthropod fauna at the Kapolei Harborside Center project site is somewhat less than what was reported in the Lualualei survey (Evenhuis 1997). This could be expected given the fact that most of the site is disturbed by mining agricultural and commercial activities, while much of the Lualualei survey was in large tracts of native vegetation. Also, the current survey was conducted over a ten day period in late September.

The median annual rainfall in the Barbers Point region is 50 cm (20 inches). Most of the rain falls in the winter months. From May through September the median monthly rainfall is 1.25 cm (0.5 inches) (Christensen and Kirch 1986). Because the arthropod survey was conducted near the end of the dry season, the list of species may not include all species that occur on the site. The pollen- and nectar-feeding species may be underrepresented because of the lack of abundant flowering at the time of the survey. Foliage-feeding species such as caterpillars and true bugs may

also be underrepresented on the list. Only one Noctuid moth came to the UV lights during 4 nights of sampling and no plant bugs (Miridae) were found on foliage during the day. Both could be expected in greater abundance and species diversity earlier in the year. For example, during an arthropod study conducted at the Lualualei Naval Base fourteen plant bugs and nineteen noctuid moths were observed during a full year of sampling (Evenhuis 1997).

The results of this arthropod survey at the Kapolei Harborside Center project site indicate there are no special concerns or legal constraints related to invertebrate resources in the project area. Although several species of Hawaiian endemic arthropods may occur on the 'Ewa plain, these species are not likely to be abundant in the highly disturbed quarry and dredged spoil disposal areas around Kalaeloa/Barbers Point Harbor or on the former agriculture lands further inland that comprise the Kapolei Harborside Center project site. No invertebrate species listed as endangered, threatened, or that are currently proposed for listing under either federal or State of Hawai'i endangered species statutes are known to exist at the project site (DLNR 1997, Federal Register 1999, 2005).

VII. BIBLIOGRAPHY

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