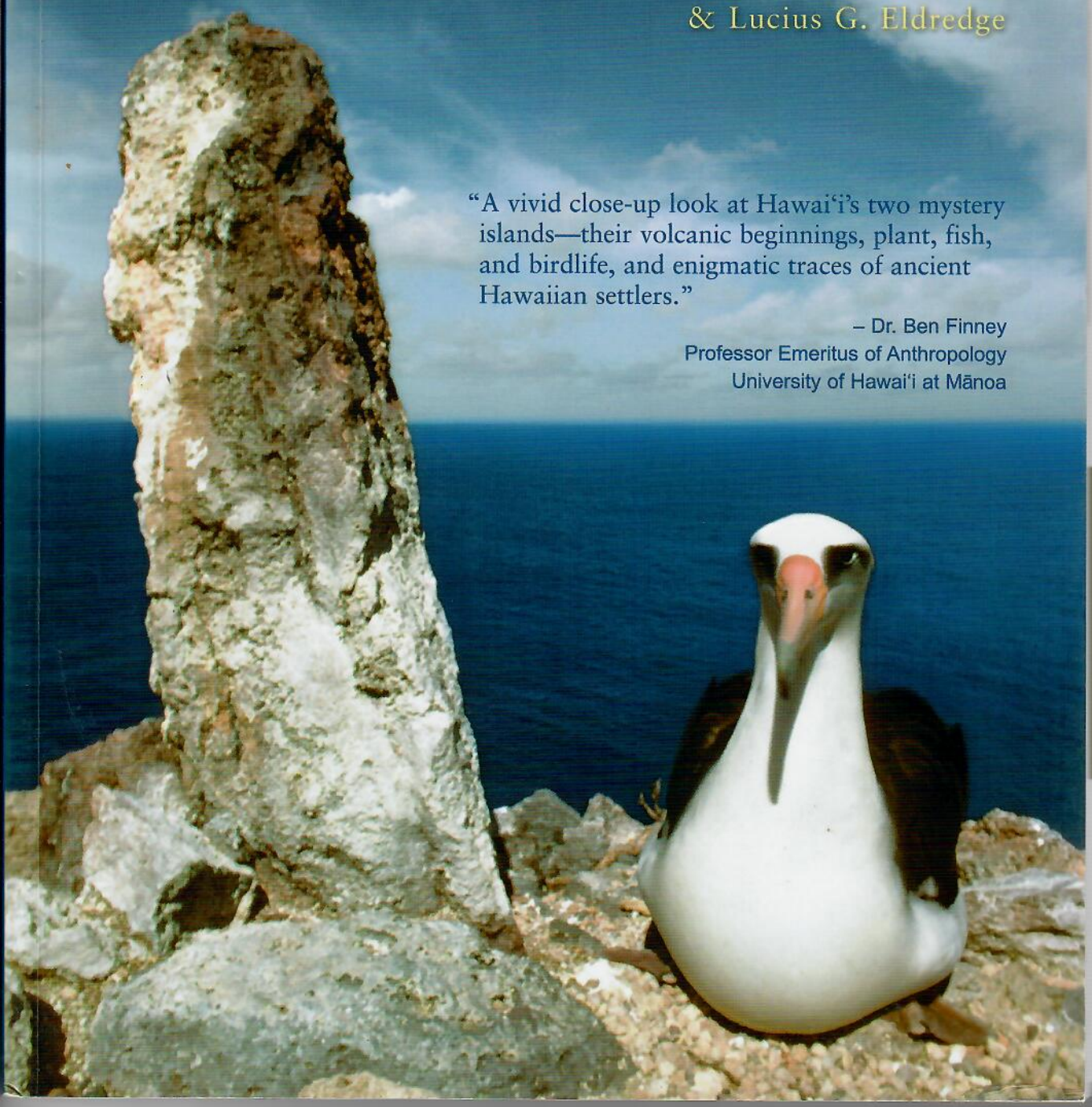
Natural History of Nihoa and Necker Islands

Edited by Neal L. Evenhuis
& Lucius G. Eldredge



"A vivid close-up look at Hawai'i's two mystery islands—their volcanic beginnings, plant, fish, and birdlife, and enigmatic traces of ancient Hawaiian settlers."

– Dr. Ben Finney
Professor Emeritus of Anthropology
University of Hawai'i at Mānoa

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A HAWAII BIOLOGICAL SURVEY HANDBOOK

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PREFACE

The Northwestern Hawaiian Islands of the State of Hawaii receive scant attention from most people compared to the better-known main islands (Ni'ihau, Kaua'i, O'ahu, Moloka'i, Lāna'i, Maui, Kaho'olawe, and Hawai'i) that together form the center of the state's current human population and its commercial, agricultural, and tourism infrastructure. However, these remote Pacific islands contain the largest coral reef system in the United States and some of the most pristine underwater habitats in Hawai'i. As such, they offer unique opportunities for the study of natural history and how islands progress in geologic time from growth to maturity and eventual senescence into atolls.

The islands of Nihoa and Necker (Mokumanamana)* are the two most southerly of the Northwestern Hawaiian Islands and are the subjects of this natural history. Their isolation from the larger, more southeasterly main Hawaiian Islands and the remaining Northwestern Hawaiian Islands has helped keep them and their surrounding waters in an almost untouched condition since they were first discovered. Nihoa and Necker together harbor over 1200 organisms (excluding viruses and bacteria), with the great majority of these species being either endemic (found only in Hawai'i) or indigenous (naturally occurring in Hawai'i but also found elsewhere).

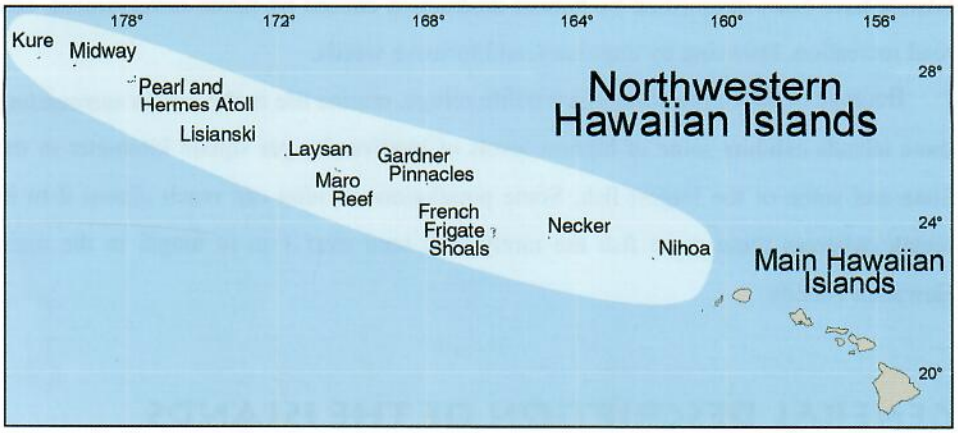
This book offers the reader a special opportunity to learn of the plants and animals found on these two islands but is not intended as a travel guide because these two islands as well as the rest of the Northwestern Hawaiian Islands are federally protected and travel to them is restricted through the U.S. Fish & Wildlife Service.

Nine researchers in cultural, geological, and natural history studies at the Bishop Museum have contributed to this book, making available their expertise to others in the hopes that the stories told in these pages of the various plants, animals, and cultural artifacts found on Nihoa and Necker will contribute to furthering our knowledge of the unique natural and cultural heritage of the Hawaiian Islands.

—The Editors

* Mokumanamana is an ancient Hawaiian name for Necker. We use Necker throughout the book except in the chapter on cultural history.

Habitats and Climate



Brad Evans, Bishop Museum

The NWHI are unique in the state of Hawai'i in being the minute rocky and sandy remnants of once-robust volcanic islands. Their surviving terrestrial vegetation and animal life and virtually pristine marine environment allows us to imagine what the present highly disturbed coastal and dry lowland zones of the main islands and surrounding marine waters may have looked like in ancient times. Terrestrial environmental conditions in the NWHI dictate that only species adapted to harsh, dry, salty, windy, coastal conditions can survive there. Harsh underwater conditions have also restricted growth of a shallow-water fringing coral reef system around Nihoa and Necker. Throughout the year, Nihoa is subjected to powerful ocean waves. Northeasterly tradewind-generated waves occur with a major impact from the north Pacific swell during the winter. As a result, sand shifting on the shelf tends to inhibit coral settlement and growth. Instead, the coral reef ecosystem surrounding these islands is found in deeper waters.

In some cases, terrestrial vegetation assemblages in the NWHI represent the best remaining examples of their kind in the state, such as shrublands of *'ohai* (*Sesbania tomentosa*) and *pōpolo* (*Solanum nelsonii*). Corresponding examples in the main Hawaiian

IKONOS, Inc.

Northern cliffs of Nihoa and Tanager Peak.

Islands have been diminished by habitat destruction caused by urban development, off-road recreation, browsing by ungulates, and invasive weeds.

Because of their protection in a wildlife refuge, marine life in the waters surrounding these islands exhibits some of highest levels of biodiversity per square kilometer in the State and some of the largest fish. Some populations of *ulua* can reach almost 2 m in length, whereas these same fish are rarely ever seen over 1 m in length in the main Hawaiian Islands.

GENERAL DESCRIPTION OF THE ISLANDS

Nihoa and Necker are the two southernmost islands and the two highest islands in the NWHI chain. Nihoa is located at roughly 23°3.6' N 161°55.4' W and lies 250 km northwest of Kaua'i. Necker is northwest of Nihoa at roughly 23°45' N 164°42' W and about 510 km from Kaua'i.

NIHOA

Nihoa is the largest and highest of the uninhabited Hawaiian Islands with an area of 0.631 km^2, a length from east to west of 1.35 km, and a width of 450 m. It has two peaks with a broad swale between them. Miller's Peak, in the northwestern corner, rises to a height of

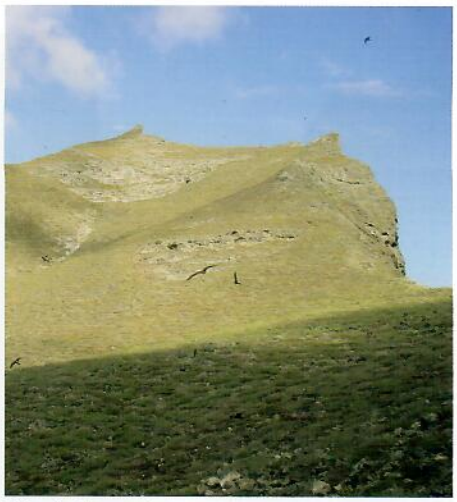
Jim Maragos, USFWS

Nihoa Island from the air looking east.

269 m and Tanager Peak, in the northeastern corner, to 256 m. The northern side of the island is a sheer sea cliff 110–265 m high. The western and eastern sides of the island are also sea cliffs ranging from 10–245 m in height. Numerous caves occur along the base of the sea cliffs, generally at the intersection with dikes at sea level, and may be caused by the combined action of groundwater flowing along the dike interface and wave action. One cave on the eastern end of the island has been cut through the 100 m thickness of the eastern promontory and is navigable by small boat.

The southern side of the island features a 15–30 m high sea cliff with a 1–2.5 m high, 3–5 meter-wide wave-cut terrace at its base; this terrace provided a landing site for the 1923 and 1924 Tanager Expedition boats. Fragments of the terrace are found at the base of the western sea cliffs and can provide a landing site from the leeward side. One section of the terrace on the western side is about 30 m wide and 80–90 m long.

Six valleys slope from north to south and converge toward the middle of the south shore of the island: West Valley, West Palm Valley, Miller Valley, Middle Valley, East Palm Valley, and East Valley. A small sandy beach (Derby's Beach or Derby's Landing) is found at the western end of the island in Adam's Bay.



Beth Flint, USFWS

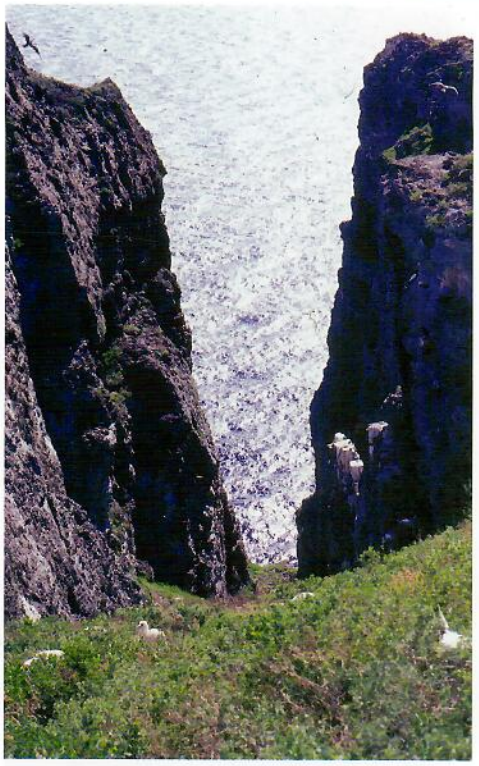
Nihoa looking northwest at Miller's Peak. Dry season.

Beth Flint, USFWS

Nihoa looking west toward Dog's Head. Dry season.

Larry Basch, NPS

Nihoa south shore. West Palm Valley (center).



Sheila Conant, UH

Devil's Slide (left) and Needle Peak (right) on Nihoa.

Some geophysical features on the island have taken on names befitting their purpose or reflect the impression they gave the person who named them. Albatross Plateau (or Miller Plateau) is a relatively flat plain on the northwestern side of the island that serves as a bird nesting area and is large enough to allow for the ungainly landing techniques of the Laysan and black-footed albatrosses without having them tumble off the cliffs into the seas below. At Devil's Slide, a steep, narrow talus channel between two basalt monoliths just east of Albatross Plateau slopes steeply to the edge of a vertical cliff that then drops straight down to the surging waves 60 m below. And there is Dog's Head Peak, the southwesternmost point, named for its likeness to a dog's head.

NECKER

Necker represents a small, thin, fishhook-shaped sliver of remaining rock of a once larger volcanic island geologists believed was as large as O'ahu. It is only 1370 m long by about 150 m wide at its widest point and its highest elevation is 82 m.

Necker is relatively steep-sided all around with two low saddle areas on its eastern end,

thus making it appear at some angles as three separate islands. The island actually consists of two parts. The principal one is a ridge extending nearly due east-west, 1200 m long and varying from 60–180 m in width. On this ridge are five peaks 75, 55, 83, 78, and 69 m high, from west to east. The saddles between the peaks are shallow, except the most westerly, which drops to only 23 m above sea level. From the westernmost peak a peninsula extends 150 m north-northeast to a gap only a meter or so above sea level. In rough weather, waves splash through this gap. The lesser part of Necker, called Northwest Cape, extends about 245 m northeast from this gap and has a maximum elevation of 48 m. At the eastern end of the main part of Necker is a low islet about 23 m wide and 60 m long. It is awash at high water and waves break over it continually. Going from west to east, the prominent geophysical features are Northwest Cape, Annexation Hill, and Flagpole Hill (all three of which bound Shark's Bay to the north), Summit Hill, and Bowl Hill. In between Northwest Cape and Annexation Hill is West Cove, and the westernmost point of the island west of the Annexation Hill summit is sometimes called Mo'o Head.

Jim Maragos, USFWS

Necker from the air looking west.

Beth Flint, USFWS

Necker looking east toward Summit and Bowl Hills.

Sheila Conant, UH

Necker Island. Shark's Bay looking toward Annexation Hill.

LAND HABITATS

While many of the islands in the NWHI have been reduced to low sandy or limestone substrates, Necker and Nihoa differ in being relatively high, steep basaltic remnants of once-large volcanoes. Although they are not high enough to capture much condensation from moisture-laden northeastern tradewinds that sweep across the ocean most of the year, the vegetation composition of the two islands still differs from the rest of the NWHI in being clothed with low, coastal dry shrublands dominated by *'ilima* (*Sida fallax*) or *'āweoweo* (*Chenopodium oahuense*) or dry grasslands of *kāwelu* (*Eragrostis variabilis*). In mesic valley depressions on Nihoa are groves of *loulu* (*Pritchardia remota*) palm forest. Necker is virtually devoid of any large vegetation. It has no trees and only supports six species of plants, all of which are low-growing.

LITTORAL ZONE

The rocky shoreline and cliffs of both islands serve as the interface between marine and terrestrial life. Both plants and animals living in this area need to be able to tolerate a saline environment and adapt to the surging sea and resulting splash of waves onto the rocks or cliffs. The giant rock cricket, *'ūhini lele* (*Caconemobius nihoensis*) on Nihoa has adapted well to this environment and can withstand the splash of the pounding waves by hunkering down in between the rocks and boulders of the shoreline as it searches for food. The only sandy beach (Derby's Beach in Adam's Bay on Nihoa) is another component of the littoral zone and is home to the endangered Hawaiian monk seals (*Monachus schauinslandi*) that rest and sun themselves here.

Sheila Conant, UH

Rocky south shoreline of Nihoa. Habitat for the giant rock cricket (*Caconemobius*).

Geology

DEEPER MARINE WATERS

Deeper waters harbor a vast amount of fish and invertebrate life (see Appendix). Although both islands have steep underwater features, there are still shallow areas that harbor corals, and the steep basaltic underwater features contain many cracks and crevices that support a bountiful array of marine life. On Necker, the submerged shelf that was once part of the emerged island is 65 km long and 25 km wide (some 128,000 hectares in extent) and supports a large coral reef ecosystem. Nihoa has a similar coral reef system on a submerged shelf that is roughly 57,500 hectares in extent, with many of the encrusting coral species found below 12 m.

CLIMATE

Being relatively low islands, both Necker and Nihoa are primarily oceanic in climate and feel the full force of winds without much protection on the lee sides of the islands. Although they are both at a higher latitude than the main Hawaiian Islands, they still are within the subtropical tradewind belt and are subject to the same storm fronts and hurricane patterns that make their way through the main Hawaiian Islands each season.

Additionally, their low profile restricts their ability to condense water from the atmosphere (known as orographic rainfall) or to create local weather conditions found on the larger and much higher Hawaiian islands to the southeast. Thus, Nihoa and Necker, like their low elevation NWHI neighbors to the northwest, are dry islands with very little if any fresh water or moisture.

The volcanic rocks of Nihoa are mainly olivine basalts and minor olivine-free basalts, characteristic of the shield-building stage of Hawaiian volcanoes. No volcanic bombs, tuff, or ash have been described, suggesting that the volcanic remnant comprising Nihoa is made up of only shield-stage lava flows and dikes.

Sheila Conant, UH

Seep pool on Nihoa ca. 2 m in diameter.

Sand analysis from the western cove beach shows that the sand is representative of deposits on and around the island: olivine makes up 62%, carbonate material 17%, iron oxides 13%, and other material 8%.

ARCHAEOLOGY

Abundant archaeological remains studied during the Tanager Expeditions have been described by Kenneth P. Emory. Several of these sites made use of striking columnar-jointed basalts from either thick dikes or sills. Whether these rocks were locally quarried is not known, but it is unlikely that they would have been transported great distances due to their size and weight.

A more thorough treatment of the cultural history of Nihoa and Necker is presented elsewhere in this book, but a recent geochemical sourcing study on some fragments of tools and implements from Nihoa concluded that the rocks used to make the implements are from Nihoa. Therefore, the inhabitants made their implements from local material there on the island and did not transport them from elsewhere.

GEOLOGY OF NECKER

Necker is the subaerial remnant of a once larger volcano 90 by 110 km at its base. The seamount has a flat top ~30 km by 75 km and ~30 m deep covering an estimated 1314 km^2. This shallow shelf is subjected to severe wave action throughout the year, which directly impacts the bottom and continually moves sand across the shelf areas. Abrasion and burial inhibit shallow-water coral reef development, so coral coverage is low.

The dip of the lava flows is north-northeastward, indicating that the original caldera was south-southwestward of the island. The platform on which the island lies was cut by wave erosion across a large volcanic massif, but the position on the platform of the island and of the former center of the volcano suggests that the massif was not a single shield, but a group of shields similar to the present island of Hawai'i. The original size of the island is hard to estimate, but based on the dip of flows and the size of the submarine edifice, it was probably at least the size of O'ahu.

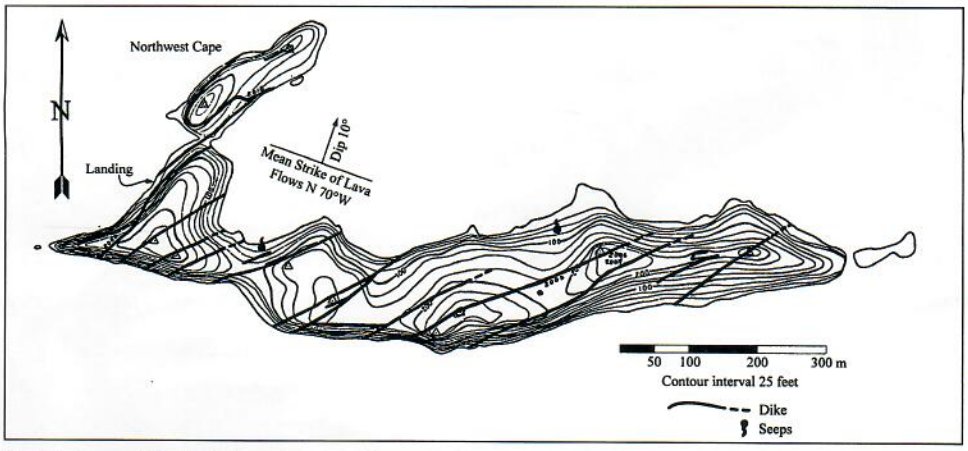
The rocks of Necker are mostly olivine basalt, but at least one flow of basaltic hawaiite and several of ankaramite (olivine + augite bearing alkalic basalt) are present, suggesting that the volcano had entered the post-shield stage. Several dikes and flows show chemical similarities to post-erosional or rejuvenation stage lavas from O'ahu.

The peaks and intervening swales along the crest of Necker are remnants of an old stream-eroded topography. The edges of the island are sea cliffs, at the base of which there is usually a wave-cut bench a few meters above sea level.

Although restricted, accessibility to different parts of the island is fairly easy due to its small size and low elevation. The Tanager Expedition found an excellent landing on the wave-cut bench at the west end of the main island in the lee of Northwest Cape. The footing along the wave-cut bench is very good, but on the higher parts of the island many rocks are loosely held in the soil. Northwest Cape has a denser bird population than the rest of the island and the guano has accumulated to a depth of a few inches making a precarious surface.

The upper surface of the island slopes gently to the north. The saddles that separate the peaks are shallow except the most westerly one, which has an elevation of 23 m. It is 45 m lower than the west peak and 33 m lower than the peak to the east. The other three saddles range from 8–20 m in elevation below the adjacent peaks.

There are no well-defined stream channels on Necker. The water that falls as rain



Kevin Johnson, Bishop Museum

Geological map of Necker (redrawn from hand-drawn map from Tanager Expedition).

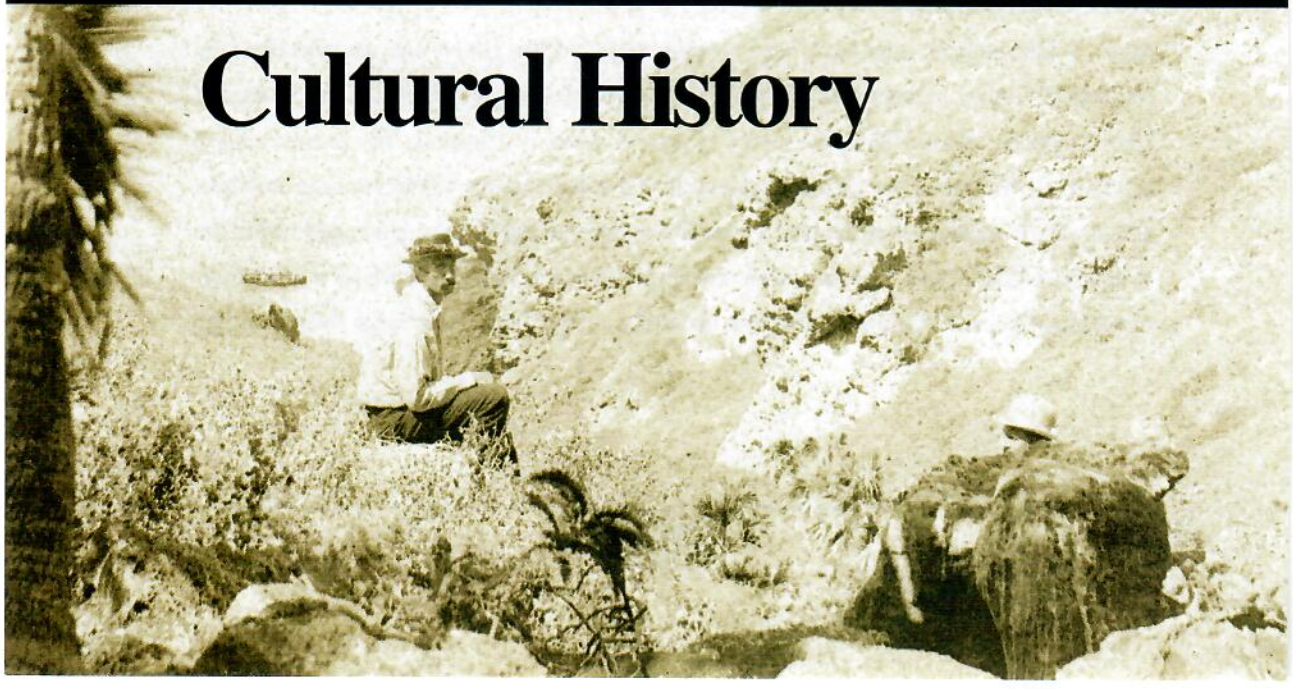
either sinks into the rock or runs off through unorganized channels. Two small seeps of ground water together produce less than 40 liters of water a day. One is at an elevation of about 15 m on the north slope of the main island a little west of a cave in which stone and wooden artifacts were found. The other seep is about 10 m above sea level on the north side of the westernmost saddle of the main island. The water of both seeps is strongly acrid, presumably from bird droppings.

In some of the shallow caves, stalactites and stalagmites of gypsum with good crystal outlines are observed. These growths have been ascribed to leaching of calcium in the basalt by sulfuric acid generated by guano or to redeposition of gypsum from evaporated salt spray.

ARCHAEOLOGY

Many archaeological sites have been identified on Necker Island and are described by Kenneth P. Emory in a detailed account of archaeological work carried out on Nihoa and Necker Islands. As on Nihoa, the source of potable water is a mystery. The present supply of less than 40 liters a day of acrid, guano-tainted water that we would consider undrinkable is clearly inadequate to support a population large enough to have built and lived in the structures on the island. The above-mentioned geochemical sourcing study of artifact fragments from Necker Island indicated that the artifacts were made from local volcanic rock.

Cultural History



Oral traditions portray the Hawaiian Islands as siblings, part of a large *'ohana* (family) that includes the Northwestern Hawaiian Islands. Archaeological evidence proves that the Northwestern Hawaiian Islands have been visited or inhabited by native Hawaiians for more than a thousand years. Oral tradition and archaeological evidence suggest that Hawaiians never considered the Northwestern Hawaiian Islands to be barren, isolated, inhospitable, or marginal.

By combining the traditional *mele* (chants) and *mo'ōlelo* (stories) and the archaeological evidence, the cultural history of the Northwestern Hawaiian Islands can be illustrated. The *mele* and *mo'ōlelo* included in this chapter were documented by nineteenth-century native Hawaiian scholars and students. These *mele* and *mo'ōlelo* consist of birth chants, migration stories, and historical chronicles. The archaeological data included here come from religious shrines, residences, agricultural terraces, water diversion structures, quarries, and artifact assemblages. This blending of oral traditions with archaeological evidence produces a cultural history of these islands that may be combined with their natural history to create a unique story of Hawai'i that would not otherwise be possible.

ORAL TRADITIONS

An 1835 transcription of an ancient *mo'ōlelo* includes the islands of Ka'ula and Nihoa. The *mo'ōlelo* is titled "*Mooolelo no na kanaka kahiko mai ka po mai, a me ka poe moku i hanau mai i*" and records the history of the people from the gods and the birth of the islands. Kaiaikawaha, an adult student, documented this *mo'ōlelo* while he attended Lahainaluna Seminary. It provides names of the islands stretching from Kahiki (Tahiti or any distant place beyond the horizon) to Polapola (Bora Bora) to Hawai'i Island to the Northwestern Hawaiian Islands, and possibly beyond. Twenty-three island names appear after Kaua'i and Ni'ihau. In island order, the first four are Ka'ula, Kamokupapapa, Nihoa, and Ha'ena.

Mokumanamana, which many believe is an ancient name for Necker Island, appears in a *ka'ao* or legend published in the Hawaiian-language newspaper *Ka Hoku o Ka*

Photo of the 1885 royal expedition with Princess Lili'uokalani to Nihoa.

Pakipika in 1861. In the story, a man named Pueo travels through the islands on his voyage east to his island home. As he goes, he identifies the islands he passes: just past Nihoa is Kamokumanamana.

Other *mele* and *mo'ōlelo*, including the Pele migration chants, mention names of leeward islands beyond Nihoa. These islands include Mokupapapa, Kuaihelani, Hanakeaumoe, Hanakaieie, Mokuakamohoalii, Ōnū Nui (also Ununui), Ōnū Iki, Kanehunamoku, and Mokumanamana; their geographic arrangement remains unknown.

The Pele migration chants tell the story of Pele and her family voyaging from Kahiki in search of a new home. On their voyage they traveled by way of Polapola (Bora Bora) and approached the Hawaiian Archipelago from the northwest. They traveled down the Hawaiian chain, stopping at several islands to determine their suitability for habitation, finally settling on the island of Hawai'i.

In one version, Pele traveled with Kamohoali'i, Kāne'āpua, Kānemilohai, Hi'iaka, and many other relatives. She left her brother Kānemilohai on Mokupapapa. She stopped at Nihoa, where she planted her *pāoa* (staff) only to find the island unsuitable for residence. Pele banished her brother Kāne'āpua to stay on Nihoa, while she and others continued to Lehua. Although Lehua was also determined to be unsuitable, Pele crowned the island with a wreath of *kauno'a*, while Hi'iaka blessed the island with *lehua* she took from her neck. Taking pity on her brother on Nihoa, Pele and the others returned to rescue him before heading to Ni'ihau.

Nihoa is identified as a sibling of Ni'ihau and Ka'ula in a chant composed by Kahakuikamoana:

O Wanalia ke kane,	Wanalia was the man
O Hanalaa ka wahine.	And Hanalaa was the woman.
Hanau Niihau he aina, he moku,	Of them was born Niihau, a land, an island.
Ekolu lakou keiki	There were three children of them
I hanau i ka la kahi.	Born in the same day.
O Niihau, o Kaula, Nihoa pau mai.	Niihau, Kaula, ending with Nihoa.
Pa ka makuawahine,	The mother then conceived no more,
Oili moku ole mai mahope.	No other island appeared afterwards.

Many of the chants and *mo'ōlelo* also mention the names of gods, important cultural sites, and landmarks associated with these northwestern islands. Other names come from Ni'ihau oral traditions written down by Tava and Keale in 1989. No place names have yet

been found associated with the ancient island names of Hā'ena or Mokumanamana (Necker).

The 1885 Lahainaluna *mo'ōlelo* provide details about two religious sites on Nihoa: Mauloko and Ninioa. Mauloko is a *leina a ka'uhane*, a place where souls or spirits leaped into the netherworld. Ninioa is a *heiau* that stood on the western side of a precipice by the sea. The offerings to the gods were brought on canoes, including human sacrifices, hogs, and bananas. Kahiupewa, a shark god, was the guardian of this *heiau* and a relative of two shark gods of Ka'ula, Kamohoali'i, and Kuhaimoana. When people settled on Kaua'i during the reign of Kapulauki, Kapu was sent to be the officiating priest of Ninioa. He was the first human priest of Ninioa and the first to offer sacrifices to Kamohoali'i and Kuhaimoana on Ka'ula.

Some elders on Ni'ihau still recall traditions in which their ancestors sailed double-hulled canoes to Nihoa, Lehua, and Ka'ula for birds and feathers, turtles, fish and shellfish, and other terrestrial and marine resources. On Nihoa they gathered leaves and wood for spears from the *loulu* fan palm and grass for making cordage and stuffing.

They would have timed their voyages to catch favorable winds in the spring and fall. These winds could have carried them from Ni'ihau to Nihoa in about one-and-a-quarter days, and from there to Mokumanamana in an additional one-and-three-quarters days. It would have taken less than another day to reach French Frigate Shoals.

By stopping at each island, they could have acquired fresh drinking water to supply their needs as they moved up the northwestern part of the chain. Oral traditions detail the names of some of the *punawai* or water springs on Lehua, Ka'ula, and Nihoa.

Oral traditions mention a *punawai* on Nihoa called Waiakonohoaka as well as references to rain, and a wind called Waialoha. A chant from Kaua'i mentions Nihoa and Lehua and the water of Kāne:

E u-i aku ana au ia oe,	A question I ask of you:
Aia i-hea ka Wai a Kane?	Where is the water of Kane?
Aia i Kau-lana-ka-la	Out there with the floating Sun,
I ka pae opua i ke kai,	Where cloud forms rest on Ocean's breast,
Ea mai ana ma Nihoa,	Uplifting their forms at Nihoa,
Ma ka mole mai o Lehua;	This side the base of Lehua;
Aia i-laila ka Wai a Kane.	There is the water of Kane.

Rain figures prominently in a *mele* composed by Kaweloamahunaali'i:

Ea mai ana ke ao ua o Kona,	The rain cloud of Kona rises,
Ea mai ana ma Nihoa	It rises over Nihoa
Ma ka mole mai o Lehua,	Beyond the base of Lehua.
Ua iho la pulu ke kahawai.	It pours down and floods the streams.

Fresh water, winds, and birds are prominent in an incomplete chant attributed to Kiaaina:

Hono uli ka makani Nihoa	Cloudy is the wind of Nihoa,
Waialoha ka makani kaapuni Nihoa	The wind, Waialoha, blows around Nihoa,
Na makani o Kaula wili Koolau	The wind of Kaula and the Koolau wind blow wildly about,
Ka makani Kaulakahi	The wind from Kaulakahi,
Lele ka 'iwa, malie, kaikoo	The iwa bird flies in the calm, over the stormy sea
Ku wau e hele, e hele no	I stand and go; aye, go.
Makani o Lehua	Windy is Lehua,
Pa'apa'ainu ai ka makani o Lehua	The wind of Lehua makes a sharp sound.
Hooheno ka ua naulu,	Pleasing are the Naulu rain and
ka wai huna a ka paoo	the hidden water of the *paoo* fish.
Paa ia ka mano'o me oe	Hold the thought fast to you,
Hoolaau ka makemake me oe	Let insistent desire be within you.

ARCHAEOLOGICAL EVIDENCE

The archaeological evidence on Nihoa and Necker (Mokumanamana) complements the oral traditions. The cultural sites dotting the landscapes of these islands document native Hawaiian inter-island voyaging and occupation leeward of Ni'ihau and Kaua'i. The few radiocarbon dates obtained from cultural materials on Nihoa and Necker indicate colonization occurred sometime between A.D. 1000 and A.D. 1700. Oral traditions and historical accounts document continuity of some traditional activities in the leeward islands during the last several hundred years.

In ancient times, native Hawaiians voyaged to the Northwestern Hawaiian Islands to hunt and gather terrestrial and marine resources, grow crops, establish settlements, and to worship. These activities are documented by cultural sites on Nihoa and Necker. Thus far, 88 cultural sites are known on Nihoa and 52 on Necker.

These inter-island voyages of men, women, and children extensively settled Nihoa for at least part of the year, while very small groups stayed briefly on Mokumanamana. Their skills were diverse. There were fishermen, bird catchers, farmers, and specialized craftsmen and practitioners.

On Nihoa, they built religious shrines, residences, agricultural terraces, and water diversion structures. They obtained fresh water from seeps in Middle, West Palm, and East Palm valleys and by capturing rainwater in containers and catchment features. They established landing areas, fishing grounds, trails, and burial sites. They quarried rocks from natural outcrops, dikes, old streambeds, and the beaches to build enclosures, platforms, terraces, living floors, walls, and cairns, and to make a variety of tools, implements, and containers.

Their religious shrines are broadly distributed across the island, including some on coastal ridges, on summit peaks, valley slopes, on flat terrain, or inside rockshelters. These shrines include stone uprights, cairns, or coral offerings, which were placed either singularly or in association with pavements, terraces, or platforms. Some may be *ko'a* or fishing shrines.

The families on Nihoa established large residential terrace complexes in the valleys and smaller residences in rockshelters. Their

Sheila Conant, UH

Walled cave habitation on Nihoa.

Sheila Conant, UH

House site on Nihoa.

Sheila Conant, UH

Upright stones of a *marae* on Necker (Mokumanamana).

terrace complexes supported thatched houses, domestic activity areas, religious features, and nearby agricultural fields. They enhanced the living area of some rockshelters by paving the interior with small stones, placing stone uprights near the rear wall, constructing terrace areas beyond the shelter entrance, or by building rock walls to block the wind and rain.

Their agricultural terraces cover about fifteen percent of the island, blanketing the relative flat and gentle areas and rising in fish-scale fashion up the valley slopes. Such terraces are extensive in East Palm Valley, in the large swale east of Middle Valley, and in the upper reaches of Middle Valley. Clusters of agricultural terraces also can be found near rockshelter residences in Middle and East Valleys.

The native Hawaiians who resided on Mokumanamana for short periods may have lived on Nihoa during part of the year or may have briefly landed while voyaging to or from other islands in the archipelago. Some stayed long enough to quarry stone for building architectural features and for making tools, implements, and containers. These short-term residents erected more than 30 shrines and constructed residential terraces, walls, and floors at some of the rockshelters. They constructed other terraces that may have supported thatched dwellings or small agricultural plots. They collected water from several seeps, established trails, landing areas, and places for bird catching, fishing, and for gathering other marine resources.

The skilled builders of the shrines on Mokumanamana generally followed a rectangular floor plan containing several interior spaces and a rear platform with a row of upright stone slabs along the back. In some, they also erected one or two central uprights near the rear platform and one or more uprights on a lower interior platform. Several

Bishop Museum Archives

Spearing fish on Necker (Mokumanamana). 1923 photo.

shrines have exterior walls or have associated terraces or enclosures, and a few grade into rock outcrops or cliff slopes. All exhibit strong similarity in design and possible religious function with shrines atop Haleakalā on the island of Maui and atop Mauna Kea and Mauna Loa on the island of Hawai'i.

The residents on Mokumanamana also constructed terraces, windbreaks, and stone pavements to maximize the living space of the island's rockshelters. Ash from a hearth was found in one rockshelter, while an extensive assemblage of cultural objects was found in Bowl Cave. This shelter cave is the largest residential site on the island. The floor of the rockshelter was paved and a few feet from the entrance is the largest fresh water seep. Archaeological excavations within Bowl Cave yielded stone bowls and containers, adzes, grindstones, as well as fishing gear (stone sinkers, a wooden shuttle, bone fishhooks, and shell octopus lures).

CULTURAL HISTORY

Oral traditions and archaeological evidence combined suggest the following cultural history for Nihoa and Mokumanamana. Sometime early in the first century A.D., native Hawaiian voyagers using double-hulled canoes explored the entire Hawaiian Archipelago. By the beginning of the second century A.D., they had settled the eight main Hawaiian Islands and were actively engaged in inter-island voyaging. Upwards of 100 to 150 people may have visited and resided seasonally on Nihoa and a much smaller population could have resided there year round.

The native Hawaiians residing on Nihoa were well positioned to launch seasonal voyages to Mokumanamana, French Frigate Shoals, Laysan, and the more distant Leeward Islands, or to voyage in the opposite direction to Ka'ula, Lehua, Ni'ihau, Kaua'i, and beyond. These inter-island voyages tied the population on Nihoa to communities in the main Hawaiian Islands, particularly on Ni'ihau and Kaua'i. These social, economic, political, and religious ties are reflected in the archaeological evidence of Nihoa and Mokumanamana.

The architectural remains and cultural objects found on Nihoa and Mokumanamana, even the unique stone images, all belong to the same native Hawaiian cultural traditions

found in the main Hawaiian Islands. The dryland agricultural terraces and water diversion or catchment features are constructed using the same dry-laid masonry techniques present throughout Hawai'i. The shrines on Nihoa share many traits with shrines on the main Hawaiian Islands, as do the grindstones, fishing gear, and bone tools. Whereas some of the types of stone bowls and adzes on Nihoa and Mokumanamana are uncommon elsewhere in Hawai'i, they all reflect traditions represented on the main islands.

The native Hawaiians living on Nihoa and Mokumanamana made some cultural objects using the stone, plant, and animal resources found on their islands. Other items they acquired through contact with communities in the main Hawaiian Islands. Some of these imports may have included unmodified pieces of stone, wood, bone, shell, or plant fibers. Imports may also have included food (such as *taro*) and completed items, such as canoes, *'umeke* (wooden bowls), gourd containers, and *kapa*.

Native Hawaiians were still voyaging leeward when foreign explorers reached Hawai'i in the late 1700s. The earliest of these explorers observed the inter-island ties among communities on Ni'ihau and Kaua'i and their voyaging to Ka'ula to obtain valued resources.

In 1822, Queen Ka'ahumanu's historic voyage to Nihoa affirmed oral traditions about the island and native Hawaiian voyaging in the Northwestern Hawaiian Islands. She observed evidence of past settlement and planted *loulu* fan palms. Native historians documented this historic voyage in *mo'ōlelo* that appeared in Hawaiian-language newspapers beginning in the 1860s. These *mo'ōlelo* tell of how Ka'ahumanu learned about Nihoa from the oral traditions of Ni'ihau and Kaua'i and how, upon her return, she named children and places "Nihoa" in remembrance of her voyage.

During the second half of the nineteenth century, the native Hawaiian royalty, government officials and surveyors, scientists, tourists, and captains and crews that landed on various leeward islands expanded on Ka'ahumanu's findings. They concluded that native Hawaiians had settled Nihoa and Mokumanamana and had constructed the residential, agricultural, and religious sites and had made the cultural objects found there. Some of these activities, observations, or findings were recorded in oral traditions or Hawaiian-language writings, while others were described in English-language newspapers, scientific manuscripts, maps, and government records.

NATURAL HISTORY

The cultural history produced by combining the oral traditions and archaeological evidence can then be combined with the natural history to produce a more complete cultural history of these islands The natural history of Nihoa and Mokumanamana comes from observations written by scientists, government officials, and native Hawaiians in the nineteenth and twentieth centuries. These observations include climate, especially winds and rainfall, vegetation, terrestrial and marine life, especially birds, and soils and rocks. Rainfall is critical because it provides the only source of fresh water, while wind is crucial to voyaging. Rainfall may have been greater a thousand years ago when native Hawaiians settled Nihoa and established short-term residences on Mokumanamana. Greater rainfall may have supported a greater diversity of plants and animals than exists on these islands today. Vegetation and terrestrial and marine life provided the essential subsistence resources, while soils and rocks were essential for farming and making structures, tools, and implements.

Together the oral traditions, archaeological evidence, and natural history suggest a rich cultural history for Nihoa and Mokumanamana. The native Hawaiians who voyaged to or from Nihoa and Mokumanamana relied on favorable seasonal winds to carry them to more distant Leeward Islands or southeasterly to Ka'ula, Lehua, or the main Hawaiian Islands. In the spring, they would have timed their leeward voyages to catch the southeasterly winds that temporarily replace the regular tradewinds. In the fall, they would have timed their southeasterly voyages with the westerly and northerly winds that appear after the Kona or southerly winds.

These voyagers likely sought morning landings on Nihoa to avoid the rougher seas associated with the afternoon tradewinds. Their best landing was on the east side of the middle cove that forms the south shore. In favorable weather, they would have been able to easily jump from their canoes to the wave-cut terrace. They may also have swum from their canoes to the sand beach on the western cove. Above the benches they had easy routes for traveling overland from one valley to the next.

Native Hawaiians visited and possibly settled Nihoa in the early second century A.D.

They found sheer sea cliffs devoid of vegetation, south slopes covered by several varieties of grasses, valleys densely carpeted by shrubs and stands of *loulu* fan palms. Oral traditions suggest that these settlers likely used the palm trees for timber, thatch, and firewood. The archaeological evidence indicates the residents of Nihoa also made use of *hau*, *kukui*, *ulu*, and *wiliwili*, although none are known to have grown on the island. Other archaeological evidence indicates that Polynesian rats and human population expansion may have played a role in the loss of coastal *loulu* fan palm forests on the main Hawaiian Islands during the period in which Nihoa was initially occupied. Whether these trees were similarly reduced in numbers and distribution on Nihoa remains unknown. On Nihoa today, these trees are limited to a small grove in East Palm Valley and a larger grove in West Palm Valley.

The settlers on Nihoa may have raised sweet potato and other crops requiring little water. They built agricultural terraces and stone structures to divert water in each of the valleys, including valleys that lack indications of flowing water today. Some of their diversion structures were designed to redirect rainwater and small streams into a single flow, while others collected water in small beds. By planting crops next to seasonal or temporary water flows, residents could maximize catchment or diversion of rainfall to water their fields. They hunted birds and fished. The seventeen bird species and abundant fish and shellfish species would have provided important sources of protein for the island's residents and voyaging visitors. The wave-cut terrace along the south shore provided an excellent platform from which they could collect marine resources, including inshore or near shore fishes, sea turtles, crabs, sea urchins, limpets, and octopus or squid.

The native Hawaiian voyagers who stayed on Mokumanamana would have found it difficult to grow crops because of the paucity of soil and water. There are no stream channels, and only six species of flowering plants exist, including low shrubs and grasses. The native Hawaiians who stayed on Mokumanamana positioned rocks at the seep near Bowl Cave to support containers for collecting and storing fresh water. This catchment system supplied water to the largest rockshelter occupation on the island. These residents also may have tried to grow crops in a few terraces containing a thicker accumulation of soil than elsewhere on the island. It is uncertain if some of the terraces supported dwellings. If so, where they acquired sufficient wood for timbers or thatching remains unknown. No trees grow on the island today. The archaeological evidence includes several pieces of *wiliwili* from Bowl Cave, which may have been brought from another island; none of the charcoal

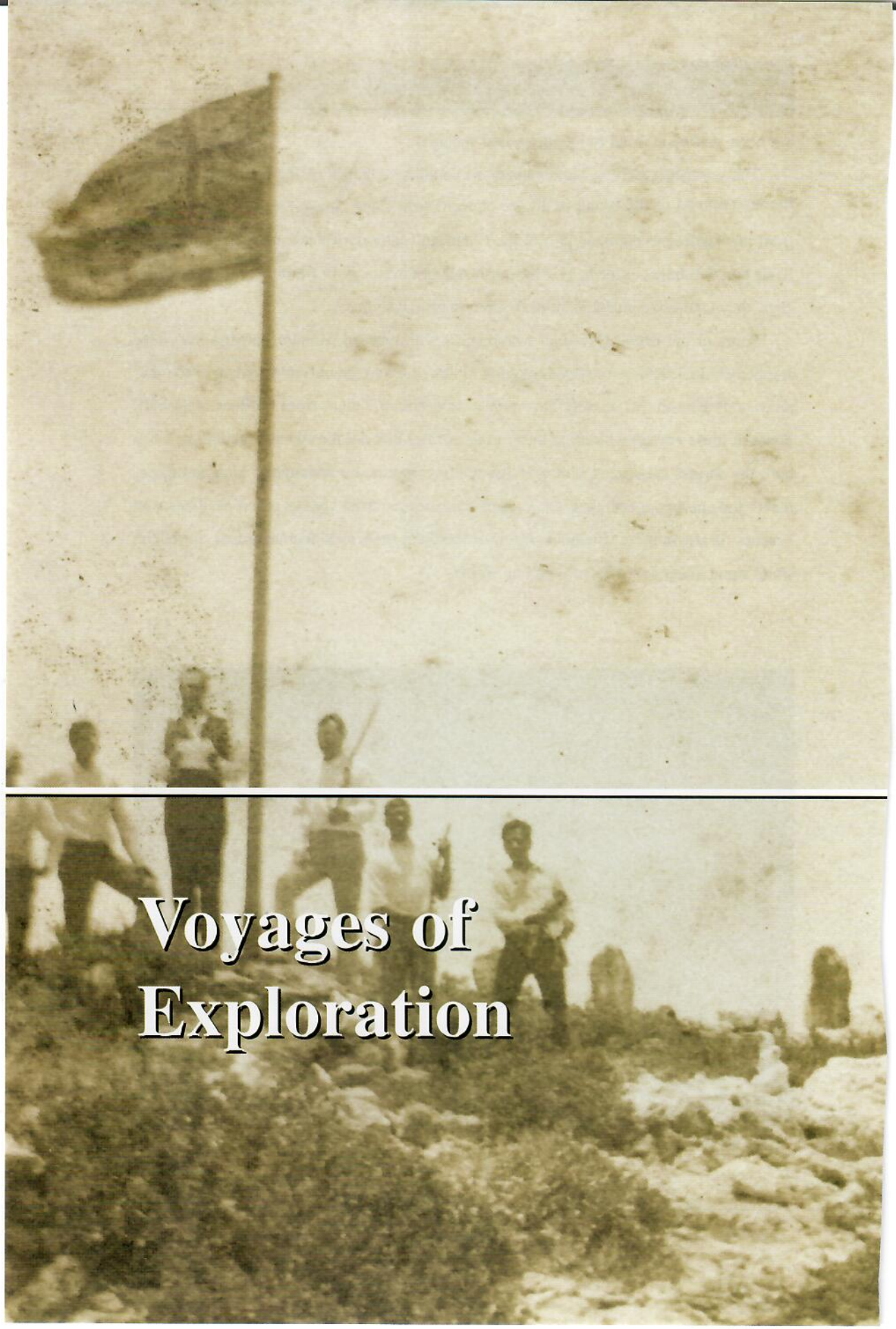
has been studied in order to identify wood species.

The voyagers reaching Mokumanamana could have landed on the wave-cut bench on the western end of the island in the lee of Northwest Cape. Several trails provide access from this landing to the main part of the island. In southerly weather, they may also have landed on the shores of the bay on the north side of the island. In addition to birds and bird eggs, they could obtain abundant near-shore marine resources.

Some of the native Hawaiian worshippers who reached Mokumanamana may have stopped on the island before continuing on to more leeward islands in the chain or to other parts of Polynesia. Some may have come from Nihoa, others from Ni'ihau or Kaua'i. Some of these voyagers built the thirty-three shrines that dot the island's landscape. They built the shrines consistent with a design that incorporated a rectangular plan and alignments and clusters of uprights. They selected local stone from various outcrops, dikes, and beaches for use in these structures. A few of these voyagers to Mokumanamana carved the small stone images associated with one shrine.

Sheila Conant, UH

Upright stones of *marae* on Necker (Mokumanamana).



Voyages of Exploration

NIHOA

James Colnett, aboard the *Prince of Wales* and sailing from "Oneehow" (Ni'ihau) on his way back to the west coast of North America first sighted Nihoa on 20 March 1788. This was the first time any European had sighted the island. The following morning he made the following brief note before heading northeast across the Pacific to Vancouver Island:

> "I looked attentively with a Glass, did not observe a single Shrub; in some of the Cracks there was a little green but it was very small Quantity in the point of view we now had [of] it, it Shewd like two Isles but I think it was Join'd by a low narrow beach. It may be 7 Miles circumference and its greatest extent from E to W the face of the Rock was white or light Colour, perhaps occasion'd by the Dung of Birds its only Inhabitants we saw from the Quantity of them around it must be a great number."

It was not until 1789 that more information was noted. Early in the morning of 17 March 1789, Captain William Douglas, on board the H.M.S. *Iphigenia Nubiana* in company with the schooner *North West America* both on their return from Hawai'i to the Northwest coast of North America, caught sight of the island in the dim light of the nighttime sky and hove to until daybreak. The following morning, notes were made on observations of the island and its latitude and longitude recorded. John Meares, sea captain and trader, in 1790 related the following notes in his narrative of the journeys taken by these ships in 1788 and 1789:

Bishop Museum Archives

Sketch of Nihoa based on observations of Captain William Douglas on board the *Iphigenia Nubiana* in 1789.

> "The island or rock, bears the form of a saddle, high at each end and low in the middle. To the south it is covered with verdure; but on the north, west, and east sides, it is a barren rock, perpendicularly steep, and did not appear to be accessible but to the feathered race, with which it abounds. It was therefore named Bird Island. It lies in the latitude of 23 degrees 07' north, and in the longitude of 198 degrees 10' East, by a medium of several observed distances of the sun and the moon."

The *Iphigenia Nubiana* and *North West America* did not stay much longer at Nihoa and returned to Meares' trading post at Nootka on Vancouver Island.

A few vessels sailed past in the ensuing years without making a landing, but in 1822, Queen Ka'ahumanu, having learned of Nihoa through oral history, assembled a party of native Hawaiians and, sailing with three ships under the command of Captain William Sumner, arrived at Nihoa. While there, the landing party noted the previous habitations and planted *loulu* palms. After her return, the reports of her trip spurred interest in others to learn about the cultural and natural history of this island.

The mid-1850s saw many Pacific islands being investigated for potential commercial interest of guano harvesting. Guano was used in the production of fertilizer and many of the Pacific islands were known to have substantial bird colonies with guano. Nihoa was the subject of such an investigation by the British schooner *Havana* in 1856. After arriving in Nihoan waters, but not landing due to heavy surf, the captain on board determined that Nihoa had no harvestable guano and that there were not many birds. Despite this, the Hawaiian government became alarmed that a foreign ship was exploring in its territory for commercial interests. On 23 April 1857, King Kamehameha IV and Captain John Paty landed on Nihoa and formally annexed it to the Hawaiian kingdom.

One of the first visits that included scientific observations and collections of artifacts and biological specimens took place in July 1885. An excursion party of over 200 people accompanying Her Royal Highness Princess Lili'uokalani arrived on Nihoa via the steamer *Iwalani*. Sanford B. Dole made observations on the birds, and Sereno E. Bishop made geological and topographical observations. Reports of the visit claimed that birds, eggs, and feathers had been collected and photographs taken of the voyage, but the collections have not been found and were no doubt destroyed upon departure when two of the landing boats swamped.

Small surveys and monitoring expeditions took place in the ensuing years in order to

assess bird poaching—of which there was none observed probably due to the inability of most visitors to land on the island. During these trips, lists of birds were made, but none were thorough investigations.

The first rigorous survey of the cultural and natural history of Nihoa took place on 10 June 1923 when the Tanager Expedition arrived at Nihoa and dropped off scientists who set up camp. The next day, the *Tanager* went to Necker and dropped off a smaller party of scientists to work there and the two parties kept in contact via radio between the two islands. Archaeological, biological, hydrographic, and geological work was conducted on Nihoa for about ten days. The specimens, artifacts, and data obtained during this expedition have served as the basis for all further studies on Nihoa and contributed a great deal toward out knowledge of the cultural and natural history. In 1924, the *Tanager* again visited Nihoa primarily to finish archaeological and geological work, but botanical collecting also took place.

Numerous visits to the island were conducted subsequent to the Tanager Expedition with most focused on bird and plant observations. Some were done to assess the numbers of the rare *loulu* palm that had been devastated by the fire of 1885. Population counts continue to today, but counting is sometimes difficult because sprouting palms may be concealed by the thick understory of palm fronds, surrounding thickets, and numerous birds that use the palms and thickets as roosts.

In the 1960s, the Northwestern Hawaiian Islands came under the jurisdiction of the U.S. Fish & Wildlife Service as a wildlife refuge. As such, routine surveys took place to monitor the islands' plants and animals and assess population counts of birds and rare plants.

The most recent extensive biological survey of Nihoa took place as part of the larger Northwestern Hawaiian Islands Rapid Assessment and Monitoring Project (NOWRAMP) in September 2000. During this survey, marine and terrestrial plants and animals were collected and observed. The data from these surveys has allowed for the first comprehensive list of the biota of Nihoa (see Appendix).

NECKER

On the evening of 4 November 1786, the French navigator, Jean-François de Galoup, Comte de La Pérouse, on board the frigate *Boussole* accompanied by the *Astrolabe* on its voyage around the world, sighted a small rocky island. The ship stayed off shore for the night anxiously awaiting the morning light to evaluate their discovery. The following morning, La Pérouse made the following observation in his log (translated to English):

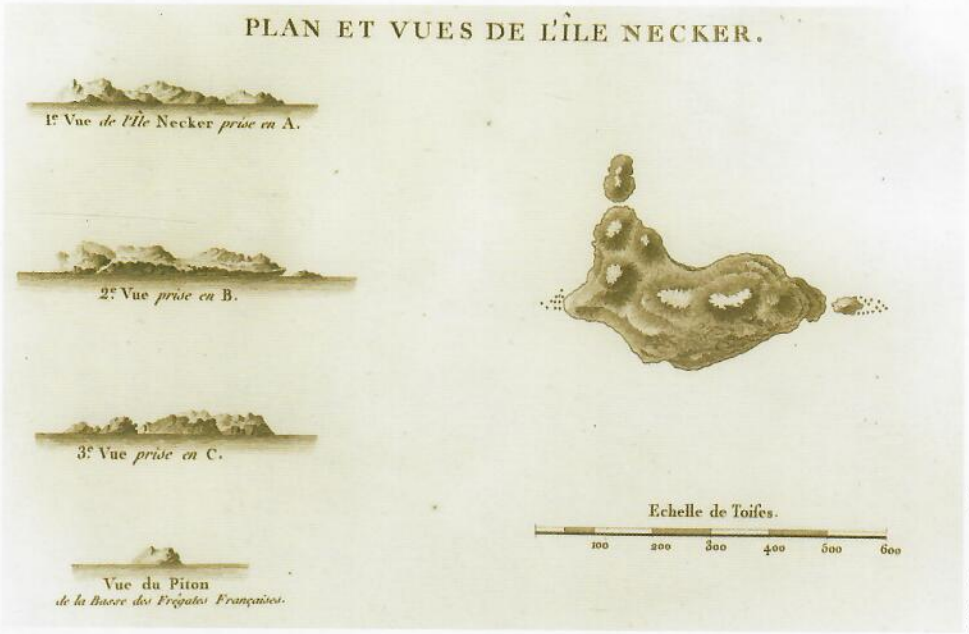
> "This island, which is very small, is almost a mere rock, about five hundreds *toises* [= 1000 yards] long, and at most sixty [= 120 yards] high; and thought totally destitute of trees, it is furnished with a great deal of herbage towards the summit. The naked rock is covered with the dung of birds, and appearing white, forms a contrast with the various red spots, where grass has not grown. I approached it within a mile and its shores were as perpendicular as a wall, the sea breaking violently against it in every part, so that it was impossible to attempt a landing. As we went almost round this island, we laid it down with great precision. Its latitude and longitude, as determined by Mr. Dagelet, are 23°34' north, and 166°52' west of Paris. I call it Isle Necker [named for Jacques Necker, Minister of Finance under Louis XVI.]. If the fertility of this island renders it of little importance, its precise place is extremely interesting to navigators, to whom it might otherwise be fatal."

No landings were made at the time of this observation and apparently none were made until the beginning of the 1800s. A few ships sailed by after La Pérouse noted its existence in his logs, and were close enough to make cursory observations, but any serious interest in the island did not take place until the 1890s, when questions of what country laid claim to it were being asked.

In May 1894, on rumors that the British were en route to claim the island, the Hawaiian government ordered Captain James A. King, Minister of the Interior for the Government of Hawai'i, to sail immediately to Necker and claim it for Hawai'i. On 27 May 1894, Captain King, accompanied by members of the crew of the *Iwalani*, went ashore and claimed the island for Hawai'i, erecting a flagpole and hoisting the Hawaiian flag.

Subsequent visits of ships were made to the island for the purposes of scientific exploration and surveying the island and its surrounding waters for possible commercial interests. Among the more notable are the following.

In 1902, the *Albatross*, engaged in deep-sea investigations on behalf of the U.S. Fish Commission, visited the island and its biologists conducted scientific observations and collections.



Bishop Museum Archives

Map of "Ile Necker" based on observations of La Pérouse on board the *Boussole* in 1786.

In 1923 the Tanager Expedition made visits to the island in June to conduct biological, archaeological, and geological research. In 1924, the National Research Council obtained the services of the *Tanager* once again, but this time to complete archaeological and geological research on the island.

In 1964, the U.S. Fish & Wildlife Service assumed responsibility for patrol and investigation of Necker and in 1967 it was declared a natural area within the Northwestern Hawaiian Islands Wildlife Refuge. This designation stipulates that the island's ecology is to be kept as free as possible from outside disturbance and influence. Visits to the island are therefore restricted and permission to land has to be obtained from the U.S. Fish & Wildlife Service, pending approval of the proposed purpose of the visit.

In 2000, the NOWRAMP Expedition stopped at Necker for a few days when Bishop Museum entomologist Gordon Nishida and U.S. Fish & Wildlife biologist Beth Flint conducted biological surveys, the results of which have been incorporated in the Appendix to this book.

Natural History

Nihoa and Necker are essentially just tiny dots on the much larger map of the Hawaiian Archipelago. Together they total 0.797 km^2 of land area, which amounts to 0.0047% of the total land area of the Hawaiian Islands (16,636 km^2). Despite this miniscule remaining land area of once larger volcanic islands, they both contain a remarkably large percentage of species of various groups of organisms found in Hawai'i (see Table 1). Many of these biodiverse groups (e.g., algae, mollusks, fish) are marine, where the protection of the coral reefs and waters surrounding these two islands have served to allow a rich biodiversity of marine organisms to survive and flourish. Additionally, a safe haven of land without humans or other threatening predators has allowed a large percentage of Hawaii's seabirds to roost or nest on these islands.

Table 1. Numbers of species from Nihoa and Necker

Taxon	Totals	Hawaii total*	% of total
Cyanobacteria	5	201	2.5
Algae	184	1123	16.4
Other protists	0	1229	0.0
Fungi (including lichens)	24	3185	0.8
Flowering plants	27	2142	1.3
Other plants	1	639	0.2
Crustaceans	92	1512	6.1
Cnidarians	27	393	6.9
Other invertebrates	72	2234	3.2
Mollusks	239	2163	11.0
Insects	218	8155	2.6
Other arthropods	56	1060	5.3
Lower chordates	4	76	5.2
Fish	221	1245	17.8
Reptiles	3	29	10.3
Amphibians	0	7	0.0
Birds	29	183	15.8
Mammals	1	44	2.2
Totals	**1204**	**25620**	**4.7**

* Data updated from: Eldredge, L.G. & Evenhuis, N.L. 2003. Hawaii's biodiversity: a detailed assessment of the numbers of species in the Hawaiian Islands. *Bishop Museum Occasional Paper* 76, 28 p.

ENVIRONMENTAL THREATS

However, all is not necessarily well in paradise. Oceanic islands are fragile ecosystems that can easily be altered, sometimes irrevocably, by the trauma of introduced organisms and activities of humans. By virtue of their restricted land areas and small populations, the organisms making up the terrestrial biota of Nihoa and Necker are at constant risk of extinction. The effects of small environmental introductions are magnified and can have severe long-term impacts. An inadvertent introduction of an alien plant, insect pest, or disease can quickly spread and devastate native plant populations and their associated bird, insect, and snail populations. Any oceanic islands that encounter the intervention of humans during their history are subjected to immediate threats to their native fauna and flora. Although remote from the main Hawaiian Islands, Nihoa and Necker are no less threatened than any other such oceanic islands. Over the years since the first scientific surveys of plants and animals have taken place on these islands, there has been a steady increase in the recorded numbers of non-native species (see Tables 2 and 3 for examples of this phenomenon using the numbers of insects).

Some of this introduced biota is relatively innocuous and there have been no deleterious effects noted by their presence. Yet, there are other introductions that have had or certainly will have damaging effects on the living landscape of these islands. One such introduction is that of the vagrant grasshopper, *Schistocerca nitens,* on Nihoa. It was first discovered on Nihoa in 1990. In 2000 it was seen again it moderately low numbers, but its potential for damage to vegetation was noted. In the latest survey of Nihoa in 2002, the population of the grasshopper had suddenly spiked and literally thousands of individuals were observed grazing on every type of vegetation on the island. The millerbirds and finches on the island are slightly smaller than the grasshopper and unfortunately are not adept at catching them for food—the birds would often capture only a leg after a significant amount of effort was expended in pursuing the insects.

Nihoa has survived disasters in the past. In 1885, a landing party accompanying Princess Lili'uokalani accidentally started a fire that consumed virtually all of the *loulu* palms on the island. The palms have come back and, at last count, were at around 700 in

number. If the vegetation of Nihoa is strong enough to survive the devastation of fire, we hope that it will also be able to survive the damage caused by a plague of grasshoppers. Only time will tell.

Table 2. Numbers of Insects from Nihoa (aliens in parens) (% aliens in second parens)

Group	1923	1962,1964	2000
Blattodea	4(4)	4(4)	4(4)
Coleoptera	19(10)	26(10)	36(10)
Collembola		1(0)	2(0)
Dermaptera	1(1)	1(1)	4(2)
Diptera	10(5)	21(7)	32(14)
Embidiina	1(1)	1(1)	1(1)
Heteroptera	5(2)	14(8)	15(8)
Homoptera	1(1)	10(8)	10(8)
Hymenoptera	13(5)	18(10)	41(23)
Isoptera			1(1)
Lepidoptera	10(7)	15(9)	23(9)
Orthoptera	1(0)	1(0)	5(2)
Phthiraptera			
Psocoptera	1(1)	1(1)	3(2)
Siphonaptera			1(0)
Thysanoptera		2(2)	2(2)
Thysanura	1(1)	1(1)	2(1)
Totals	**67(38) (57%)**	**116(62) (53%)**	**182(87) (48%)**

Table 3. Numbers of Insects from Necker (aliens in parens) (% aliens in second parens)

Group	1923	1962,1964	2000
Blattodea	1(1)	1(1)	2(2)
Coleoptera	10(2)	14(2)	11(2)
Collembola			
Dermaptera	1(1)	1(1)	1(1)
Diptera	5(2)	13(4)	13(5)
Embidiina	1(1)		2(2)
Heteroptera	1(0)	3(0)	4(0)
Homoptera	1(1)	7(6)	7(6)
Hymenoptera	5(4)	8(4)	7(4)
Isoptera			
Lepidoptera	10(3)	10(3)	14(6)
Orthoptera			2(2)
Phthiraptera			3(0)
Psocoptera	1(0)	1(0)	
Siphonaptera			
Thysanoptera		2(2)	3(3)
Thysanura	1(1)		1(1)
Totals	**37(16) (43%)**	**60(23) (38%)**	**70(34) (49%)**

The Land

TERRESTRIAL REPTILES

Reptiles are distinguished from other vertebrates by skin that is covered with scales. They are also ectothermic or "cold-blooded" and regulate their body temperatures by obtaining heat from their surroundings. This group, which includes crocodiles, turtles, lizards and snakes, is cosmopolitan with about 8100 species known.

There are 21 species of terrestrial reptiles recorded from Hawai'i. All are thought to represent human introductions. Seven of these species, all lizards, are widespread in the Pacific and may have been brought to Hawai'i by early Polynesian settlers. Four of these species have been recorded from the NWHI but only two of those have been recorded from Necker and Nihoa.

GEHYRA MUTILATA

STUMP-TOED GECKO

A NI

The Stump-Toed Gecko occurs throughout much of the Indo-Pacific region. It occurs on all the main Hawaiian Islands, but in the NWHI has been reported only from Nihoa, which may represent a recent introduction. It is highly arboreal and occurs in human habitation but also occurs in forests and other natural areas. It is slightly larger than the Mourning Gecko and adults may reach 115 mm in total length. It is mostly brown to gray dorsally, often with small white and brown spots and blotches. There are often faint yellowish bands along the tail. The underside is cream, often with a yellowish tinge. *Gehyra mutilata* is superficially similar to the Indo-Pacific house gecko, *Hemidactylus frenatus*, familiar to most residents in Hawai'i, but differs from that species in lacking whorls of enlarged spinose scales around the tail and in having enlarged caudal ventral scales.

This species probably breeds through the year. Females produce a clutch of two hard-shelled eggs which are placed in secluded places such as under loose tree bark or in the leaf axils of palm trees. *Gehyra mutilata* is nocturnal. Its feeds on small insects and spiders. When handled it readily sheds patches of its skin, a characteristic alluded to in the specific name "*mutilata*".

TELESPIZA ULTIMA

NIHOA FINCH

E* NI

Found only on Nihoa, this finch is related to honeycreepers found elsewhere in the main Hawaiian Islands and to a closely related species endemic to Laysan Island. The sexes differ. The male has a bright yellow head, neck, and breast. The back is yellowish with some suffusion of gray, and the belly is whitish. There is a gray collar extending around the back of the neck and part way down the sides. Females have a yellowish brown head and yellowish throat and a breast streaked with brown. The back is a mixture of brown and black. Both sexes have a conical-shaped bill. This species has a loud, melodious call and also produces twills and whistles.

The Nihoa Finch is found throughout vegetated regions of the island and is omnivorous, feeding on plants, seeds, insects, bird eggs, and carrion. Breeding takes place from January to early July. Females construct nests from dry grass, twigs, and sometimes seabird feathers, and generally lay an average of three eggs by February. Nests are placed in crevices among the island's rocks rather than in vegetation.

The estimated population has fluctuated from about 900 to 6600 during the past 30 years. The Nihoa Finch was added to the U.S. Endangered Species List in 1967.

Sheila Conant, UH

Nihoa Finch (*Telespiza ultima*) pair (female, left; male, right).

LEPIDODACTYLUS LUGUBRIS
MOURNING GECKO

A NI, NE

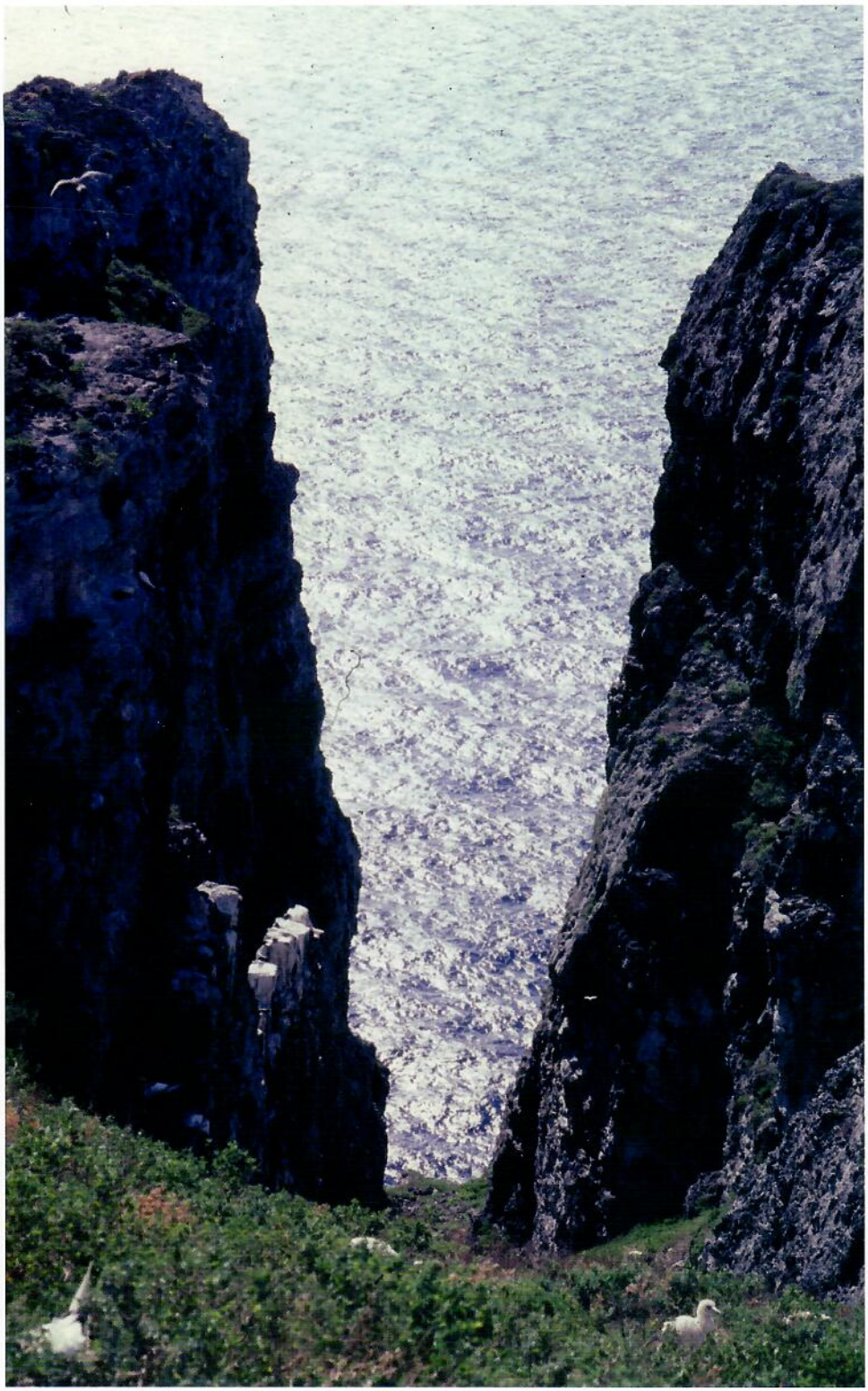
This distinctive arboreal gecko has been recorded from both Necker and Nihoa. It is relatively uncommon there and may represent a recent introduction. It otherwise occurs throughout the Pacific where it commonly occurs in human habitation as well as forests and other more natural areas. It is about 80–95 mm long (including tail) and is gray to beige above with a series of indistinct "W" markings along the back. There is often a dark line running from the tip of the snout through the eye to the neck. The underside is white, sometimes with a yellowish tinge.

Mourning gecko populations consist of only females. They reproduce by a phenomenon known as parthenogenesis. Females produce two self-fertilized hard-shelled eggs that are deposited in secluded places such as under loose tree bark or in crevices within buildings. It probably breeds throughout the year with reduced activity during the winter months.

Lepidodactylus lugubris often calls in the early morning and has a quiet "tst" call that is given at irregular intervals. It is otherwise active mainly at night. Its diet consists entirely of small insects and spiders.

Allen Allison, HBS

The Mourning Gecko (*Lepidodactylus lugubris*).



Sheila Conant, UH

Achatinellid land snails (*Tornatellides* sp.) in the bases of leaf blades of *Eragrostis* on Nihoa, previously unknown to science.

ENDODONTID AND ACHATINELLID SNAILS

ENDODONTA and TORNATELLIDES SPP.

E NI

These small land snails are found at the bases of the bunch grass *'emoloa* (*Eragrostis*) on the island of Nihoa and are apparently endemic. Although scientific voyages had been to Nihoa numerous times to search for plants and animals, these previously unknown and rare land snails were only first discovered by Sheila Conant in the early 1980s. Along with their three described cousins, they are the only land snails known from these islands.

Endodontid land snails were once plentiful throughout the Hawaiian Islands, but many are now thought to be extinct, perhaps due to predation by introduced ants. The fact that these ants are also present on Nihoa and Necker make it imperative that efforts be made to protect these snails before they too suffer an untimely death.

The Seashore and Underwater

FISHES

The kinds of fishes found at Nihoa and Necker do not differ greatly from those found around the main Hawaiian Islands. However, very noticeably different are the increased numbers of gamefish seen (e.g., *ulua* or jacks), their larger sizes, and their lack of wariness toward humans. This is to be expected in such remote areas of the Hawaiian chain with minimal, if any, human contact and little to no fishing pressure on the fish populations. Without human fishing pressure, the predator-prey relationships are left to balance with the available food resources and the result is an expressed dominance by top carnivores and herbivores, reflected in the numbers of *ulua* (carnivores) and *nenue* (herbivores) typically seen in abundance. Several areas around the main Hawaiian Islands afford similar views but the effect is magnified at Nihoa and Necker and fish numbers are further enriched by the influx of plankton-rich water from nearby deep drop-offs.

Most noticeable among the top carnivores of Nihoa and Necker are the *ulua* or jacks, amberjacks (*kāhala*), the Green Jobfish (*uku*), and the gray sharks. All can be commonly seen just off the reef, patrolling the drop-offs over deep water. Jacks feed primarily on small reef fishes such as goatfishes, surgeonfishes, and some baitfishes. Gray snappers, too, make frequent feeding forays into the inshore environment, primarily targeting small reef fishes, and crustaceans. Sharks and barracudas are only occasionally seen inshore.

In deeper water, other snappers dominate. The red snappers in particular (*'ula'ula, koa'e* or *onaga*, *'ehu*, *kalekale*) occur in good numbers, along with others in the family (e.g., *'ōpakapaka*). One of the most noticeable snappers is a relative newcomer to the Hawaiian Archipelago: the Bluestripe Snapper, *Lutjanus kasmira,* or *ta'ape* (Tahitian name). Introduced from the Marquesas Islands to the main Hawaiian Islands in 1958 and with no specific predators to keep populations in check, this species has been able to exploit food resources so successfully that its numbers have rivaled those of some endemic species. It has become so abundant as to cause concern among fishermen and conservationists alike, and its success may be at the expense of some other more commercially desirable fishes. The consequences of this introduction further underscores the fact that caution must always be exercised whenever alien animals (and plants) are intended to be introduced into a vulnerable Hawaiian environment.

School of gray chubs in waters off of Nihoa.

Other carnivorous fishes occur around Nihoa and Necker including the wrasses (*hīnālea*) and squirrelfishes/soldierfishes (*'ala'ihi*, *'ū'ū* or *menpachi*), which feed mainly on crustaceans and mollusks in and around rocky crevices and holes. Butterflyfishes (*kīkākapu*), feed primarily on live coral polyps; and goatfishes (*weke, kūmū*) feed on small crustaceans and worms buried in rubble or sand bottoms. While the "greater carnivores" (such as sharks) are the occasional reef invaders, these "lesser carnivores" maintain the micro-health of the reef creatures with which they come into daily contact. Each cannot achieve what both groups do in concert, and the result is a healthy and balanced reef fish population.

In addition to those above above are the herbivorous fishes. These include the *nenue* (*Kyphosus* spp.) often seen in huge schools; their feeding effect on algae such as *Dictyota* and *Turbinaria* is substantial. In contrast, surgeonfishes are bottom grazers of delicate filamentous algae. Parrotfishes (*uhu*) are prominent grazers of certain filamentous algae that grow on dead coral. As parrotfishes graze heavily on the algae, their beaks grind into and break off chunks of dead coral that are subsequently ground to a fine consistency in toothed bony plates known as a pharyngeal mill—the ground algae is digested for energy, the sand is excreted as intermittent coralline rain.

Damselfishes, blennies, and surgeonfishes are the primary consumers of low-growing algae in the shallow water marine environment and in turn serve as food resources for predators—piscine and otherwise. It is an intricate balance being maintained among the many classes of reef organisms that comprise the marine ecosystem, not only of Nihoa and Necker but of the entire Hawaiian Archipelago.

NIHOA-NECKER CULTURE

While no actual history survives of life on Nihoa and Necker, it is reasonable to conclude that cultural practices mirrored those of the main Hawaiian Islands, with exceptions forced by practicalities and limitations of the environment. The fish uses and traditions offered herein are but a glimpse into the heritage of a culture that thrived in the Hawaiian Islands for hundreds of years. It must be remembered that variations of practice can be expected from island to island, and even place to place on each island, and this applies to local fish names as well. Thus, these cultural glimpses should act as a basis for further learning with full realization that the Hawaiian culture remains fluid and dynamic to this day.

Those who established habitations on Nihoa and Necker unquestionably included raw fishes in their diet as a source of protein and, very likely, vital fluids, potable water being a scarce commodity. Fishing implements (a single fishhook from Nihoa, net and line sinkers, and octopus lures) have been found on both islands, with those and other artifacts indicating a sparse, sporadic human presence on Necker and a more robust settlement on Nihoa, the latter leaning toward an agricultural society based on the sweet potato. However, we do not know how successful the people of Nihoa and Necker were in obtaining the fish resources from the surrounding waters.

Native Hawaiians caught fishes with baited bone hook, by chumming with whole live fishes or crushed fishes in corded bundles, by net, by woven basket or trap, and by spear. The best fishing masters, *po'o lawai'a*, had their secret techniques passed down through oral tradition and knew of ideal locations and times to fish. Although women gathered as much that was edible that could be obtained by hand, including fishes, men, under the leadership of the *po'o lawai'a,* were the ones to engage in the forays into the ocean to harvest the sea's bounty.

Native Hawaiians ate their fish mostly raw (never without having been salted to some degree, lightly or heavily) and whole, but broiling or roasting over an open fire, or baked in *imu* were also popular preparation methods. When eaten raw, entrails were consumed as well to enhance flavor, but scales were first removed. Bones sucked clean of flesh were discarded or used as fuel for fires. When cooked, fishes were often wrapped in *ti* leaves to keep the flesh moist.

A fermented mash of fish pieces mixed with crushed roasted *kukui* nuts was a popular way of eating *hīnālea* (wrasses); whether this recipe was used on Necker or Nihoa is not known as both islands lacked the plant, although *kukui* nuts from the main Hawaiian Islands would have been easy to transport to the islands and are storable for a reasonably long period.

Of primary significance to native Hawaiians for offerings were red fishes (e.g., *kūmū*), or triggerfishes (*humuhumu-nukunuku-ā-pua'a*). White fishes, such as *weke* or *āholehole,* were also traditional and esteemed offerings.

A system of *kapu* (taboos) to protect and thereby ensure continued food resources (including fishes) was well-established in early Hawaiian culture, strictly practiced by those responsible for gathering food, and enforced by those of high rank. It is unclear what effect pressures of survival on Nihoa or Necker (especially) would have had on such practices over time.

KYPHOSUS PACIFICUS — *NENUE*

GRAY CHUB — ① — NI, NE

The *nenue* has an oval body and slightly forked tail and is uniformly gray, gray-blue, or brown in color, with a few individuals markedly entirely yellow or white, occasionally splotched with black. The species is native to the Hawaiian Archipelago and is found throughout the Indo-Pacific region.

Nenue feed on algae, both suspended in the water and growing on the bottom, cropping with their incisiform teeth. Because of this herbivorous habit, the entrails and flesh take on a very pungent smell, reminiscent of the smell of brown seaweed drying exposed at low tide on a rocky coastline. *Nenue* flesh was savored raw by Hawaiian *ali'i* and rarely consumed by persons without high rank or social standing. Historically, in the Kāne'ohe area of O'ahu, *enenue* referred to the adult fishes and *nenue* to the young.

Nenue are typically seen today at about 30–46 cm long, with some approaching 75 cm, but these giants are rare. *Nenue* are commonly seen schooling in inshore areas of coral, rubble, and sand. A rarely seen yellow color form has cultural significance in Hawai'i, said to represent the queen of the school, *nenue makua*, and harbor the spirit of a departed *ali'i*.

Jim Maragos, USFWS

A school of gray chubs or *nenue* (*Kyphosus pacificus*) at Nihoa.

The wave-swept shores of Nihoa and Necker are similar to those of Kaua'i and Ka'ula. In the upper intertidal zone *'opihi*, hermit crabs, and sea urchins abound. In the small tide pools several different kinds of algae are attached and small fishes swim in and out of the irregular surfaces. The *'opihi* are larger than those found on the main Hawaiian Islands, since they are not harvested. The currents around the islands are strong and keep the bottom relatively clear of unattached plants and animals; however, every groove and crack has something living in it. In the near-shore shallows several slightly different types of fishes and invertebrates are seen, as well as an occasional green turtle. Along the hard shallow shelves, soft corals spread out and form a low-lying tough cover. They are more abundant here than on the sandy and rocky shores of the islands further to the north. In deeper waters 20 species of stony corals are found. This is the southernmost habitat for the staghorn coral that is found to the north but not in the main Hawaiian Islands. A few mushroom corals are found at Necker, as is the orange cup coral, a small coral without symbiotic algae. A great number of marine snails are scattered along the shore. Eleven cowries with the endemic granulated cowrie and the groove-toothed cowrie are found here. Numerous fishes swim along the bottom and in the mid waters. Many are much larger and more abundant than the same species in the main Hawaiian Islands. Large jacks aggregate in large schools. The endemic spiny lobster is relatively common among various outcroppings. And a black coral forms small "forests" along the bottom.

Jim Maragos, USFWS

Diver surveying marine life in waters off of Necker.

MARINE ALGAE

There are many photosynthetic organisms (not all are plants) that have long been classified as "algae" or seaweeds. Molecular studies of nucleic acids show that these aquatic organisms belong to several unrelated evolutionary lines. Among those present on Necker and Nihoa are species assigned to the Cyanophyta, or Cyanobacteria ("blue-green algae"); the Rhodophyta (red algae); the Phaeophyta (brown algae); and the Chlorophyta (green algae). Only the Chlorophyta are considered true plants, grouped in the plant kingdom; the other algae are now classified as kingdoms in their own right. Although the majority of algal species known from the two islands are found in the marine environment, the ephemeral freshwater seeps and pools on Nihoa are also home to species of Cyanophyta and Chlorophyta.

CAULERPA RACEMOSA

SEA GRAPES ① **NI, NE**

This green alga belonging to the Chlorophyta is called sea grapes in English; it has no Hawaiian name although the Filipino name *ararucip* is now used locally for it in the Hawaiian Islands. *Caulerpa racemosa* is found worldwide in tropical oceans and throughout the Hawaiian Islands, including Necker and Nihoa. Several taxonomic forms have been described and some of these are known only from the waters around a single island. It occurs on rocky substrates and is most abundant in the wave-washed intertidal and the shallow subtidal areas where sunlight is brightest, but it will grow on rocks down to a depth of 20 m. It is common in tide pools, on rocky shores, and reef flats.

Caulerpa racemosa is variable in size and shape and forms patches on rocks, intermixed with other seaweeds. Plants grow in mats held together by creeping yellowish-white, cylindrical rhizomes that produce upright, iridescent bluish-green branchlets ranging from 1–20 cm tall with bead-shaped tips. Plants cling tightly to rocks by hair-like rhizoids. In sites with heavy surf, the green stems are only 1–2 cm tall and very compact; in deeper water or more sheltered spots not subjected to wave action, the stems grow longer

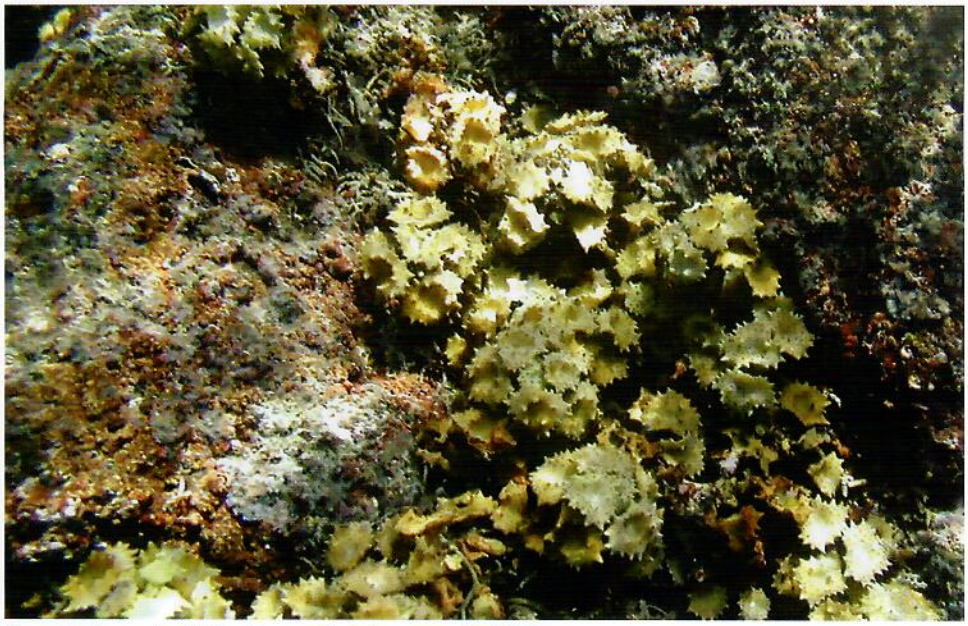
Larry Basch, NPS

Sea grapes (*Caulerpa racemosa*) in shallow waters off of Nihoa.

and are more diffuse. The almost turquoise color underwater becomes a pale grass-green when viewed in the air. Bruised plants turn yellowish. The grape-like clusters of spherical stems are distinctive, making this seaweed easily distinguishable from others.

There is no documentation that this seaweed was traditionally eaten by Hawaiians. Its contemporary use has been imported from the Philippines, where *C. racemosa* is eaten as a vegetable; sea grapes are eaten in Hawai'i today primarily by Filipinos. Some strains of the seaweed produce high levels of a toxic compound called caulerpicin, while others produce almost none. When eaten, caulerpicin produces symptoms rather similar to those produced by ciguatera fish poisoning. Care should be taken to test sea grapes for edibility before consuming it in quantity.

Numerous variant forms have been recognized with scientific names throughout the vast range of this species. At least four of these taxonomic varieties have been documented in the NWHI as follows: variety *clavifera*; variety *imbricata*; and variety *laetevirens*, all from Necker; and variety *peltata*, known from both Necker and Nihoa.



Larry Basch, NPS

The marine brown alga *Turbinaria ornata* in shallow water off of Necker.

TURBINARIA ORNATA

Ⓘ NI, NE

This is a widely distributed brown alga found in tropical and subtropical areas of the central and western Pacific and Indian Oceans. It is indigenous in the Hawaiian Islands, where it has been recorded from Kure, Pearl and Hermes Reef, Lisianski, Laysan, French Frigate Shoals, Necker, Nihoa, and all the main islands except Ni'ihau and Kaho'olawe.

Turbinaria is a common alga found locally in a wide variety of habitats, including tide pools, exposed rocky intertidal zones, intertidal benches, reef flats, and in deeper water to at least 30 m depth. Although native to Hawai'i, *Turbinaria* is considered to be potentially invasive because of its tendency elsewhere to take over subtidal and reef crest environments. In French Polynesia, where it is considered invasive because of recent dramatic increases in biomass, low mats of *T. ornata* often dominate the intertidal and subtidal zones, especially fringing reefs and outer reef flats and slopes, along with other brown algae (e.g., *Sargassum*). Floating mats of thalli torn off of reefs aid in dispersal of the species. Locally, it has displayed invasive tendencies in developed coastal areas with high water motion and elevated nutrient levels.

Natural History

A member of the family Sargassaceae, which includes the widespread genus *Sargassum, Turbinaria* is a stiff, erect, light yellowish brown to dark brown plant usually up to 20 cm tall when reproductive. One erect, cylindrical main axis from the holdfast produces thick, conical blades rimmed by a double row of stiff spines, and many blades also have hollow centers that function as floats. The plant can spread vegetatively from basal stolons that attach to the substrate and initiate new plants.

The morphology of *Turbinaria* suits it well to its environment. The thick, tough thalli discourage herbivores and is able to withstand the constant pounding of waves in its intertidal habitat, and the holdfast fastens tightly to the substrate and repropagates new blades when they are scoured away by high wave action.

Turbinaria has been documented as a part of the Hawaiian Green Turtle (see p. 125) foraging diet, along with the algae *Caulerpa, Codium, Spyridia,* and *Ulva*.

There are no recorded uses or cultural significance associated with this alga. It is currently being investigated for biologically active substances for potential medical or pharmaceutical applications.

Larry Basch, NPS

A marine alga (*Chaetomorpha antennina*) in tide pools of Necker.

MARINE REPTILES

CHELONIA MYDAS — HONU
GREEN TURTLE — T — NI, NE

There are five species of sea turtles recorded from the waters around Hawai'i, but only one of these, the Green Turtle, has been recorded from around Necker and Nihoa where it is a relatively uncommon visitor. The Green Turtle occurs throughout the tropical and subtropical waters of the world's oceans. It breeds on small islands throughout the region, laying upwards of 150 eggs in a nest excavated by the female in warm sand above the high tide level. In Hawai'i the main breeding area is at French Frigate Shoals.

The Green Turtle feeds largely on marine algae. Adults reach a shell length of around 105 cm and a body mass of around 180 kg. The upper shell, or carapace, is generally dark brown, often with yellowish and black streaking, and the lower shell is yellowish. The name green turtle refers to the greenish color of the body fat.

George Balazs, NMFS

Green Turtle (*Chelonia mydas*).

Green turtles resting with monk seals on a lava bench on Necker.

The isolated islands of Nihoa and Necker (Mokumanamana) are the two most southerly of the Northwestern Hawaiian Islands and have remained virtually untouched since their discovery by westerners in the late 1700s. Although the first Polynesian settlers to these islands have long since departed, Nihoa and Necker still harbor an impressive variety of wildlife. Today almost 1,200 organisms (excluding viruses and bacteria) can be found on and around these islands, with an overwhelming majority of the species being either endemic (found only in Hawai'i) or indigenous (naturally occurring in Hawai'i but also found elsewhere). Excellent as a resource and guide, *Natural History of Nihoa and Necker Islands* includes:

- Over 130 full color images and descriptions of selected plants and animals found on Nihoa and Necker and in the surrounding waters
- The first full list of all known plants and animals from each island
- An overview of the geology, cultural history, and voyages of exploration of Nihoa and Necker
- Special notations for those plants and animals that are currently listed as rare, endangered, or threatened.

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