

HISTORICAL LAND USE, COASTAL CHANGE, AND SEDIMENTATION ON SOUTH MOLOKAI REEFS

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ABSTRACT

The south coast of Molokai has the distinction of having the longest continuous fringing coral reef in the major Hawaiian Islands. While many of the world's coral reefs are in decline, much of this reef is thriving, albeit with some striking exceptions. Questions abound as to why some areas are distinctly healthy and others are not, and the source and nature of the stressors in those areas not thriving. This paper provides a survey of the island's past, focused on the *kona* district, Hoolehua Saddle, and the adjoining reef platform, building a foundation for understanding conditions as they exist today. It provides a brief examination of early soil deposition patterns, followed by a chronicle of affective human activity from the early settlement to the present. It is primarily concerned with evidence--archaeological, historical, or observable--of a variety of human activities. These include land settlement and clearing, livestock introductions and raising practices, construction of shoreline fishponds, inter-island war, and other human activities likely to have influenced the speed, volume, and extent of terrigenous erosion, sediment deposition, and change in the coastal margin and near-shore reef areas of South Molokai.

INTRODUCTION

Sedimentation, human activity, and environmental change are closely intertwined in the history of Molokai, particularly in the southeastern and central areas of the island. For much of its history, the southeastern coastal or *kona* district carried most of the population (deLoach 1975). The district's gentle plain, rich alluvial soils, and adjacent broad shallow reef flat were well suited to the traditional activities of Pacific Islanders: small-scale farming, sea-gathering, and fishing. Early in their tenure, Hawaiians began adapting this area to their use, clearing, terracing, and planting, thus affecting the rate and pattern of deposition of terrigenous sediments along the coastal margins and the near-shore reefs. This interaction between the land and human practice and how each influenced the other along the coast of South Molokai is the prime focus of this paper.

The second area of importance in this examination is the Hoolehua Saddle, a region of thick sediments in central Molokai formed by more than a million years of erosion of the island's two main volcanoes. With the arrival of Westerners, activities in this region caused rapid upland erosion, affecting measurable progradation of portions of the south coast.

THE PHYSICAL BASE

Molokai is a roughly rectangular island, resulting from the coalescence of two separate shield volcanoes (Baker 1987), reaching an elevation of a bit over 1000 feet in the west and 5000 in the east. Five major elements, shown in Figure 1, provide the physical base for this examination.

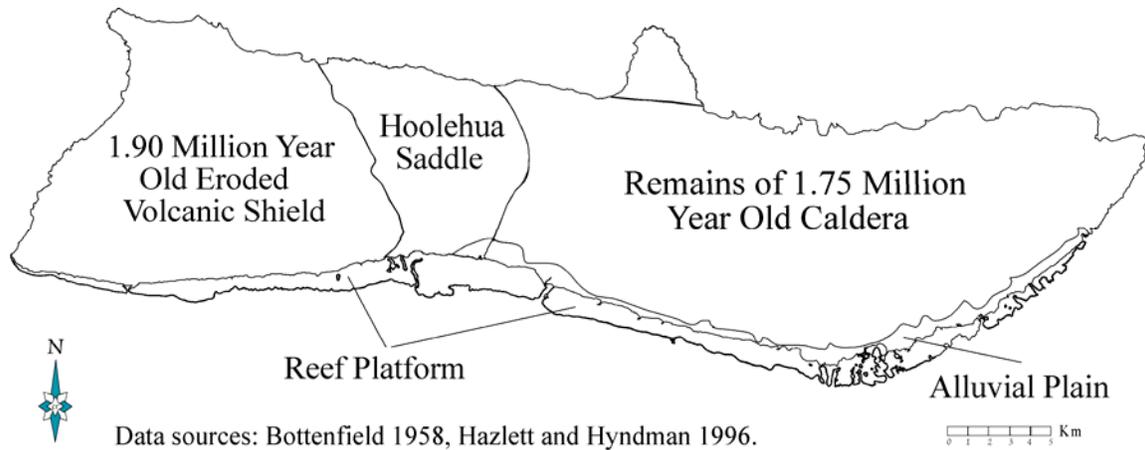


Figure 1. Five physical elements related to soil erosion/deposition in South Molokai

Modifying these elements, the stream courses seen in Figure 2 helped shape the island and the reef platform. Because of this combination of base and streams, Stevenson noted in 1889, “the whole slope of the isle and the channeling of watercourses run to the south”(1973: 77). Both the Saddle and the soils of the southern plain comprise rich sediments, loosely compacted and easily eroded, with those of the Saddle being deeply weathered lateritic, stained red with iron oxide (Hazlett and Hyndman 1996). In addition to the stream erosion and occasional storm generated sheet erosion, Molokai soils are subject to the influence of strong, gusty winds. Field observation has confirmed that soils of the Saddle not anchored by vegetation are subject to ready movement by these oft-present winds. Indeed, this has apparently long been so, confirmed by an old Hawaiian chant, “*‘Ula Kala’eloa I ka lepo o ka makani*”, or “Kala’eloa (an area roughly covering the upper elevations of the Saddle) is red with the wind’s dirt” (Summers 1971:27).

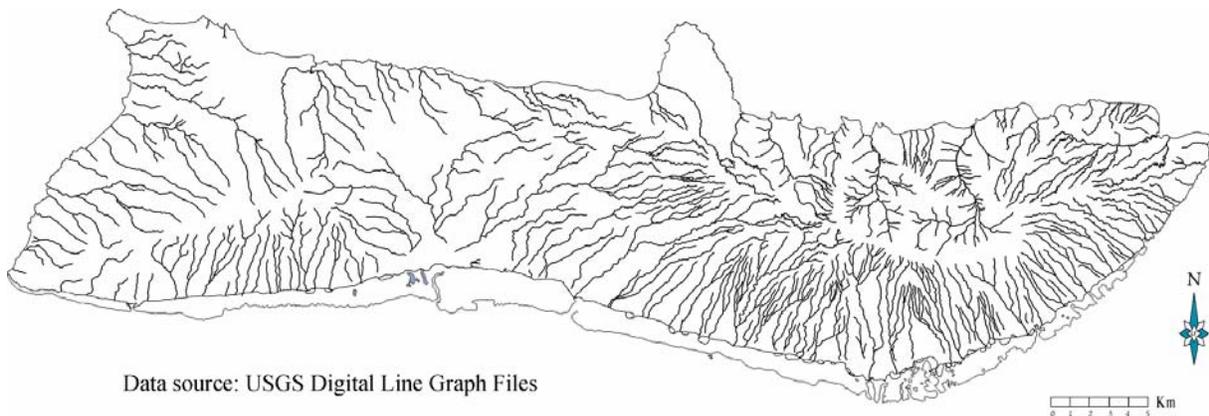


Figure 2. Stream courses of Molokai

HUMAN-INDUCED CHANGE

Humans used the combination of thick loose soils, streams and springs, low irregular shoreline, and the relative protection and resources of the reef platform to develop a regime of coastal activities more extensive than may be seen elsewhere in Hawai'i:

600CE (Common Era) to 1000CE

Although there are no written records from the early period of human habitation, there are indicators of how settlement patterns developed in South Molokai. Localized archaeological evidence, as examined by Weisler and Kirch (1985), and knowledge of social organization in the source areas of the Pacific lead to an approximation of what occurred during the first five to eight hundred years.

From the first Polynesian settlements at the eastern tip, circa 600CE, people gradually moved westward along the south coast. These early Hawaiians brought with them their customs and traditions, important among which was their system of land organization and use. In this feudal scheme an *ali'i* (chief) assigned the use of a portion of the land (*ahupua'a*) to a small group or family unit. This portion commonly comprised a valley, from the top of the watershed to the shore, and the adjacent reef and near-shore waters. Each provided access to all the people might need: water from a stream or localized springs, wood from the higher elevations, forage from the lower slopes, bottom land along the coast for cultivating, and access to the full resources of the adjacent reef flat and slopes.

Clearing and farming activities centered on the growing of the traditional Polynesian staples: taro and sweet potatoes. Botanists believe that early Polynesians also introduced many other plants: sugar cane, bananas, coconut, breadfruit, ginger, pepper, and mulberry (Bryan 1954). There were no villages in this scheme, only occasional small residences and perhaps a community *hieau* (altar or sacred site). Although some burning is thought to have occurred as part of the clearing process, with few people and a broadly scattered population, initial impact appears minimal.

1000CE to 1400CE

Early in this period the *ali'i nui* (high chiefs) of the larger islands seem to have ignored this small, lightly populated place, battling over larger prizes. Archaeological evidence suggests this is the period in which many stone works were completed, including terraces for the growing of taro (deLoach 1975) and more than fifty fishponds, most of which were completed by the early fourteenth century. Fishponds encompassed portions of the reef platform varying from several to hundreds of acres with enclosing walls averaging 5 feet in height and ten in width (Kepler and Kepler 1991) and depths ranging from 3 feet to as much as 30 feet. Figure 3 shows a portion of the shoreline with and without the ponds, illustrating the extent to which they modified the coastline and likely altered the transport patterns of materials, both down-slope and along-shore. For down-slope transport, the ponds form relatively protected catchment basins. As the prevailing winds and currents along the south coast move east to west, the long-shore influence of each pond varied with its configuration.

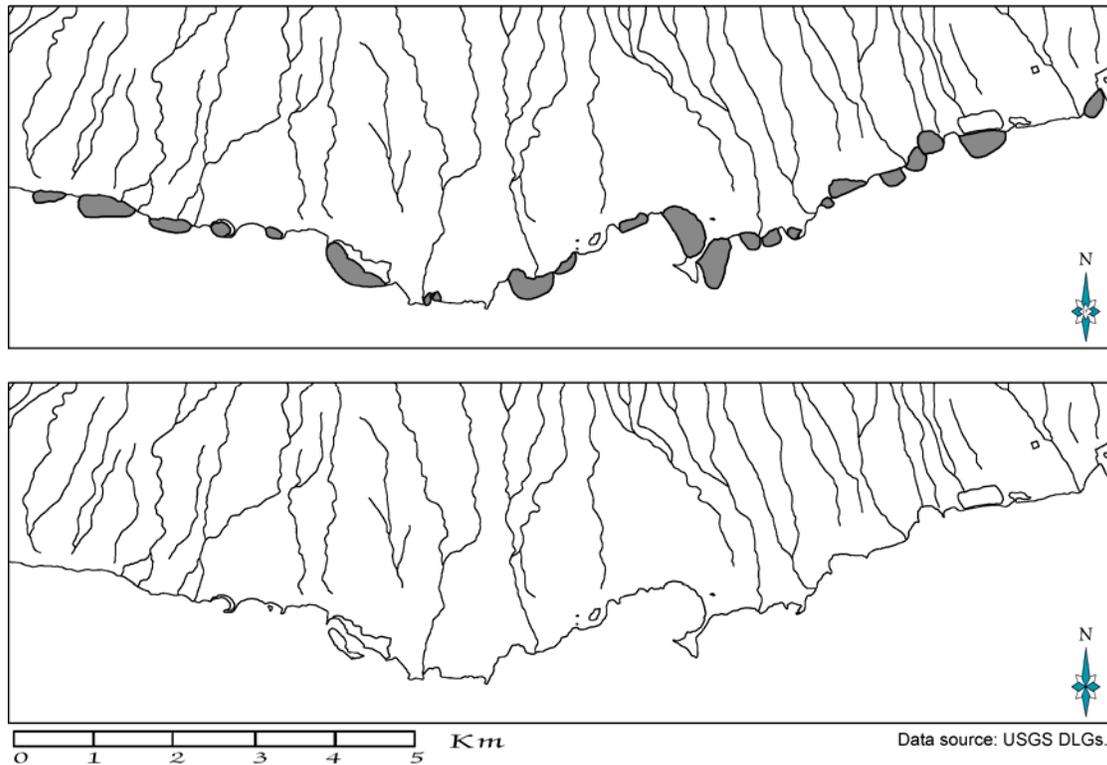


Figure 3. Portion of southeastern coast of Molokai with and without fishponds.

1400CE to 1778CE

By the beginning of this period, all the major islands of Hawaii were settled and ripe for an escalation of disputes among the *ali'i nui*. Tradition hints at Molokai having developed a quiet level of prosperity, with plentiful crops and ponds filled with fattening fishes. Located between the warring factions of Hawaii, Maui, and Oahu, Molokai initially served as both a refuge from war and as a source of provisions prior to battles elsewhere (deLoach 1975). Power over Moloka'i must have been won and lost by *ali'i nui* of other islands over time, for a narration tells of Kapi'iohokalani, an *ali'i nui* whose ruled Oahu in the 1730s: "Kapi'iohokalani invaded Moloka'i somewhere around 1736. He attacked with a large force, and his army broke down sea walls and destroyed many fishponds" (DeLoach 1975:27).

1778CE to 1900CE

While the *ali'i nui* of the larger islands were battling for power, the fateful winds brought the outsiders, beginning with Cook and Vancouver in the 1770s. Conflict among the *ali'i nui* continued for at least three decades after the arrival of the Westerners, until Kamehameha used Western firearms and small, fast ships to conquer his opponents and consolidate his power over all the islands. It is said of his taking of Molokai that, "Kamehameha's descent upon it had desolated the country" (Menzies 1920:118). Stevenson paints a vivid picture of the devastation, "...upon this island a battle was fought in which it has been computed that thousands were

engaged; and he who made the computation, though he lived long after, has seen and counted, when the wind blew aside the sands, the multitude of bones and skulls” (1973:75).

Western commodities and ideas dramatically affected Molokai in the century that followed. The introduction of livestock, along with the concepts of large volume trade and the private ownership of land were responsible for the most obvious changes. The first, and by some accounts most insidiously problematic livestock introduced on Molokai, was the goat. Captain Cook left a ram and two ewes on Niihau in February 1778 (Henke 1929), and these were followed in short order with more such animals left as a source of food on several islands by both Vancouver and La Perouse (Kepler and Kepler 1991). On Molokai these animals thrived and multiplied.

The first half of the nineteenth century saw a procession of animal introductions and expansion of their number. In 1832, there was one horse on the island, but no cattle (Judd 1936). A year later there were 200 head of Longhorns (Cooke 1949). By 1852 there were 400 horses (Judd 1936) and several herds of cattle, as well as the goats, swine, and sheep. In 1870, the Duke of Edinburgh arranged for a small herd of deer to be transported from Japan as a gift to Kamehameha V, who promptly had them transported to Molokai. Here they were allowed free range under a royal *kapu* (prohibition) and thus flourished (Judd 1936).

The native vegetation of Molokai was not adapted to withstand this invasion of grazing animals. There were no naturally occurring terrestrial mammals in Hawaii (Bryan 1954) and the flora evolved without defenses against grazers--soft bark, tender greenery, no thorns. As the numbers of animals grew and their range expanded, Molokai's native vegetation was decimated and the environment began to change, for without vegetative cover to hold the soils on the upper slopes, erosion accelerated. As the topsoil washed downslope, recovery of any remaining vegetation became more difficult, eventually altering the microclimate of much of the district. Many of the streams and springs, which in former times provided life-giving water, dried up as a result of this deforestation (Kepler and Kepler 1991).

The first real commercial venture in Hawaii is said to have been the sandalwood trade (Cooke 1949). Early in the 1800s, sandalwood--highly prized in the Orient--became a great trade commodity. Molokai's stands were reputed to be considerably smaller than those found on other islands, but were sufficient to warrant the digging of a 'sandalwood boat', a hole in the ground the size of a ship's hold, used for measuring the amount of wood needed to provide a full cargo. To support this venture, the *ali'i* directed the men to leave their fields in order to focus on the harvesting of the trees (Bottenfield 1958). According to Cooke, "It is said that the extinction of sandalwood was caused by the natives destroying young sandalwood plants. They did not wish their descendants to undergo the hardship of obtaining the sandalwood from the cold, wet mountains and having to transport it to the shore" (1949:61).

Among the ideas of serious consequence for the lands of Molokai were the private ownership of land and the use of plantation monoculture. Sugar cane was one of the first crops introduced and was grown in several areas along the southeastern coastal plain (Jackson 1882), "[b]ut the holdings were abandoned when it was found that the artesian water being used was too salty" (Keesing 1936: 27). Between the destruction of native vegetation necessary for plantation

monoculture and the insects and diseases introduced by the *haole* (foreigner), even taro and some vegetables could no longer be grown in certain areas, changing land use patterns long after the sugar plantations disappeared (Gast 1982). Thus the clearing necessary for such monoculture again heightened the susceptibility of the soils to erosion.

The ways in which the presence of grazing animals intensified the erosion of the watersheds of the southeastern shore and Hoolehua Saddle vary somewhat. Damage to the southeastern watersheds appears to have been caused mainly by wild cattle and other feral animals. This problem was perhaps exacerbated by the decline in human population. From early estimates of 10,500 people in 1779 (Summers 1971), most of whom were to be found along the southeastern shore, numbers declined to less than half that, 5000, by 1840, at which time they were still to be found mainly along this shore. By 1896 this dropped to 2307 (Bottenfield 1958), with the population shifting westward. Thus as the feral animal population in the eastern watersheds grew, the numbers of people who could hunt them and keep them in check dropped substantially.

Beginning in the mid-1800s, cattle ranching was the primary activity in a large part of the upper reaches of the Saddle. Low-quality cattle, used for hides and tallow, were raised in large number, overstocking the area. When ready for market, the cattle were driven south to Palaau for shipment. The damage done by the trampling of driven herds was added to the damage done by grazing. By the end of the 1800s, sediments were being deposited in the central lowland plain at a rate of one foot every six years (Cooke 1949) causing the progradation illustrated in Figure 4.

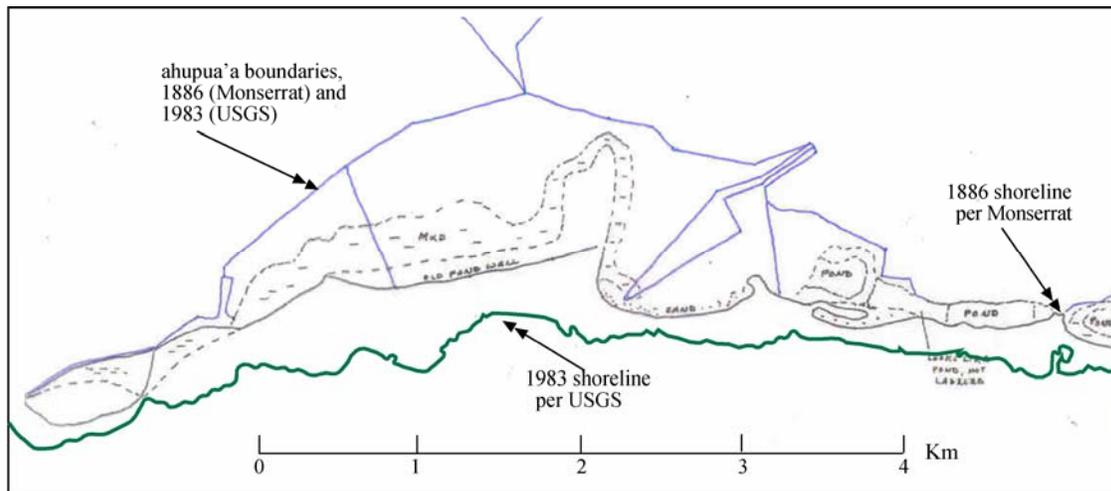


Figure 4. Progradation of the south central coast of Molokai

A picture of the southeastern coast near the close of nineteenth century was provided by Robert Louis Stevenson in 1889, "...the reef far out, enclosing a dirty, shoal lagoon--a range of fishponds, large as docks and the slope of the sandy beach on which we mostly rode, occupied the left hand. On the right the mountain rose in steps of red clay and sprouts of disintegrated rock, sparsely dotted with the white-flowering cow thistle. Here and there along the foreshore stood a lone pandanus and once a trinity of disheveled palms. In all the first part of that journey, I recall but three houses and a single church. Plenty of horses, kine, and sullen-looking bulls were there: but not a human countenance. 'Where are the people?' I asked. 'Pau kanaka make.

Done; people dead,' replied Apaka [his guide], with the singular childish giggle which the traveler soon learns to be a mark of Polynesian sensibility. 'No people? No houses?' I would cry, at the turn of every bay; and back would come the antiphon: '*Pau kanaka make*' " (Stevenson 1973: 75). Notable in Stevenson's observations are the details of the environment at the time, providing both information and corroboration: The waters of the reef platform were turbid, yet the beach was still sandy; the watersheds and coastal flats were practically barren; the population of the area dramatically reduced.

The end of the nineteenth century found Molokai with very few people, many feral animals, and large once-forested areas denuded. Much of the water-retaining native flora of the upper areas of the south-draining watersheds was gone. With the depletion of the population and the changes introduced by outsiders, the vestiges of the old managed watershed system were lost. With insufficient fresh water provided by upland streams, farming in South Molokai dwindled.

1900CE to 1999CE

The twentieth century brought a complex mix of affective human activity. Environmental damage was finally recognized as problematic. Yet some who advocated corrective measures continued practices which spread the damage still further. So much occurred in this period that it can here be painted only in broad strokes:

- Between 1898 and 1905 Molokai Ranch, the largest landholder on the island shifted from open country grazing to a paddock system, thereby limiting the impact of a herd on the vegetation in any given area. A major effort was made during this time to reduce the number of wild goats and deer (Henke 1929).
- In 1902 mangroves (*Rhizophora mangle*) were introduced by the American Sugar Company in an effort to stabilize the coastal mudflats in south central Molokai (Kepler and Kepler 1991). In a 1917 letter, George Cooke wrote that the purpose of the introduction of the mangrove was to hold back 'soil washed down by every heavy rain into the sea' (Allen 1998: 62).
- By 1907, the sheep population on Molokai reached 17,000 animals, grazing mostly on the grasses of the Saddle and denuding large areas of pasture. Sheep raising was finally discontinued "only because of reduced grazing areas and a poor wool market"(Henke 1929: 18).
- In 1912 the Molokai Forest Reserve was created, covering a large part of the eastern uplands of the island as a cooperative effort of government and local landowners. Fencing and volunteer restraint were used to give the upper slopes of the south-draining watersheds a chance to recover from the livestock damage. Effectiveness varied with those involved.
- In the 1920s, much of the Hoolehua Saddle was set aside as Hawaiian Homestead lands. Clearing the land for farming served to make the loose red soil more susceptible to the eroding effect of the prevailing winds, while the planting of windbreaks was only marginally successful in mitigating the damage. Ironically, the homesteaders found it more beneficial to lease their homesteads to the big pineapple producers than to farm them individually, leading to the additional environmental damage often associated with extensive monoculture.
- By 1930, much the island was devoted to either pineapple cultivation or to grazing. Both activities continued the alteration of the lands of the Saddle and the coastal plain. As Handy noted (1931), by this time most fishponds had been abandoned and were filled with mud.

- In 1934, the modern pier at Kaunakakai, the capital, was built (Kepler and Kepler 1991). This full, large-rock structure had a base substantial enough to carry a two lane truck road, and an expanded landing facility. Its position, jutting as it did at least 1500 yards across the reef platform along the eastern edge of a natural cut, deeply disrupted the long-shore flow of water. Today it is easy to observe the re-suspension of accumulated silt in the waters of the adjacent reef platform when the easterly winds blow.
- There was much agricultural experimentation during the first half of the century, testing such crops as corn, oats, wheat, barley, cotton and beans. All proved susceptible to various pests (deLoach 1975). Attempts to further develop the ten thousand acres of Hawaiian Homestead Lands in the Saddle were hampered by lack of water and occasional severe drought. Thus pineapples and cattle remained the products of choice, both requiring little water, but causing continued soil degradation.
- In 1948 the Molokai-Lanai Soil Conservation District was formed by the US Department of Agriculture to assist local residents in reversing the environmental damage and improving the management of their lands. A Molokai field office was established to disseminate information and assistance to landowners, farmers, and tenants to promote their conservation efforts by a broad variety of means (pers. comm. S. Cox 2000). Because of limited funding, success has been mixed.
- *Development* on Moloka'i has always been addressed in terms of agriculture. In the second half of the 1900s, tourism became an alternative, having visible consequences on the south coast. In 1965, Hotel Molokai opened its doors two miles east of Kaunakakai,. In the early 1970s an attempt at marina development was made a few miles further east. A large area of the reef platform was dredged and the material used as fill in order to alter the shape of the remains of of a large fishpond from rectangular to a three-leaf clover. However, after completion of the dredging and accompanying reshaping of the coast in this area, the project was apparently abandoned.
- Additional development along this shoreline has been mainly small scale residential, including low-rise condominiums and private homes. The county sewage treatment plant serves only the town of Kaunakakai (pers. comm. J. Souza 2000), and uses injection wells on the plant site west of town and a quarter mile north of town, in Kaunakakai Gulch. Newer residences outside the town have septic systems, while the older ones have cesspools. Condominiums have their own small primary treatment systems with on-site injection wells. Underground seepage along the shore may be contributing to 'blooms' of undesirable algae and cyanobacteria along the near-shore areas of the reef platform near population centers.
- The Nature Conservancy established an office on Molokai in 1983 (pers. comm. E. Misaki 2000), adding their efforts to those of others attempting to reverse centuries of environmental damage and halt its progress. Since that time they have been working with local hunters and state and Federal agencies to try to control the feral goat population (Kepler and Kepler 1991:58).

2000CE and Beyond

Molokai is today coming to grips with the need for environmental remediation coupled with the local desire for economic growth. There are those who wish to remain a small, undeveloped community, while others see advantages in an expanded economy. In holding back the hand of

advancing development from outside, the silt-covered beaches of the south coast have provided a perverse benefit. As one resident noted, Molokai still belongs to the local people because resort developers do not want brown beaches.

SUMMARY

Change is a continuous and anticipated part of all natural systems. However, *rate* of change varies broadly and is susceptible to human intervention. The rate of the natural processes of erosion, deposition, and coastal change in South Molokai have been altered significantly since the appearance of humans some 1400 years ago. Initially population numbers were too small to have any significant effect on this area (600 to 1000CE). However, once people began modifying the environment by clearing areas for planting and constructing coastal fishponds, the rate of change was altered in ways both visible and measurable (1000 to 1400CE). The destruction caused by war accelerated the erosional processes, with broad damage predisposing the area to further erosion, increasing the rate to 'low-medium' (1400 to 1770sCE). After this time both the rate of erosion and the rate of change accelerated, for with the introduction of grazing animals and the practice of broad-scale clearing of extant vegetation, humans lost a large measure of control over their environment (1778 to 1900CE). Research has shown that erosion and reef-ward deposition was most accelerated during this period.

During the past century the human residents of Molokai began to realize the extent to which they affected the rate of change in their environment and began efforts to understand and possibly reverse the acceleration. Today scientists continue to study the near-shore reef environment, examining the physical evidence of change while seeking to quantify alterations in the rate of change and learn the causes, both past and present, of these alterations. Perhaps knowledge of Molokai's past will help the residents deal more effectively with present and future threats to their remaining coral reefs.

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