BEACH MANAGEMENT PLAN FOR MAUI

Prepared by:

University of Hawaii Sea Grant Extension Service

and

County of Maui Planning Department

December 1997

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

The *Beach Management Plan for Maui* seeks to promote beach preservation and sustainable development of the coastal zone. The report makes recommendations on how Maui County can better address beach management issues. It is intended to be a guiding policy document, rather than be adopted in its entirety as formal law, although specific recommendations may best be implemented through revisions of existing rules and regulations. Issues discussed in this plan include:

- Where and why coastal erosion and beach loss have occurred
- Recommendations for more effective management of shoreline areas and the development of increased options for resource conservation and erosion mitigation

We have identified thirteen areas for implementing more effective beach management practices. Each area has a short introduction followed by a statement of objectives and specific recommendations. Although the sections are numbered, they are not ordered chronologically nor in order of priority or importance. In fact, many of the recommendations will need to be implemented concurrently in order to be most effective.

ACKNOWLEDGMENTS

The report is a cooperative effort between the University of Hawaii's Sea Grant Extension Service and the County of Maui's Planning Department.

The Maui County Regional Coastal Processes Extension Agent is jointly funded by the University of Hawaii's Sea Grant Extension Service (UH FMIS # 6-54355), the County of Maui (Grants G-0413 and G-0433), and Maui Community College.

We also thank the Beach Management Plan Advisory Group members for their helpful comments and suggestions.

Robert Mullane
Maui County Regional Coastal Processes Extension Agent
UH Hawaii Sea Grant Extension Service

Daren Suzuki
Maui County Planning Department

INTRODUCTION

The natural beauty of Maui's sandy beaches and shoreline areas is an extremely valuable resource to residents as well as to visitors from throughout the world. Beaches are vital environmental, cultural, recreational, and economic resources. The beach supports the habitat for many marine and terrestrial organisms including many endangered native Hawaiian plants. Healthy beaches are central to the health and vitality of the shoreline area and coastal waters. Beaches buffer ground water discharges into the coastal zone as well as discharges from septic systems and cesspools.

Beaches also provide for diverse cultural opportunities including religious activities and traditional ceremonies. Recreational activities tied directly or indirectly to the beach include windsurfing, surfing, snorkeling, sunbathing, walking/jogging, swimming, and picnicking, to mention a few. Furthermore, this unique attraction with diverse opportunities drives the economy by supporting numerous jobs and providing services to maintain Hawaii's thriving visitor industry.

Unfortunately, some of our sandy beaches are eroding and disappearing as a result of natural shoreline processes, development and **hardening** along the shoreline, and other human impacts. Recognizing the importance of Maui's beach resources, it is imperative that they be preserved, protected and restored where possible.

The State Department of Land and Natural Resources (DLNR) has prepared a *Coastal Erosion Management Plan* (COEMAP) for the State of Hawaii, which reviews shoreline management options and policies in Hawaii. This statewide plan also provides a framework to encourage cooperation between County, State and Federal agencies, as well as community and environmental groups interested in and directly responsible for the management of our shoreline resources. COEMAP was recently adopted by the Board of Land and Natural Resources.

This document, the *Beach Management Plan for Maui*, focuses specifically on shoreline issues for the Island of Maui and is intended as a statement of the Maui County Planning Department's long-term commitment to preserve beach resources through effective beach management practices. Maui citizens can benefit from this plan by understanding coastal processes and potential negative impacts to beaches and related environments. Issues discussed in this plan include:

- Where and why **coastal erosion** and **beach loss** have occurred
- Recommendations for more effective management of shoreline areas and the development of increased options for resource conservation and erosion mitigation

Shoreline processes are the net result of many interrelated systems. Effective management of shoreline resources requires input from several different fields of study.

The *Beach Management Plan for Maui* has been reviewed by a diverse group of experts (Table 1), and their comments and suggestions have been incorporated in this report.

Table 1. Beach Management Advisory Committee Members

Eric Brown, coral reef researcher, University of Hawaii-Manoa
Warren Bucher, coastal engineer, Oceanit Laboratories
Ann Coopersmith, biologist, Maui Community College
Charles Fletcher, coastal geologist, University of Hawaii-Manoa
Skippy Hau, marine biologist, Division of Aquatic Resources, State of Hawaii Department of Land and Natural Resources
Edward Laws, oceanographer, University of Hawaii-Manoa
Phil Ohta, Maui District Land Agent, State of Hawaii Department of Land and Natural Resources
Peter Rappa, coastal resource management extension agent, University of Hawaii-Manoa
Glenn Shepherd, marine geologist, Maui Community College
Lolly Silva, environmental planner, U.S. Army Corps of Engineers
Kathy Smith, Kealia Pond National Wildlife Refuge Manager, U.S. Fish and Wildlife Service
Scott Sullivan, coastal engineer, Sea Engineering
Dean Uchida and Sam Lemmo, Land Division, State of Hawaii Department of Land and Natural Resources
Wendy Wiltse, West Maui Watershed Coordinator, State of Hawaii Department of Health

COASTAL ECOSYSTEMS

Beaches

A **beach** is defined as an accumulation of sediment—usually sand or gravel—that occupies a portion of the coast. The **active beach**, the area of loose sediment subject to transport by wind, waves, and currents, is divided into three regions: the **backshore**, the **foreshore**, and the **offshore**, as shown in Figure 1. The active beach is backed by the **coastal upland**, which can be a **dune**, a cliff, a soil embankment, a fossil **berm**, or an engineering structure such as a seawall or a revetment. Common geomorphic features of the beach include berms, **scarps**, and offshore sand bars (Figure 1).

The amounts and fluxes of sediment in a beach are collectively known as the **littoral budget**. Healthy beaches are in a state of **dynamic equilibrium**, where the net influx of sediment—or sources, equals the net loss of sediment—or sinks. Sources of beach sediment include skeletal material from coral reef ecosystems, onshore transport of sand, **longshore transport**, headland erosion, volcanic glass, river input, and erosion (scarping) of the coastal upland. Sediment sinks include loss to deep water, harbors, and channels, offshore transport, longshore transport, impoundment by engineering structures, and **storm surge overwash**. When there is an imbalance between sources and sinks, the beach will either erode or accrete.

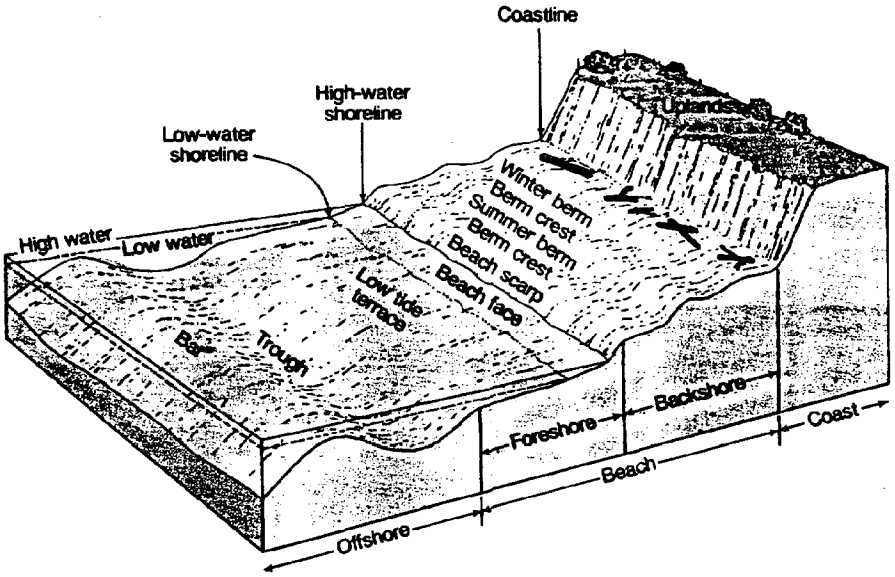

Figure 1. Common beach features. (DUXBURY AND DUXBURY, 1996).

Coastal processes such as **erosion** and **accretion** are site-specific, season-specific, and interannual. Different beaches have different geomorphic characteristics and are subject to different oceanographic conditions. Beach processes can vary dramatically from one end of a particular beach to the other. Site-specific factors such as extent and health of coral reefs, alterations to dune systems, sediment runoff from upland areas, and other human activities also affect coastal processes. Wave and current patterns change dramatically from season to season, and from swell to swell. Because of these variations, each segment of each beach will have its own history of erosion and accretion trends.

Sand Dunes

Dunes are accumulations of wind-blown sand. Although some dunes are bare, most are vegetated with coastal plants, which help stabilize the dune (Figure 2). Vegetation traps wind-blown sand and then grows up through the new sand accumulation. This process is repeated to build larger dunes. The thick root system of native plants slows coastal erosion during high-wave events and helps trap wave- and wind-deposited sand during post-event recovery. Many dunes are host to burial sites and are legitimate environmental systems that support specific ecosystems. Because of their cultural and environmental sensitivity, many dunes are worthy of all due protection.

Dunes are dynamic features; they erode during periods of high waves and accrete during normal wave conditions. During a storm or a large swell, waves attack and erode the

Figure 2. Twenty foot high vegetated dunes, Spreckelsville, Maui.

dune. This process, known as **scarping**, releases sand that was stored in the dune to the active beach. The influx of sand is often carried offshore to build sand bars, which help attenuate incoming wave energy. Erosion of pristine coastal dunes does not release silt to the near-shore area, degrade water quality, or harm the coral reef ecosystem since these dunes are composed of clean sand. When storm waves subside, normal waves dismantle the offshore bars and rebuild the beach. Although some sand may be permanently removed from the beach system (transported to deep water by sand channels), eventually most of this beach sand is reincorporated into the dune. On undeveloped beaches, the post-storm recovery of the dunes is often complete.

Coral Reef Ecosystems

Coral reefs are also important components of the beach system. Reefs are natural breakwaters; they absorb much of the incoming wave energy and help protect the shoreline from wave attack. Without the wave buffering and sand production that coral reefs provide, rates of coastal erosion and beach loss would be significantly higher.

Furthermore, coral reefs provide habitat for a rich diversity of marine life (Figure 3). Several reef organisms build their skeletons and shells out of calcium carbonate. When these organisms die, their skeletal remains are transported to the beach or are cemented into the framework of the reef. Most of the light-colored sand on beaches derives from coral reefs.

Figure 3. Coral reef. Photo courtesy of John Pye.

Coral reefs are sensitive environments that require pristine coastal water quality. Corals are very efficient marine organisms that thrive in nutrient-poor environments. This is because coral polyps contain **zooxanthellae**—unicellular, symbiotic algae that produce food for their hosts through photosynthesis. Photosynthesis requires sunlight, and the depth and intensity of sunlight penetration is reduced by suspended sediments. Silt can also settle out on corals and interfere with feeding and recolonization.

Corals can survive occasional short-term **siltation** events. When stressed they produce mucus, which helps them shed the fine-grained sediments that have settled upon them. However, repeated or chronic silt plumes or a single large event will kill coral. Nutrient loading is also harmful to coral reefs. Excess nutrient levels in coastal waters can lead to **algal blooms**, which compete with coral colonies for space and light and disrupt the coral reef ecosystem.

COASTAL EROSION, BEACH LOSS, AND CORAL REEF DEGRADATION

Preliminary examination of a report on shoreline changes from 1949 to 1989 suggests that 62% of the sandy shoreline studied on Maui is eroding at an average rate of 1.25 ft/yr (HWANG AND FLETCHER, 1992), and as much as 30% of Maui's shoreline has experienced beach loss or significant narrowing (MAKAI OCEAN ENGINEERING, INC. AND SEA ENGINEERING, INC., 1991). Based on field and photographic observations, nearly all of this beach degradation is in front of or adjacent to shoreline **armoring** such as **seawalls** and **revetments**.

Typically, these armoring structures are erected when coastal erosion threatens beachfront development. Armoring the shoreline usually halts coastal erosion and protects property and structures, but on shorelines undergoing long-term retreat, it often leads to beach loss (FLETCHER, ET AL., 1997). The impact that armoring has on the adjoining beach creates a conflict between the rights of coastal property owners to protect their land and the rights of the public to utilize the beach resource.

Coastal Erosion

Sea-level rise, wave and current impacts, and sediment deficiencies drive coastal erosion (Figure 4). Sea-level rise, currently averaging about 2.5 cm/decade on Maui, causes the **littoral system** to shift landward by eroding the upland area—usually a **coastal dune** or the **coastal plain**. This natural process, known as coastal erosion, has occurred for millennia as sea level has risen nearly 110 meters since the last ice age. The retreat of the shoreline—and associated loss of coastal lands—is the natural response of the beach to rising sea levels (TAIT AND GRIGGS, 1990) and has been the underlying premise of coastal engineering theory for over thirty years (e.g. "The Bruun Rule", BRUUN, 1962). The influx of sediment released to the active beach by erosion of the coastal upland helps maintain beach width.

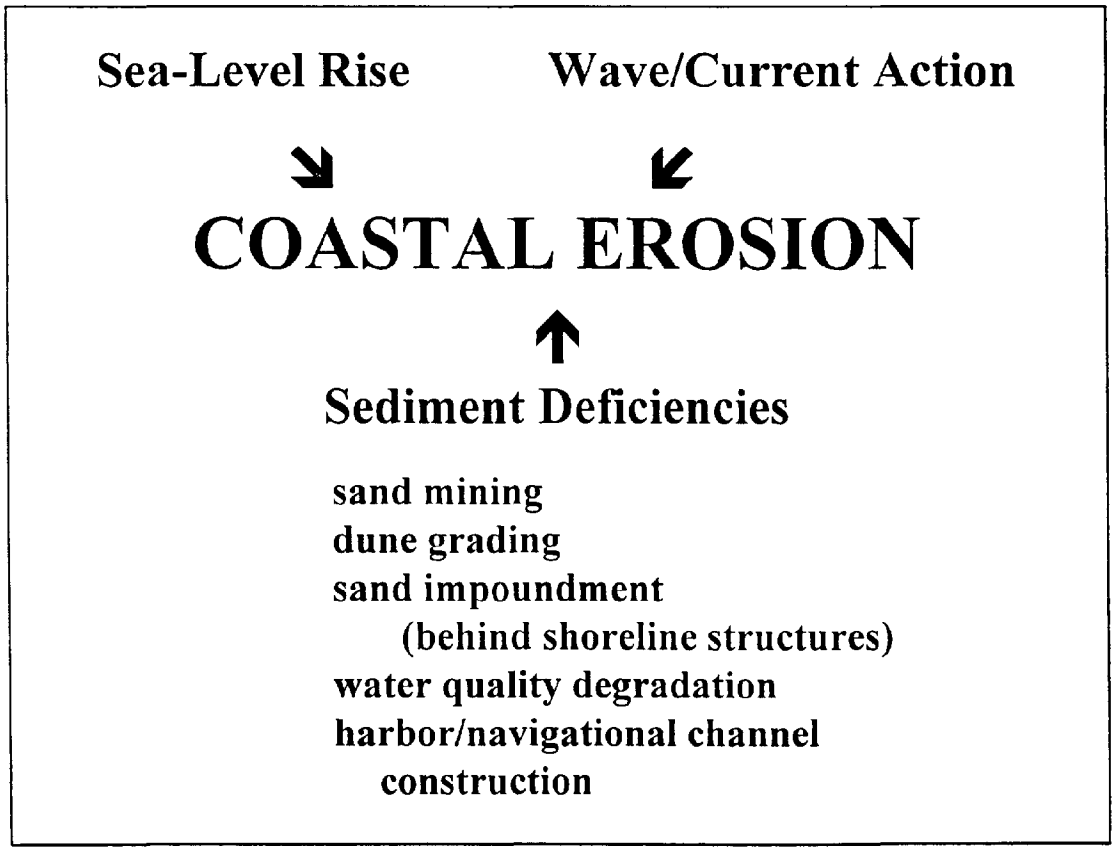

Figure 4. Causes of coastal erosion. Sea-level rise, wave and current action, and sediment deficiencies drive coastal erosion.

Certain human activities create significant sediment deficiencies and aggravate coastal erosion. These include sand mining, dune alteration (e.g., dune grading and building on dunes), construction of shoreline structures such as seawalls, revetments, and **groins**, degradation of coral reefs, and construction of harbors and navigational channels.

Sand mining on the beach removes sediment from the beach system leading to beach narrowing and **deflation**. Up until the early 1970's, large volumes of sand were mined from beaches around Maui to provide cement aggregate for construction and lime for sugar cane processing.

Dune grading entails bulldozing the upper portion of the dune to flatten it, often in order to allow an unobstructed view of the ocean or as part of a building's construction. This practice sharply reduces the dune's natural capacity to buffer coastal erosion and other coastal hazards. Furthermore, if the dune is then covered with soil fill, subsequent coastal erosion will release silt and other fine-grained sediments to the ocean, which degrade water quality.

Harbors and navigational channels can interfere with sediment transport. Sand moved by nearshore waves and currents is deposited in these artificial depressions and is removed from the littoral system.

Beach Loss

Armoring shorelines undergoing long-term retreat with structures such as revetments and seawalls halts coastal erosion, but refocuses the erosion onto the beach in front of the structure (TAIT AND GRIGGS, 1990; FLETCHER ET AL., 1997). This causes **beach narrowing**, a decrease in the usable beach width, and **beach loss**, the volumetric loss of sand from the active beach (Figures 5 and 6). Coastal armoring often aggravates erosion along **downdrift** properties by decreasing the supply of sediment to downdrift areas.

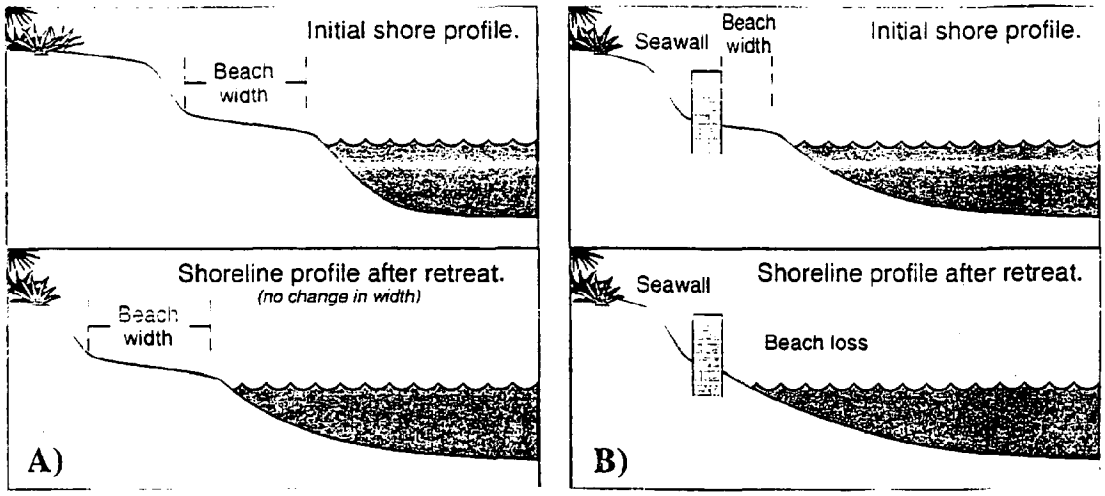

Figure 5. Coastal erosion vs. beach loss. Coastal erosion does not normally threaten beaches, but armoring to protect coastal lands may lead to beach loss (after TAIT AND GRIGGS, 1990).

Figure 6. Beach width on an armored vs. a natural shoreline, Speckelsville, Maui.

The site-specific history of coastal processes for a particular beach segment must be assessed to help guide the most effective beach management practices. Certain management tools—**beach nourishment** and **dune restoration**, for example—can counteract coastal erosion and beach loss. Other management tools—such as requiring sufficient **building setbacks** and wiser construction codes—can delay or prevent the need to armor the shoreline to protect beachfront development. Hence, coastal erosion does not necessarily present a conflict between coastal property owners and the public. It can be mitigated through effective beach management strategies.

Reef degradation

Harbor and navigational channel construction compromise the reef's wave buffering capacity. If a portion of the reef is dredged during harbor and channel construction, larger waves can reach the shoreline and accelerate erosion.

Many other human activities degrade water quality and harm coral reef ecosystems. Since most carbonate sand ultimately derives from the coral reef ecosystem, poor water quality reduces the amount of sand produced by the reef and delivered to the beach. Impacts to water quality caused by human activities include: siltation, **nutrient loading**, and **urban runoff**. In addition, over-fishing can deplete the reef ecosystem of certain species of fish and upset the ecological balance necessary for healthy coral reef ecosystems, and introduced species have disrupted the preexisting food web, which also disrupts the reef ecosystem. Finally, anchoring on reefs causes physical damage to coral, as does standing on or touching these sensitive creatures.

In some cases, coastal erosion can have adverse effects on water quality and harm the reef. The erosion of dirt embankments or coastlines that have been artificially filled releases fine sediments to the nearshore waters. Furthermore, the significant increase in drainage outlets for recent developments and concrete channelization for flood protection have both had significant impacts on near-shore water quality and sediment loads.

PROGRESS TO DATE

Some progress has been made in Maui County and the State of Hawaii to reduce the impact of many of these activities. For example, large-scale sand mining was prohibited in 1986. In 1990, the Maui County Planning Department revised the shoreline setback rules to require some building setbacks to be based on average lot depth. Recently, DLNR's Division of Aquatic Resources in cooperation with the University of Hawaii's Marine Option Program has installed **day-use moorings** at a few popular snorkel and dive sites (e.g. Molokini) to reduce the amount of anchor damage to coral reefs. While these recent efforts have had a positive impact, much more action is needed.

OBJECTIVES AND RECOMMENDATIONS

The *Beach Management Plan for Maui* seeks to promote beach preservation and sustainable development of the coastal zone. The report makes recommendations on how Maui County can better address beach management issues. It is intended to be a guiding policy document, rather than be adopted in its entirety as formal law, although specific recommendations may best be implemented through revisions of existing rules and regulations.

We have identified thirteen areas for implementing more effective beach management practices. Each area has a short introduction followed by a statement of objectives and specific recommendations. Although the sections are numbered, they are not ordered chronologically nor in order of priority or importance. In fact, many of the recommendations will need to be implemented concurrently in order to be most effective.

1. Identification of Erosion Hotspots and Erosion Watchspots

Erosion hotspots are areas where coastal erosion has threatened shoreline development or infrastructure. They are existing management challenges. In most cases, the shoreline has been armored to protect property and development, and there has been a noticeable environmental impact and/or a decrease in recreational use. Erosion hotspots can be restored, but restoration will require substantial economic resources. **Erosion watchspots** are areas where the coastal environment will soon be threatened if shoreline erosion trends continue. A potential conflict between the desire to protect property and the desire to maintain the beach resource exists at erosion watchspots. **Lost beaches** are a subset of erosion hotspots. Lost beaches lack a recreational beach, and lateral shoreline access is very difficult—if not impossible.

It is essential to recognize these existing and potential erosion problem areas when planning developments or redevelopments, regulating structures, and considering prospective areas for coastal protection or beach nourishment projects. A list of preliminary hotspot and watchspot erosion areas appears in Table 2. These areas were identified by an analysis of a coastal erosion rate study (MAKAI OCEAN ENGINEERING, INC. AND SEA ENGINEERING, INC., 1991), reports of long-time coastal residents, and site inspections.

Table 2. Preliminary Erosion Hotspots, Watchspots, and Lost Beaches for Maui.

LOCATION	HOTSPOTS	WATCHSPOTS	LOST BEACHES
WEST MAUI	North end of Puuoa Point	Hanakaoo Point	Lahaina Town
LAHAINA TO NAPILI	Hyatt Regency	Maui Surf (Westin)	Wahikuli State Wayside Park
	Portions of Kaanapali Beach	Ends of Kekaa (North Beach)	Either side of Honokowai Beach Park
	Mahana Condominium	Mala Wharf area	Either side of Kahana Point
	Honokowai Beach		Honokeana Cove
	Honokowai Point		
	Honokowai Beach Park		
	Kahana Point		
	Kahana Sunset (Keonenui Beach)		
	Alaeloa Beach		
	Napili Bay		
	Kapalua Bay (shower, steps and sidewalks threatened)		
SOUTH MAUI I	East end of Hauoli Street, Maalaea	Maui Lu to Suda's Store	West end of Hauoli Street, Maalaea
MAALAEA TO KALAMA	Kealia Beach hotspot areas		Koa Lagoon, Maui Lu area
	Maipoina Oe Iau Beach Park		Menehune Shores
	Maui Sands		South end of Halama Street - Waimahaihai
	Hale Kai O Kihei - end of Lipoa St.		Kalama Beach Park
	Central Part of Halama Street		
SOUTH MAUI II	Hale Hui Kai Hotel - No. Keawekapu	Mokapu Beach	none
KAMAOLE TO MAKENA	South Keawekapu Beach	Polo Beach	
	Ulua Beach	Palauea Beach	
NORTH SHORE	Hobron Point to Kaa	Baldwin Beach Park	Wailuku/Kahului Wastewater Reclamation
KAHULUI HARBOR	Kaa to Kanaha Beach Park	Mantokuji Bay	Facilities
TO KUAU	Most of Kanaha Beach Park		Portions of Stable Road Beach
	Spreckelsville Beach		Baldwin Beach Park lime kiln
	Most of Stable Road Beach		Portions of Kuau Bay
	Sugar Cove (lost, but replenished)		Portions of Tavares Bay
	East end of Lower Paia Bay		

Objective

1.1) To identify existing and potential erosion problem areas along Maui's shoreline

Recommendations

1.1a) Sponsor a study to better identify Maui's erosion hotspots and watchspots and to analyze the possible causes of erosion

1.1b) Acknowledge the special nature of erosion hotspots and watchspots when planning shoreline developments, infrastructure, and restoration projects

1.1c) Require data on shoreline erosion/accretion trends for any proposed coastal development

2. Guidelines for Shoreline Protection Measures

When coastal erosion threatens property, coastal landowners are usually unaware of the different types of coastal protection measures that are available and the applicable environmental concerns and permitting requirements. Since conventional coastal protection structures such as seawalls and revetments have been shown to cause beach narrowing and loss, the County should identify and recommend more environmentally compatible alternatives.

For example, the use of sand bags and large sand-filled geotextile tubes known as **sea bags** that temporarily control coastal erosion has become popular recently. Another example may be concave or "V" shaped structural hardening designs which may retain sand better than linear structures. This study should discuss how and where these structural alternatives can effectively be used.

Currently, the County of Maui has entered into a contract with Oceanit Laboratories, Inc., to conduct such a study. Oceanit's study is entitled *Coastal Protection and Beach Nourishment Study* and is expected to be completed by January 1998.

Objective

2.1) To establish guidelines for governmental agencies and the coastal community to determine the most appropriate type of coastal protection in a particular location

Recommendations

2.1a) Develop a study to provide technical recommendations for the restoration of sandy shorelines through beach nourishment

2.1b) Provide suggestions on alternative coastal protection designs where beach nourishment is not feasible

2.1c) List acceptable structures for emergency (temporary) coastal protection

2.1d) Address permitting requirements for beach nourishment and structural alternatives

3. Beach Nourishment

Beach nourishment, a technique used to restore an eroding or lost beach or to create a new sandy shoreline, involves the placement of sand fill with or without supporting structures along the shoreline to widen the beach. It is the only management tool which serves the dual purpose of protecting coastal lands and preserving beach resources. Beach nourishment is a common management practice on the mainland (NATIONAL

RESEARCH COUNCIL, 1995). Miami Beach. FL; Myrtle Beach, NC; Ocean City, MD; and several other locations have ongoing beach nourishment projects.

Although Maui has limited experience with beach nourishment, a few small-scale projects have successfully restored lost or eroding beaches (Figure 7). Most restoration projects that have taken place on Maui were privately funded and carried out without a thorough engineering study.

Beach nourishment requires large volumes of beach-quality sand. The initial nourishment project typically requires thousands of cubic meters of sand per kilometer of shoreline, and most beaches need periodic renourishment. Maui should take measures to more effectively manage its limited sources of readily available sand and should build its capacity to tap new, currently unavailable sources of sand.

Sand Sources for Beach Nourishment

Sand for nourishment projects is from a variety of environments. Terrestrial sources of sand include coastal dunes, coastal plains, and inland sand dunes. Offshore sources include dredge spoils from harbor maintenance, shallow-water sand fields, medium-depth sand channels, and deeper-water sand banks. Harbor spoils can be accessed from land with a clamshell dredge but comprise only a minor portion of Maui's sand resources. Larger sources of sand must be hydraulically dredged with a suction dredge. Currently, Maui lacks its own suction dredge and hence lacks the capacity to tap large offshore sand resources.

To date, most small-scale nourishment and coastal protection projects on Maui have used sand mined from inland dunes. The fine-grained nature of dune sand may not be compatible for high energy beaches that typically have coarser-grained sand. Because some sand dunes contain burial sites, sand should be acquired only from quarries designated free of cultural sites. Inland sand mines on Maui charge $10 to $18 per cubic yard, which is relatively inexpensive. In contrast, dune sand from Kaua'i for the creation of four pocket beaches at Ko'olina Lagoons on O'ahu cost $80/cubic yard in place. Nonetheless, terrestrial sources of sand are limited. Sand shipment off island—primarily for cement companies on O'ahu—has occurred for decades. This constitutes a loss of valuable Maui sand that could be used for local beach nourishment projects. The export of Maui's sand resources should be restricted, perhaps by introducing new legislation.

Maui should build its capacity to tap offshore sand resources. Potential offshore borrow sites should be identified, mapped, and sampled. Local scientists and consulting firms have mapped offshore sand resources for O'ahu (SEA ENGINEERING, INC., 1993). Although a similar study was done for Maui and Moloka'i in 1971 (CAMPBELL, ET AL., 1971), this study did not include extensive sampling and should be updated. Sampling is necessary because offshore sand may not be suitable for beach nourishment. A recent sand nourishment viability study on O'ahu found that offshore sand is often fined-grained and discolored for beach nourishment (SEA ENGINEERING, INC., 1993). Funding for

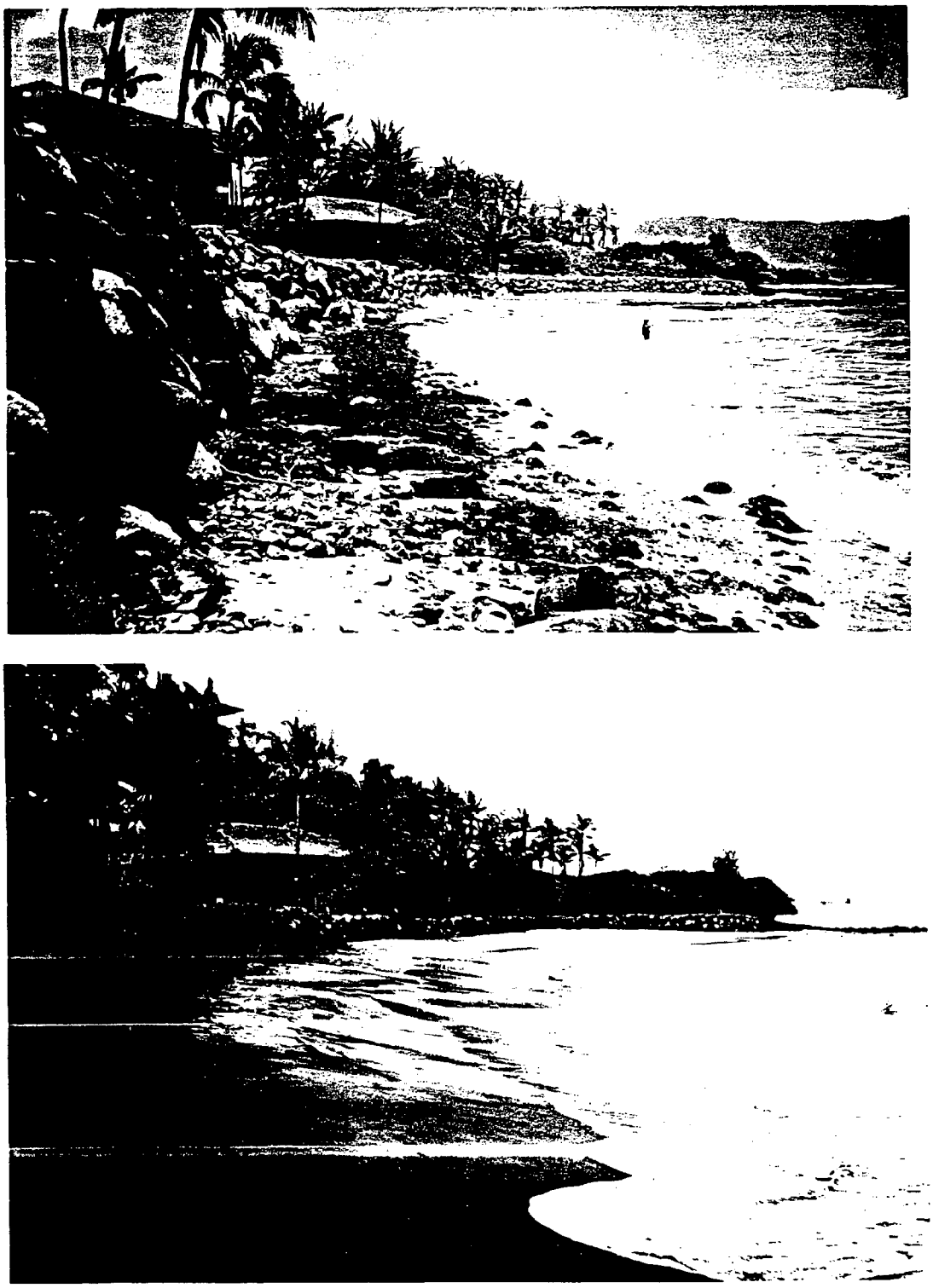

Figure 7. Beach Nourishment at Sugar Cove, Spreckelsville, Maui. Before and after small-scale beach nourishment project implemented entirely with private funding. Above photo taken June 1996; below photo taken October 1997.

the updated offshore sand resource study could be shared by Maui County, DLNR, the University of Hawaii, and the United States Army Corps of Engineers (USACOE).

Pilot Beach Nourishment Project

Beach nourishment is the only management tool that protects coastal development without degrading the beach. Preserving or restoring a sandy beach has direct, beneficial impacts on recreational opportunities and property values. Some homeowners associations—Sugar Cove Condominiums in Pa'ia, and Kana'i O Nalu in Ma'alaea, for example—have implemented small-scale, privately-funded beach nourishment projects. Both of these projects were deemed successes; it was worth the expense to restore the recreational use and value of the beach. The demand for beach nourishment on Maui as well as statewide has grown in recent years and will likely continue to grow. The County of Maui should anticipate this growing demand and take the lead in promoting and implementing beach nourishment.

A pilot project is very much needed. It would illustrate the engineering requirements of nourishment as well as surface all the environmental and permitting requirements, problems, and concerns. An action plan for a pilot beach nourishment project should be prepared based on guidelines from the *Coastal Protection and Beach Nourishment Study.* Site selection should consider erosion rates, geographical location, beach configuration, sand availability, cause of erosion, public use and access, and cost sharing. In order to better ensure a successful pilot beach nourishment project, a site-specific, coastal engineering study will likely be necessary.

Objective

3.1) To promote beach nourishment by more effectively managing the limited sources of readily available sand and building its capacity to tap new, currently unavailable (offshore) sources of sand .

Recommendations

3.1a) Earmark beach-quality sand that is periodically removed from Maui's harbors for nourishment projects

3.1b) Restrict the export of Maui's dune sand resources, perhaps by introducing new legislation

3.1c) Limit sand mining to quarries designated free of cultural sites

3.1d) Identify, map, and sample potential offshore borrow sites

3.1e) Consider acquiring a suction dredge to use to tap offshore sand resources, provided offshore borrow sites have sand of good quality, and dredging will not cause long-term environmental impacts

3.1f) Identify and implement one or more pilot beach nourishment projects

4. Dune Preservation and Restoration

Sand dunes are important components of the littoral budget. Dunes trap windblown sand, store excess beach sand, and serve as natural erosion buffers, protecting beach-front property and coastal infrastructure during storms and high-wave events. Pristine dunes are vegetated by native Hawaiian species such as *'aki'aki*, *'akulikuli*, *naupaka*, and *pohuehue*, which are salt-tolerant, have dense root systems, and are effective wind-breaks and wave buffers (Figures 8 to 11). Healthy sand dunes are vital to the health of the beach and nearshore marine environment.

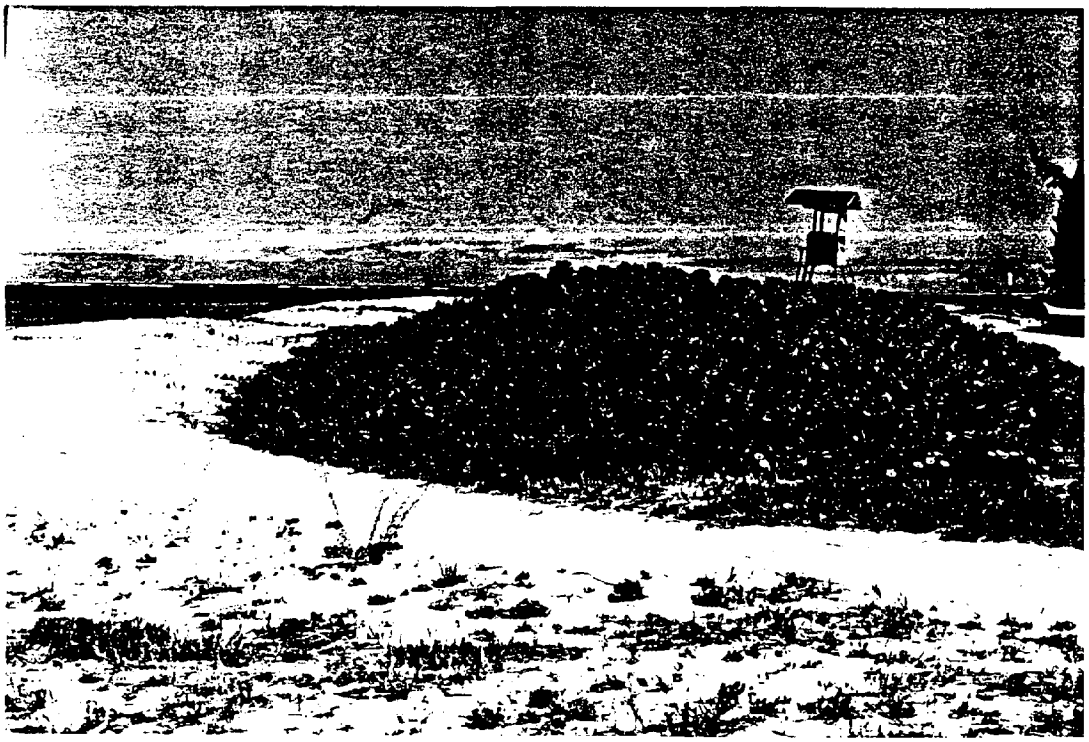

Figure 8. Vegetated dune, Kanaha, Maui. *Naupaka* shrub and *'aki'aki* and *pohuehue* (with purple flowers) ground cover at center. *'aki'aki* (sparse ground cover) in background.

Because of the natural erosion buffer that coastal dunes provide, dunes should be preserved and, in some cases, restored. Dune restoration projects took place at Kama'ole I in 1983, Kama'ole II in 1984, and Memorial Beach Park in 1987 (Figure 12). All three of these restoration projects significantly enhanced the recreational value of the beach and upland areas.

Figure 9. Close up of *'aki'aki.* Photo from JOHNSTONE, 1997.

Figure 10. Close up of *'akulikuli.* Photo from JOHNSTONE, 1997.

Figure 11. Close up of *pohuehue*, Honokahua, Maui Common name: beach morning glory.

Figure 12. Dune restoration project at Kama'ole II in 1984.

Objectives

4.1) To preserve existing sand dunes

4.2) To restore degraded sand dunes

Recommendations

4.1a) Map coastal dunes, and limit development on top of or in front of these dunes

4.1b) Prohibit grading (leveling) or mining of coastal dunes

4.1c) Guide landscaping in dune areas (e.g., limit topsoil fill, encourage the planting of native coastal species rather than turf grass, which is not consistent with the natural littoral environment)

4.1d) Establish moveable **dune walkovers** to provide pedestrian access without trampling dune vegetation (Figure 13)

4.2a) Encourage and support dune restoration efforts (dune fencing, revegetation, sand nourishment, etc.)

4.2b) Publish a handbook detailing the methodology for future dune restoration projects

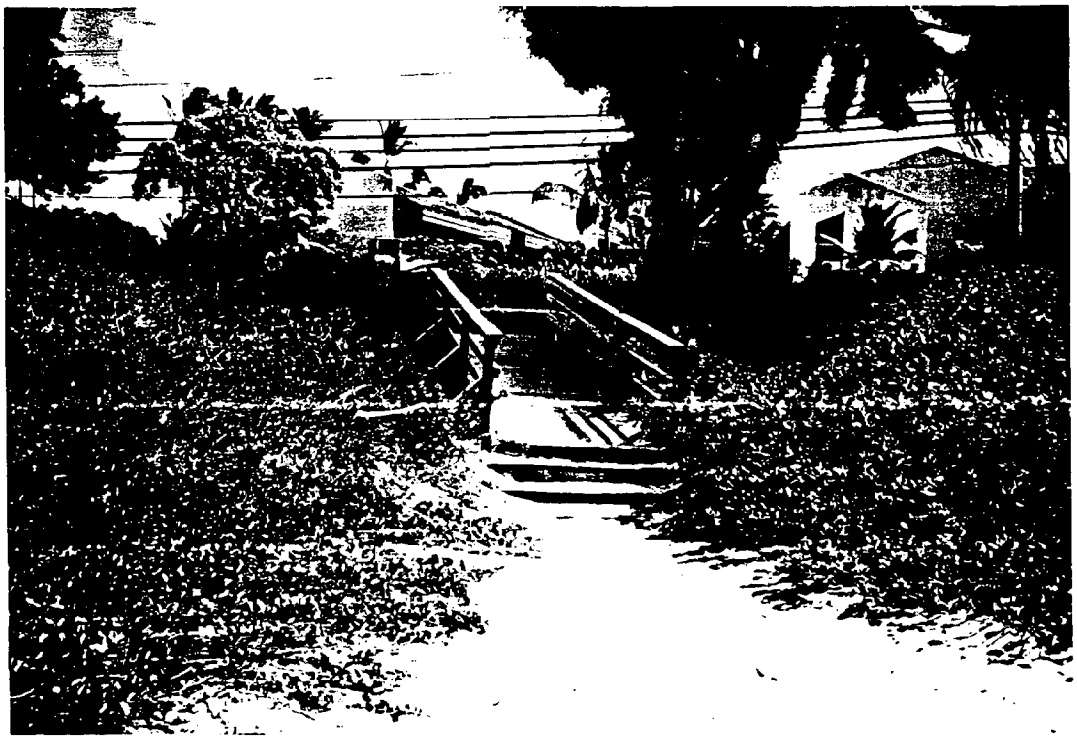

Figure 13. Dune walkover at Kama'ole II, Maui.

5. Coral Reef Ecosystems, Water Quality, and Upland Activities

The health of beaches is closely tied to the health of the coral reef ecosystem, which is itself closely tied to upland land practices. Hence, effective beach management requires a geographically broader approach known as integrated coastal zone management. Although this report has focused mainly on the shoreline area—the beach, the dunes, and the coastal plain—we have included some recommendations for more effective protection of the coral reef ecosystem and better management of upland land practices.

In many cases, improper control of runoff at agricultural lands and construction sites, even those far from the coast, has degraded the water quality of coastal areas. For example, recent construction without adequate erosion control measures for the Maui Ocean Center has led to frequent silt plumes in Ma'alaea Bay and negative impacts on the coral reef. Silt diminishes light penetration and eventually settles out on the seafloor. This harms coral and other marine organisms (e.g., *foraminifera*, an important component of beach sand) and limits safe and enjoyable ocean recreation. Runoff also transports nutrients, pesticides, and other pollutants to coastal waters compounding the impacts on water quality.

Golf courses, resorts, and other urban developments have impacts on water quality through the overuse of fertilizers, pesticides, and the leaching of other pollutants, including chlorine from the drainage of swimming pools. In some cases, nutrient loading of coastal waters has led to algal blooms. Most upland runoff can be prevented from polluting the coastal waters through adherence to the best management practices (BMPs) outlined in the *West Maui Watershed Owners Manual* (WEST MAUI WATERSHED MANAGEMENT ADVISORY COMMITTEE, 1997), which is available to the public from the Hawaii Department of Health. Major recommendations for agriculture and construction are highlighted below. The *West Maui Watershed Owners Manual* also provides recommendations for landscaping.

According to the *West Maui Watershed Owners Manual*, best management practices for agriculture include, but are not limited to, the following.

- Expanded use of sediment retention basins
- Regular maintenance of sedimentation basins and other erosion control measures
- Use of diversions, terracing, contour farming, and crop residue to intercept and slow sheet flow and stabilize the surface
- Improved water management practices
- Development of precision agriculture in order to insure efficient application of fertilizer and pesticides based on local soil/crop needs

Best management practices for construction sites include the following.

- Use of detention basins to prevent runoff
- Use of dust suppression measures such as dust screens and watering

- Limiting the surface area of exposed soil and coordinating activities with periods of low rainfall

Other recommendations in the *West Maui Watershed Owners Manual* include

- Revising the Grading Ordinance to reduce soil erosion
- Providing training and education for contractors, developers, and equipment operators
- Improving inspection and enforcement of requirements for erosion control

Upland activities such as landscaping, agriculture, and construction must become more environmentally responsible. Currently, the county Department of Public Works and Waste Management (DPWWM) and state Department of Health (DOH) are responsible for enforcing compliance with proper environmental controls at construction sites. Communities and non-governmental organizations can assist DPWWM and DOH in enforcement. To facilitate this, public awareness should be increased. Contracting firms and developers should attend workshops on environmentally sound construction practices and have their projects certified as "reef-friendly."

Objective

5.1) To reduce impacts to water quality and coral reef ecosystems

Recommendations

5.1a) Continue to educate the public—especially the ocean recreation users such as ocean activity centers and dive/snorkel tour boat operators—on the importance of coral reef ecosystems and how to reduce damage to these resources

5.1b) Support studies to determine the status of Maui's coral reef ecosystems

5.1c) Insure that upland construction and agricultural practices become more environmentally responsible by increasing public awareness

5.1d) Amend the grading ordinance to implement best management practices for dust and sediment control, as approved by the Natural Resource Conservation Service, and the Department of Public Works and Waste Management (This is currently being considered by the Maui County Council.)

5.1e) Provide BMP workshops to contractors at construction sites

5.1f) Improve enforcement of the grading ordinance

5.1g) Implement suggestions of the *West Maui Watershed Owners Manual* including guidelines for the reduction of soil erosion and the development of and adherence to best management practices protective of coastal water quality

5.1h) Promote sand fill along shoreline properties rather than soil fill

5.1i) Review existing water quality standards, testing, and enforcement

5.1i) Support a study of nearshore circulation patterns to help determine environmental impacts of various drainage master plans

6. Shoreline Setbacks and Coastal Erosion Hazard Data

The intent of **shoreline setbacks** is to establish a coastal-hazard buffer zone to protect beach-front development from high-wave events and coastal erosion. Adequate setbacks allow the natural erosion and accretion cycles to occur and help maintain lateral beach access. Furthermore, setbacks provide open space for the enjoyment of the natural shoreline environment.

It is the experience of the Planning Department that the generally applied 40-foot shoreline setback was often inadequate because setbacks are not determined by historical site-specific rates of coastal erosion. Along much of the Maui coastline, this setback has failed to protect developed beach-front property from coastal erosion and has failed to provide adequate environmental open space for coastal processes. An analysis of coastal erosion trends would provide data on a property scale to enhance decision making in the coastal zone area.

Historical erosion rates can be determined on a parcel by parcel scale and used to project the future erosion hazard area along the shoreline. Maps of the projected 30-, 60-, and 90-year shorelines can be prepared assuming that future shoreline trends will be similar to historical trends. The areas makai of the projected shorelines are known as the 30-, 60-, and 90-year erosion hazard zones. Maps of erosion-hazard zones provide a scientific basis for more effectively regulating proposed structures and activities in beachfront lots.

Coastal-erosion hazard maps could be used to establish rate-based building setbacks. Setbacks would be site-specific—literally at the property scale—to reflect the site-specific nature of coastal erosion. These setbacks would also incorporate the proposed style of development. Construction-style considerations would include the size and expected lifetime of the planned structure. Larger, immovable buildings and those with lifetimes of more than 50 years would have deeper setbacks than small, movable structures. For instance, a ten-story, 200-unit condominium would have a deeper setback than a single-family house built on posts.

Establishing setbacks that reflect site-specific coastal processes and building styles could be incorporated directly into the Shoreline Setback Rules for the Maui Planning Commission along with certain construction and land-use performance standards for areas that fall within a particular erosion-hazard zone. Site-specific setbacks would also offer a basis for dune conservation.

Variable-rate setbacks may be difficult to adopt. Projected erosion rates along shorelines with a history of severe coastal erosion could significantly limit the buildable area of a beach-front parcel. The projected hazard-zone may even consume the entire property. Provisions for possible exceptions to rate-based shoreline setbacks would need to be included with any rule changes. Even if variable shoreline setbacks are not adopted by the Planning Commission, erosion-hazard maps would still provide valuable data that would be used during planning, developing, and redeveloping coastal properties. For

example, erosion hazard maps could be used to identify areas prone to high rates of coastal erosion and help determine the causes of and methods to address coastal erosion.

Objectives

6.1) To provide relevant information for governmental agencies and the coastal community when purchasing shoreline property and/or planning and designing any development along the shoreline

6.2) To provide a scientific basis to assess and regulate proposed structures and activities within projected shoreline erosion hazard zone

Recommendations

6.1a) Develop a detailed coastal erosion hazard analysis that will determine historical shoreline positions and map the projected position of the shoreline 30, 60, and 90 years in the future. (Maui County has already prepared and advertised an RFP to develop such a study.)

6.1b) Quantify the amount of beach loss that has occurred to help identify the possible causes and potential mitigation of coastal erosion

6.2a) Incorporate site-specific erosion rate data and performance standards (e.g., construction style and estimated lifetime of structure) into the determination of shoreline building setbacks

6.2b) Initiate meetings with neighborhood associations to help develop performance standards for variable setbacks in areas with high rates of coastal erosion

7. Proactive Development of Coastal Lands

Proactive management occurs in the planning stages of new developments or redevelopments along the shoreline, well before project layout is finalized. This type of planning is beneficial to coastal landowners and developers who are not always aware of shoreline processes, coastal hazards, and the potential impacts of development on the beach and other nearshore areas. The permitting agency should apprise the applicant of the recommendations listed below during project layout. Incorporating the advice of the Planning Department would streamline the permitting process and decrease the risk of coastal hazards.

Developers and landowners should be encouraged to pre-consult with various experts and governmental agencies familiar with coastal erosion in order to get appropriate recommendations on project design. Developers and landowners should also acknowledge that developments along the shoreline are subject to the risk of coastal erosion and high wave events and that any request to protect structures and property with shoreline armoring is currently discretionary based on grounds of hardship and impacts on the environment.

Objectives

7.1) To encourage proactive shoreline developments and increase awareness of coastal hazards

7.2) To increase awareness of the discretionary nature of permitting shoreline armoring to protect property

Recommendations

7.1a) Encourage developers and landowners to pre-consult with various experts and governmental agencies familiar with coastal erosion in order to get appropriate recommendations on project design

7.1b) Make the *Beach Management Plan for Maui* available to developers, contractors, and landowners as a reference guide

7.1c) Encourage greater setbacks for erosion hotspots and watchspots and other areas with a high rate of erosion (Figure 14)

7.1d) Discourage slab-on-grade construction (Figure 15)

7.1e) For major condominium/hotel type developments, encourage layouts with less linear frontage (Figures 16, 17, and 18)

7.1f) Encourage minor structures to be non-permanent and portable (Figure 19)

7.1g) Encourage major structures to be hurricane/tsunami resistant (ie., built on posts) (Figure 20) and located away from areas of high coastal hazard

7.1h) Encourage developers to construct building additions on the mauka side of the structure rather than within the shoreline setback area

7.1i) Encourage use of sand fill and native vegetation for shoreline landscaping

7.2a) Require developers and landowners to acknowledge that shoreline armoring is discretionary and based on grounds of hardship and impacts on the environment

Figure 14. Example of large setback and open space, Ritz Carlton, Kapalua, Maui.

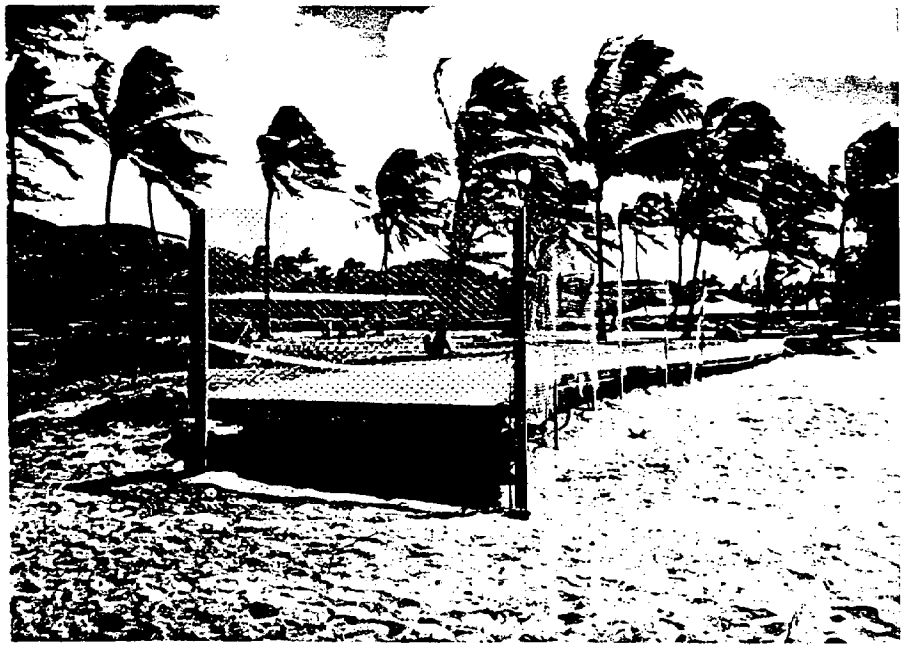

Figure 15. Undermined slab on grade sidewalk at Kahekili Park, North Beach, Ka'anapali. This sidewalk is very hazardous to beach users and interferes with coastal processes. This structure should have been readily movable when coastal erosion posed a threat.

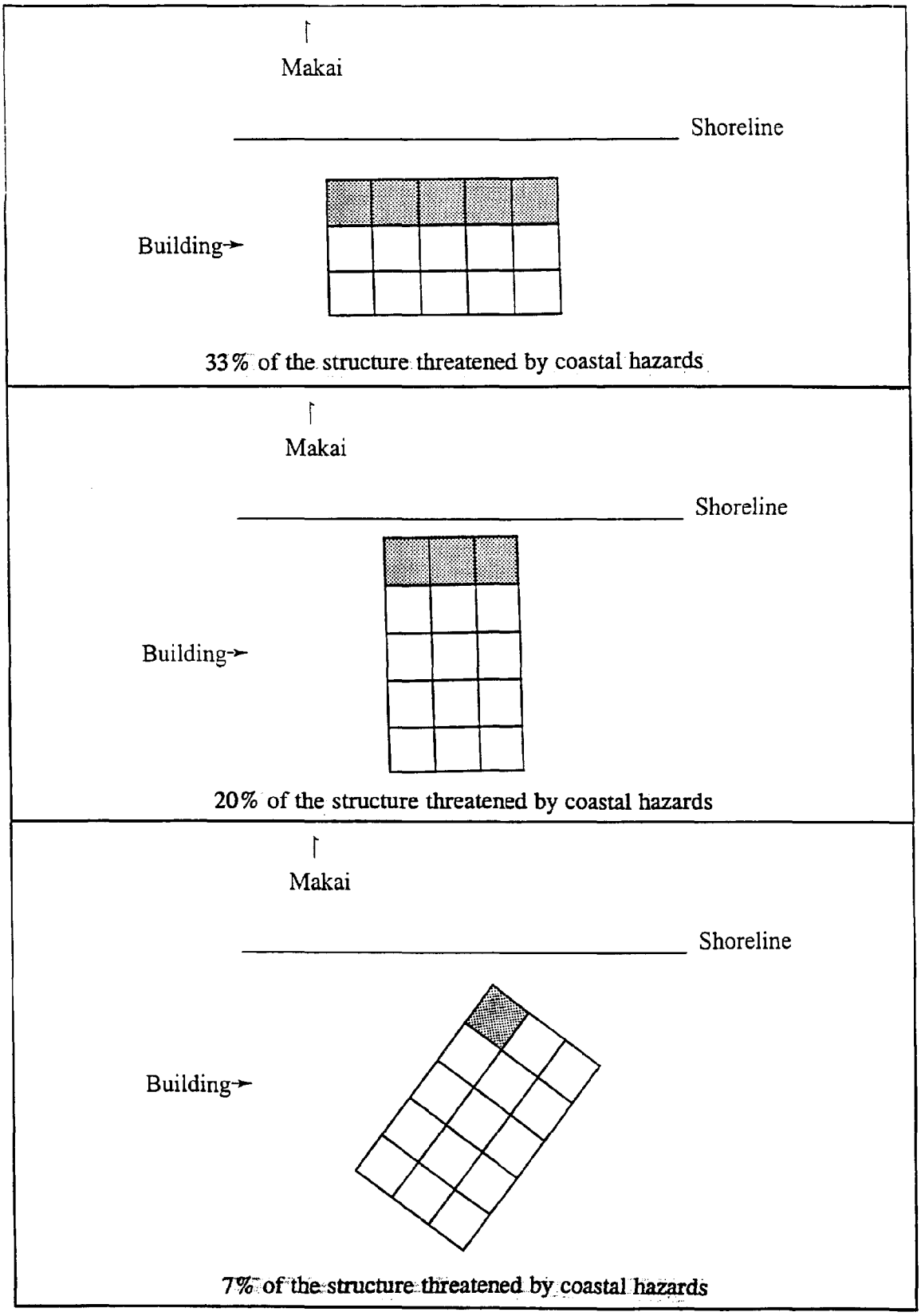

Figure 16. Different layouts of shoreline development with varying linear frontage. V-shaped layouts confine the risk of high-wave events and coastal erosion to a small portion of the building instead of the entire structure.

Figure 17. Shore-parallel type development, Honokowai, Maui. Maui Kai and Mahana Condominiums. Revetments front both condominiums.

Figure 18. Less linear type development, Royal Kahana area, Kahana, Maui. Note sandbagging is limited to the corner portions of the structure closest to the ocean.

Figure 19. Movable boardwalk constructed using recycled plastic, Kama'ole I, Kihei, Maui.

Figure 20. Houses built on cement pillars, Paukukalo, Maui.

8. Inter-agency Coordination

Much of the coastline of Maui consists of parks, highways, and other public works projects, which are threatened or will soon be threatened by erosion and other coastal hazards. Inter-agency communication and education is necessary to more effectively plan for or mitigate coastal hazards and implement more environmentally sound projects. Better inter-agency coordination would also reduce delays, duplications, paperwork, and resource demands in permit processing, resulting in cost-savings to both permit applicants and governmental agencies.

For example, the Department of the Army has proposed a General Permit for beach nourishment and restoration in Hawaii. The purpose of the General Permit is to expedite the authorization of minor non-controversial projects (e.g., beach nourishment and offshore submerged berms). Activities that do not conform to the provisions and limitations of this permit will still require an individual permit from the USACOE and/or a project-specific DOH Section 401 Water Quality Certification and a Coastal Zone Management (CZM) Federal Consistency determination. This General Permit has already been reviewed for Hawaii Coastal Zone Management (CZM) Program Federal Consistency.

Beach nourishment projects and other shore protection measures often fall within two or more jurisdictional boundaries (e.g., Federal and State, State and County, or Federal, State, and County). This leads to jurisdictional conflicts. Each agency is often not fully aware of the other agencies' permitting requirements and the status of pending applications.

Some progress has recently been made towards the coordination of county and state shoreline management efforts. Maui County and the State DLNR are discussing the formation of **improvement districts** (see section on Beach Management Districts), the selection of pilot beach nourishment sites, and data-management needs through the *Coastal Erosion Management Plan for the State of Hawaii.*

However, more interagency communication is needed. For example, better cooperation between State Parks and the County Parks and Recreation should be sought since many of our beach parks are maintained by these departments. In addition, discussions should be enhanced with the State Department of Transportation (DOT), because some highway facilities are threatened or will soon be threatened by coastal erosion. In most cases, state highway facilities are the major or only thoroughfare between regions. Proactive planning of new highway construction, widening, and realignment could reduce the threat of coastal erosion, high-wave hazards, and beach loss by anticipating future shoreline trends (Figure 21).

Maui County should continue to work with the Federal and State agencies to improve coordination on shoreline matters in order to avoid duplication, expedite permit processing, and encourage more environmentally sensitive shoreline protection measures.

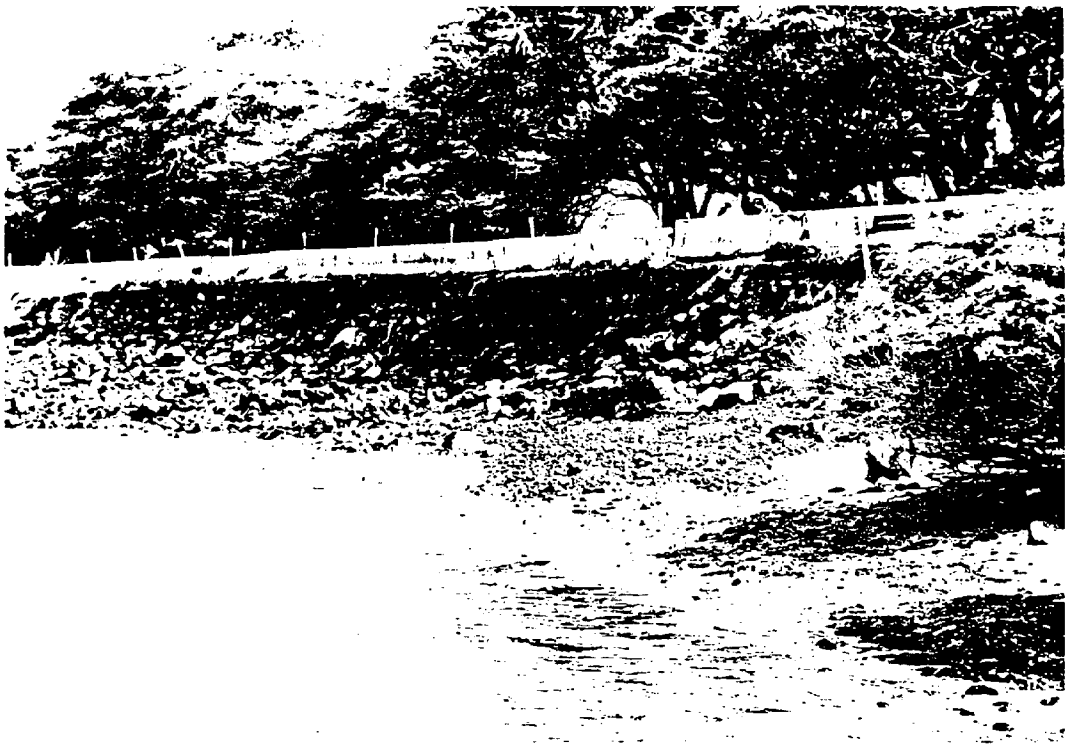

Figure 21. Launiupoko State Park, Lahaina, Maui. This section of the state highway is being threatened by ongoing coastal erosion and is earmarked for a revetment project by the State DOT and the USACOE. However, the project was questioned by the County since it seemed to be a short-term solution to a long-term problem and would likely promote construction of other similar structures. Beach nourishment with cobbles or highway relocation may be more appropriate solutions.

Objectives

8.1) To enhance coordination with federal, state, and other governmental agencies with jurisdiction over shoreline management issues—Army Corps of Engineers, Natural Resource Conservation Service, State and County Parks Departments, the State Department of Transportation (Highways and Harbors Division) the State Department of Land and Natural Resources, State Department of Health, and the County Department of Public Works

8.2) To develop an atmosphere which allows communities to act proactively to meet demands for shore protection and preservation

Recommendations

8.1a) Maintain ongoing discussions and improve coordination on shoreline matters with other agencies in order to avoid duplication, expedite permit processing, and encourage more environmentally sensitive shoreline protection measures

8.2a) Proactively plan highway construction, park improvements, and other infrastructure projects

9. Structures and Activities within the Shoreline Area

Certain shoreline structures have been shown to have an impact on coastal processes. Although pre-consultation and cooperation with governmental agencies results in more effective, proactive management and planning, certain recommendations on shoreline development must be formalized through adoption of rule changes.

Minor Structures

Concrete sidewalks, in-ground swimming pools, and other beach-use facilities historically have been permitted within the shoreline setback area as "minor structures". Some of these existing structures are threatened by coastal erosion or hinder the normal coastal processes (Figure 22).

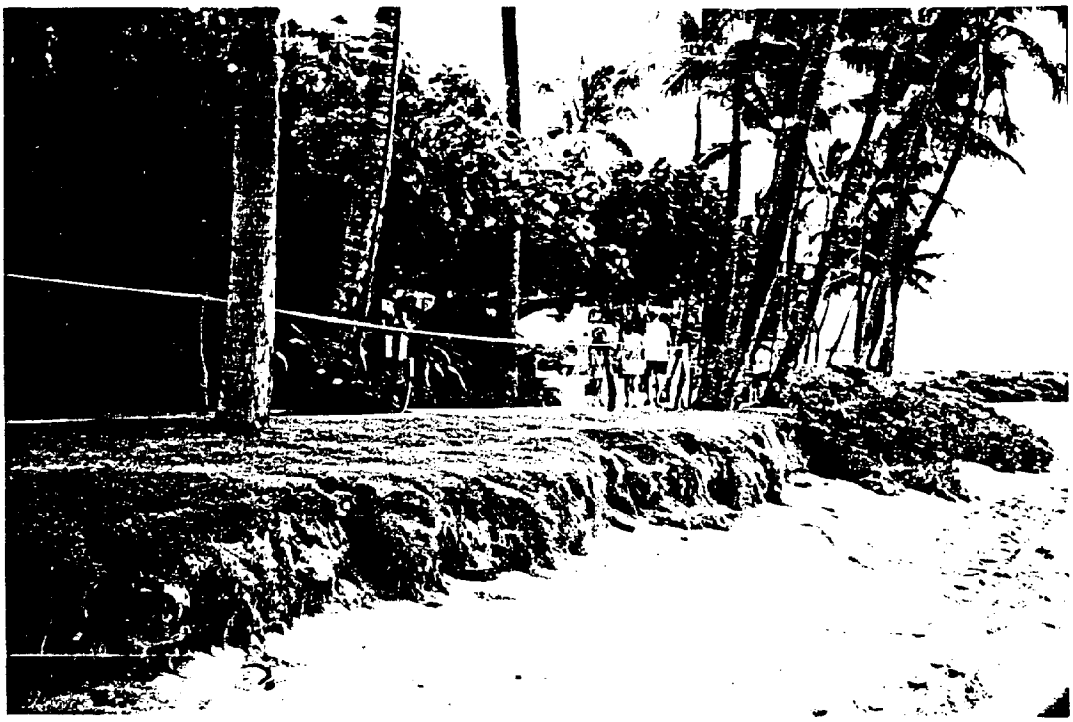

Figure 22. Hyatt Regency swimming pool threatened by coastal erosion, Ka'anapali, Maui. Also refer to Figure 15.

The shoreline setback rules should be amended to regulate these type of permanent and immovable structures within the shoreline area by limiting minor structures to those that are portable, expendable, or under a certain dollar value (see Figure 19). If the structure is threatened by coastal erosion or has an adverse effect on shoreline processes, the structure should be conditionally relocated or removed.

Permit processing on the County level for sand nourishment projects that would stabilize and enhance the shoreline area should be expedited to the extent possible. Sand is dynamic; it comes and goes naturally, depending on the tides, wind, seasons, and wave

action. Furthermore, nourishment may have a beneficial impact to surrounding properties and often will increase the recreational value of a particular beach. By streamlining this environmentally sensitive method of erosion control, the construction of illegal shoreline hardening structures may be deterred. Guidelines, however, must be created to regulate sand compatibility with the existing beach and sand cleanliness to minimize adverse impacts on water quality and marine resources.

Major Structures

Major structures include buildings and extensions, patios and paved areas, and parking lots. Although these are usually restricted from the shoreline setback area, the criteria for granting a shoreline setback variance is currently very broad. For example, shoreline hardening structures have been historically permitted in the setback area for coastal erosion control.

Unfortunately, shoreline hardening along coasts undergoing long-term coastal erosion has led to widespread beach loss on Maui. The county is very concerned about possible environmental impacts of coastal armoring and other major structures, especially with regard to beach processes. The Planning Department critically reviews each proposed shoreline setback variance and discourages the use of permanent coastal armoring structures along sandy shorelines. A proposed major structure in the setback area should be justified only after a thorough analysis of: 1) practicable alternatives, 2) reasonable use of land, 3) desire to protect private property and structures, 4) shoreline erosion rates, 5) impacts to the environment, and 6) loss of public benefit.

Finally, one of the major flaws in the current shoreline setback rules is that parcels must "abut the shoreline" in order to be subject to these rules. In other words, properties fronted by even a sliver of a State beach reserve may construct major structures near the makai edge of the property boundaries. This constitutes a major loophole in the current shoreline setback regulations with potentially serious consequences to both the beach environment and the property owner.

Objective

9.1) To regulate certain structures and activities within the shoreline area in a manner consistent with proactive planning recommendations

Recommendations

9.1a) Limit minor structures to those that are portable, expendable, or under a certain dollar value, and require them to be relocated or removed if shown to adversely affect shoreline processes

9.1b) Expedite permit processing for sand nourishment projects, provided that guidelines are created through the Shoreline Setback Rules to minimize adverse impacts on water quality and marine resources

9.1c) Specifically define the criteria for granting a shoreline variance for major structures

9.1d) Require that shoreline setback rules apply to all lands that abut the shoreline or abut a state beach reserve

9.1e) Consider incorporating other recommendations in this plan as formal rule changes (e.g., prohibition of soil fill and sand dune grading along the shoreline)

10. Beach Management Districts

Beach management districts should be established on a neighborhood scale to help maintain or restore nearby beaches and other shoreline areas. A beach management district (BMD) is a special designation for a group of neighboring coastal properties that provides a mechanism for implementing erosion mitigation projects at multi-property scales. BMDs streamline the permitting requirements for beach preservation and restoration projects and facilitate cost sharing between the group of neighborhood owners and county, state, and federal agencies. Further details about establishing beach management districts and the advantages and challenges of establishing them are thoroughly discussed in a 1992 report entitled *Beach Management Plan with Beach Management Districts* by Hwang and Fletcher.

Certain beach management projects (e.g., large beach restorations) affect several beachfront properties. The formation of a beach management district allows a group of adjacent landowners to address shoreline issues as a unit rather than as individual property holders (HWANG AND FLETCHER, 1992). As a beach management district, the group can pool its resources and streamline the permitting process for such projects. Often, county, state, and federal agencies will participate in cost sharing for a particular project, if it benefits the public. Some condominium associations and neighborhood boards already act as *de facto* beach management districts.

Objective

10.1) To encourage and implement beach management districts in order to coordinate beach management on a neighborhood scale

Recommendation

10.1a) Establish beach management districts at erosion hotspots, especially those proposing to implement a beach restoration project

10.1b) Set up a mechanism at the county and/or state levels for evaluating petitions to form a beach management district

11. Public Awareness and Education

Coastal and marine environments are greatly influenced by the activities of humankind. Increasing public awareness of the sensitivity of these environments would sharply decrease human impacts. Policy makers and agency personnel should be provided with guidance for more effective beach management practices. Equally important is increasing awareness and education of general public. Although Maui has many well-informed individuals with stewardship attitudes, both the private sector and the public need to become more aware of coastal and marine resource issues.

Policy makers and agency personnel need to be better informed so that their decisions are environmentally and economically responsible. The same applies to developers and contractors, especially those working at shoreline properties. A better informed public will support decisions that need to be made.

Hawaii Sea Grant and Maui Community College should develop a public awareness and education program on coastal and marine resource issues. Sea Grant should team up with local scientists and environmental groups to sponsor K-12 teacher training workshops. Maui Community College can support post-secondary education and research by continuing to offer marine science courses through its Marine Option Program. Offering a bachelor's degree program in Marine Science should be a longer-term goal at Maui Community College.

Public awareness can also be increased through educational presentations to various groups (e.g., community associations, neighborhood boards, rotary clubs, ocean activity owners and County commissions). Other ways to increase awareness include creating a web site on coastal processes and development guidelines, issuing press releases, publishing information in booklets, and giving presentations at conferences and symposiums similar to the Coral Reef Symposium and the Coastal Zone Management Conference, both of which took place on Maui in September 1997.

Objective

11.1) To increase public and private sector awareness and education on coastal and marine resource protection

Recommendations

11.1a) Identify key target audiences (e.g., schools, community associations, neighborhood boards, rotary clubs, developers and contractors, ocean activity owners, county commissions, etc.)

11.1b) Continue disseminating information by issuing press releases, publishing booklets and posters, and giving presentations at conferences and to key user groups

11.1c) Sponsor the creation of a web site on coastal processes, development guidelines, and beach management

11.1d) Partner with local scientists and environmental groups to sponsor K-12 teacher training workshops

12. Research

Several University of Hawaii research projects have focused on Maui County's coastal and marine resources. These projects have greatly increased our knowledge of the coastal and marine environments and processes and have led to improved management of the coastal zone. Further research is necessary to increase our understanding of coastal and marine science and to insure the effective and efficient management of the coastal zone.

Hawaii Sea Grant can help identify new projects and potential funding partnerships. The most likely partners would be Sea Grant, DLNR, DOH, DBEDT's Coastal Zone Management Program, the United States Geological Survey (USGS), the Environmental Protection Agency, the Federal Emergency Management Agency, and NOAA's Hawaii Humpback Whale National Marine Sanctuary.

An important component of research is **monitoring.** Monitoring involves the periodic collection of data to study changes in an environment through time. Two important studies relevant to beach management carried out by volunteers on Maui include the monitoring of algal blooms and the biannual collection of beach profiles (Figure 23). The collection of data on nuisance algal blooms was initiated in 1995 by *Na Maka'ala* and is currently being carried out by *Na Pale O Ke Kai*. *Na Pale O Ke Kai* also collects water samples and analyzes turbidity.

The monitoring of **beach profiles** is an on-going UH-Manoa and USGS cooperative effort. Researchers involved in this joint study have monitored 32 profile lines on Maui beaches twice yearly since January 1995. The analysis of sequential beach profiles provides data on seasonal and longer-term changes in beach volume. This information is needed to complement aerial photograph analyses of coastal erosion and to help plan beach restoration projects.

Vertical aerial photographs of the shoreline provide valuable information to coastal zone planners and developers. Recent aerial photographs of a given shoreline area can be compared with historical aerial photographs to determine rates of coastal erosion. The county currently maintains a limited archive of aerial photographs, with complete sets from 1967, 1988, and 1993. This database should be updated at least every 5 years.

Figure 23. USGS - UH beach profile survey.

Objective

12.1) To continue to help fund research in coastal and marine science and marine policy

12.2) To continue to closely monitor shoreline trends such as coastal erosion and beach loss as well as algal blooms

Recommendations

12.1a) Commission new research projects in coastal and marine science and marine policy on all scales

12.1b) Fund studies that seek to better understand site-specific causes of coastal erosion and beach loss

12.1c) Help fund a study that quantifies sand production on coral reefs

12.1d) Help sponsor a study of the economic, legal, and political challenges associated with requiring rate-based building setbacks

12.1e) Encourage Maui Community College to take a more active role in marine science education and research by further developing its Marine Option Program

12.1f) Seek participation in research on marine issues from other universities, ocean user groups, and other government agencies

12.2a) Update the County's database of coastal aerial photographs at least every five years so that county planners can make informed decisions with reasonably up to date information on shoreline development

12.2b) Help maintain and expand the island-wide network of beach profiles

12.2c) Help support the continued collection of data on water quality and algal blooms

13. Funding Mechanisms

Two effective tools for managing coastal erosion and beach loss include beach nourishment and the acquisition of coastal lands. Large beach nourishment projects and the purchase of shoreline properties can cost several millions of dollars. Additionally, continued research in coastal and marine sciences and beach monitoring will require continued funding.

The funding of these projects should be shared by federal, state, county, and private sources. Grants from outside agencies (e.g., federal agencies, Sea Grant, the DLNR, and the Department of Business, Economic Development & Tourism's Coastal Zone Management Program) can be leveraged from relatively small seed funding allocated by the County. Monetary and in-kind support from non-governmental organizations and environmental groups should also be sought.

The County could propose setting up a dedicated beach management fund. This fund would help pay for beach nourishment and dune restoration projects as well as research and monitoring needs. Some of the money for this fund could be gathered from CZM-related permit processing fees (SMAs and SSVs) and fines collected from various violations. Additional funds could be allocated in County budget. Even a small, perhaps voluntary, visitor donation for beach preservation of as little as $0.50 per person per day could generate millions annually.

Currently, the County is limited in the amount of coastal lands it can acquire. These lands may be more efficiently funded through a practice called **land banking.** Land banking is defined as the practice of acquiring land by reason of opportunity, crisis, or prudent planning, and then holding the land for either a specific or unforeseen use—the use being in the public interest. This funding mechanism, falling outside of the normal process of budget appropriations, will provide a way to regularly set aside funds for future land acquisitions in both good and bad economic times (Anthony Rankin, pers. comm.).

The Maui County Council recently unanimously endorsed a bill calling for increased county funding for public land acquisition through a surcharge on the existing state

conveyance tax. This stable funding would greatly enhance the ability of the county to acquire coastal lands for public use.

Objective

13.1) To sharply increase funding for beach management, coastal lands acquisition, and research and monitoring and seek to attract outside sources of funding

Recommendations

13.1a) Allocate a portion of the annual budget to a dedicated beach management fund, which would not only be used for land banking and beach nourishment projects but also for continued coastal zone research and monitoring

13.1b) Identify strategies for generating more revenue earmarked for beach management

13.1c) More effectively pursue matching funds from outside agencies through leveraging

13.1d) Support and recognize volunteer efforts of non-governmental agencies and community groups who are active in beach stewardship

GLOSSARY

Accretion - the deposition of sediment, sometimes indicated by the seaward advance of a shoreline indicator such as the water line, the berm crest, or the vegetation line.

Active beach - the portion of the littoral system that is frequently (daily or at least seasonally) subject to transport by wind, waves, and currents.

Algal bloom - a sudden increase in the amount of marine algae (seaweed) often caused by high levels of phosphates, nitrates, and other nutrients in the nearshore area.

Armoring - the placement of fixed engineering structures, typically rock or concrete, on or along the shoreline to reduce coastal erosion. Armoring structures include seawalls, revetments, bulkheads, and rip rap (loose boulders).

Backshore - the generally dry portion of the beach between the berm crest and the vegetation line that is submerged only during very high sea levels and eroded only during moderate to strong wave events.

Beach - an accumulation of loose sediment (usually sand or gravel) along the coast.

Beach loss - a volumetric loss of sand from the active beach.

Beach management district - a special designation for a group of neighboring coastal properties that is established to facilitate cost sharing and streamline the permitting requirements for beach restoration projects.

Beach narrowing - a decrease in the useable beach width caused by erosion.

Beach nourishment - the technique of placing sand fill along the shoreline to widen the beach.

Beach profile - a cross-sectional plot of a shore-normal topographic and geomorphic beach survey, usually in comparison to other survey dates to illustrate seasonal and longer-term changes in beach volume.

Berm - a geomorphological feature usually located at mid-beach and characterized by a sharp break in slope, separating the flatter backshore from the seaward-sloping foreshore.

Building setback - the county-required seaward limit of major construction for a coastal property. Building setbacks on Maui vary from 25 feet to 150 feet landward of the certified shoreline.

Coastal dunes - dunes within the coastal upland, immediately landward of the active beach.

Coastal erosion - the wearing away of coastal lands, usually by wave attack, tidal or littoral currents, or wind. Coastal erosion is synonymous with shoreline (vegetation line) retreat.

Coastal plain - the low-lying, gently-sloping area landward of the beach often containing fossil sands deposited during previously higher sea levels.

Coastal upland - the low-lying area landward of the beach often containing unconsolidated sediments. The coastal upland is bounded by the hinterland (the higher-elevation areas dominated by bedrock and steeper slopes).

Day-use mooring - a buoy or other device to which boats can be secured without anchoring.

Deflation - a lowering of the beach profile.

Downdrift - in the direction of net longshore sediment transport.

Dune - a landform characterized by an accumulation of wind-blown sand, often vegetated.

Dune restoration - the technique of rebuilding an eroded or degraded dune through one or more various methods (sand fill, drift fencing, revegetation, etc.).

Dune walkover - light construction that provides pedestrian access without trampling dune vegetation.

Dynamic equilibrium - a system in flux, but with influxes equal to outfluxes.

Erosion - the loss of sediment, sometimes indicated by the landward retreat of a shoreline indicator such as the water line, the berm crest, or the vegetation line.

Erosion hotspots - areas where coastal erosion has threatened shoreline development or infrastructure. Typically, the shoreline has been armored and the beach has narrowed considerably or been lost.

Erosion watchspots - areas where the coastal environment will soon be threatened if shoreline erosion trends continue.

Foreshore - the seaward sloping portion of the beach within the normal range of tides.

Hardening - see **Armoring**.

Improvement districts - a component of a beach management district established to help facilitate neighborhood-scale improvement projects (e.g., beach nourishment).

Land banking - the purchase of shoreline properties by a government, presumably to reduce development pressure or to preserve the parcel as a park or as open space.

Littoral budget - the sediment budget of the beach consisting of sources and sinks.

Littoral system - the geographical system subject to frequent or infrequent beach processes. The littoral system is the area from the landward edge of the coastal upland to the seaward edge of the near-shore zone.

Longshore transport - sediment transport down the beach (parallel to the shoreline) caused by longshore currents and/or waves approaching obliquely to the shoreline.

Lost beaches - a subset of erosion hotspots. Lost beaches lack a recreational beach, and lateral shoreline access is very difficult if not impossible.

Monitoring - periodic collection of data to study changes in an environment over time.

Nutrient loading - the input of fertilizing chemicals to the nearshore marine environment, usually via non-point source runoff and sewage effluent. Nutrient loading often leads to algal blooms.

Offshore - the portion of the littoral system that is always submerged.

Overwash - transport of sediment landward of the active beach by coastal flooding during a tsunami, hurricane, or other event with extreme waves.

Revetment - a sloping type of shoreline armoring often constructed from large, interlocking boulders. Revetments tend to have a rougher (less reflective) surface than seawalls.

Scarp - a steep slope, usually along the foreshore and/or at the vegetation line, formed by wave attack.

Scarping - the erosion of a dune or berm by wave-attack during a storm or a large swell.

Sea bags - large sand-filled geotextile tubes used in coastal protection projects.

Seawall - a vertical or near-vertical type of shoreline armoring characterized by a smooth surface.

Shoreline setback - see **Building setback**.

Siltation - the input of non-calcareous fine-grained sediments to the nearshore marine environment, or the settling out of fine-grained sediments on the seafloor.

Storm surge - a temporary rise in sea level associated with a storm's low barometric pressure and onshore winds.

Urban runoff - the input of hydrocarbons, heavy metals, pesticides, and other chemicals to the nearshore marine environment from densely populated areas.

Zooxanthellae - unicellular, symbiotic algae living within coral polyps that produce food for their hosts by photosynthesis and help efficiently recycle low-levels of nutrients.

REFERENCES

BRUUN, P., 1962. Sea level rise as a cause of shore erosion. *Journal of Waterways & Harbors Division, ASCE,* 88: 117-130.

CAMPBELL, J.F., ROSENDAHL, B.R., COULBOURN, W.T., AND MOBERLY, R.M., 1971. *Reconnaissance Sand Inventory: Off Leeward Molokai and Maui.* HIG-71-17. Hawaii Institute of Geophysics, University of Hawaii-Manoa.

DUXBURY, A.B. AND DUXBURY, A.C., 1996. *Fundamentals of Oceanography.* 308 p.

FLETCHER, C.H., MULLANE, R.A., AND RICHMOND, B.R., 1997. Beach loss along armored shorelines on Oahu, Hawaiian Islands. *Journal of Coastal Research,* 13, 1, 209-215.

HWANG, D.J. AND FLETCHER, C.H., 1992. *Beach Management Plan with Beach Management Districts.* Hawaii Office of State Planning, Coastal Zone Management Program, Honolulu, 192 p.

JOHNSTONE, H.W., 1997. *Mo'omomi, West Moloka'i: a Coastal Treasure.* University of Hawai'i at Manoa, Sea Grant Extension Service, Honolulu, 56 p.

MAKAI OCEAN ENGINEERING, INC. AND SEA ENGINEERING, INC., 1991. *Aerial Photograph Analysis of Coastal Erosion on the Islands of Kaua'i, Moloka'i, Lana'i, Maui, and Hawai'i.* Hawaii Office of State Planning, Coastal Zone Management Program, Honolulu. 199 p.

NATIONAL RESEARCH COUNCIL, 1995. *Beach Nourishment and Protection.* Committee on Beach Nourishment and Protection, Marine Board, Commission on Engineering and Technical Systems, Washington, DC, 334 p.

TAIT, J.F., AND GRIGGS, G.B., 1990. Beach response to the presence of a seawall. *Shore and Beach,* 58, 11-28.

SEA ENGINEERING, INC., 1993. *Beach Nourishment Viability Study.* Hawaii Office of State Planning, Coastal Zone Management Program, Honolulu, 95 p.

WEST MAUI WATERSHED MANAGEMENT ADVISORY COMMITTEE, 1997. *West Maui Watershed Owners Manual.* 92 p.