Chronic coastal erosion is a statewide problem

Lanikai, 1995

The traditional approach to erosion management in Hawaii has been to armor the coast and save the land.
Seawalls are constructed where there is erosion, but they do not solve the erosion – they often worsen it along adjacent shores.

Hawaii needs erosion solutions.
Oahu’s vanishing beaches

Some East Coast states have adopted policies to protect their beaches.

**Beach Loss**

- **One fourth of Oahu beaches** have been narrowed or lost over the past 70 yrs by armoring (~17.2 miles).
- **One third of Maui beaches** are estimated lost or narrowed by armoring (~9 miles).
- **Beaches are 50–75% narrower** in front of walls.

**IMPACTS**

- Public access and recreation is restricted.
- Marine coastal ecosystem is damaged.
- Dune plants and ecosystem are damaged.
- Cultural practices on beaches are lost.
- Tourism economy impacted (1/3 of all jobs; 75% of State income).
Erosion is caused by
- Human Impacts to sand availability
- Waves and Currents moving sand
- Sea-Level Rise forcing shoreline retreat
Waves are Key to Shoreline Dynamics

- Waves created by winds blowing over the ocean
- Wave height depends on
  - Wind speed
  - How long the wind blows
  - Distance over which the wind blows (fetch)

Wave Movement

- Waves travel as a form but water stays put
- Water moves in circular vertical orbits
- Water movement greatest near surface
- Energy dissipates with depth
  - Farther from force of wind
  - Orbital motion stops at about ½ of the wavelength
From Swell to Surf

When bottom shallows to less than ½ wavelength, water can only move horizontally and vertically
- Velocity and wavelength decrease, waves become closer spaced, higher and steeper – so steep that water no longer supports itself and wave crashes in surf zone
Surf to Swash and Backwash

- Waves, reduced in height, move towards the shoreline
  - Run up of water onto beach (swash) carries sediment
  - Water running back down beach slope (backwash) also carries sediment
Human Impacts

1. Sand impoundment
2. Longshore trapping
3. End scour
4. Drainage channel dredging
5. Dune leveling/filling
6. Sand mining

Poor Sand Management
Wave Refraction

- Swells usually approach coasts at angles
- As waves approach the beach, front of wave slows while maintaining speed offshore
  - Causing the waves to bend or refract
Longshore drift of sediments

- As refracted waves break on shore, swash moves sediment up beach face at an angle
- Backwash also moves sediment down beach face at a similar angle
- Combination moves sand parallel to beach face
Longshore trapping disrupts sediment movement

- Construction of groins traps sediment up current but can cause loss of beach sand down current
  - Longshore current carrying sand disrupted by groin and deposit sediment
  - Downstream of groin, longshore current and drift continue but sand supply limited – results in beach erosion

Shoreline Protection?

- What would you do if you owned beach front property and your neighbor living up-current built a groin?
Sand mining by Waialua Sugar Company at Waimea Bay caused over 200 ft of erosion.

Waves and currents move large volumes of sand.

Kailua, summer, 1997

Winter, 1998
Sea Level is rising around the world at 1.5 to 2.2 cm/decade.

SLR increased from the 19th century to the 20th century.

SLR is projected 0.19 to 0.71 m for 1990 to 2100 – this is 2.2 to 4.5 the rate of the past century.

If greenhouse gases are stabilized, SLR would nonetheless continue for hundreds of years.

The next IPCC assessment - 21st Century

Future changes in sea level:
- SL rise of 0.19 to 0.71 m (0.49 m)
- 0.23 to 0.43 m (thermal expansion)
- 0.06 to 0.16 m (alpine glacier)
- 0.08 to 0.12 m (Greenland)
- 0.11 to 0.02 m (Antarctica)

This is 2.2 to 4.5 times the 20th Century rate.

Many areas now experiencing net land uplift will shift to net SLR by 2100.

Existing extreme high water levels (storms, etc.) will occur more often even if source frequency does not change.
Studies show a 150x erosion multiplier where sea level rises along sandy shorelines. Hence, for a mean 0.24 m rise by 2050, beaches will recede 36 m (118 ft). (Leatherman et al., 2000)
COUNTY CONTROL

Present setbacks do not offer adequate protection
Large lots are subdivided, density is rising on all shores
Zoning ordinances fail to discriminate eroding shores

Kailua Beach
1996

Water Quality suffers on armored shores
High turbulence from wave reflection
Fleshy algal growth
Septic discharge
Littoral ecosystem heavily damaged
Armoring has been a universal tool in Hawaii, but new tools are moving to the forefront.

NEW POLICY DIRECTIONS

Avoid development of eroding lands

Discourage additional development in erosion hazard zones

Acquire high value coastal lands

Construction guidelines for hazard areas

Nourish eroding shores
Where will the shoreline be in 60 years?

Halama Street (Kihei Coast), Maui, Hawaii

Annual Erosion Hazard Rates (ft/yr)

End Point Erosion Rates (ft/yr)

South Sunset Beach, Oahu, Hawaii

FEMA National coastal erosion study of 60 year erosion hazard, 1996
**Five options for erosion management**

**Abandon** the shoreline — *impractical on heavily developed shores*

**Restore** the beach - *increasing costs with time, long-term sand mining impacts?*

**Control** the erosion rate with sand fill and structures - *expensive, community rejection of structures*

**Modify** human occupancy to accommodate erosion - *difficult, often impractical, requires new zoning*

**Harden** the shoreline — *beach loss, access decreased, environmental impacts*
Abandonment – what criteria support abandoning the shoreline?
(County loses revenue, State gains beach)

Beach Restoration by sand nourishment is a world-wide tool in managing coastal erosion
(are sand resources sustainable?)
Is beach-grade sand abundant in offshore fields? Can offshore sand be sustainably mined with minimal environmental impact?
Small-Scale Beach Nourishment State Program General Permit

Designed to streamline permitting for 10,000yd³ sand replenishment projects

Demonstration project showed minimal impact

No turbidity

Stable beach configuration (30-100 yds³/ft)

Community acceptance (20 ft increase)
Onshore sand resources are locally abundant, but need further research.

Unfortunately, the largest and most immediate source of beach sand often lies under our homes and roads – this sand is released by erosion of the coastline.
After a vigorous public outreach effort, in 1998 the Board of Land and Natural Resources created the Coastal Lands Program and adopted COEMAP, the Coastal Erosion Management Plan for Hawaii. In 1999, Governor Cayetano signed into law Act 84, creating the Beach Fund.

Are abandonment or modification practical on the Hawaiian shoreline? Consider the two building styles at left. Can zoning be designed to favor one over the other?
The West Maui community balked at restoring Honokowai Beach Park out of distaste for the rubble groins stabilizing the fill, and a belief that a new beach would "destroy the environment."
EA for Shoreline Armoring

- Historical Shoreline Analysis
- Causes of Erosion
- Shoreline type, Site Maps, Beach Profiles, Existing Walls
- Coastal Hazard History, Waves and Currents, Sediment Movement
- 30-yr Erosion Hazard
- Seal of Professional Engineer

U.S. Corps of Engineers history of shoreline spending: Shift from structures to beach nourishment

Structures had proliferated to such an extent that the protection actually impeded the recreational use of the beaches. Erosion of the sand continued, but the fixed backbeach line remained, resulting in a loss of beach area.

Techniques were developed that replicated the protective characteristics of natural beach and dune systems. Use of artificial beaches and stabilized dunes was an economically viable and more environmentally friendly means for dissipating wave energy and protecting coastal development.

Is Hawaii’s Coastal Zone Sustainable?

Coastal Problems are Myriad and Complex… the root cause is the large human population

- Wetland Loss
- Declining Water Quality
- Over-fishing
- Coastal Erosion & Beach Loss
- Reef Sustainability
- Coastal Hazards
- Decreased Coastal Access
As long as our population is permitted to grow without an integrated solution – these problems will persist and worsen

Wetland Functions

- Store surface and groundwater and reduce flow energy
- Maintain biodiversity and habitat
- Create a nutrient reserve for ecosystem
- Retain particulates
- Remove contaminants
- Export organic carbon to adjacent ecosystems
“Wetlands account for approximately 110 thousand acres of Hawaii landscape, spreading across the island in low-lying coastal areas, elevated lands and forested mountains. Over the past two centuries, an estimated one-third of all coastal wetlands have been lost to development activities.” 1999
Wetlands reached from Diamond Head to Pearl Harbor
“The problem is so bad that vapors escaping from the ground have reached explosive levels, vegetation dies and during heavy rains, a rising water table pushes so much petroleum to the surface it can make people sick.”
“...streams that over the years carried high levels of pesticides, bacteria and lead – things that can cause liver damage, cancer, learning disabilities and central nervous system problems...”

**Reef Sustainability**

- “Overfishing is a serious problem on every island and is in need of remediation. State fishery regulations are largely ignored and rarely enforced except in Marine Life Conservation Districts.” R. Grigg, 1997
- Gill netting
- Taking of predator species
- Local sedimentation and eutrophication within low circulation embayments
- Growth of noxious algae
- Impacts to reef sediment production
Strong Natural Limitations to Reef Development in Hawaii

- Coral reefs in Hawaii characterized by low biodiversity
- Only 47 species of reef-building corals – compared to over 500 in Indo-West Pacific
- Wave forces are strong on all sides of all islands
- Island uplift lowers long-term sea level
- Previous reef accretion limits marine accommodation space
- Periodic storms destroy decades of reef growth
- High sediment yield from high islands

Tracks of Central Pacific Hurricanes from 1949 to 1998

- AUGUST MEAN 1016 MB ISOBAR
- AUGUST MEAN 200 MB RIDGE LINE
- AUGUST MEAN WARMER OCEAN WATER > 83°F
- AUGUST MEAN COOLER OCEAN WATER < 80°F
Combined wind and storm surge damage
Iniki flooding reached:
- >800 ft inland
- >25 ft above sea level

If interested in Hawaii’s shorelines: