



BEACH DYNAMICS AND SAND BUDGETS

Principal Investigator: Dr. Charles Fletcher
Coastal Geology Group, School of Ocean and Earth Science and Technology

The Issue/Research Rationale

Beaches are fundamentally important to Hawai'i's visitor industry, the daily quality of life of residents, and as a component of the marine nearshore environment. Over the past century and a half, coastal development trends have interfered with changes in beach position threatening private property and buildings with coastal erosion. To improve management of beaches and other littoral sand-dependent environments, it is important to enhance understanding of the budget of sands and how they change through time.

1999 - 2005 Sea Grant Funding

\$178,524 SG; \$100,720 match

Hawai'i Discoveries/Contributions to Science

Three main types of Hawaiian beaches are represented by study sites in Kīhei and Kā'anapali, Maui and Kailua Bay, O'ahu. Our goal is to investigate long-term shoreline and beach behavior through research at these sites.

Along the Kīhei coast, a five kilometer segment encompassing a severe erosion problem area was investigated. Using a time series of historical aerial photographs and topographic surveys extending nearly 100 years, historical shoreline changes were documented, erosion hazard areas delineated, and maps developed. A model developed to convert horizontal movement of beach boundaries from photographs into volumetric changes was used to estimate rates of net longshore sediment transport.

Kailua Beach was studied using a 70-year time series of historical aerial photographs and topographic surveys correlated with a monthly series of beach profiles collected over 13 months and five years of semi-annual beach profiles. The study found that Kailua Beach accreted an average rate of 0.5 m/yr despite net sea-level rise over this period. Exchange with offshore deposits is a likely

mechanism for this unusual pattern of long-term accretion. Seasonal sediment dynamics were found to be more complex than earlier studies had postulated, with four alternating zones of seasonal accretion and erosion.



*Erosion at Aliomanu Bay, Kaua'i - Coastal erosion is a significant emotional and financial burden on homeowners.
~Photo by Dennis Fujimoto of Garden Island News*

Maintenance of the overall beach profile and changes in sand volume that occur in phase over the subaerial and subaqueous sections of the beach suggest the dominance of long-shore sand transport at annual time scales.

Kā'anapali Beach was studied using similar methodology to that applied in Kailua Beach. Over the 48-year period encompassed in the aerial photographic record, the beach experienced long periods of mild accretion

and erosion punctuated by severe erosion events related to Kona storms and hurricanes, and net erosion of $7.4 \times 10^4 \text{ m}^3$ of sand. Kā'anapali exhibits strong seasonal variability, with net erosion in summer and accretion in winter, and an alongshore-alternating pattern of erosion and accretion.

Each site was dominated by long-shore rather than cross-shore movement of sand. This has important implications for successful management of the beach resource. Long-term beach behavior at the Kīhei and Kā'anapali sites is found to be largely driven by severe Kona storms and hurricanes, which in turn are controlled to some degree by the Pacific Decadal Oscillation, a climatological phenomenon similar to but longer-lasting than El Niño/Southern Oscillation.

Research Impacts/Benefits

The suite of study sites encompass three major types of Hawaiian beaches: narrow and fringing reef fronted, embayed, and cusped headland beaches. The study offers insights on the dominant processes that are relevant to many beaches in the Hawaiian Islands. By documenting movement of the shoreline over many decades, estimates of areas likely to be subject to erosion hazards over the next few decades have been delineated. This allows coastal property owners to avoid developing erosion-prone areas, while simultaneously helping to preserve beaches

Selected Research Highlight: Beaches

for future generations. Maui County decided to extend this work to all of the significant sandy shoreline on the island, by incorporating the erosion hazards it delineates into the county's coastal setback regulations. Our documentation of the erosion hazard in Kihei was used to successfully request \$300,000 of federal mitigation assistance since 2001, with hopes for a full-scale beach re-nourishment.

Publications

- Rooney, J.J.B. and C.H. Fletcher. In review. Shoreline change and Pacific climatic oscillations in Kihei, Maui Hawai'i. *Journal of Coastal Research*.
- Fletcher, C.H., J. Rooney, M. Barbee, and S. Lim. In press. Mapping Shoreline Change Using Orthophotogrammetry on Maui, Hawai'i. *Journal of Coastal Research*.
- Eversole, D. and C.H. Fletcher. In press. Longshore sediment transport rates on a reef-fronted beach: field data and empirical models, Kā'anapali Beach, Hawai'i. *Journal of Coastal Research*.
- Rooney, J.J.B., C.H. Fletcher, M. Barbee, D. Eversole, S. Lim, B. Richardson, and A. Gibbs. 2003. Dynamics of sandy shorelines in Maui, Hawai'i: Consequences and causes. *Coastal Sediments '03*.
- Norcross, Z.M., C.H. Fletcher, J. Rooney, D. Eversole, and T. Miller. 2003. Hawaiian beaches dominated by longshore transport. *Coastal Sediments '03*.
- Norcross, Z.M., C.H. Fletcher, and M. Merrifield. 2002. Annual and interannual changes on a reef-fringed pocket beach: Kailua Bay, Hawai'i. *Marine Geology* 190:553-580.
- Rooney, J.J.B. and C.H. Fletcher. 2000. A high resolution, digital, aerial photogrammetric analysis of historical shoreline change and net sediment transport. Thirteenth Annual National Conference on Beach Preservation Technology, Melbourne, Florida, February 2-4, 2000.
- Fletcher, C.H. 2000. State of Hawai'i Coastal Erosion Management Plan (COEMAP). Department of Land and Natural Resources, 130 p.

Students Educated

- Dolan Eversole, M.A. 2002
John J.B. Rooney, Ph.D. 2002

Zoe M. Norcross, M.A. 2001

Significant Partnerships

Maui County Planning Department
United States Geological Survey
State of Hawai'i Department of Land and Natural Resources
National Oceanic and Atmospheric Administration Coastal Services Center
State of Hawai'i Coastal Zone Management Program.

Outreach Highlights

Dr. Fletcher's authorship of the Coastal Erosion Management Plan for the State of Hawai'i has led to the creation of the Office of Conservation and Coastal Lands. The plan has been adopted by unanimous vote of all state and county offices having jurisdiction in the coastal zone.

With maps of Maui's historic sand shoreline and erosion hazards, University of Hawai'i Sea Grant Extension worked with county personnel to improve shoreline setback regulations. Presentations were made to the county and the public regarding the methodology and accuracy of the erosion hazard maps, and on the application of erosion rates to shoreline setbacks.

UH Sea Grant Extension attended Maui County Planning Commission workshops to present the erosion hazard study and its application to shoreline setback calculations. Numerous letters and informative articles were published in state and county newspapers and newsletters explaining the basic methods and reasoning for the improved setback rules.

The methodology developed in the erosion hazard maps was presented at a national conference and was awarded *Best In Session*. Maui county will be the first Hawaiian county to develop science-based setback rules. The County's cooperation with UH Sea Grant, along with assistance from state and federal agencies, sets an outstanding example for Hawaiian counties and mainland states to follow in coastal resource management.



Charles "Chip" Fletcher joined the University of Hawai'i Faculty in 1991. In addition to his research, Fletcher teaches various geology courses and is writing a textbook on physical geology, *Planet Earth*. Dr. Fletcher received his doctorate in geology from the University of Delaware and has authored more than 50 scientific papers.

For further information:
Charles Fletcher,
Professor
Geology and Geophysics
School of Ocean and Earth
Science and Technology
University of Hawai'i
2525 Correa Road, POST 721C
Honolulu, HI 96822
Phone:(808) 956-2582
Fax:(808) 956-5512
www.soest.hawaii.edu/coasts/cgg_main.html

