Sand in Hawai`i

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COASTAL GEOLOGY

Sand composition

Beaches in Hawaii may be made of 'black sand' derived from the erosion of volcanic rocks, of 'white sand' made by marine organisms, or a mixture of both. On the windward side of the Big Island, for example, black sand beaches are very common. The beach at South Point is almost entirely green sand composed of olivine, a common mineral found in the volcanic rocks here in Hawaii. On the Kona coast of the Big Island and on the other islands, the beaches have a range of mixed compositions, some with a high volcanic (detrital) component, some dominated by calcareous (reef-derived) sediment. Beach and submarine sands in Kailua Bay on windward Oahu (my research area) are almost entirely composed of calcarous, reef-derived material. On average, only about 5% of the sand grains are volcanic minerals or rock fragments. Every beach is unique and has its own source and type of sediments.

Hanakapiai Beach, Napali coast, Kauai

Makena ('Big Beach'), Maui

Because Hawaii does not have a continental source of quartz sand like mainland beaches, the 'white' beaches and marine sediments here in the islands are primarily composed of the carbonate shells and skeletons of marine organisms, such as corals, algae, molluscs, foraminifera, echinoderms, and bryozoans.

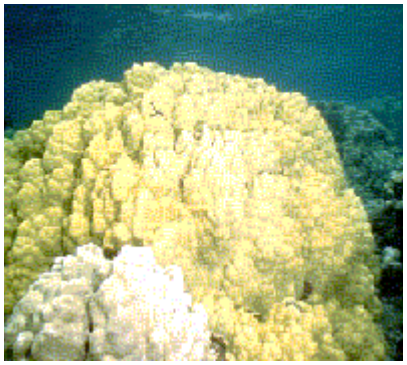
Sand-sized fragments of coralline algae, coral, and the calcareous green alga Halimeda

Sand-sized fragments of molluscs, foraminifera, and echinoderm spines

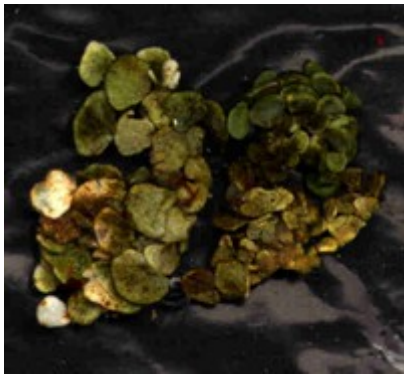
We can determine the composition of any sand sample by embedding it in clear epoxy, making a thin section, and looking at it with a petrographic microscope. These three images are of thin sections. Noticeably different are the grain sizes in each sample.

Carbonate production

Some animals (such as corals and molluscs) and plants (or 'algae' such as *Halimeda* and 'coralline' algae) living on reefs and in shallow marine waters make hard skeletons of calcium carbonate ($CaCO_3$). These organisms are quite successful at building reefs and making sand, as long as the environment they live in is a healthy one.



Porites lobata



Halimeda

Cowrie

The production of $CaCO_3$ occurs at different rates depending on the organism, location, setting, and physical factors such as water depth, amount of light, and wave energy. The table below lists some "production rates" for corals and algae in Hawaii.

Carbonate Production

◆ Framework builders

Coralline (red) algae in Hawaii — *(Agegian 1985)*

- encrusting — 2 $kgm^{-2}y^{-1}$
- branching — up to 20 $kgm^{-2}y^{-1}$

Coral in Hawaii

- *Porites, Montipora, Pocillopora* — *(Grigg 1998)*
  - growth rates — 1-10 mmy^{-1}
  - accretion rates — 1-6 mmy^{-1}
  - gross production — 3-7 $kgm^{-2}y^{-1}$
- Hanauma Bay — ~7 $kgm^{-2}y^{-1}$ *(Easton & Olson 1976)*
- coral-algal reef, Kaneohe — 2.6 $kgm^{-2}y^{-1}$ *(Webb 1979)*

◆ "Direct" sediment producers

Halimeda (green algae)	2-5 $kgm^{-2}y^{-1}$	*(Hillis 1997; field obs.)*
benthic foraminifera	0.9 $kgm^{-2}y^{-1}$	*(Harney et al. 1999)*
molluscs + echinoderms	?	

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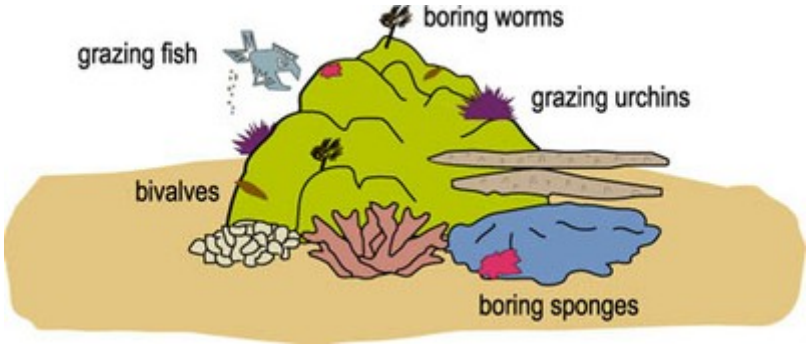
Bioerosion

As the reef is built, it is also broken down into sand by other animals ("bioerosion") and by wave action ("mechanical erosion"). These processes indirectly make sand for our beaches.

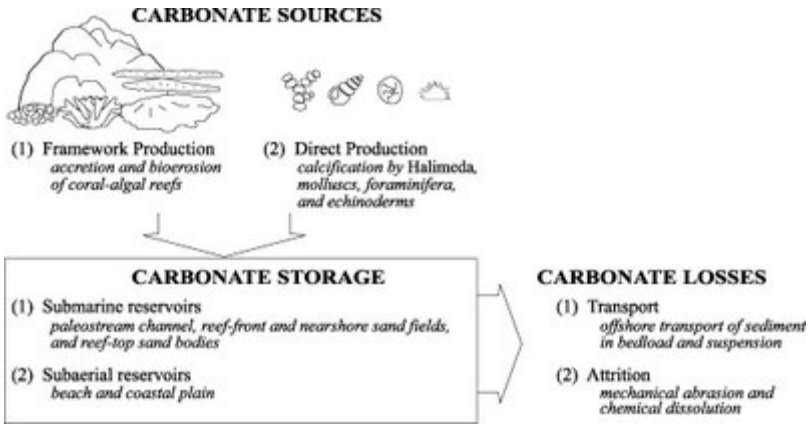


Various reef-dwelling creatures that break down reef framework into unconsolidated sediment, a process known as bioerosion.

Waves and currents create sand by breaking down the reef framework, a process known as mechanical (or physical) erosion.

Sediment "budget"

A sediment budget is a quantitative estimate of particulate sources, sinks, and losses within a geographically well-defined natural system. It includes the production of calcareous sediments by reef-dwelling organisms and also the addition of detrital sediments derived from the erosion of volcanic terrain.



Harney's sediment budget for Kailua Bay