The narrow coastal fringe that makes up 17% of the nation's land area is home to more than half of its population. In 2003, 53 percent of the nation’s population lived in the 673 U.S. coastal counties.

Sea level rise, tsunamis, hurricanes, and coastal erosion put this population at high risk and threaten the annual loss of billions of dollars of infrastructure.
Tides
Earth-moon system creates a double pull on Earth’s water as it rotates around a common center:
1. Gravitational toward moon
2. Centrifugal (inertial) away from moon

Both of these deform the water envelope of Earth and create a high tide. Earth’s surface “slides” under the water envelope during its daily rotation.

Hawaiian Waves
Winter north swell
Summer south swell
Trade wind waves and swell
Kona storm waves
Hurricane waves and swell

TIDES
The Sun also creates a gravitational pull on the water envelope.
1. Earth rotates daily on its axis, and
2. Earth-Moon system rotates daily on its axis,
3. Moon orbits Earth monthly...

Hence, in one month we experience two highest high tides (called “spring tides”) and two lowest high tides (called “neap tides”).

Spring tides occur when Solar tide and Lunar tide overlap.
Neap tides occur when Solar tide and Lunar tide are opposed.

Sea State
Swell
Wind blowing across sea surface makes waves
Water particle motion in a wave

Wave refraction

Shorelines straighten with time
Seawalls worsen erosion by impounding dune sand.
This starves the beach, often leading to accelerated erosion on adjoining beaches - widespread beach loss can develop.
When erosion strikes a coast, the traditional reaction is to build a seawall. But when seawalls are built on coasts experiencing chronic erosion, the beach disappears. Because of this management practice, Hawaii has lost many beaches.

Impacts
Access to the Ocean is lost
Marine ecosystem is damaged
Dune and beach ecosystem damaged
Cultural practices are lost
Tourism economy impacted

Erosion occurs where a beach has an insufficient supply of sand

1. Humans interfere with sand supply often causing sand starvation on a beach
2. Rising sea level causes a beach to migrate landward and erode the dune and land behind it
3. Large seasonal waves and storms may remove sand, some of which may not return when waves subside

All of these drive a beach to seek new sand, usually by eroding the adjacent land.

Many Hawaiian beaches suffer erosion because their dunes have been destroyed (even before seawalls have been built)

Coastal dunes are a storehouse of sand for the beach
Dunes store sand until high waves move it to the beach.

Beach = checking account
Dunes = savings account

Sea Level Rise

Greenland ice loss doubles in past decade, raising sea level faster.

Antarctic ice sheet is losing up to 152 cubic kilometers of ice per year.

Sea level rise 'is accelerating'

Australian researchers found that sea levels rose by 19.5 cm between 1870 and 2004, with accelerated rates in the final 50 years of that period. (1.75 mm/yr)

Sandy shorelines erode ~100 increments for every 1 increment of sea-level rise.

For a 1 m rise by 2100, beaches will recede 100 m (over a football field!)
Coastal Hazards
- Sea-Level Rise
- Extreme Tides
- Tsunami
- Hurricanes
- High Swell
- Coastal Erosion

Sea level has been rising for several centuries and will continue to rise for several centuries into the future.

1.2 inches since 1993
Extreme Tides

Tsunami – caused by any sudden movement of the seafloor

Submarine landslide

Submarine eruption

Faulting

Shaking

Jolting

Pacific Ring of Fire - Tsunamis
Wind waves come and go without flooding higher areas.

Water flows in a circle.

Tsunamis run quickly over the land as a wall of water.

Water flows straight.
An earthquake in Kona could generate a wave hitting Waikiki in 30 minutes.

A new study of hurricanes indicates, duration and intensity of the storms have increased by 50% in the last three decades.
Big Island is most vulnerable to hurricanes

Contours show number of times a hurricane (intensity > 64 knots) passes within 75 Nmi per 10 years. (Peterka, 2002)

Storm Surge and Wind Damage

Storm surge claims 9 out of 10 hurricane Victims

- Tide level
- Wind shear
- Atmospheric pressure
- Wave height
- Wave set-up
Wind-related insurance claims

Continuous load-path Window shutters

DAMAGE CONTROL

One of the best ways to protect a house from wind damage is to install impact-resistant shutters and doors. They protect windows against wind-driven objects and can slow down and dampen high winds.

HIGH SWELL

HURRICANE STRAPS OR CUPS

Metal hurricane straps or cups can be installed for better wind resistant members. These typically cost around $100 and $200.

Step One: Secure roof to upper story.

Step Two: Secure upper story to first floor.

Step Three: Secure house to foundation.
Mitigating Coastal Hazards

Avoidance-
Build up and away

Kona waterfront, restored

Mitigating Coastal Hazards

Restoration-
Nourish with sand

Kona waterfront

Mitigating Coastal Hazards

Redevelopment-
Move up and away

Change setbacks, relocate structures
A combination of solutions exist:
1. Avoid building near the shore (avoidance),
2. Restore beaches and dunes (restoration),
3. Move threatened structures (redevelopment),
4. Purchase coastal lands.

As an island community we will have to decide which mix of these tools is appropriate to protect our ourselves and our coastline.