

Engineering for Climate

Coastal Engineering Methods for Resilient Atoll Nations in Productive Oceans

Presented to Asian Development Bank (ADB), Maldives

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August 28, 2019

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Welcome to Our Future Climate



Beach & Shoreline Erosion Mitigation Protecting Against Sea Level Rise

Nature-Based Designs to Restore Eroded Shorelines & Enhance Coastal Resilience

- Engineering
- Design
- Ecosystems
- Technology

Drivers of Coastal Erosion

Land
Subsidence

Betio

Rainfall
Runoff

Currents

Wave
Runup

Rising Sea
Levels

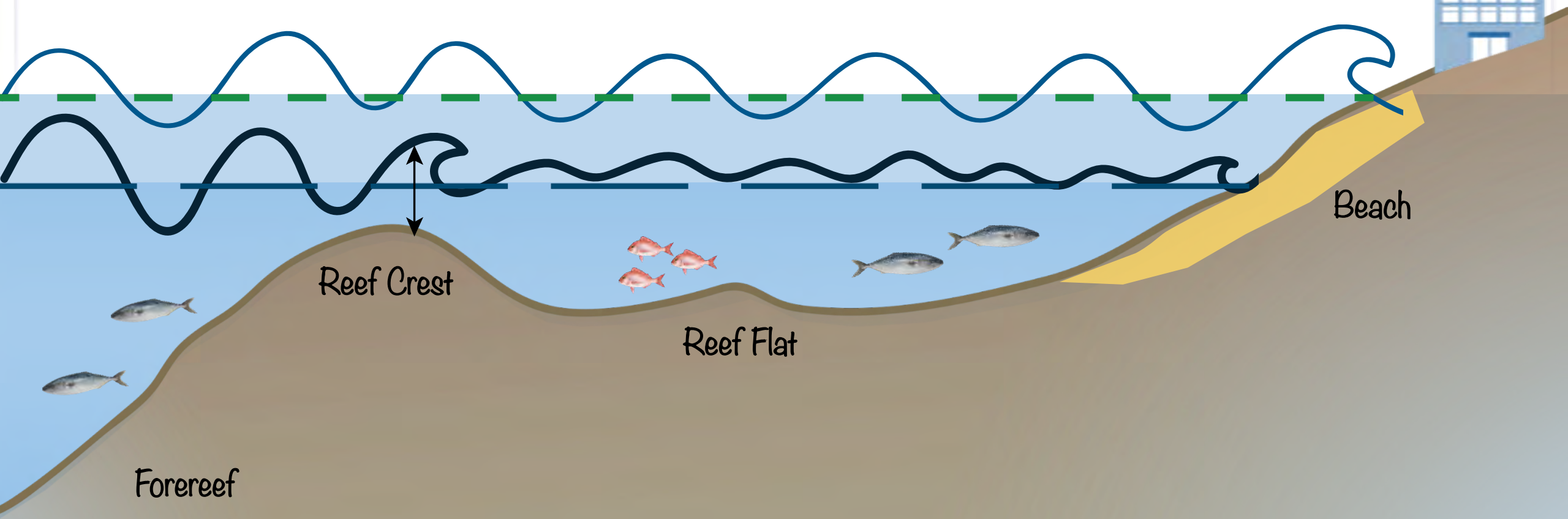
Bairiki

Image Landsat / Copernicus
Image © 2019 CNES / Airbus
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Google Earth

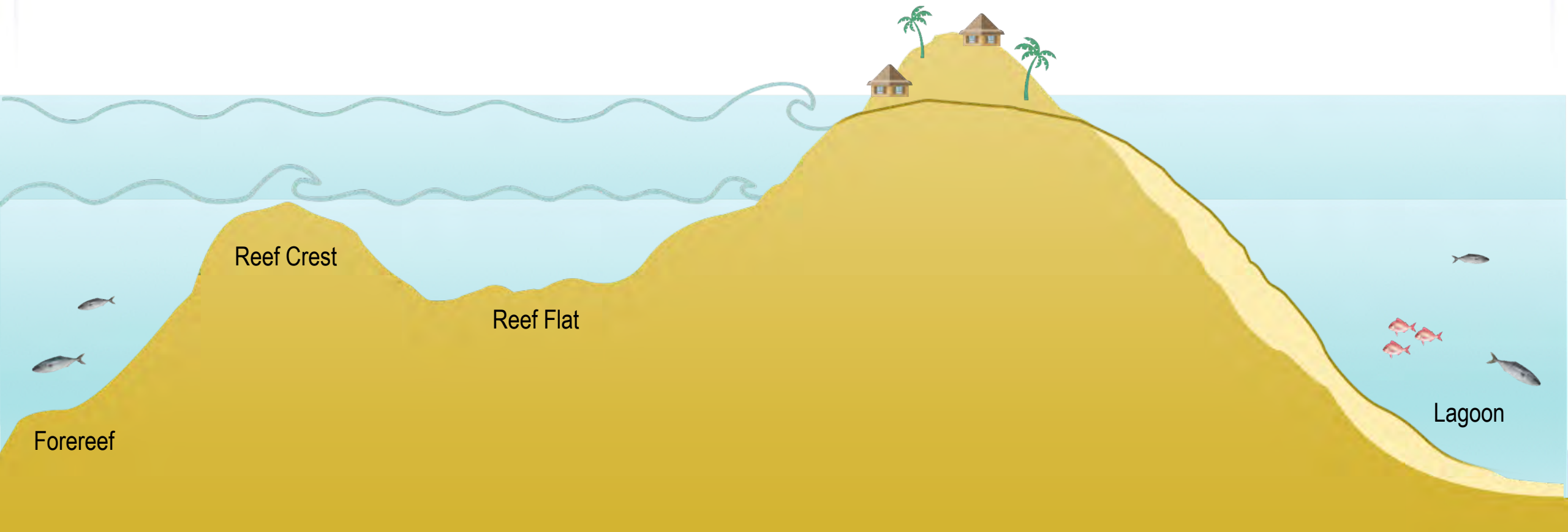
Sea Level Rise

Increases Shoreline Wave Heights and Flooding



Sea Level Rise

Bad for Atoll Islands



Mitigation of Erosion Hazards

Adaptation



Managed Retreat



Mitigation of Shoreline Erosion

Armored Slopes



Vertical Walls



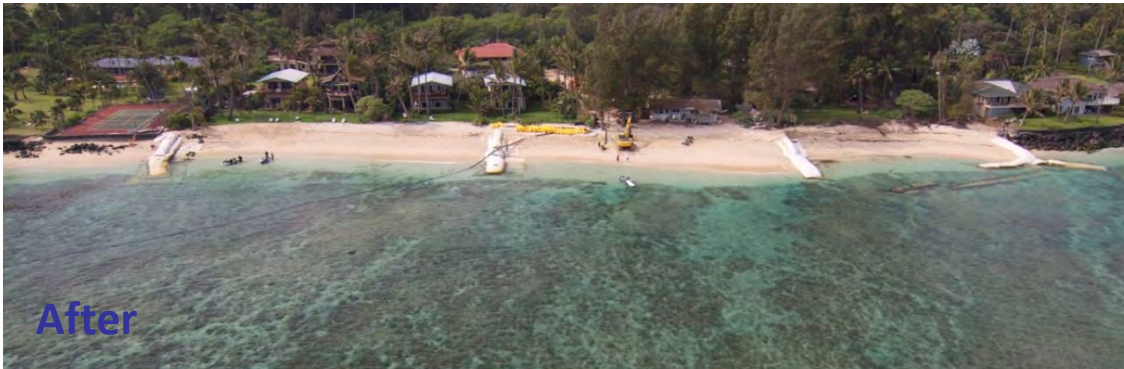
Beaches

Natural Erosion Protection



Mitigation of Beach & Shoreline Erosion

Sand Nourishment



Vegetated Coastal Berm



Beach Stabilization

Groins



Breakwaters

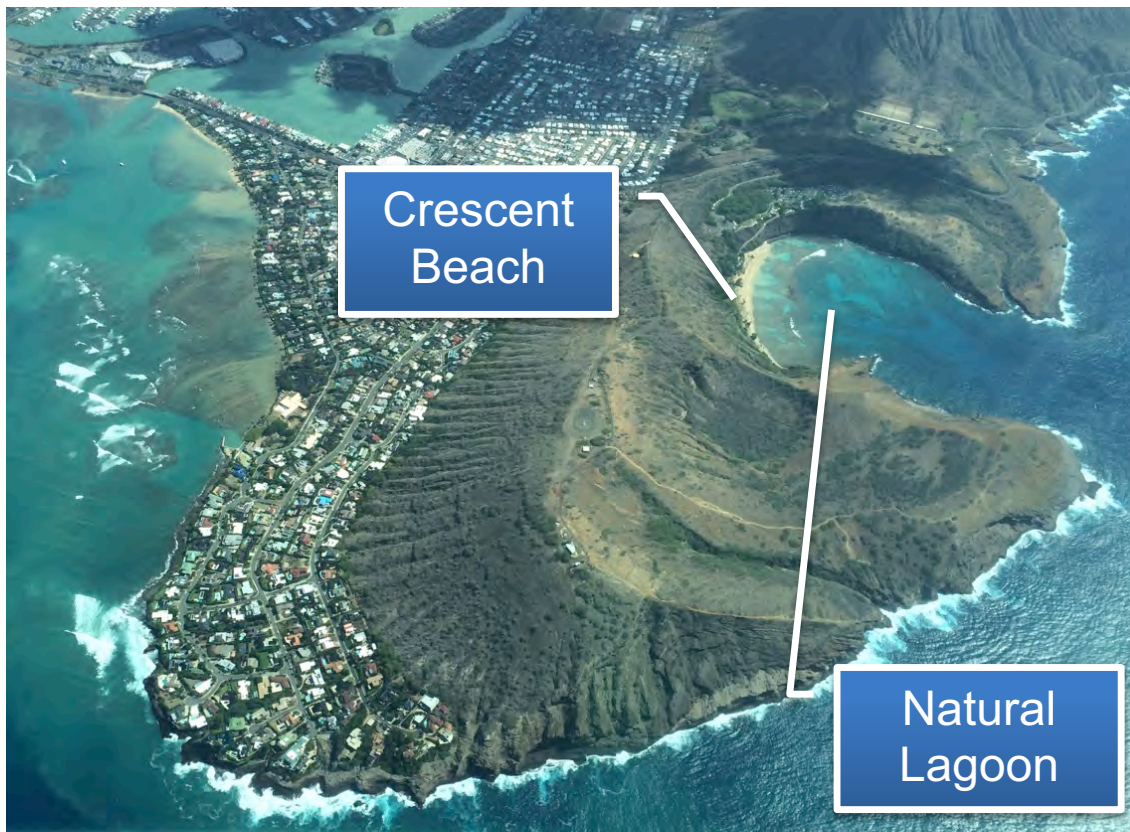


Design by Nature – Beach Stabilization



Crescent Beaches

Natural



Biomimicry



Waves Move Sand

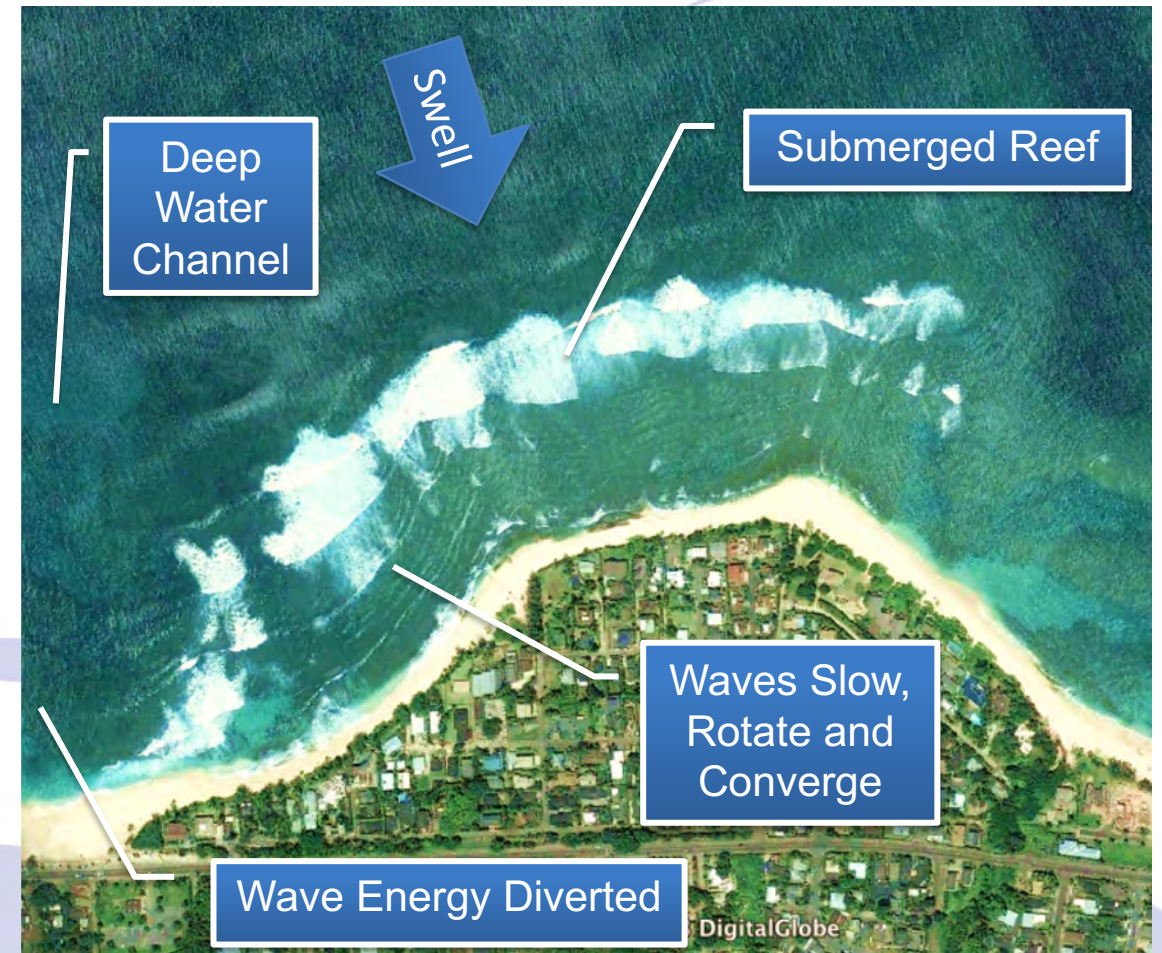
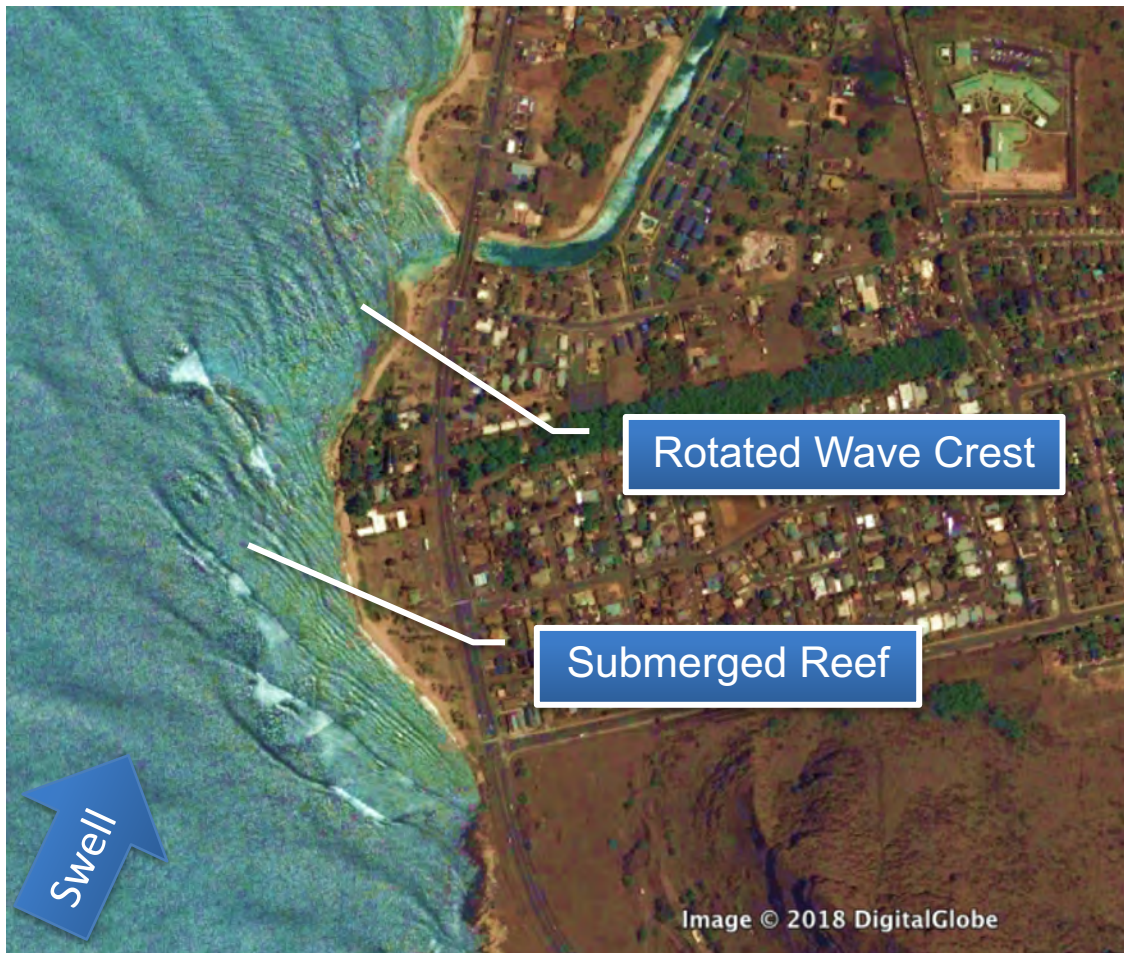
Long-Shore Sediment Transport



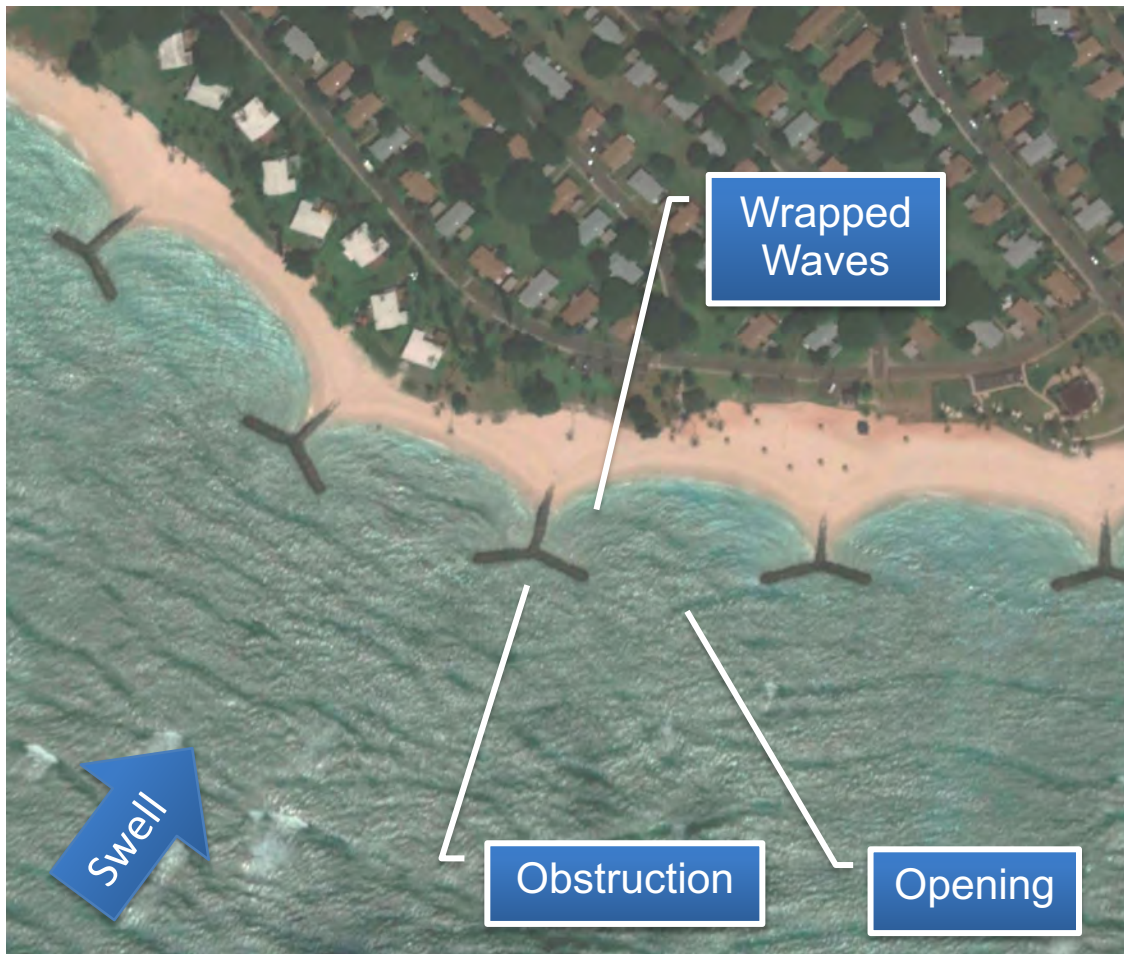
Cross-Shore Sediment Transport



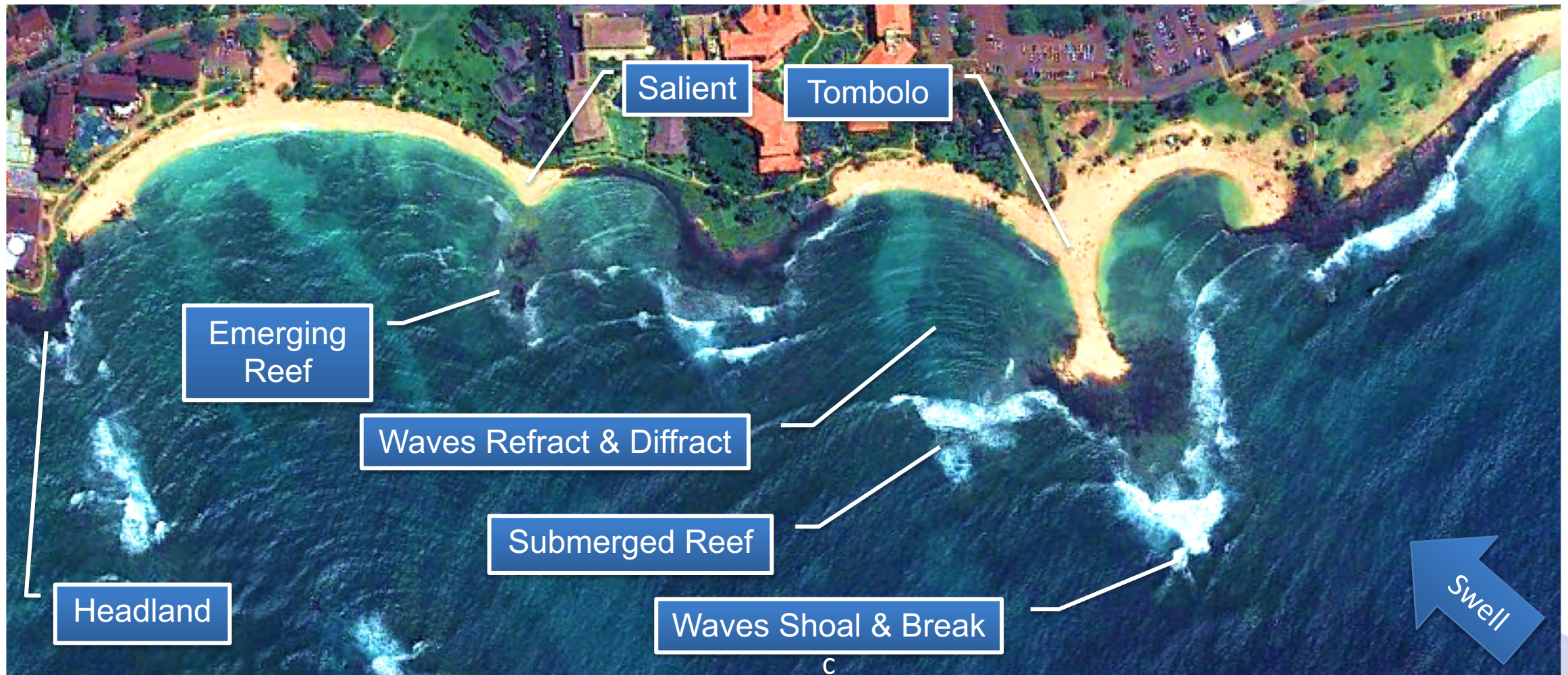
Wave Reef Interactions - Refraction



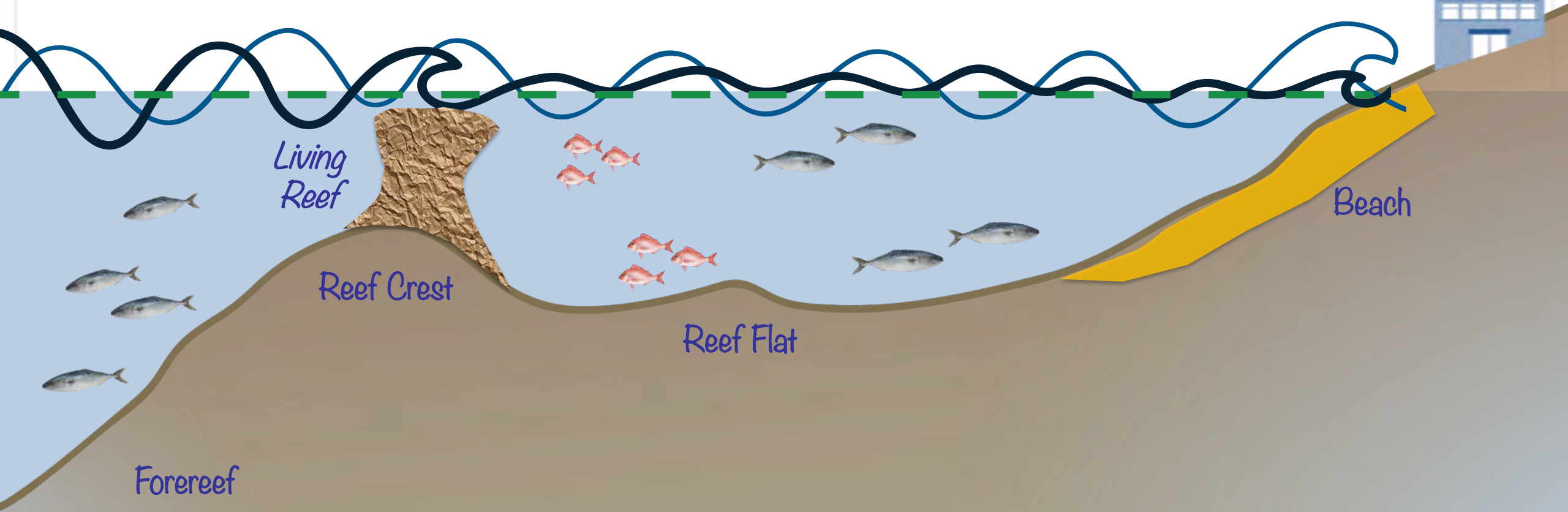
Wave Structure Interactions - Diffraction



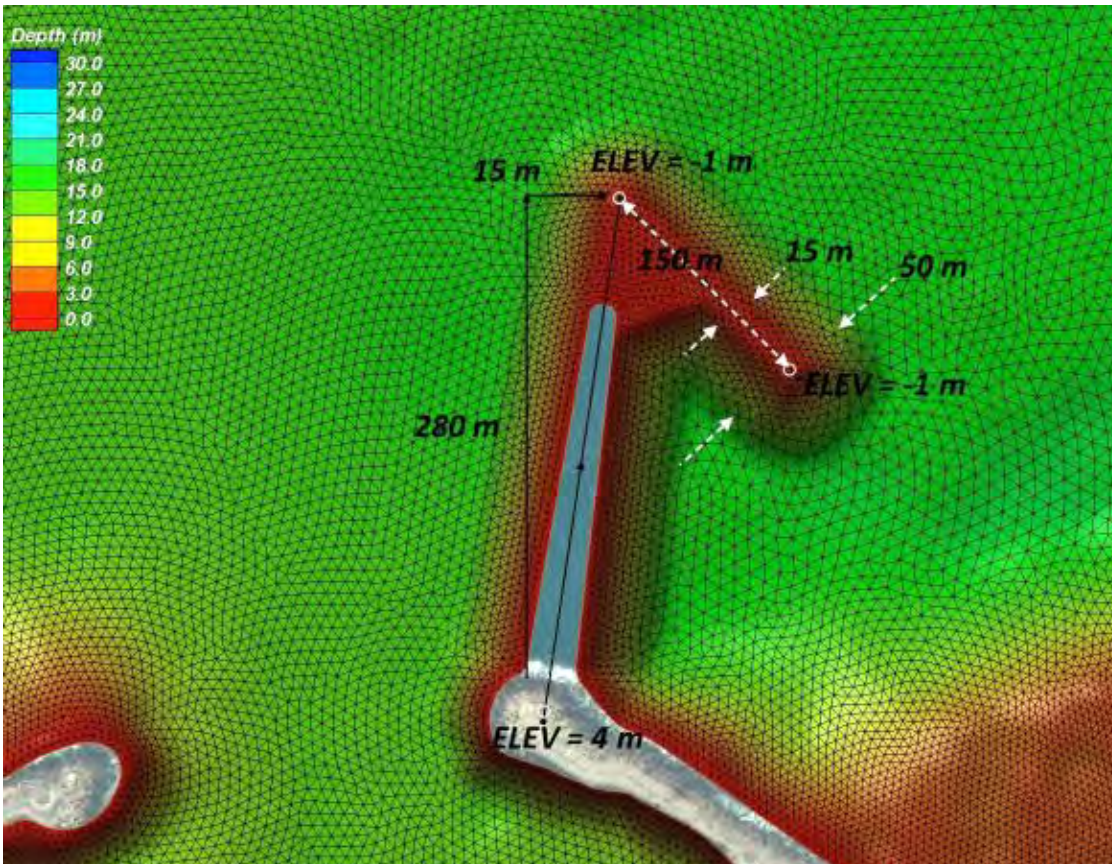
Beach Formations



Living Reefs for Coastal Protection



Design of Living Reefs



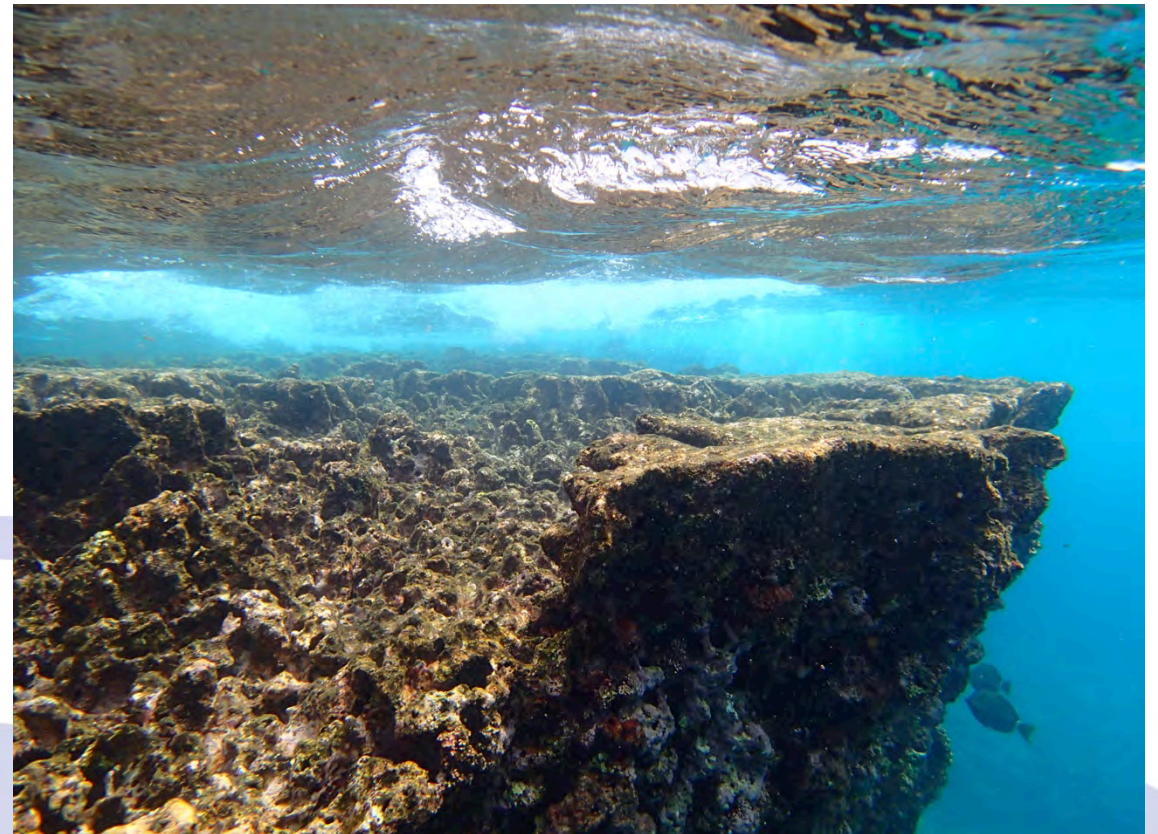
- Wave Dissipation
 - Coastal & Harbor Protection
 - Beach & Shoreline Stabilizing
- Ecosystem Habitat
 - Sand Production
 - Marine Resources
- Recreational Use
 - Diving
 - Surfing
 - Tourism

Design by Nature – Living Reefs

High Wave Energy



Structural Stability



Design by Nature – Reef Topography

Macro Scale



Micro Scale



Design by Nature - Reef Structure

High Wave Energy



Flat Coral Morphology



Reef Morphology

Calm Energy Environment



Branching Coral Morphology

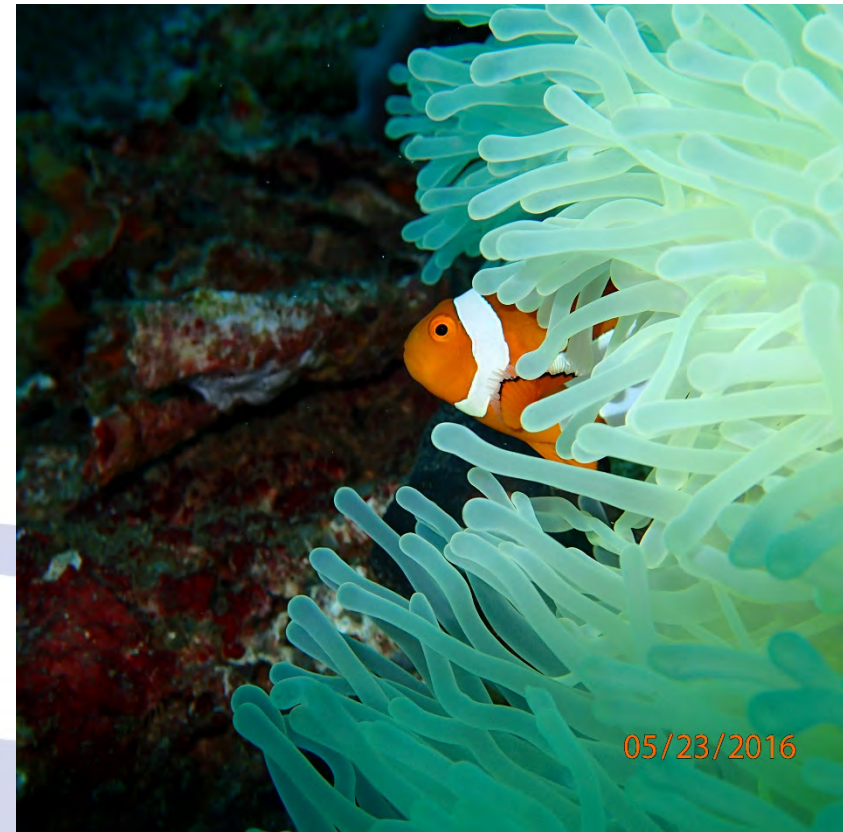


Design by Nature – Ecosystem Habitat

Macro Scale



Micro Scale



Design by Nature – Living Reef

Economically Viable Construction



Materials & Surface Texture



Design by Nature – Living Reef

Natural

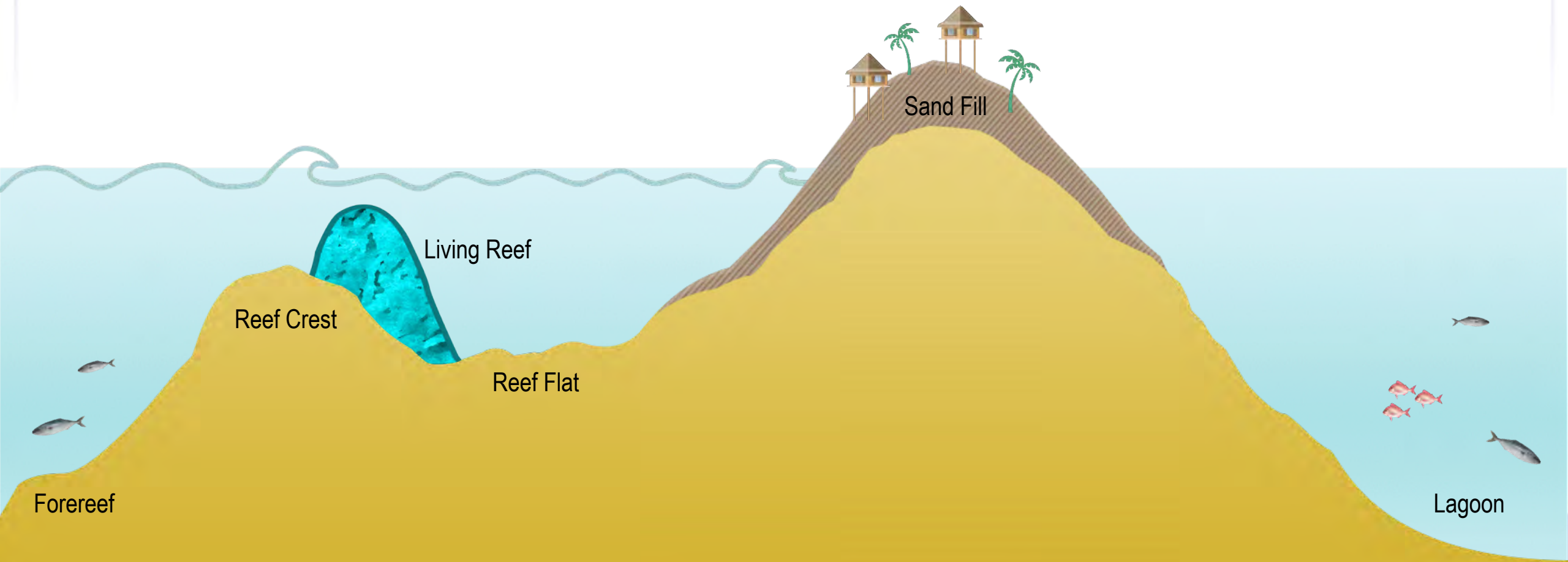


Biomimicry



Living Reefs

A Strategy for Atoll Islands



Monitoring a Changing Environment

Waves & Currents



Shoreline Surveys



Erosion Data



iBeach

Computer Vision:

Using computers

To automate tasks

*That the human visual
system can do*

*To gain high-level
understanding from*

Digital images or

Videos

iBeach

Beach Position:

..... Aug 28, 2016

— Mar 21, 2017



Lost Beach



Gained Beach



Stable Beach

From:

Aug

28

2016

To:

Apr

21

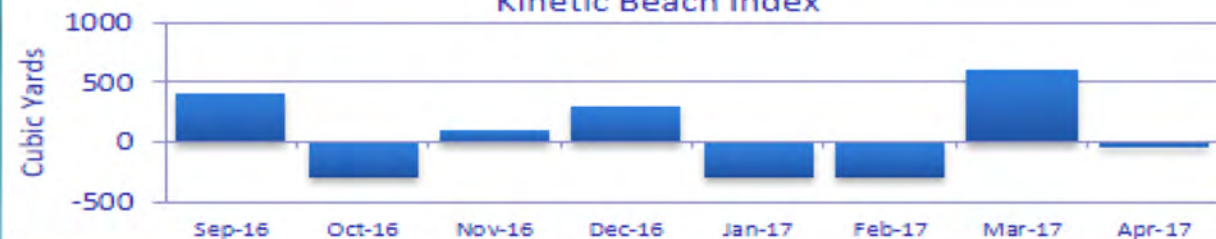
2017

Average Rate of Change: -66 sq. ft. / day or -\$200,000 / day



Estimated Change in Beach Area: -0.36 acres or -\$50 M

Kinetic Beach Index



Estimated Volume Change: -560 cubic yards or -\$56,000

Data Folder:

...Site: ☒ Show map

Camera:

Images:

Load

Process

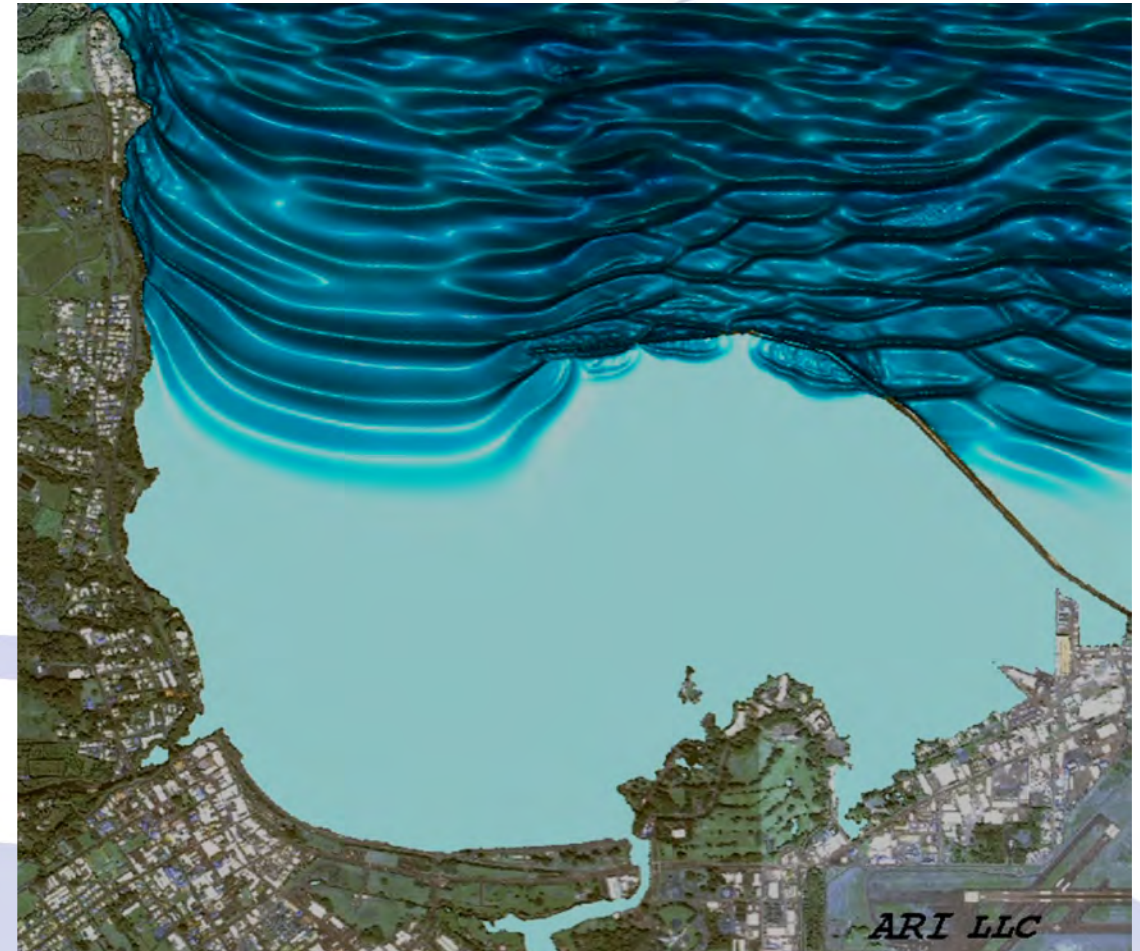
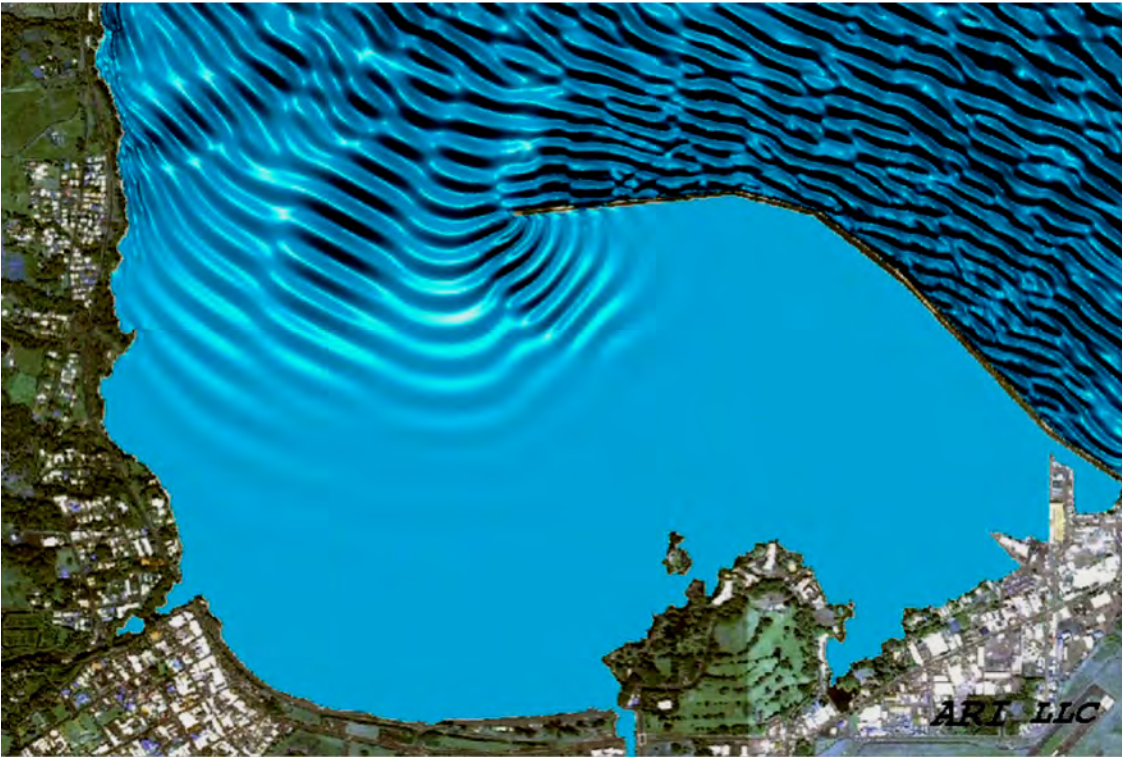
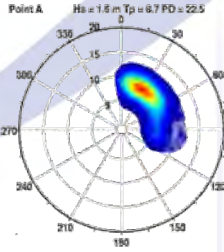
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Sand Color Range:

High	H	<input type="range"/>	40
	S	<input type="range"/>	255
	V	<input type="range"/>	255
Low	H	<input type="range"/>	0
	S	<input type="range"/>	50
	V	<input type="range"/>	10

Numerical Simulation of Wave Patterns

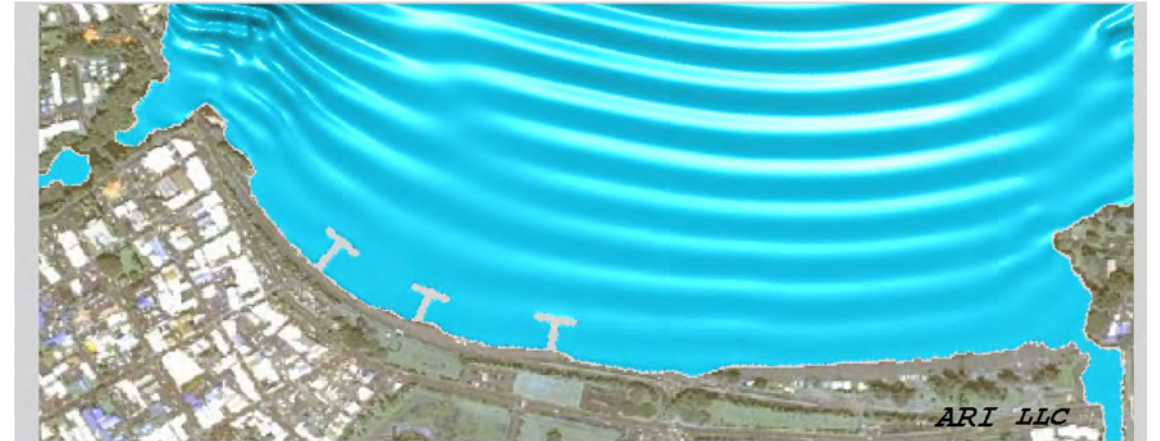


Design Verification

Existing:



Proposed :

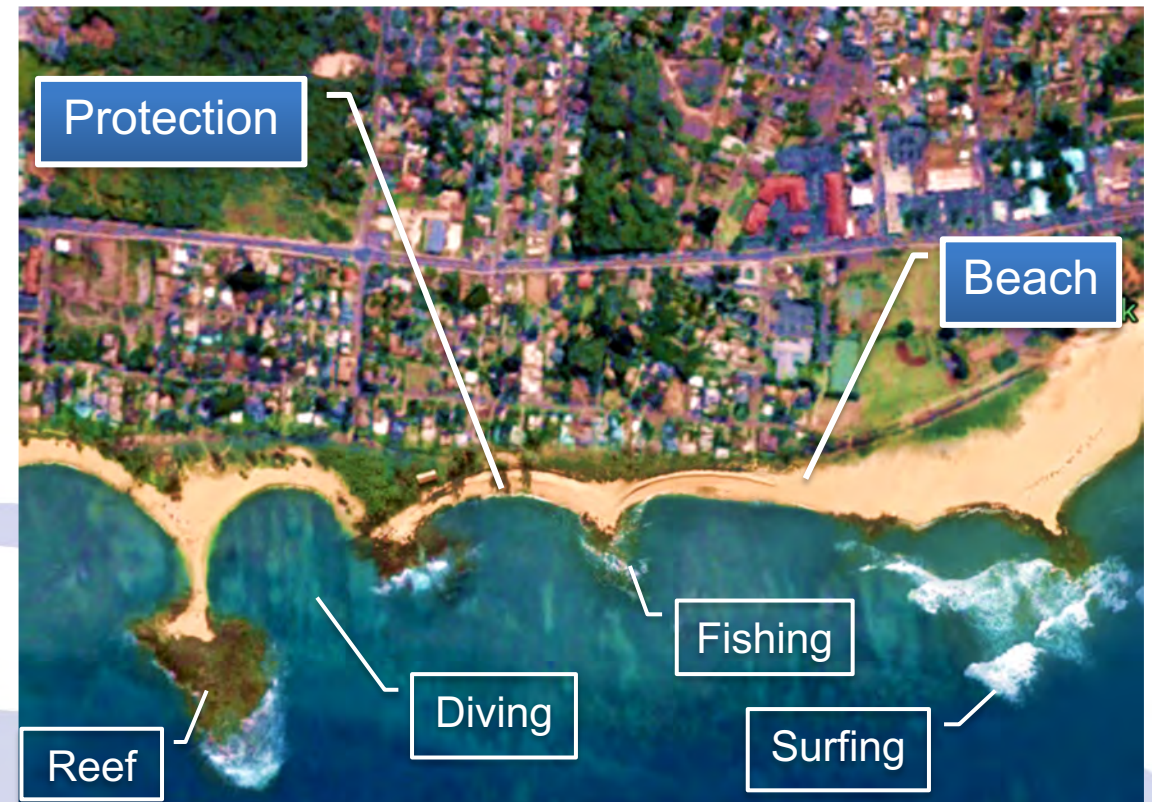


Coastal Restoration and Sea Level Rise Protection

Existing Eroding Coastline



Potential Restoration Scheme



Discussion

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