

Flood Protection Savings Provided by Coral Reefs



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Conservancy
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Why Coastal Protection Services? Coastal Hazards Are Real & Rising

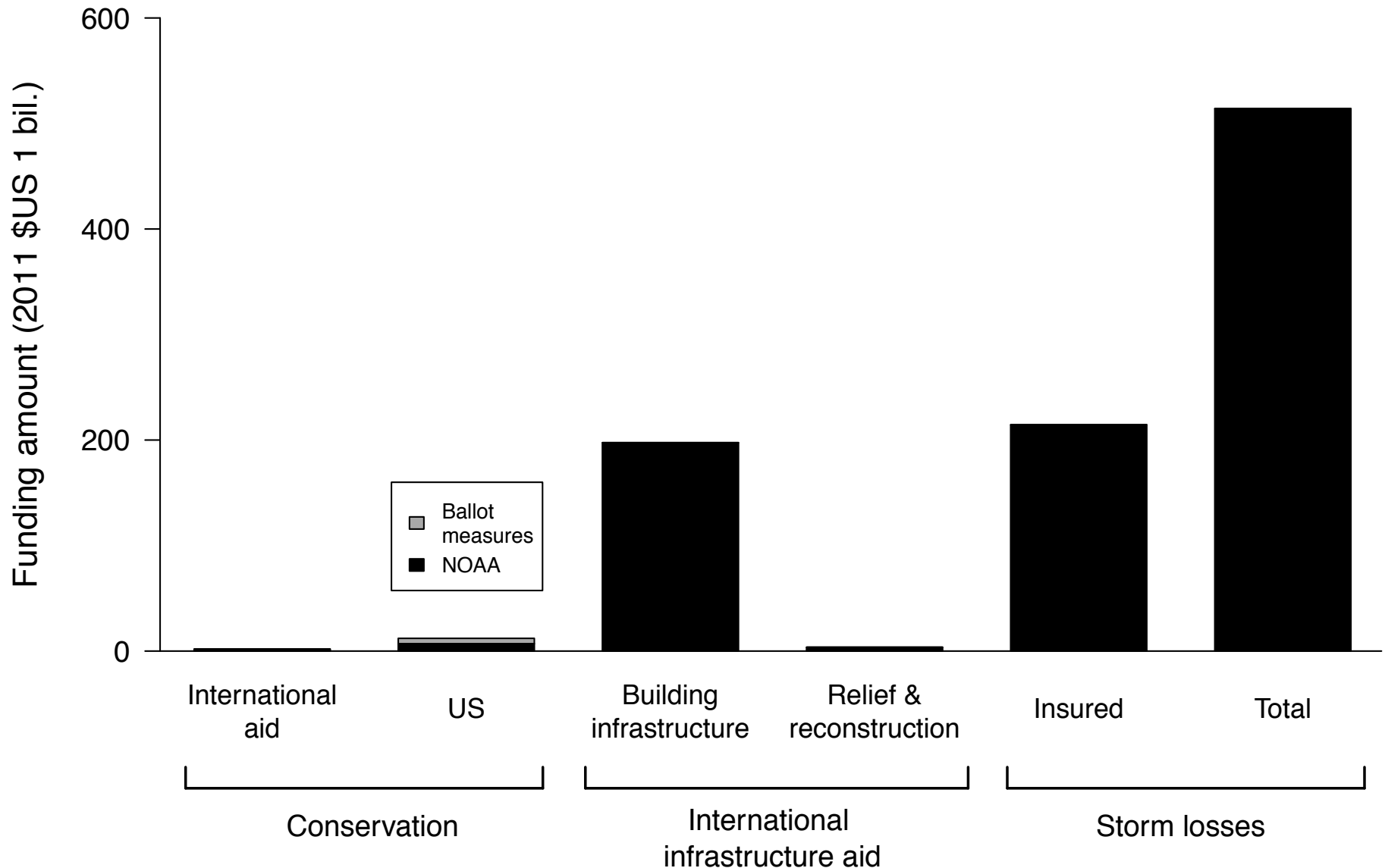


Key Questions

- When, where & how do coastal habitats affect flood risk?
- Is habitat restoration cost-effective for risk reduction?
- Can this scientific understanding inform incentives for reducing risks with ecosystems?



Coastal Funding for Conservation & Infrastructure (10 Yrs)



McCreless & Beck. In press. Rethinking our global coastal investment portfolio.
Journal of Ocean & Coastal Economics

Managing Coasts with Natural Solutions

Guidelines for Measuring and Valuing the Coastal Protection Services of Mangroves and Coral Reefs

Beck, MW, G-M Lange (eds). 2016.

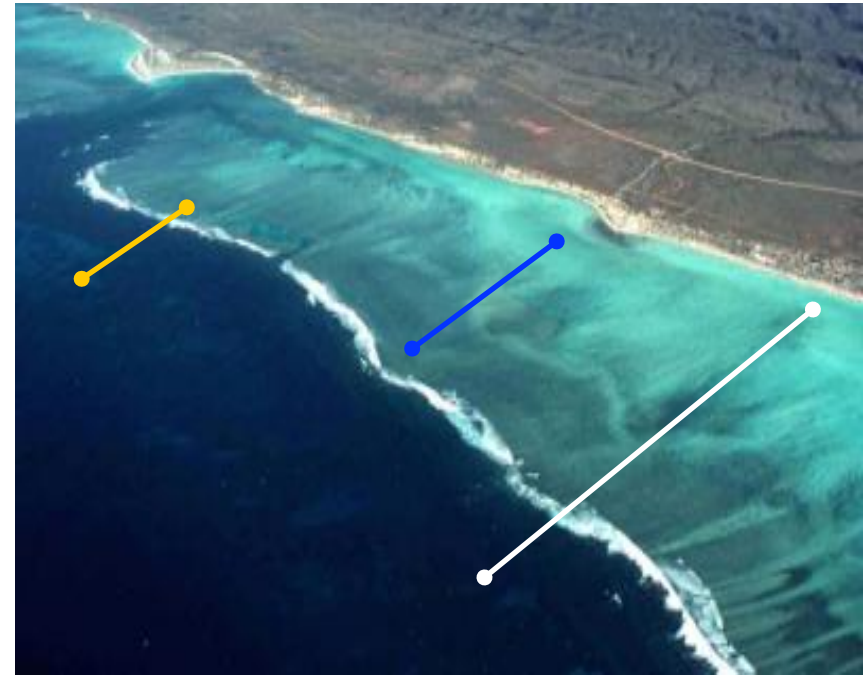
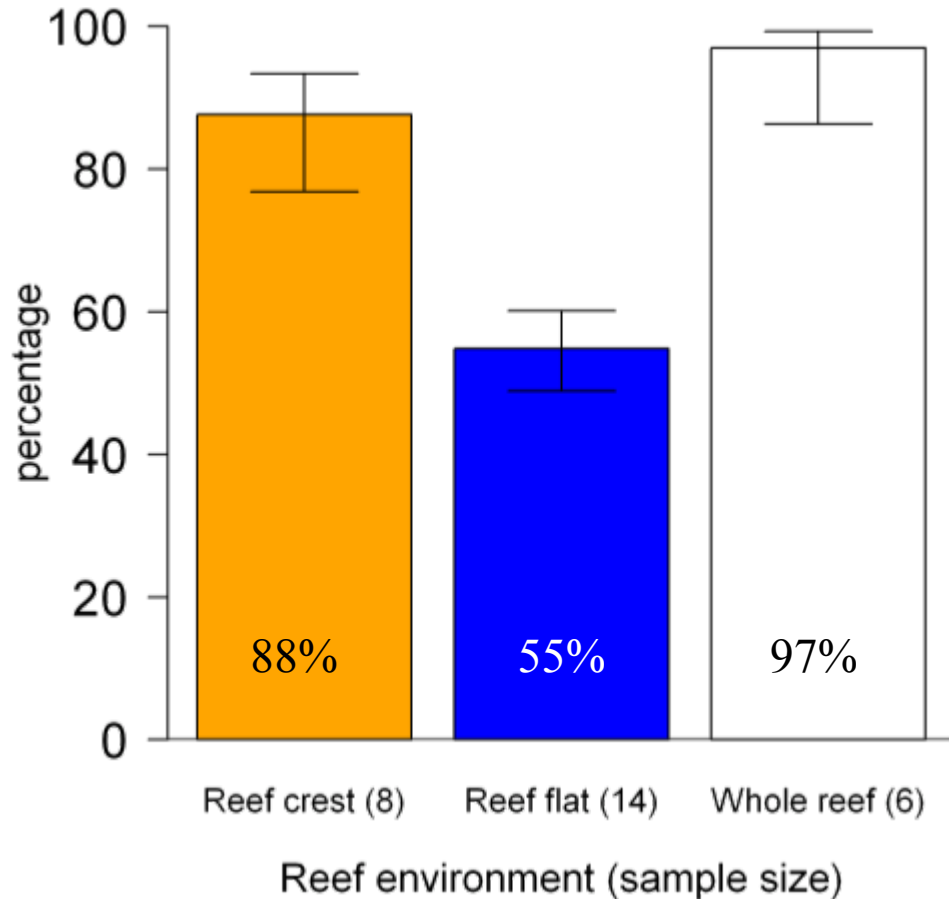


WORLD BANK GROUP



Chapter 3: Reefs & Coastal Protection

Wave Energy Reduction By Coral Reefs



Chapters 4 & 5: Recommended Approach for Assessing Coastal Protection Value: Expected Damage Function

STAGE 1



Estimate Waves Offshore

STAGE 2



Estimate Waves Nearshore

STAGE 3



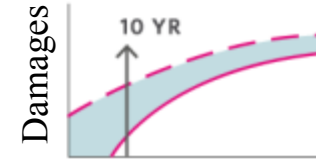
Estimate Effects of Habitats

STAGE 4

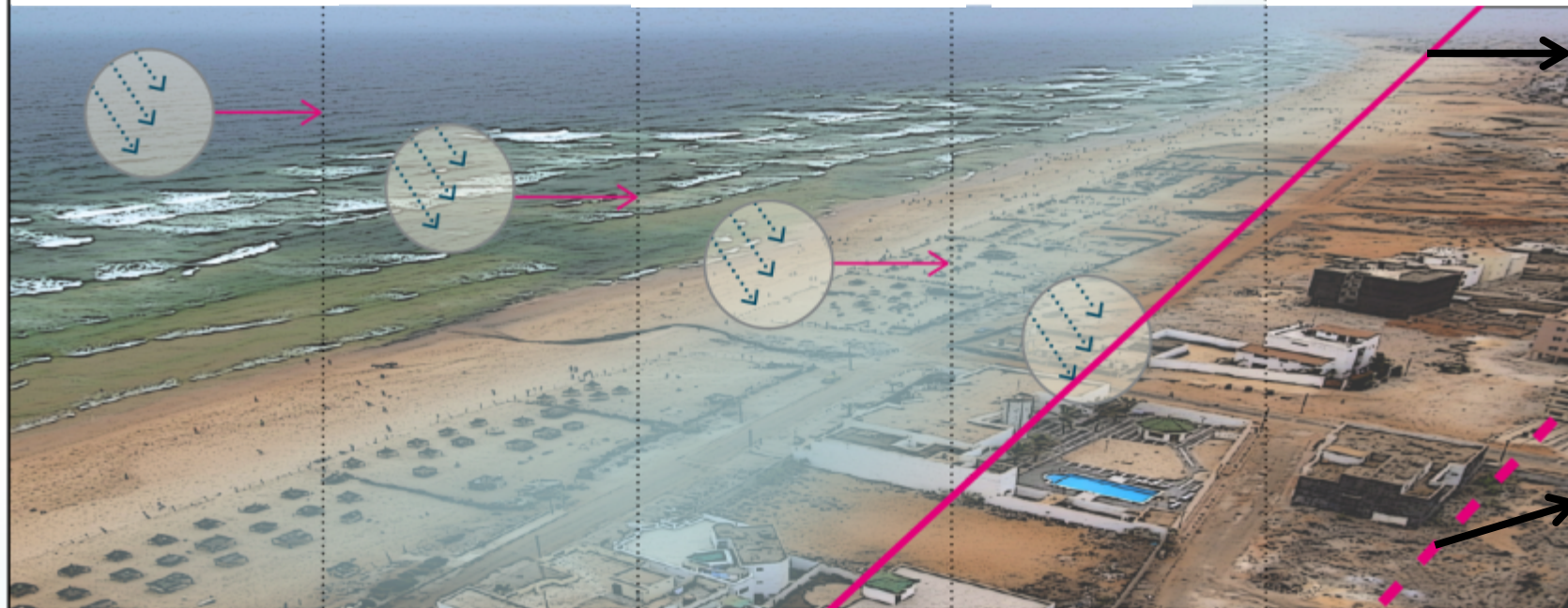


Estimate Flooding

STAGE 5



Assess Damages



10 yr with Habitat

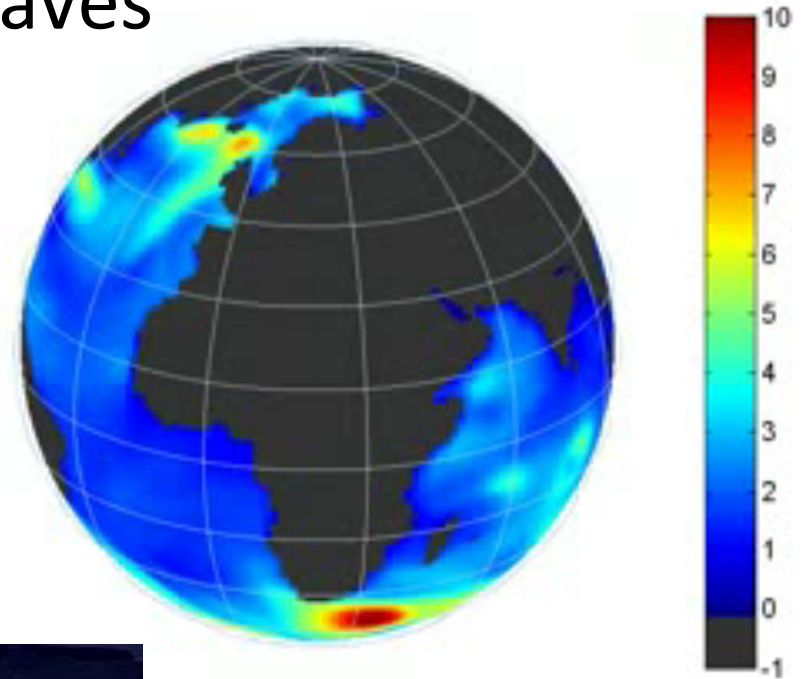
10 yr w/out Habitat

Assessing the Value of Reefs in Reducing Flood Risk

Reefs



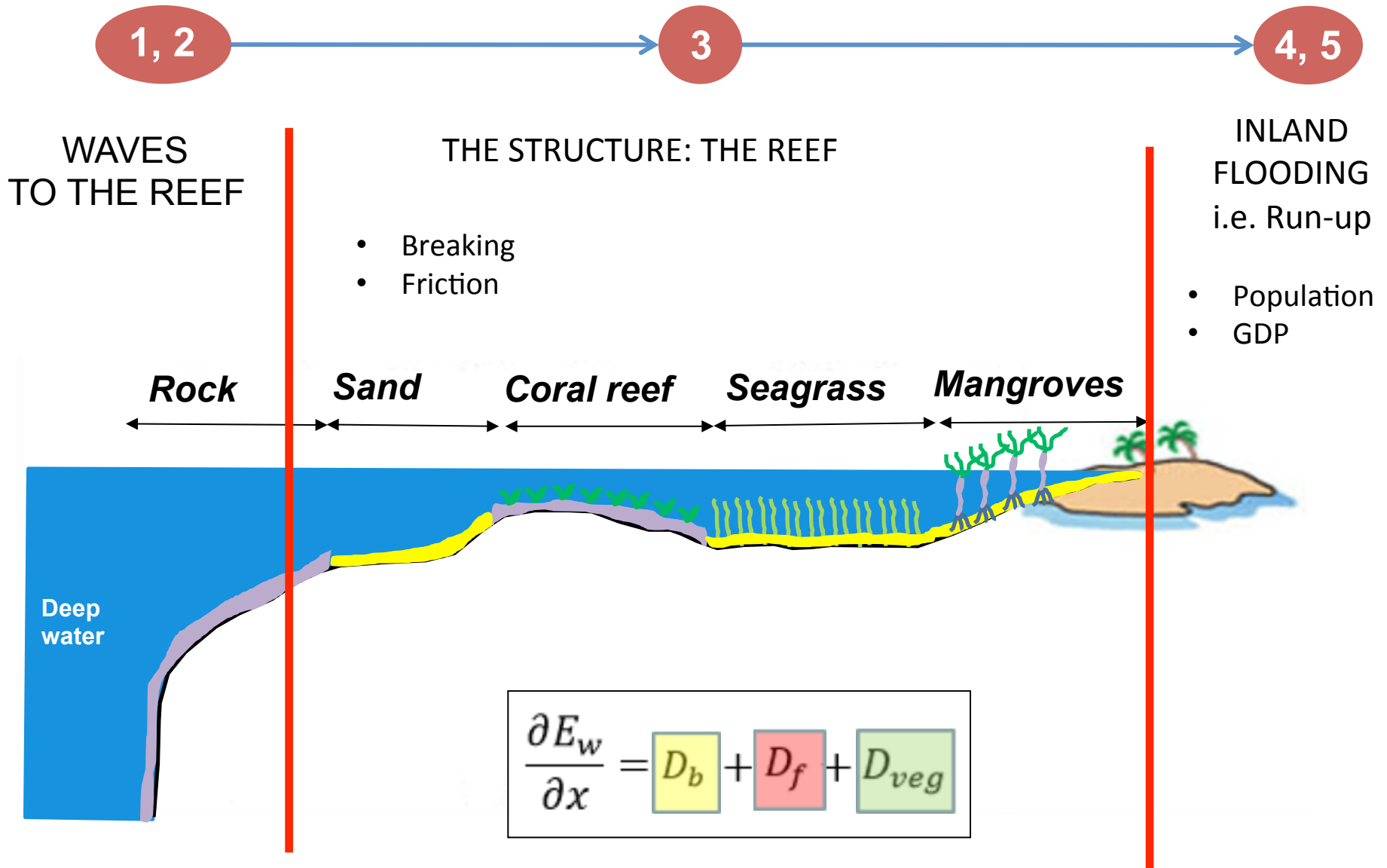
Waves



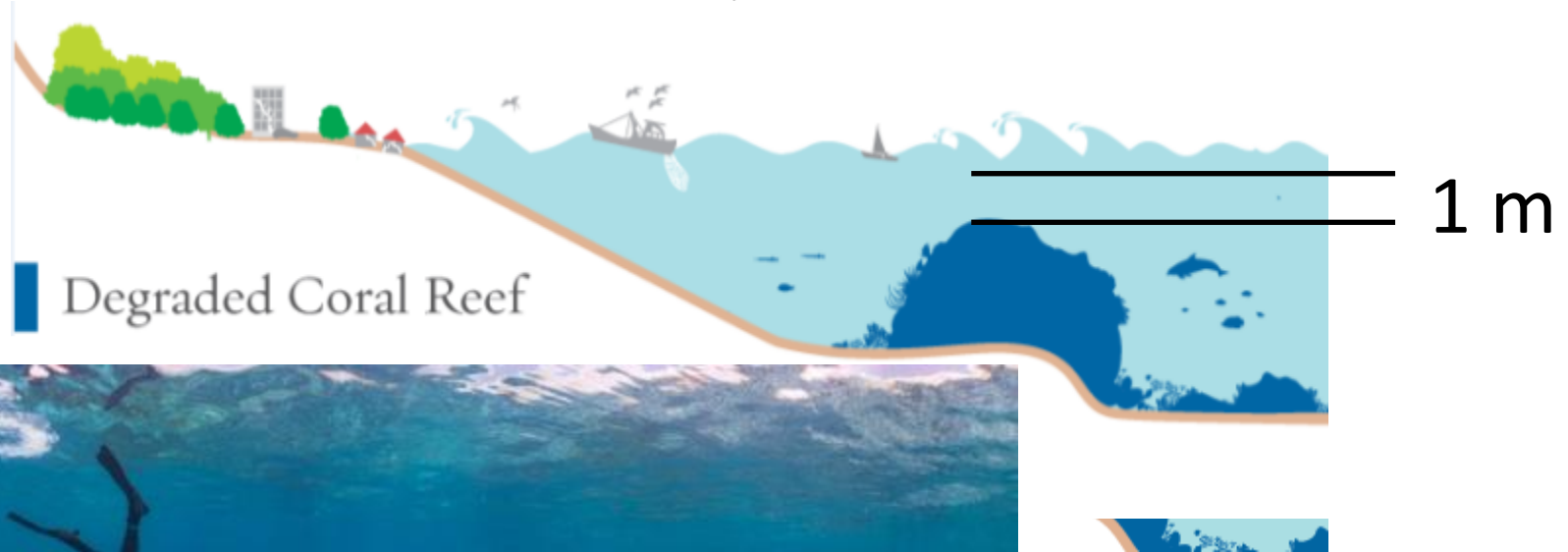
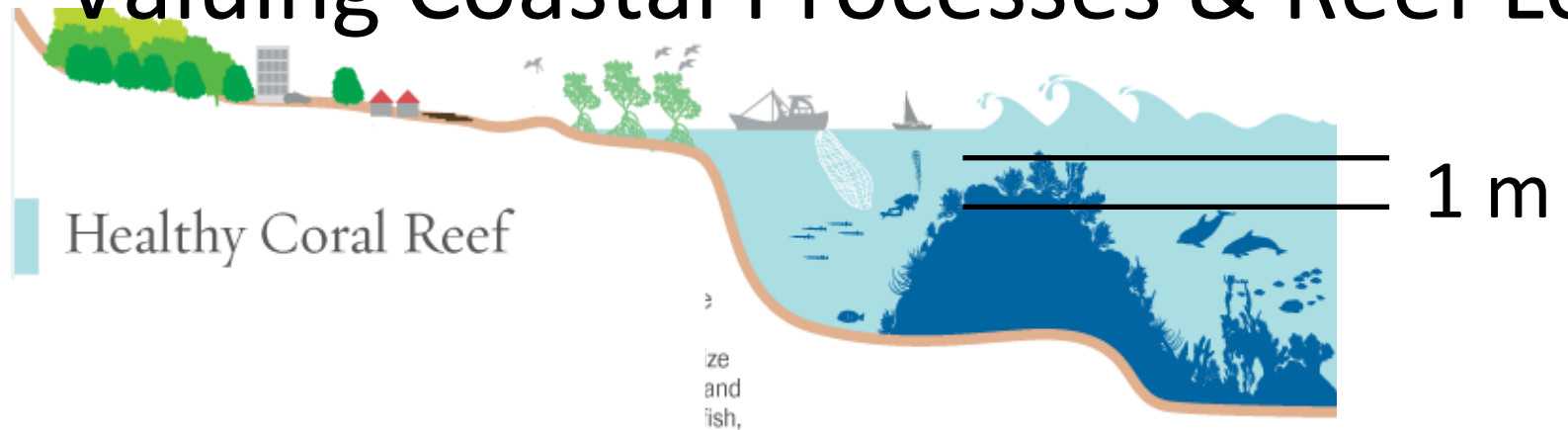
Assets

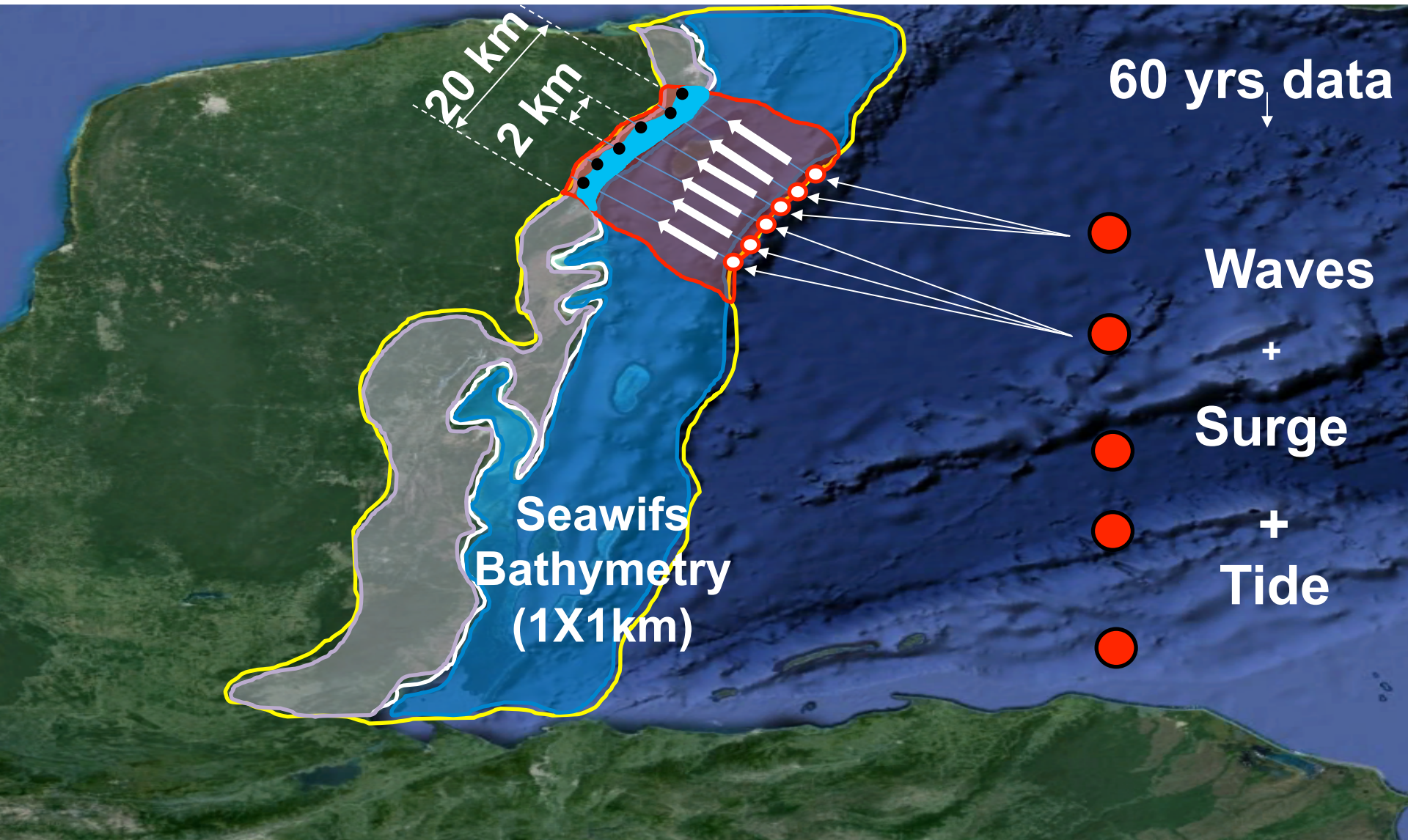


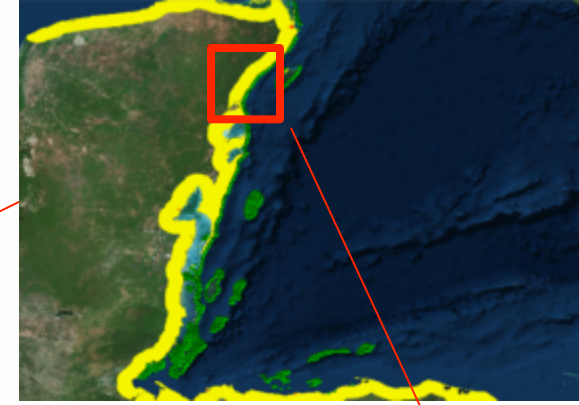
Framework for Estimating Coastal Protection Values



Valuing Coastal Processes & Reef Loss





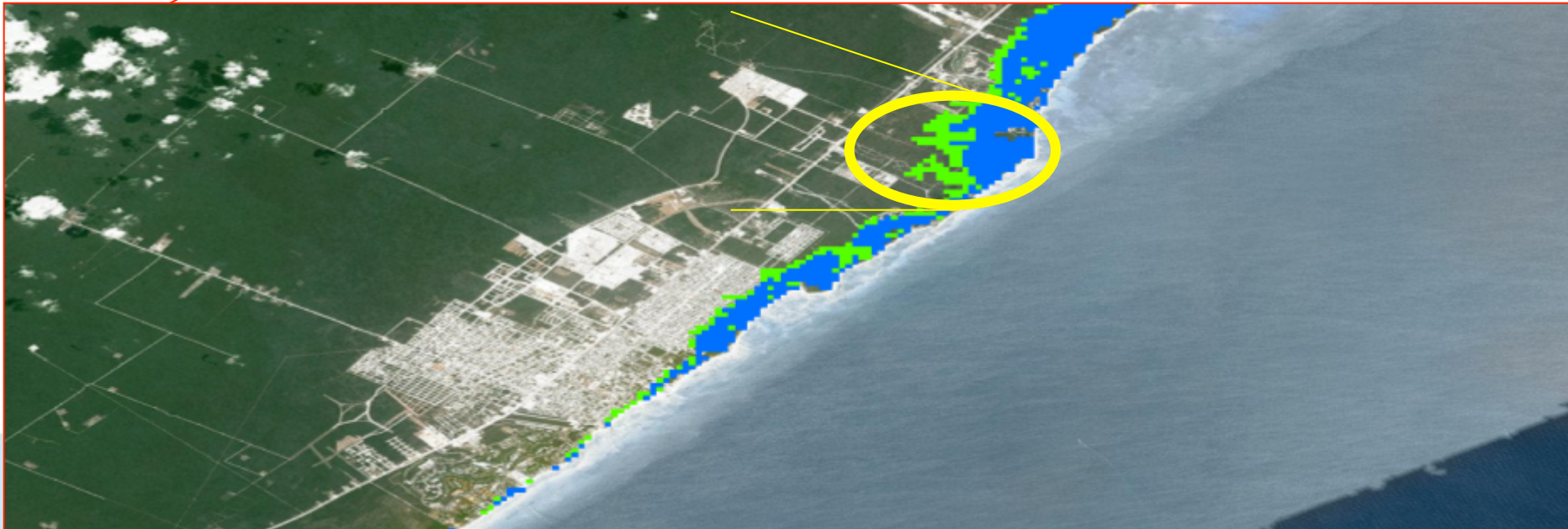


Flooding (25 - Year Event)

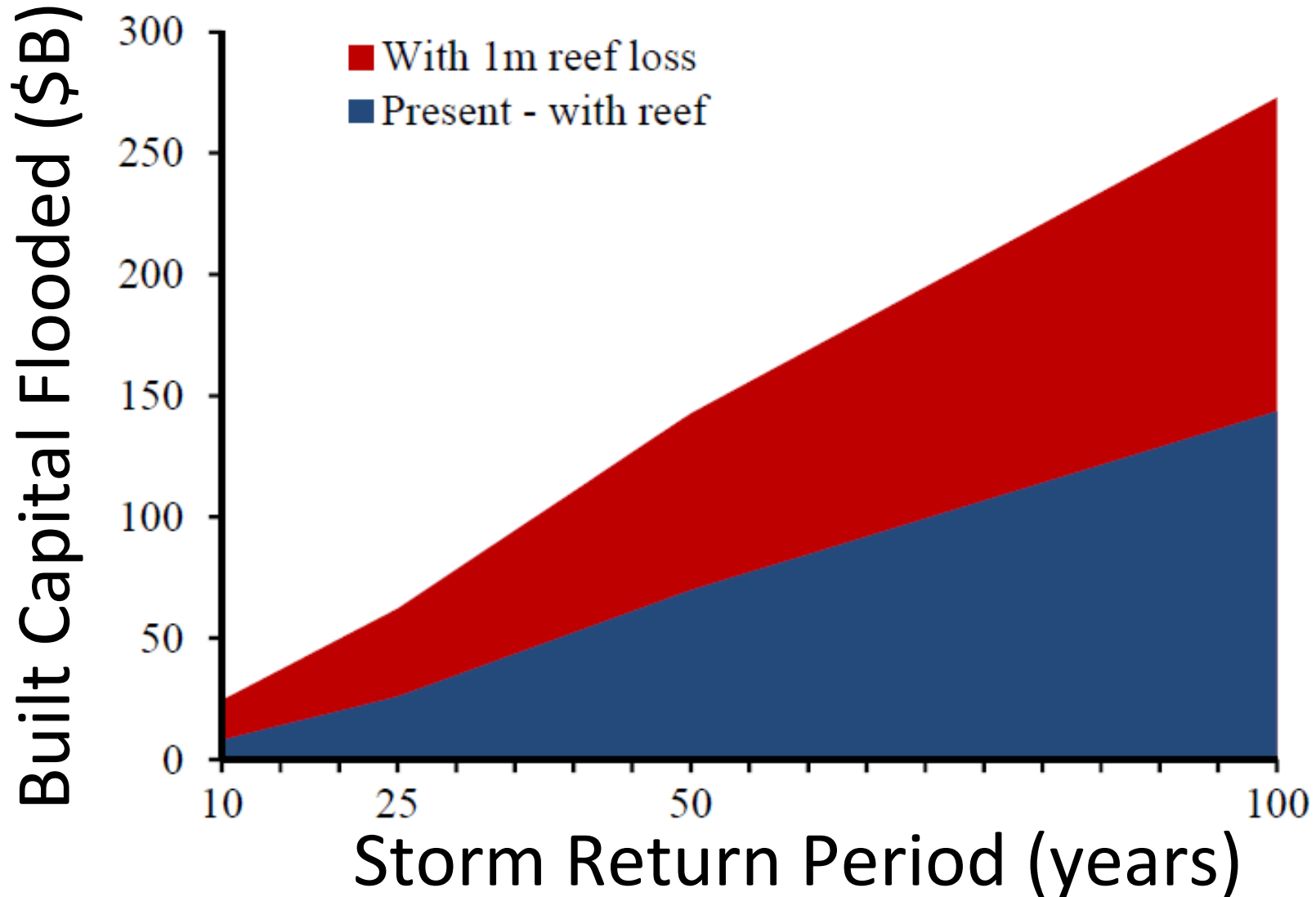
 Current Flooding

 Flooding With 1m Reef Loss

Playa del Carmen



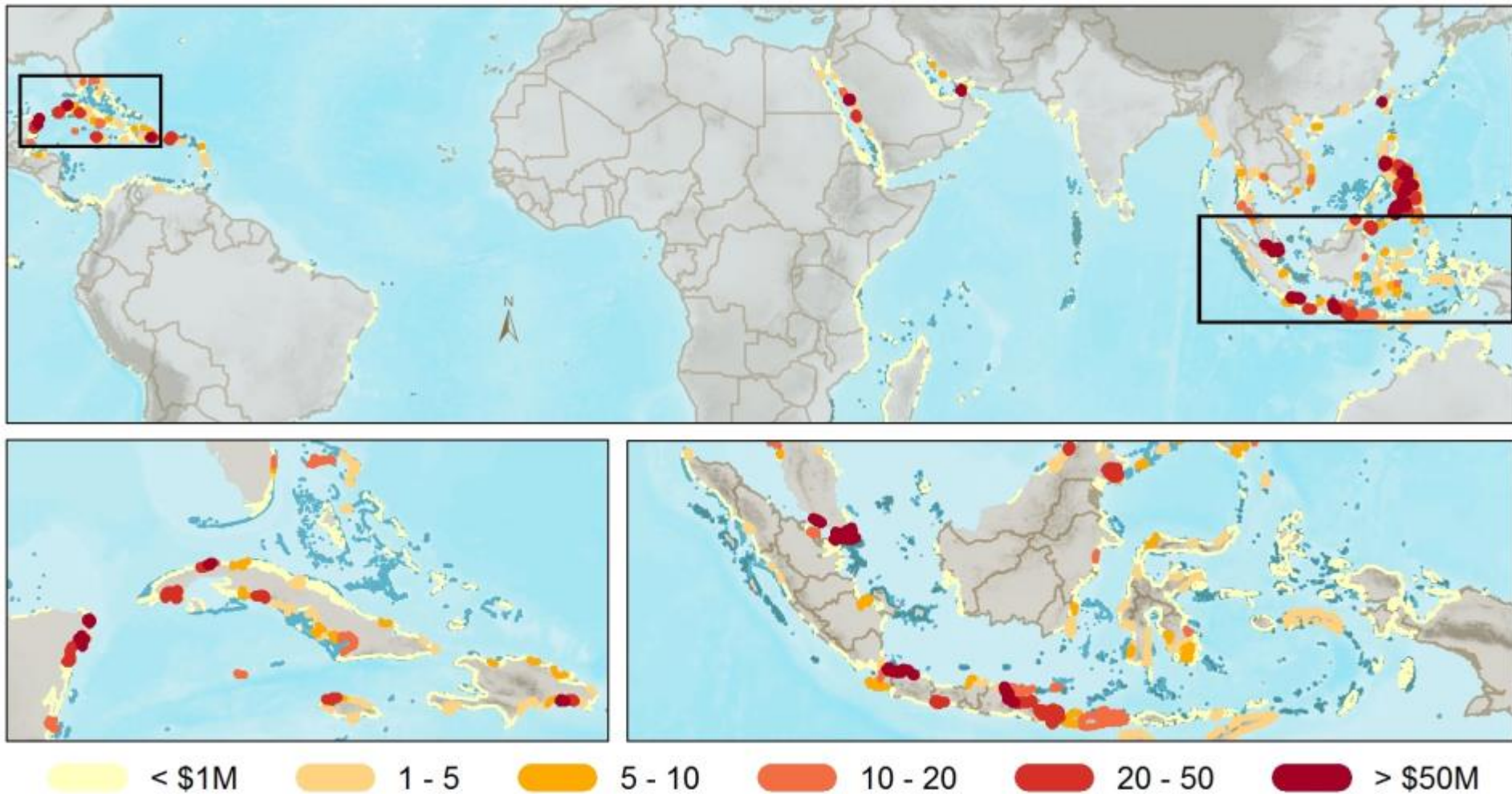
Global Flood Protection Savings from Coral Reefs



Beck et al. 2016. *Mapping Ocean Wealth*.

Beck et al. *In review (revision)*. The Global Flood Protection Savings Provided by Coral Reefs. *Nature Communications*.

Annual Expected Benefits from Reefs: Avoided Flood Damage in \$M/20 km coastline



Beck et al. 2016. *Mapping Ocean Wealth*.

Beck et al. *In review (revision)*. The Global Flood Protection Savings Provided by Coral Reefs. *Nature Communications*.

Annual Expected Benefits of Reefs for Flood Protection

Annual Averted Damages (\$Millions)			Annual Averted Damages/GDP	
1	Indonesia	639	Cayman Islands	0.98
2	Philippines	590	Belize	0.37
3	Malaysia	452	Grenada	0.30
4	Mexico	452	Cuba	0.25
5	Cuba	401	Bahamas	0.16
6	Saudi Arabia	138	Jamaica	0.14
7	Dominican Republic	96	Philippines	0.13
8	United States	94	Antigua and Barbuda	0.13
9	Taiwan	61	Dominican Republic	0.11
10	Jamaica	46	Malaysia	0.09
11	Vietnam	42	Seychelles	0.06
12	Myanmar	33	Turks and Caicos	0.06
13	Thailand	32	Guadeloupe	0.05
14	Bahamas	14	Indonesia	0.04
15	Belize	9	Solomon Islands	0.04

Flood Protection Provided by Coral Reefs

This analysis combines ecology, engineering, and economics to estimate the global role of coral reefs in flood protection.

Annual Expected Benefit ⓘ



Region:

Philippines

Storm Return Period ⓘ

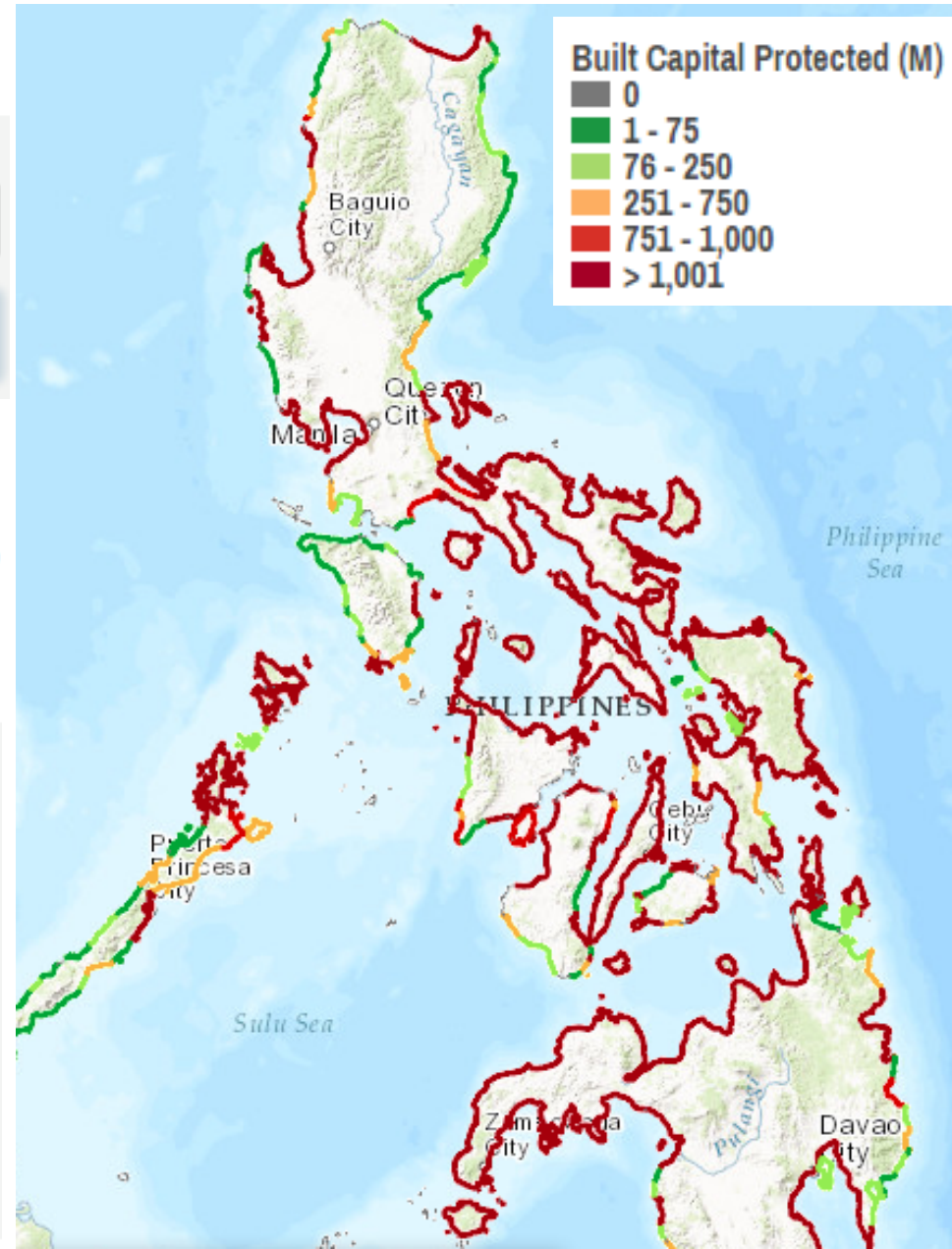
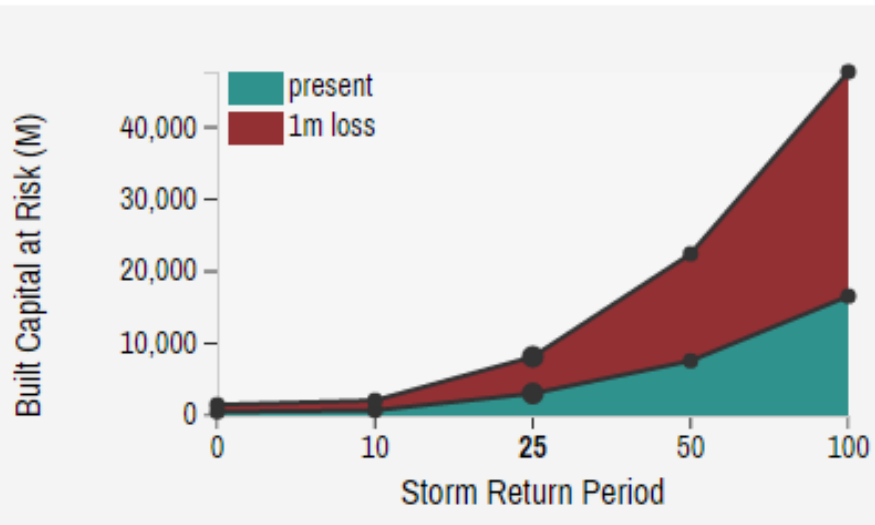
- 25 yrs
- 100 yrs

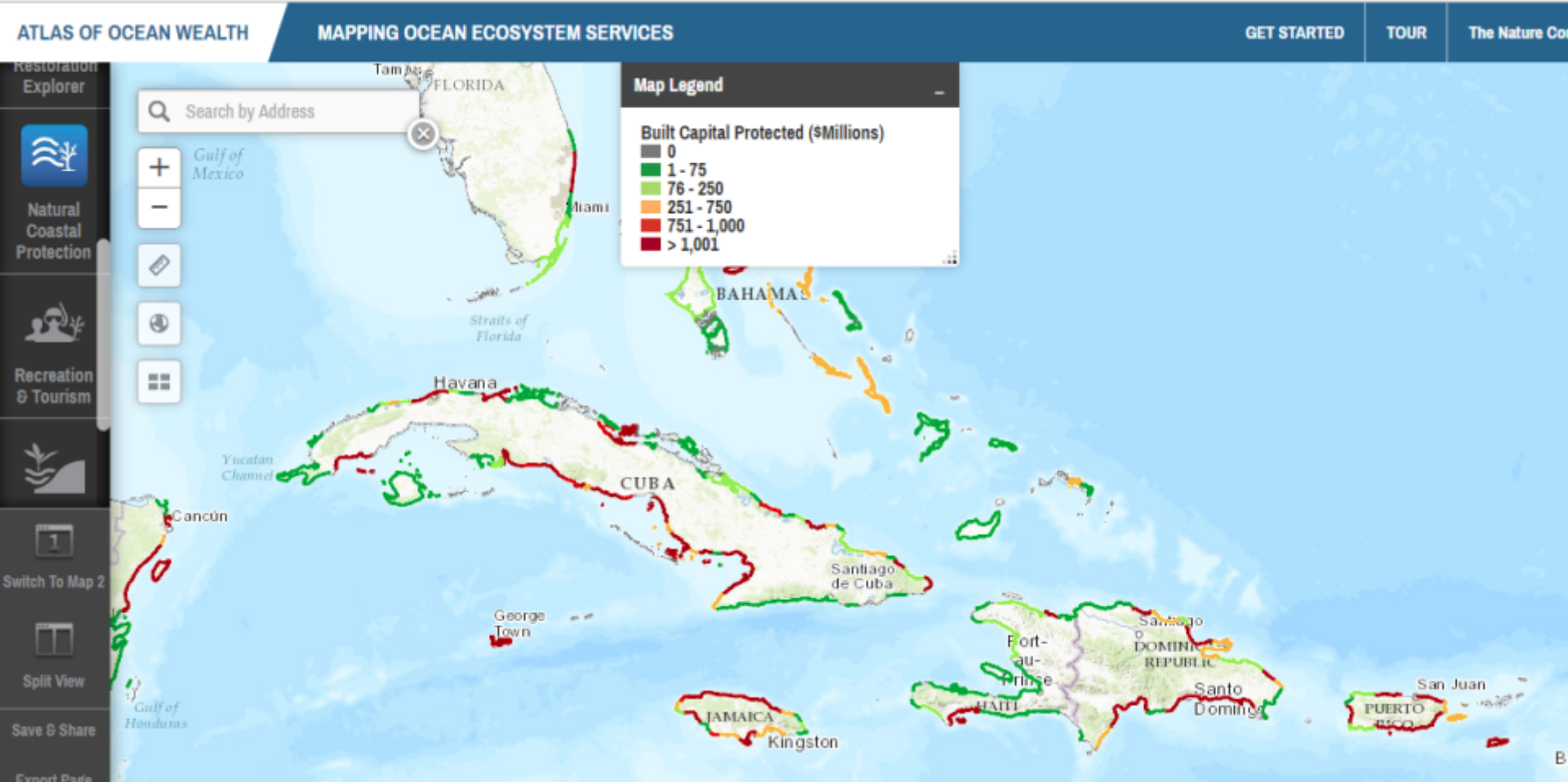
Download Country Summary

395,551 People Protected ⓘ

\$5,102M Built Capital Protected ⓘ

762km² Area Protected ⓘ

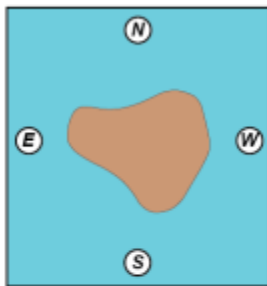




Hi Resolution Valuation of Coral Reef Protection Across the USA

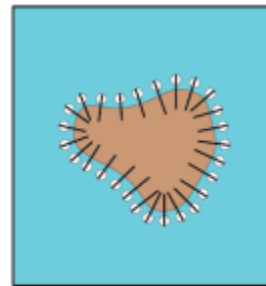
TNC UCSC USGS

HAZARDS
Downscaling waves to shore



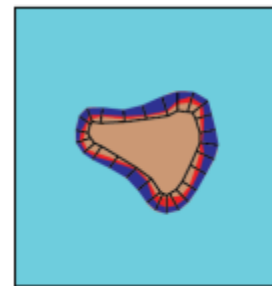
Offshore wave data

ECOSYSTEM
Reef flood modeling

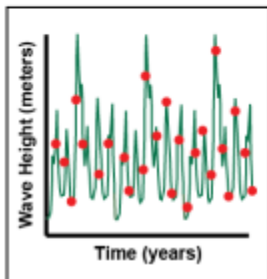


100-m reef profiles

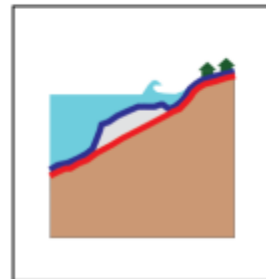
CONSEQUENCE
Assessing impact and benefits



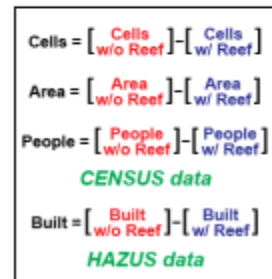
Map flood zones



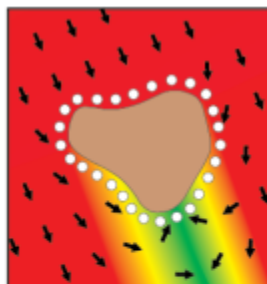
Representative sea states



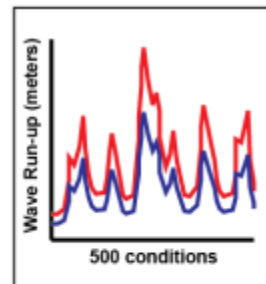
Effects of the reef



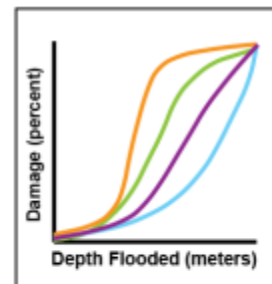
Assess exposure



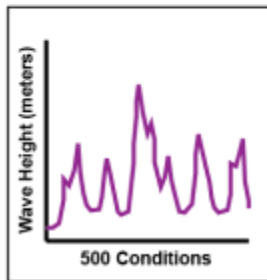
Propagate to nearshore



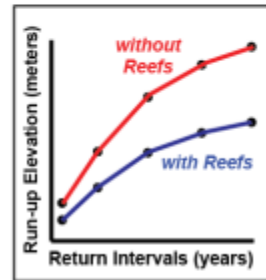
Total water levels



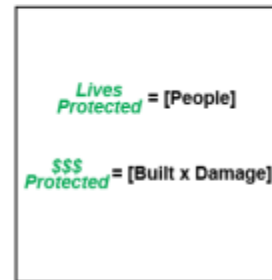
Economic damage



Reconstruct shallow water wave data

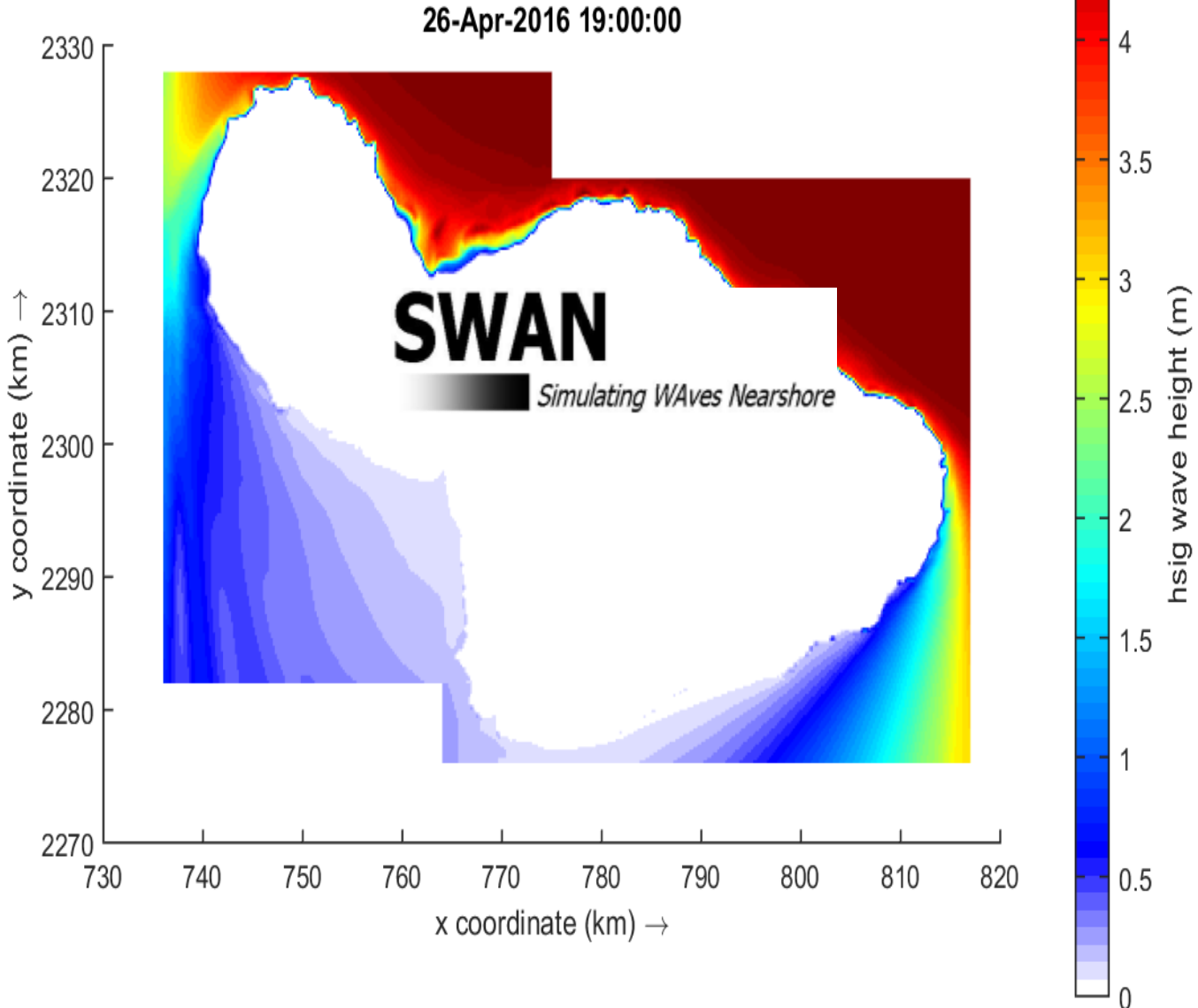


Flood frequency

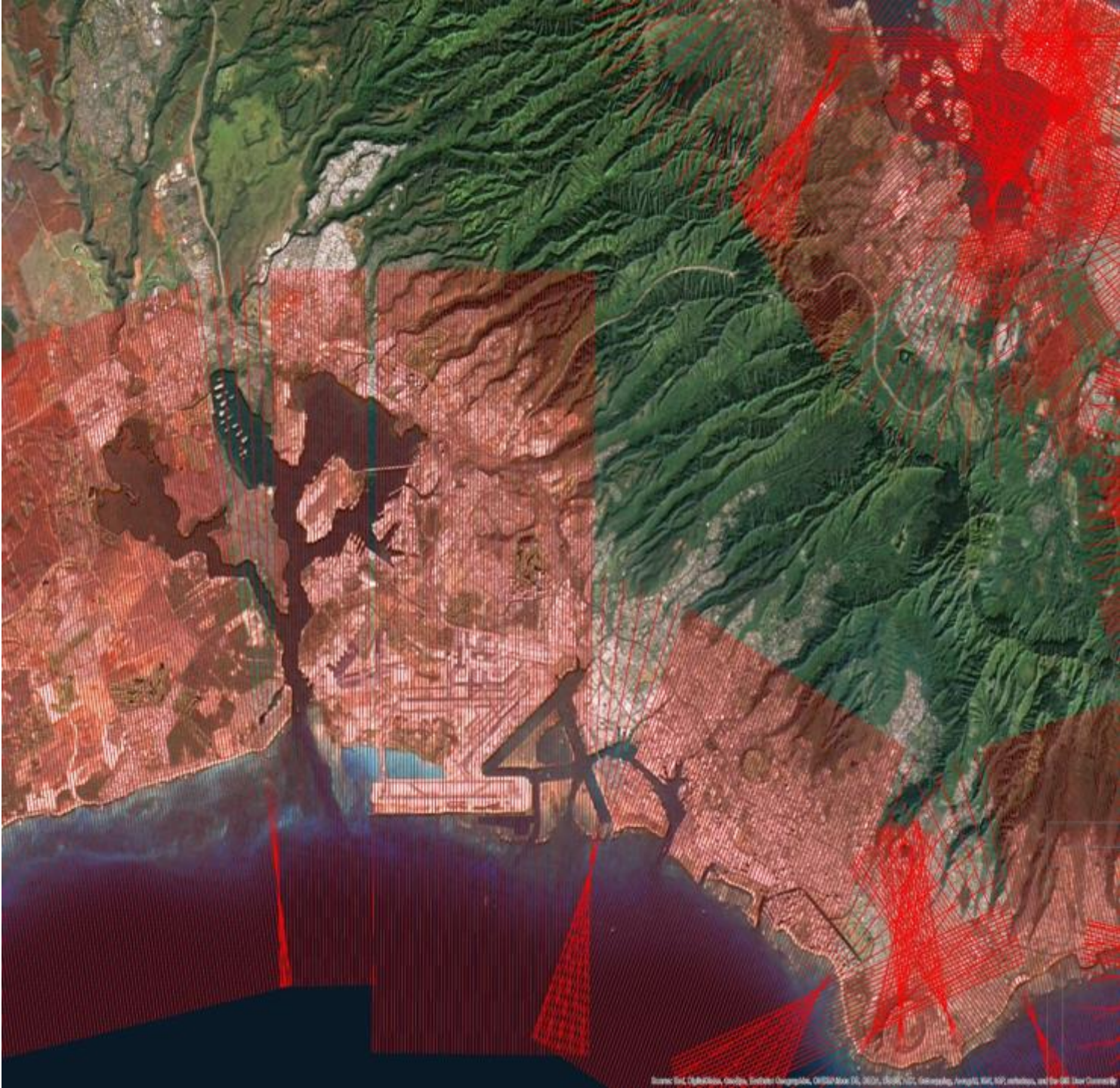


Assess risk reduction benefits

Propagation to nearshore using SWAN wave model and hybrid downscaling



Example of
spatial
resolution



CONSEQUENCES

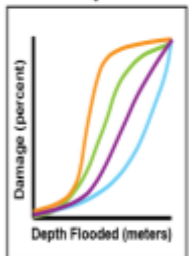
Assessing impact and benefits



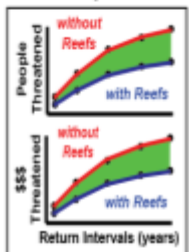
Map flood zones

Cells = [Cells w/o Reef] [Cells w/ Reef]
Area = [Area w/o Reef] [Area w/ Reef]
CENSUS data
People = [People w/o Reef] [People w/ Reef]
HAZUS data
Built = [Built w/o Reef] [Built w/ Reef]

Assess exposure



Economic damage



Assess risk reduction benefits

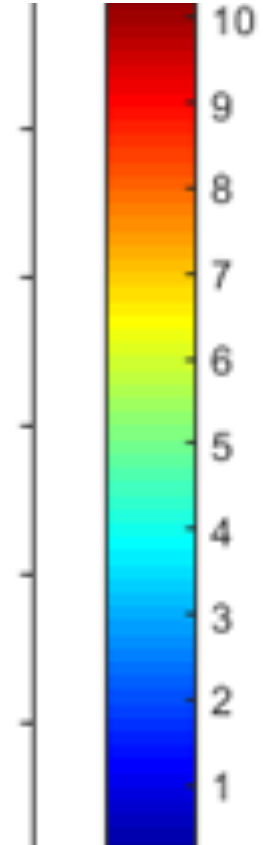


West Maui

1-in-10 year Floodplain with Reef

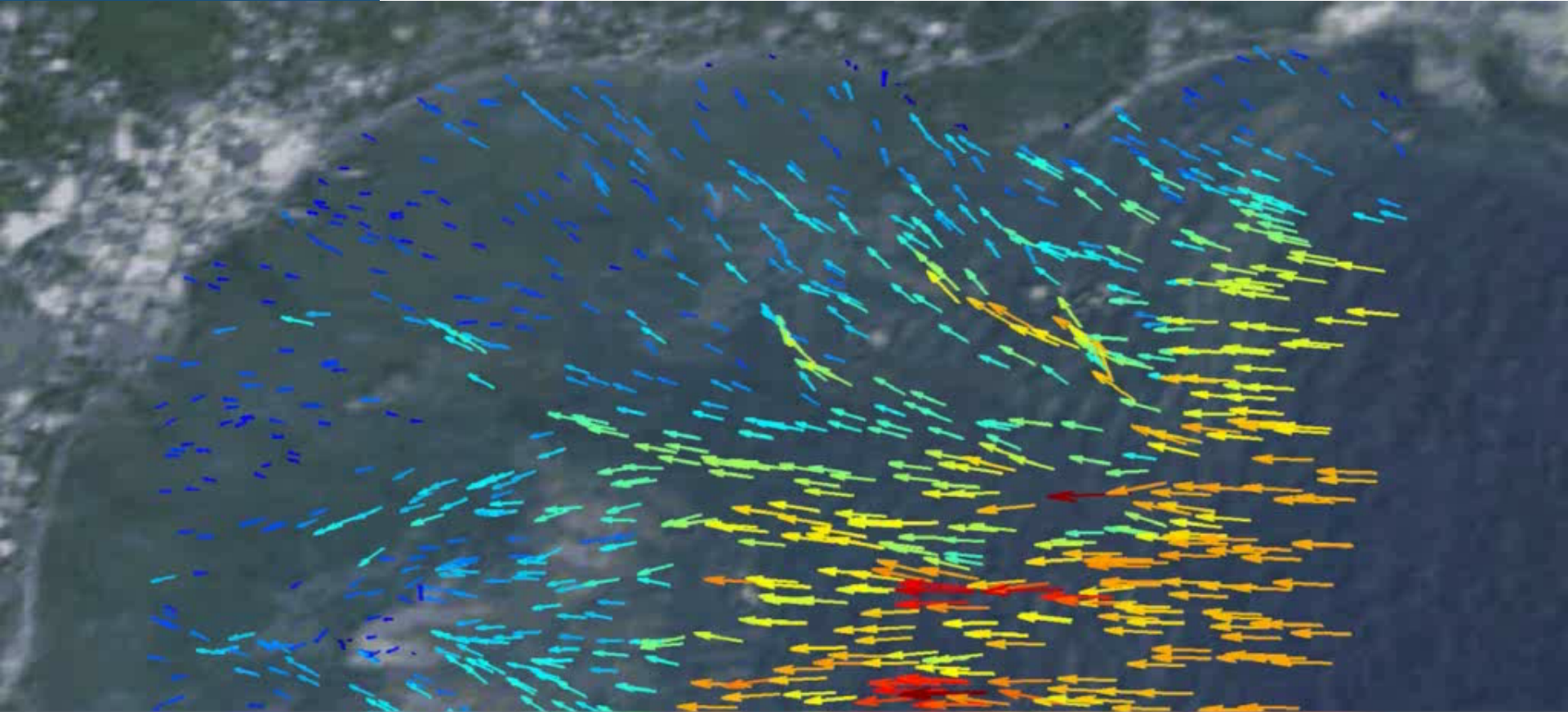


Feet



Global to Local Connection PILOT PROJECT: GRENVILLE BAY, GRENADA





Wave Height

The reef at low tide



01/21/2015

NOAA Reef Restoration: Puerto Rico Ship Grounding





COASTAL WETLANDS AND FLOOD DAMAGE REDUCTION

Using Risk Industry-based Models
to Assess Natural Defenses in the Northeast US

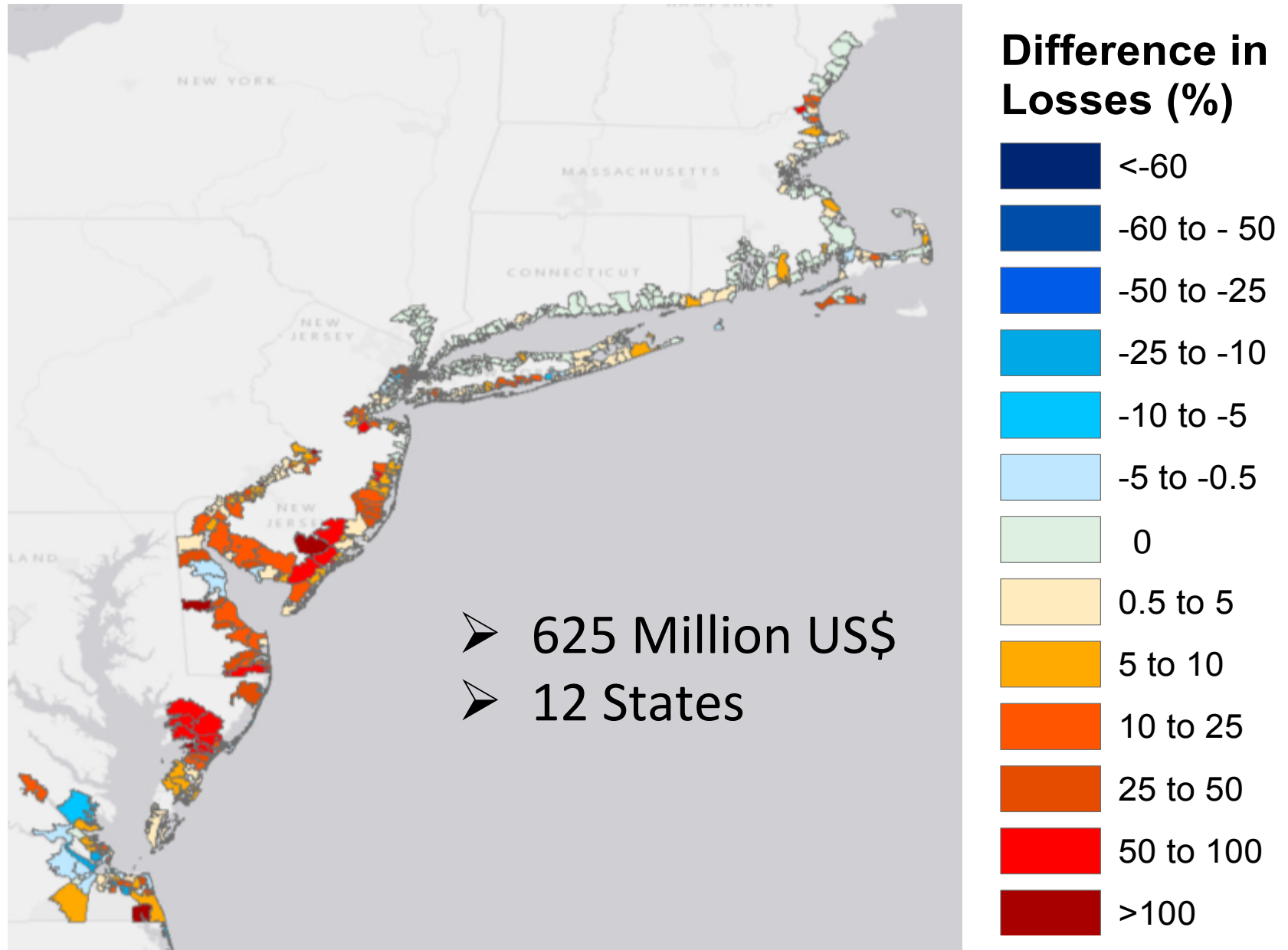


www.lloyds.com/coastalresilience



Wetland Effects on Property Damage Reduction during Hurricane Sandy

Difference in Flood Damages Between Wetland Scenarios



(Some) Implications and Opportunities

- **Include Nature in Industry Risk Models** – They often already are – but pooled.
- **Private incentives-** Insurance, Resilience Bonds
- **Public incentives-** Post disaster spending, FEMA community insurance
- **Prioritizing Natural Infrastructure in Policy** (DOT, ACoE)
- **Prioritizing Conservation, Restoration & Resilience Investments**

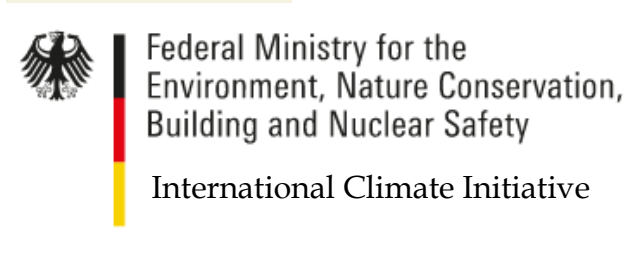


Summary

- Strong evidence that reefs and wetlands can reduce risks
- We can account for these benefits
- Conservation could be greatly expanded
- If we are willing to change some practices

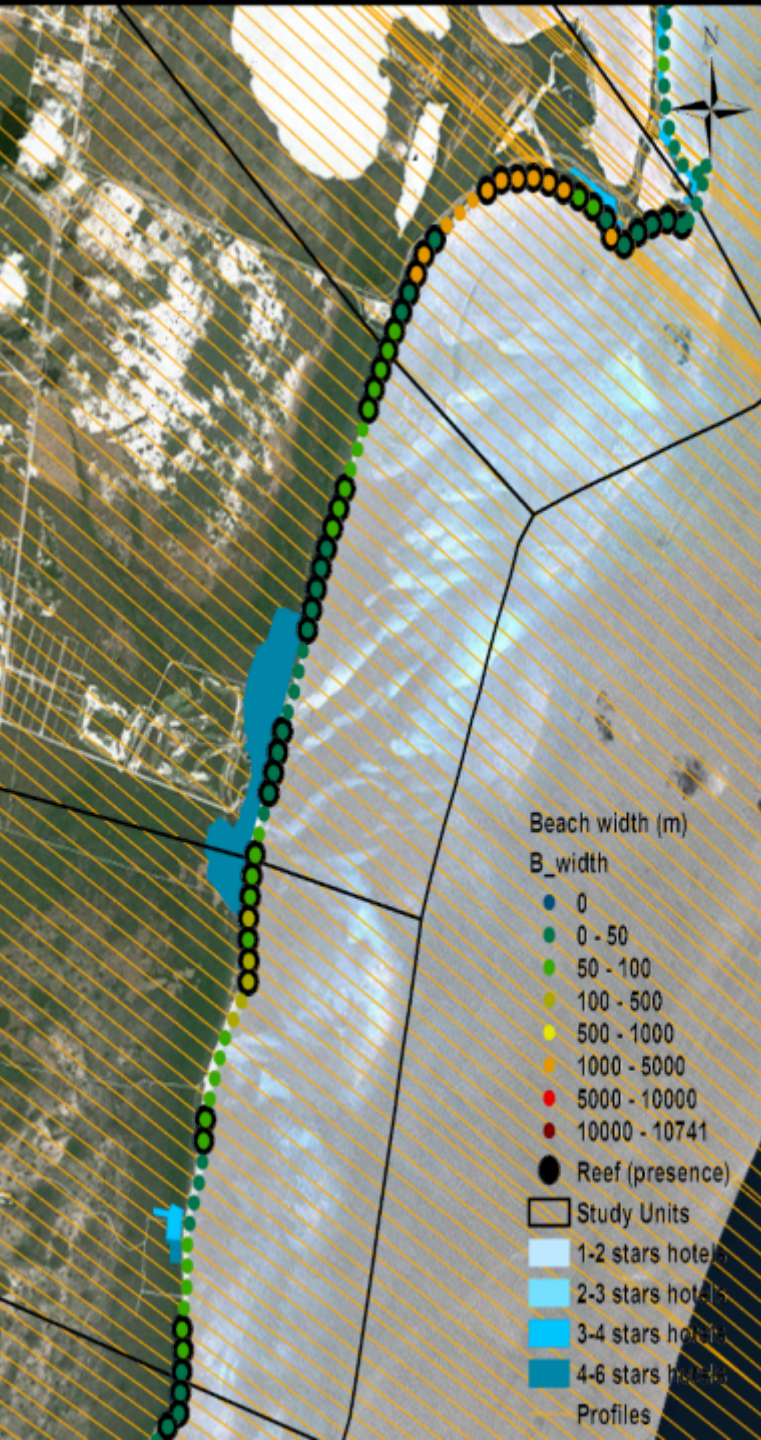


Thanks to the Funders

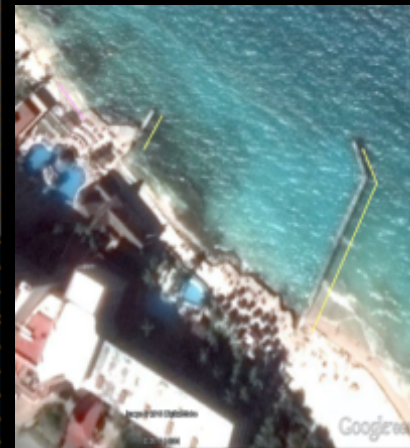


Every 200 m:

- Beach width
- Protected by reef or not
- Hotel presence



And coastal structures



Benefits of Reefs in Puerto Morelos

with reef

