Seascape Models Reveal Places to Focus Coral Reef Fisheries Management

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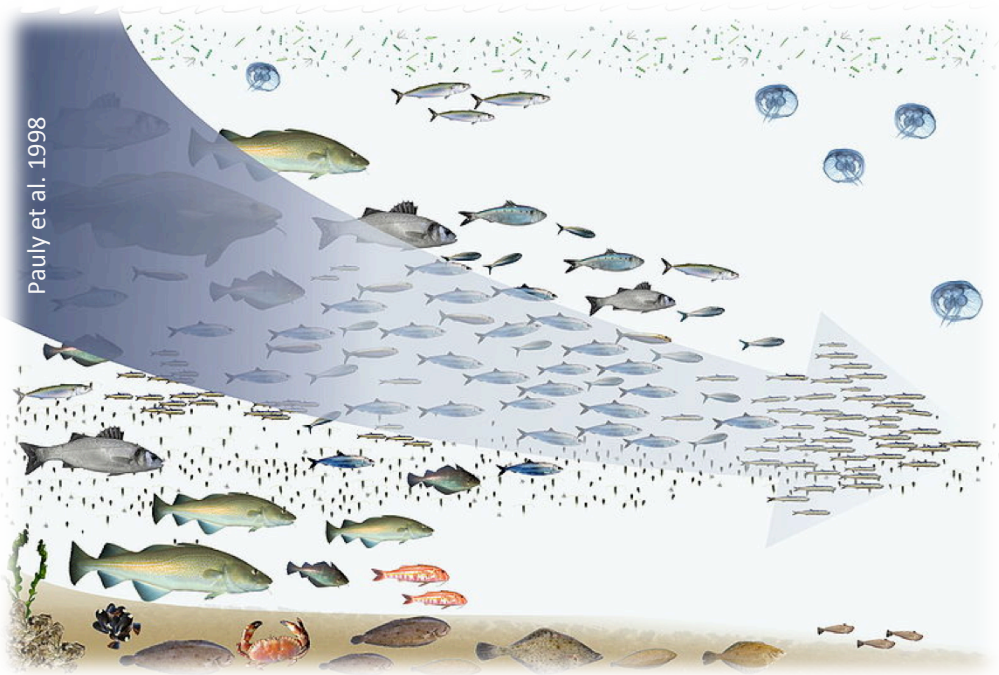
Fishing Pressure

Fish biomass removal

Alters reefs ecology:

- Distorts trophic structure (Friedlander et al. 2010, Friedlander & DeMartini 2002)



- Alters community composition (Myers & Worm 2003, Worm et al. 2008)

- Loss of functional groups & benefits (Bellwood 2004, Worm et al. 2008)

Habitat Conditions

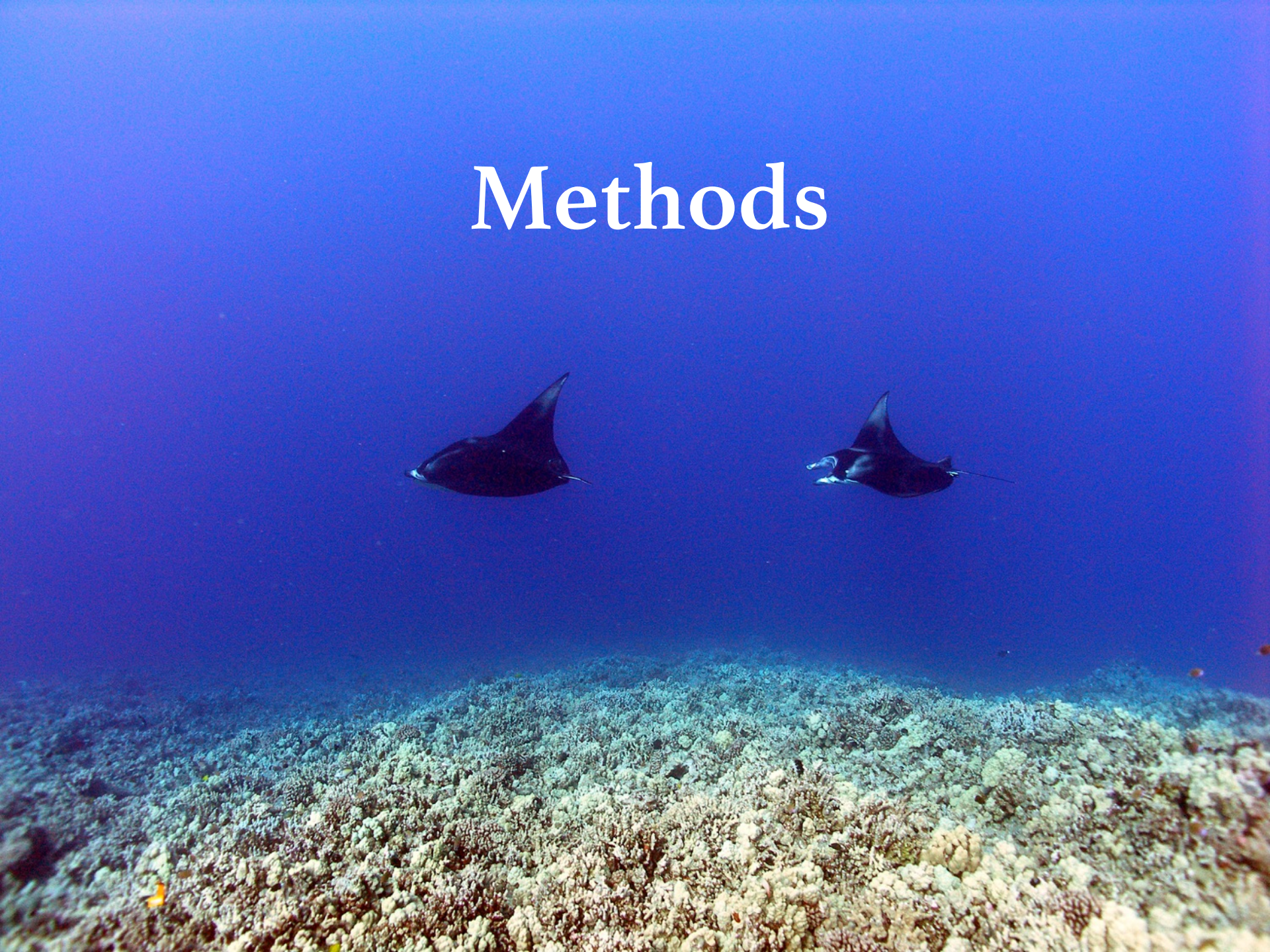
- Seafloor habitats and oceanography influence fish distributions
  - Reef structure, coral cover, waves, etc.
- Predict fish distributions based on habitat conditions
  - Combine fish surveys and remote sensing data w/ predictive modeling methods

Friedlander & Parrish 1998, Gust 2002, Kendall & Miller 2009, Pittman et al. 2009

Goals & Objectives

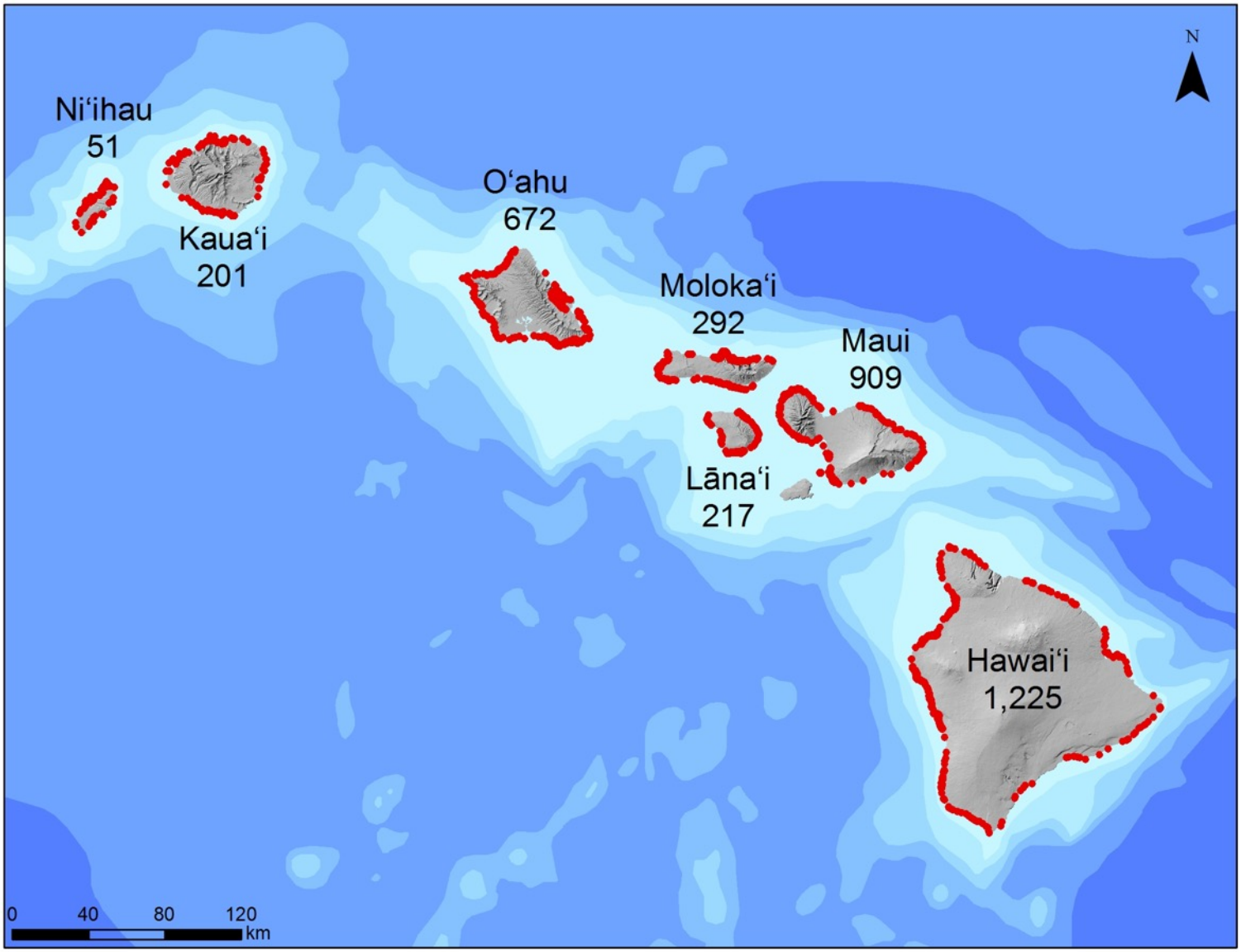
1. Map fishing pressure and habitats
2. Identify habitat conditions which support targeted reef fishes
3. Model recovery potential in the absence of fishing
4. Identify areas with the highest recovery potential to prioritize for management

Methods



Database

Friedlander et al. 2017



Hawaii Division of Aquatic Resources

Fisheries Ecology Research Lab

NOAA

The Nature Conservancy
Protecting nature. Preserving life.™

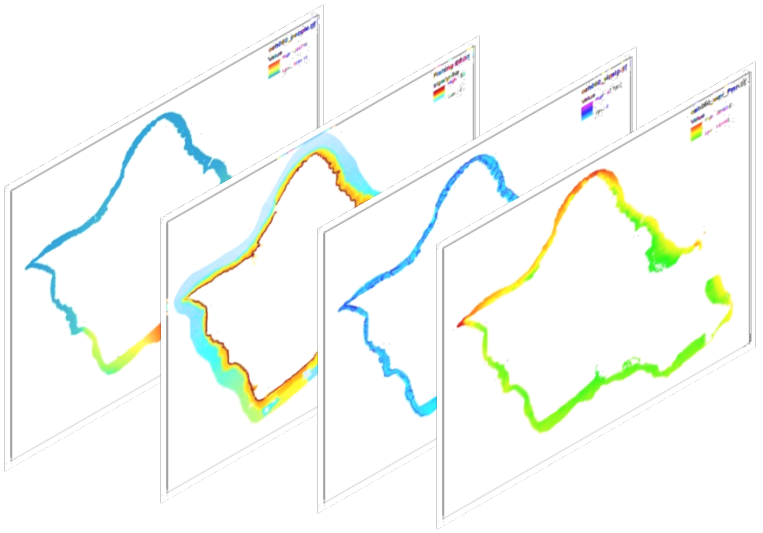
Coral Reef Assessment and Monitoring Program
Hawai'i

Modeling

- Targeted reef fishes
  - Biomass
  - Length

Dulvy & Reynolds 2002,
Dulvy et al. 2003,
Cheung et al. 2005

- Habitat conditions: 25 variables
  - Seafloor cover from habitat maps
  - Reef structure
  - Depth
  - Wave power
  - Distance to shore
  - Latitude, Longitude
  - **Fishing pressure**



Mapping Fishing Pressure

Issues and challenges in Hawaii:

- No fine scale information on near shore fishing

Data that does exist:

- Commercial report data (State)
- Non-commercial fishing effort surveys McCoy 2015
- MPA boundaries

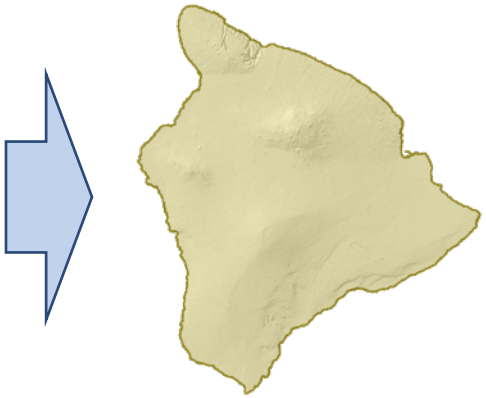
Shore Fishing

Non-commercial surveys:

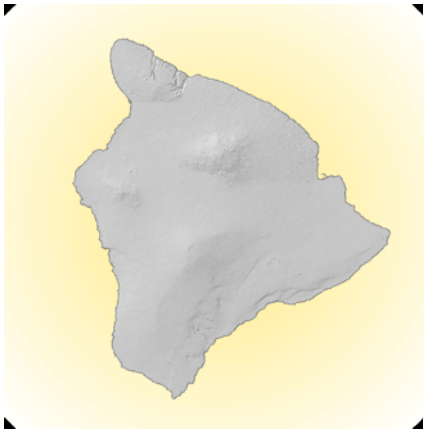
Average annual fishing effort (hrs/yr) for reef fish, by island from 2004 – 2013

Platform	Gear
Shore	Line
	Net
	Spear
Boat	Line
	Net
	Spear

Island scale estimates



Proxy Data



- Proximity to roads
- Shoreline Steepness
- Human population

Boat Fishing

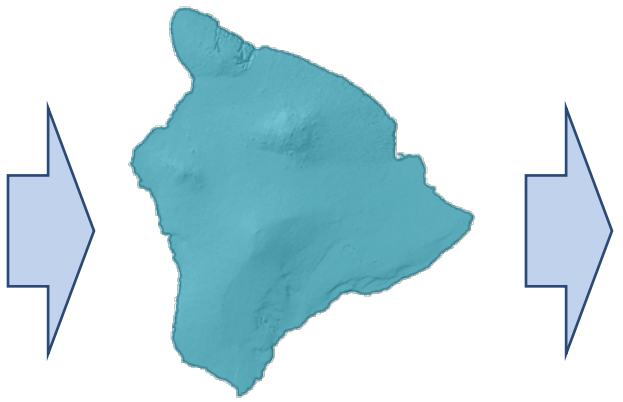
Average annual fishing effort (hrs/yr) for reef fish, by island from 2004 - 2013

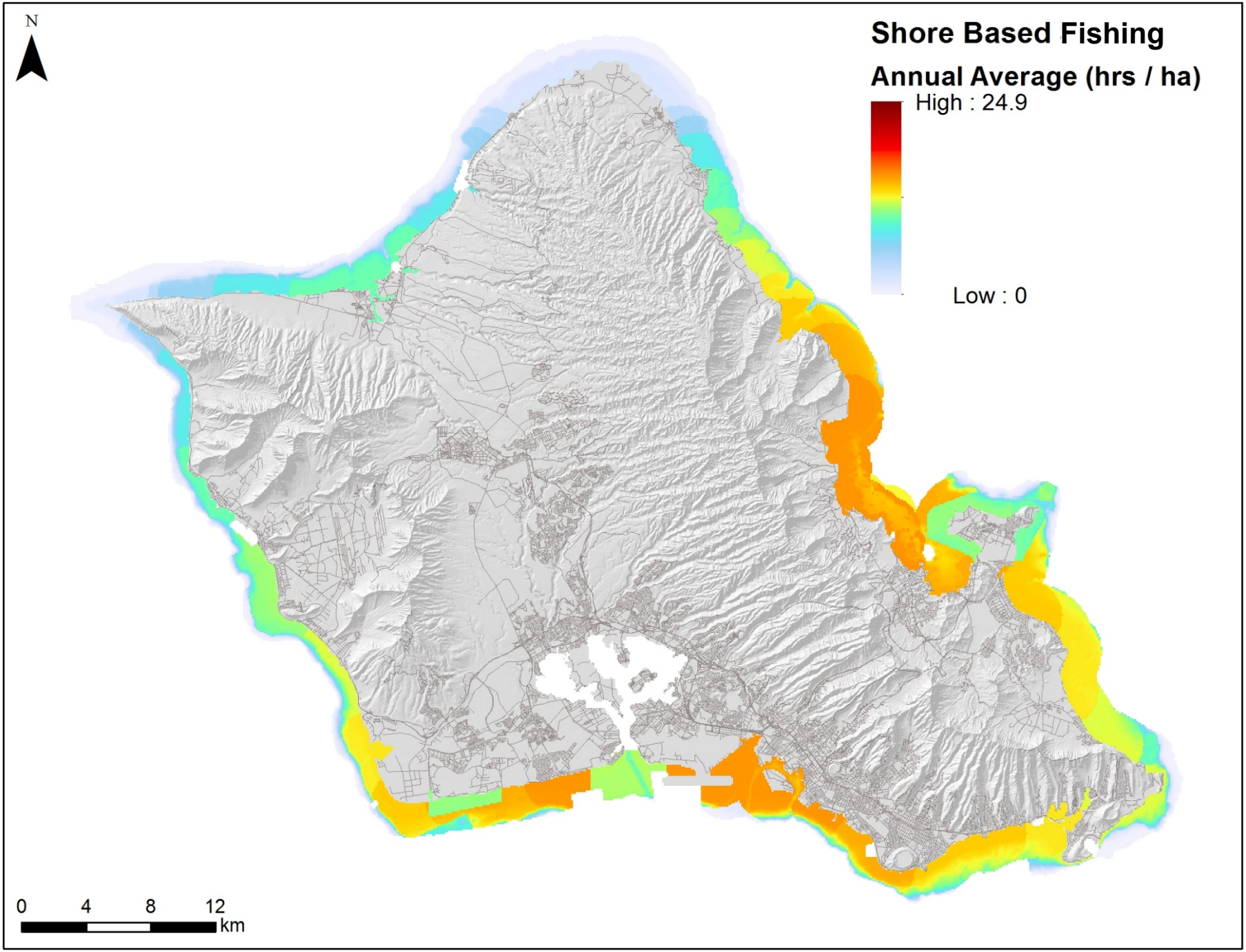
Platform	Gear
Shore	Line
	Net
	Spear
Boat	Line
	Net
	Spear

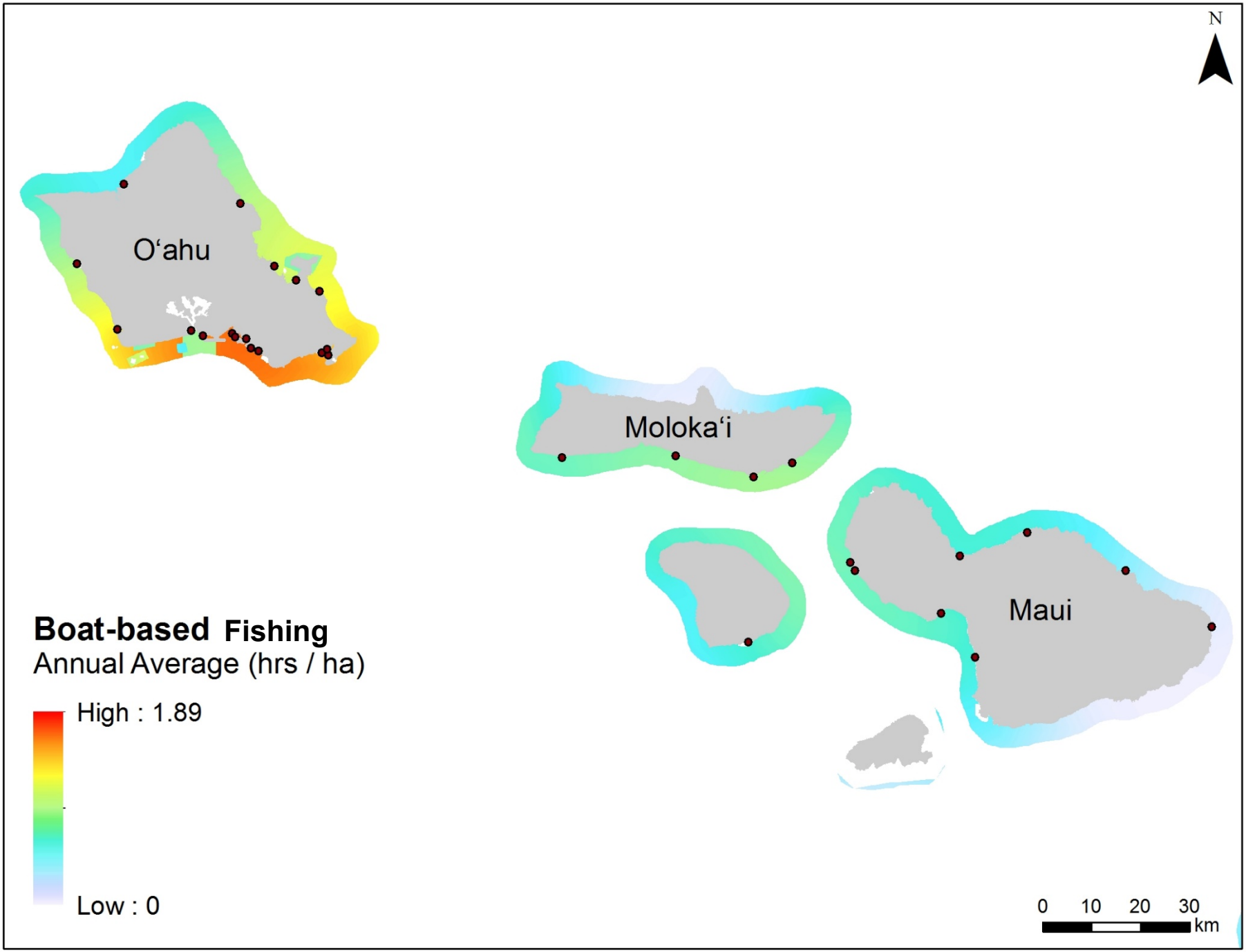
Island-scale estimates

Proxy Data

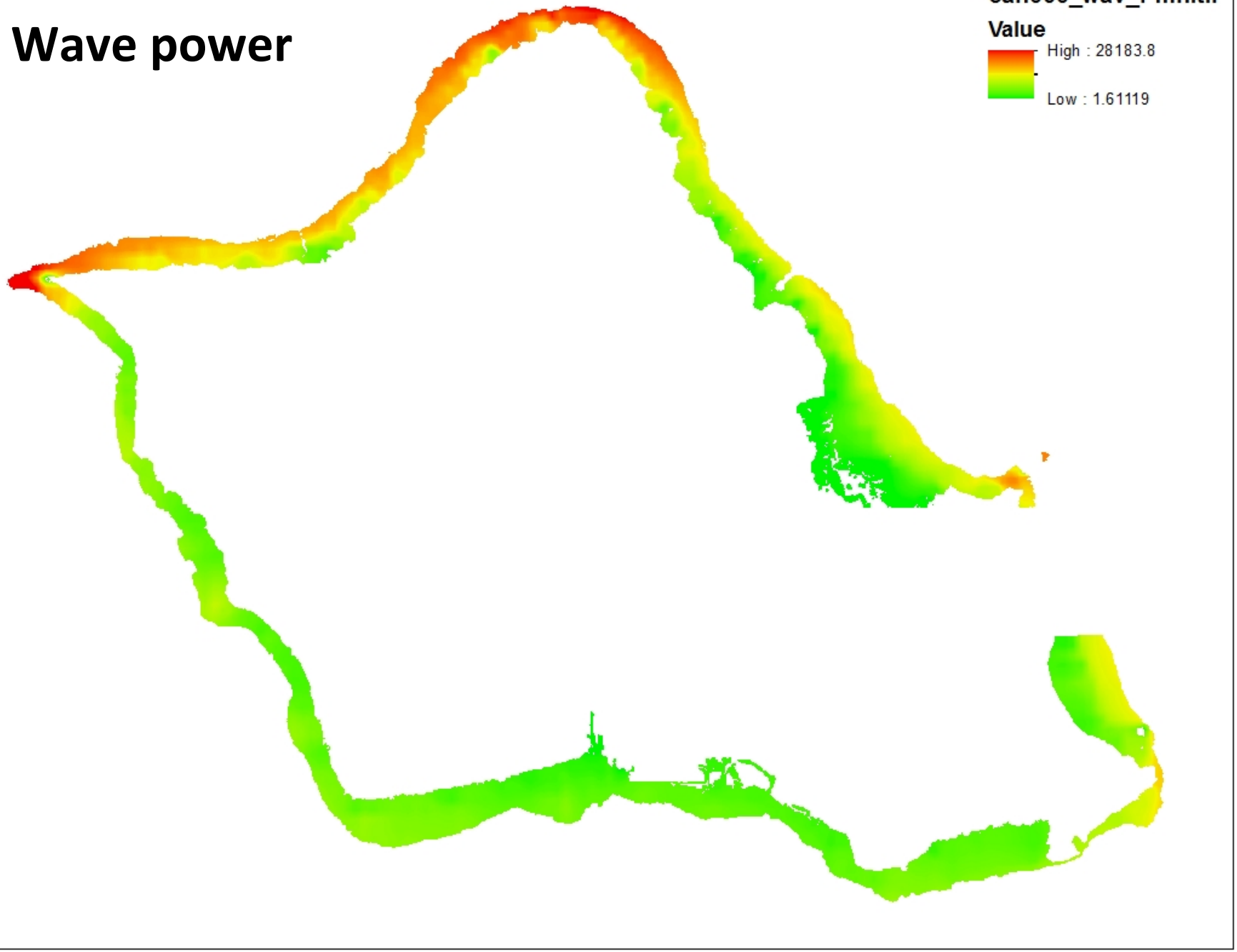
- Distance to Boat Launch/Harbor
- Human population



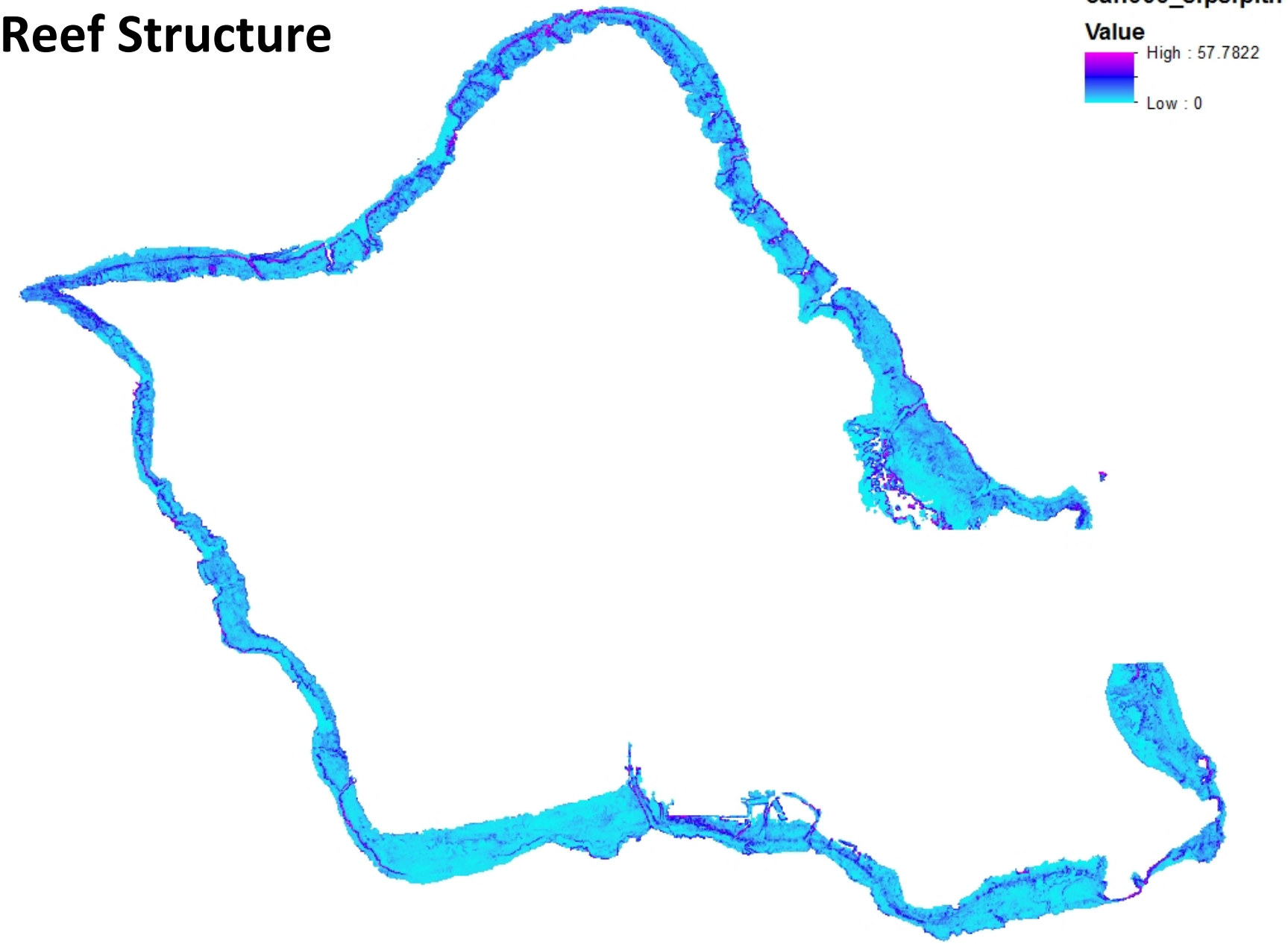

N
Shore Based Fishing
Annual Average (hrs / ha)
High : 24.9
Low : 0
0
4
8
12
km


N
O‘ahu
Moloka‘i
Maui
Boat-based Fishing
Annual Average (hrs / ha)
High : 1.89
Low : 0
0 10 20 30
km

Wave power

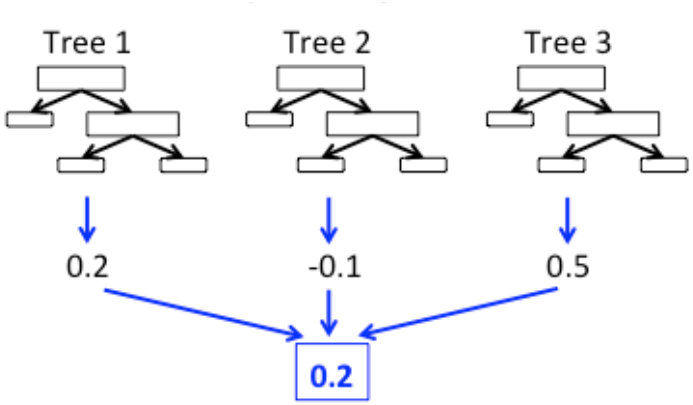


Reef Structure



Modeling Approach

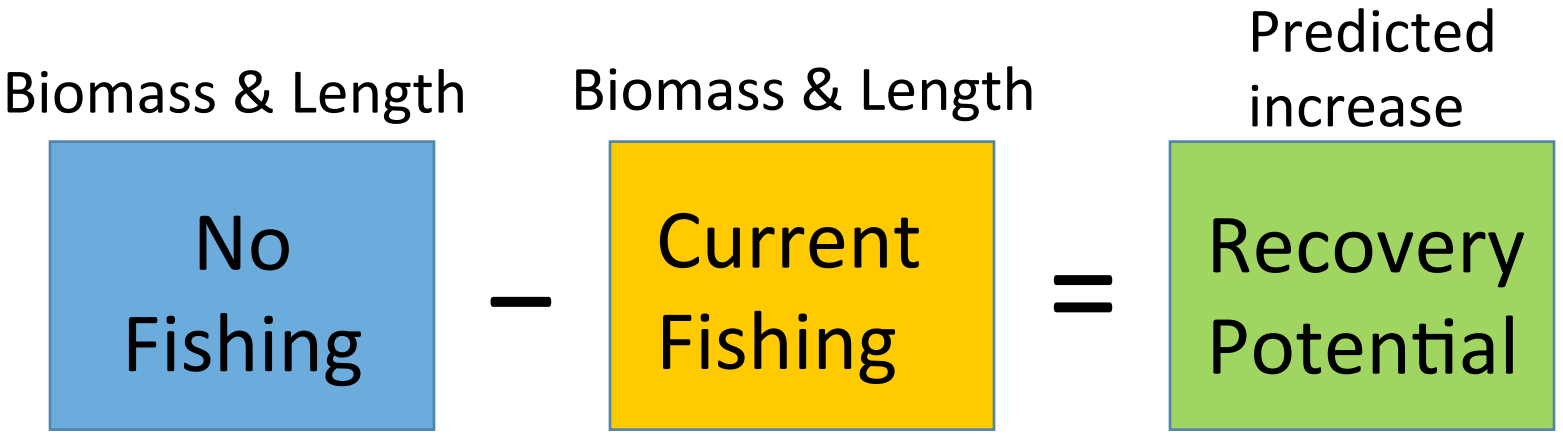
- Boosted Regression Trees (BRTs)



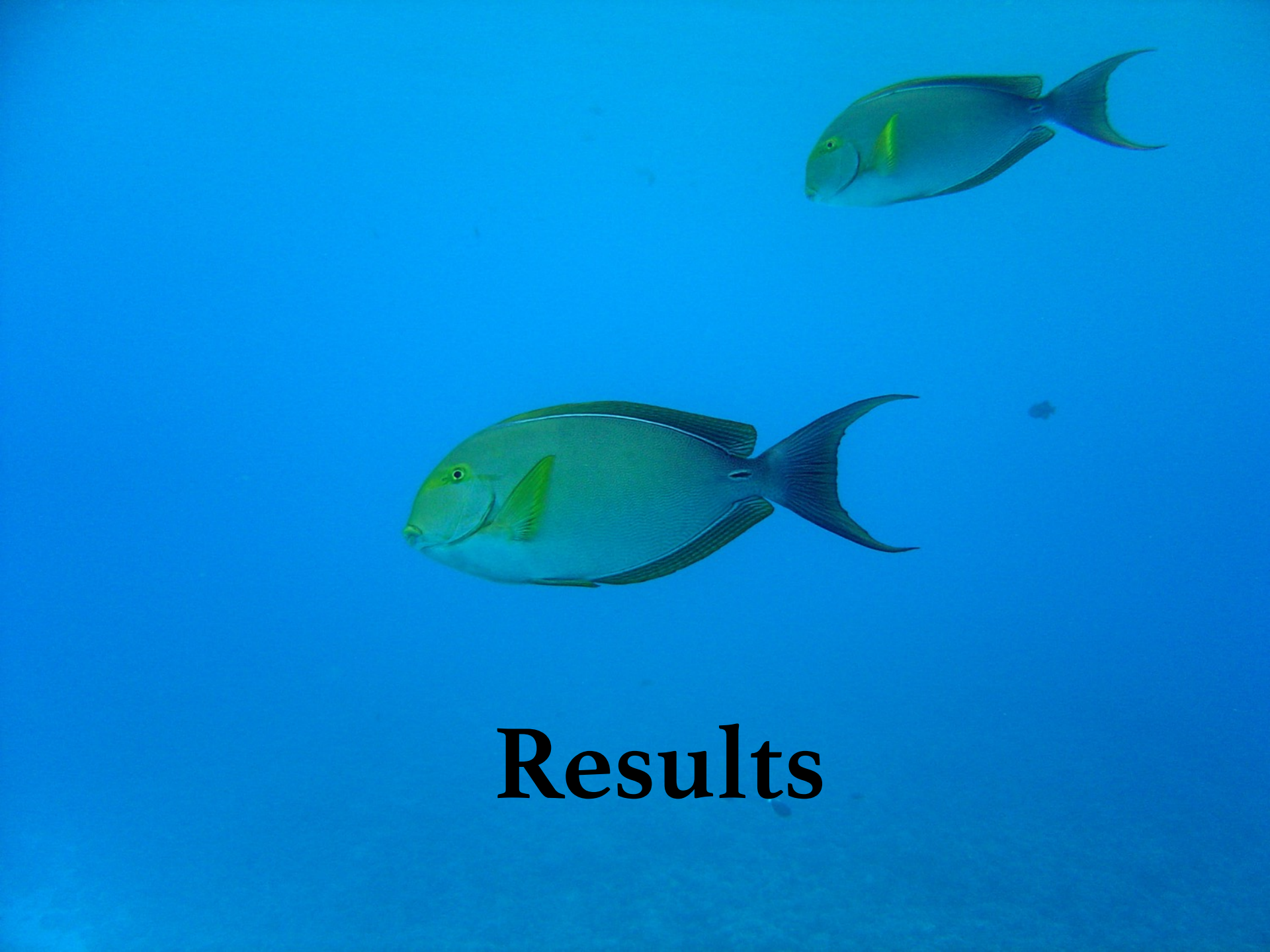
- Biomass and Length
  - Model: Fish ~ Habitat + Current Fishing Pressure
  - Scenario: Fish ~ Habitat + Zero Fishing Pressure

- Prediction - 60x60m resolution maps:

Recovery Potential & Priority Areas



- Areas with highest recovery potential (significant increase in biomass or length) were selected to represent priority areas



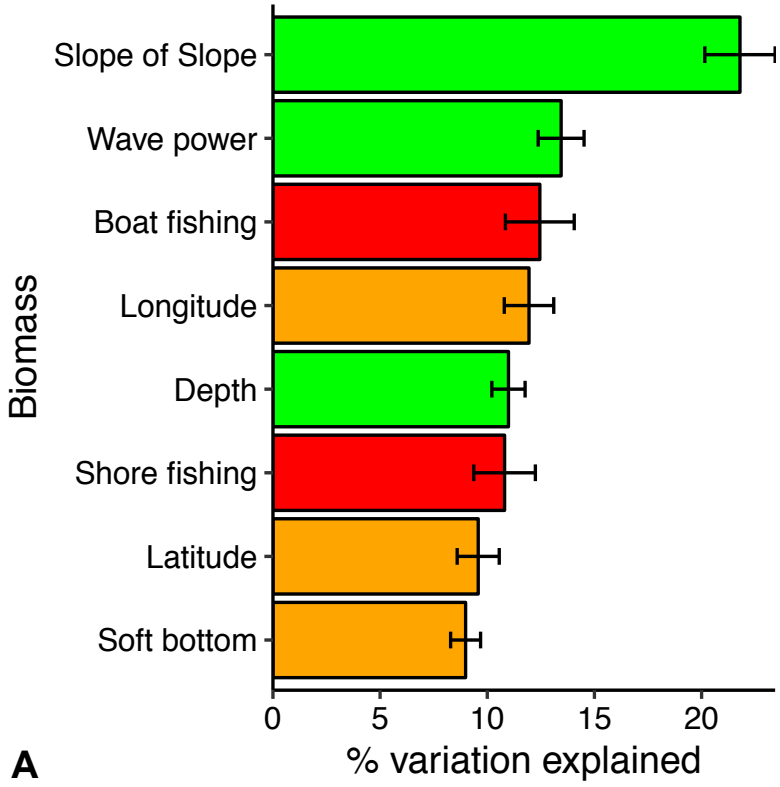
Results

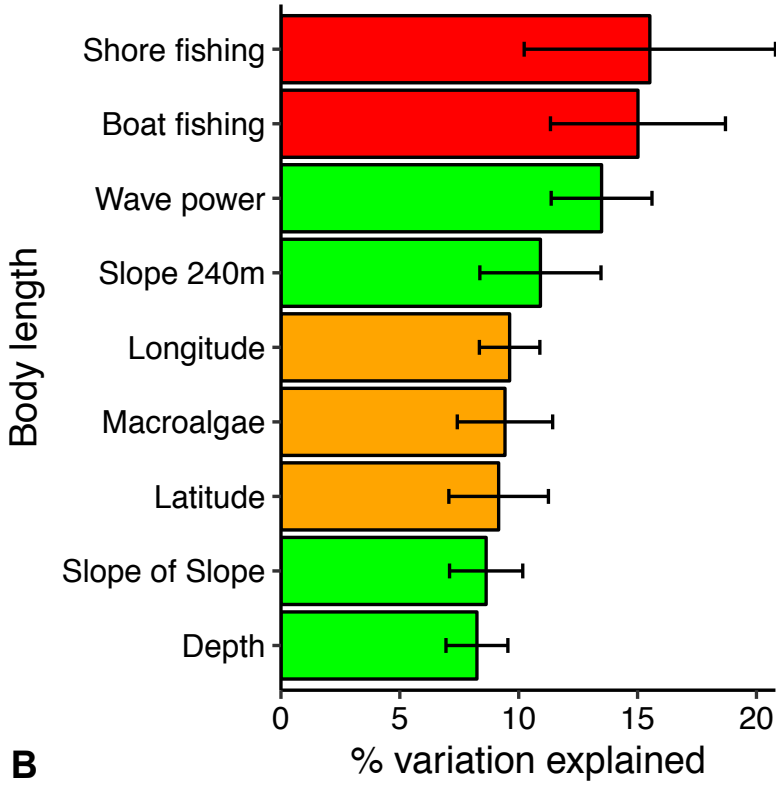
Model Performance

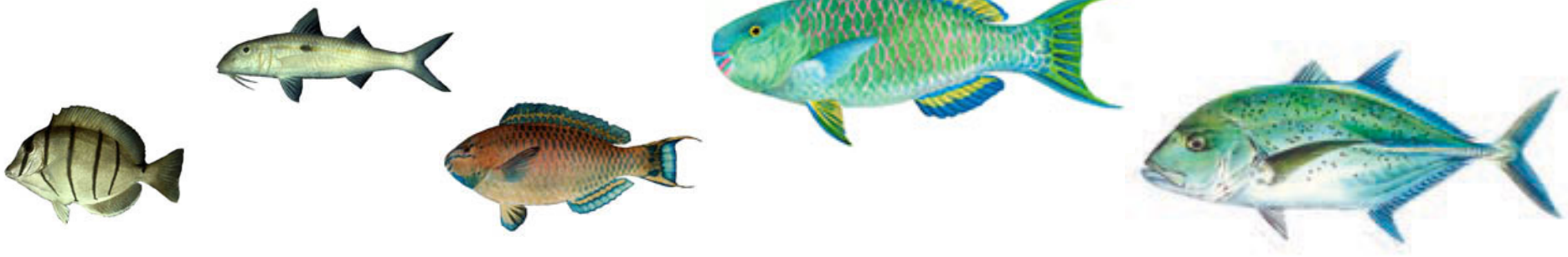
- **Current fishing pressure**
- **Biomass**
  - 61% variability explained
- **Length**
  - 41% variability explained

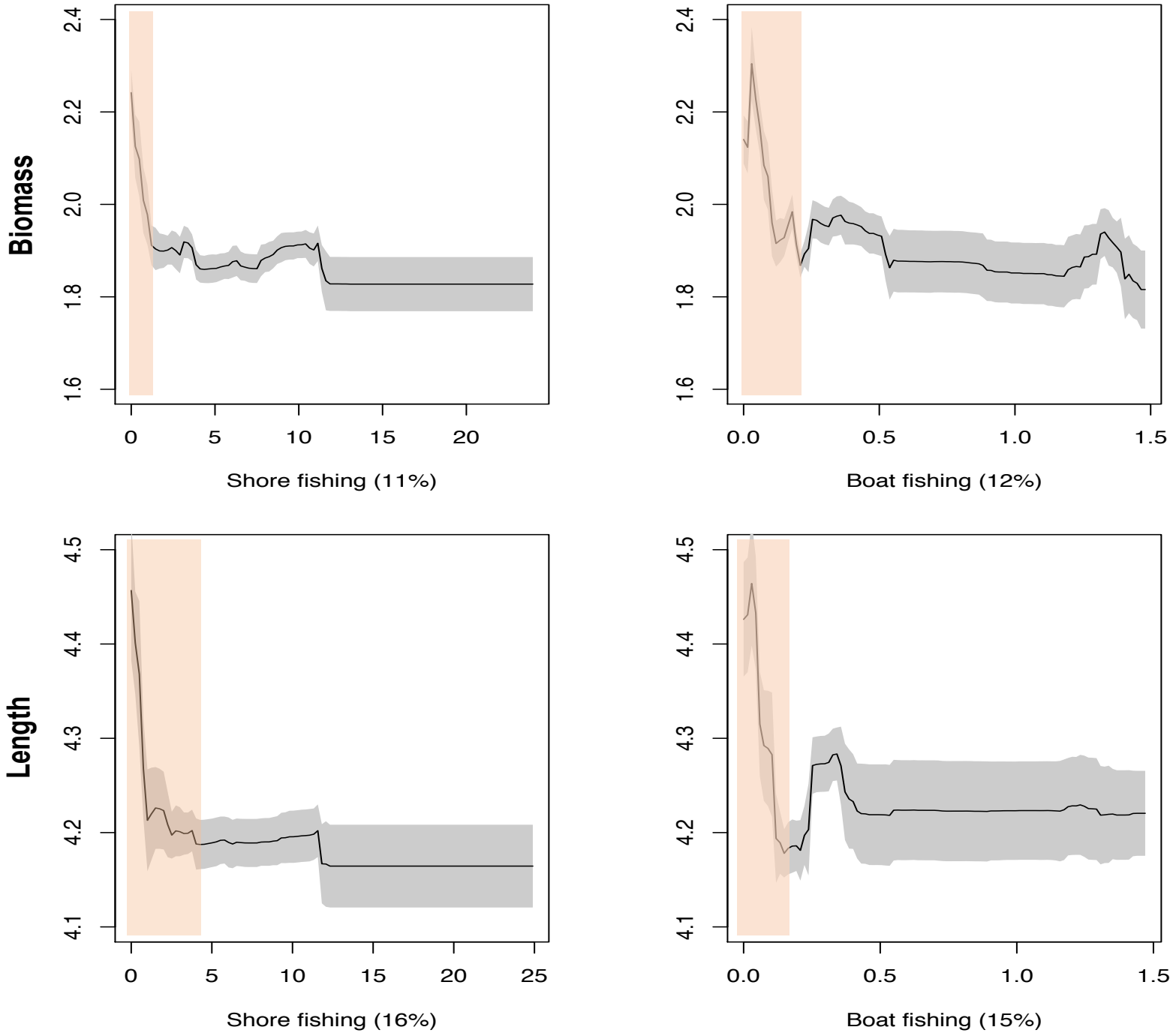
- Key variables:
  - Fishing pressure
  - Reef structure
  - Wave power
  - Depth

Biomass & Length Models

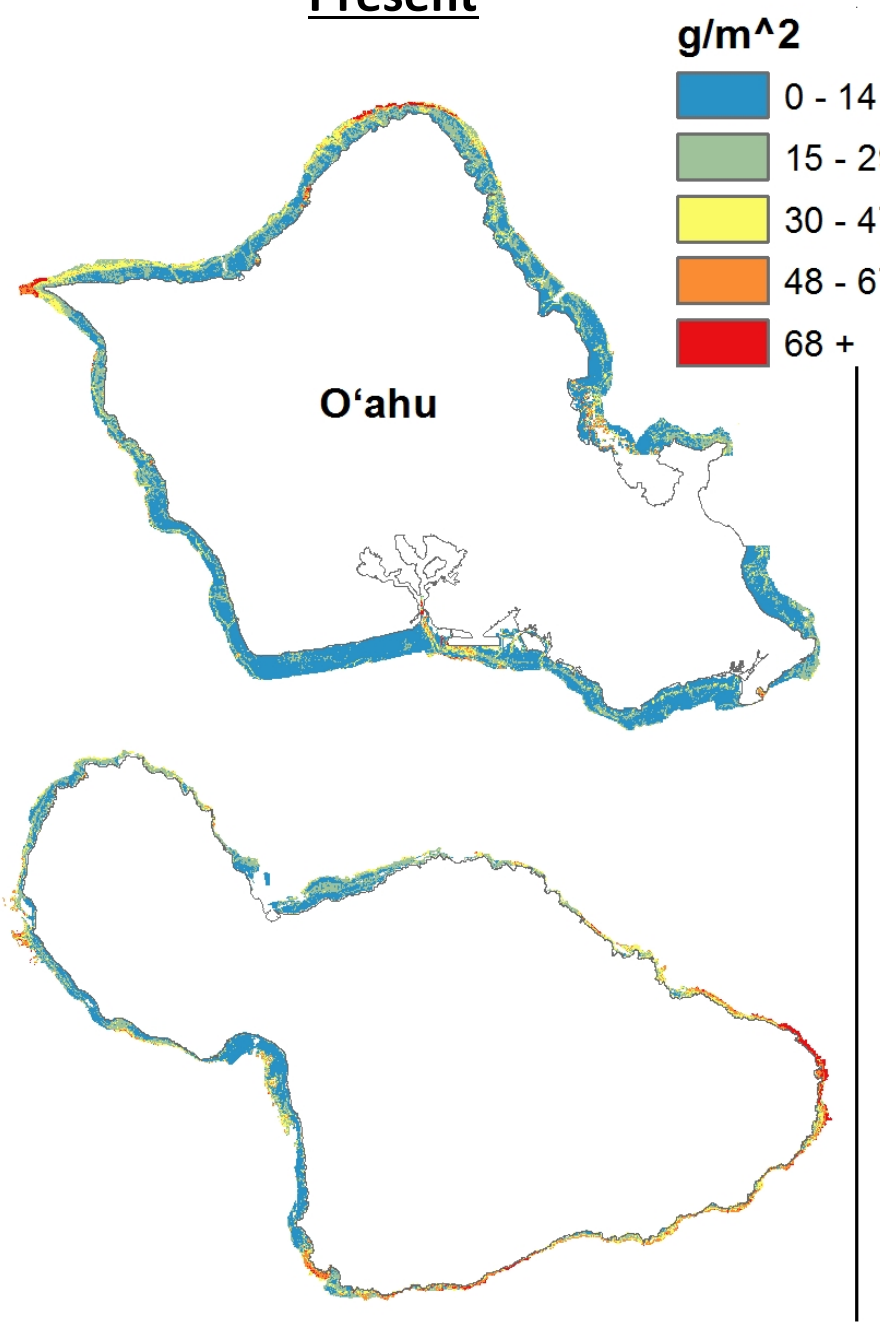






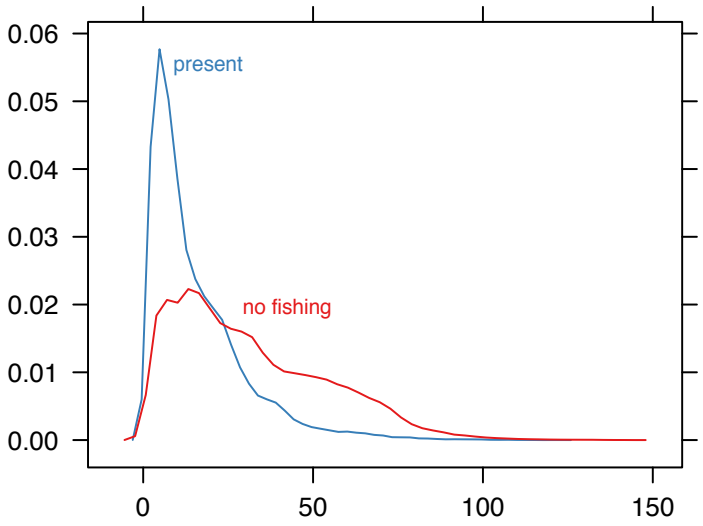

Biomass
Length
Shore fishing (11%)
Boat fishing (12%)
Shore fishing (16%)
Boat fishing (15%)

Present

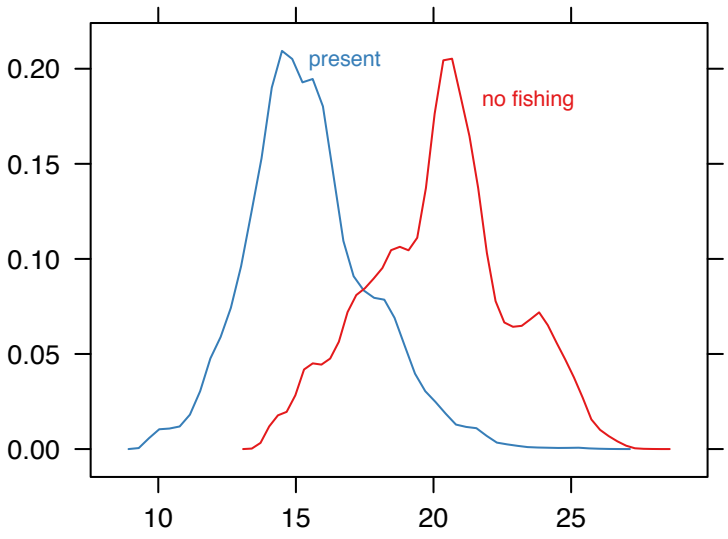


No Fishing

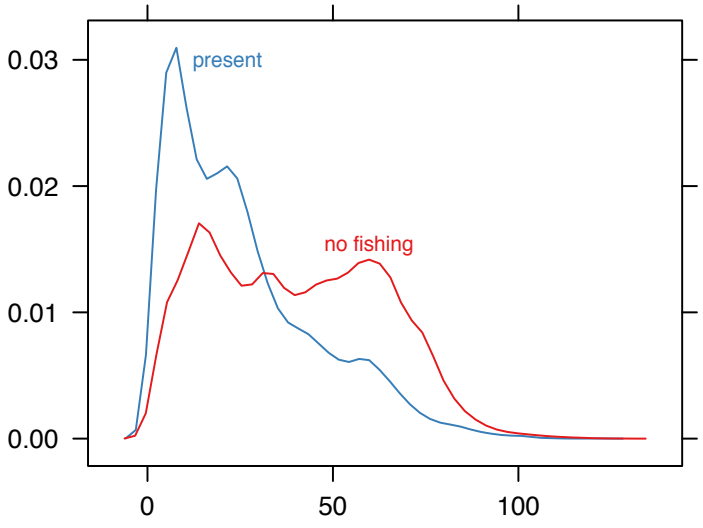
O‘ahu



O‘ahu

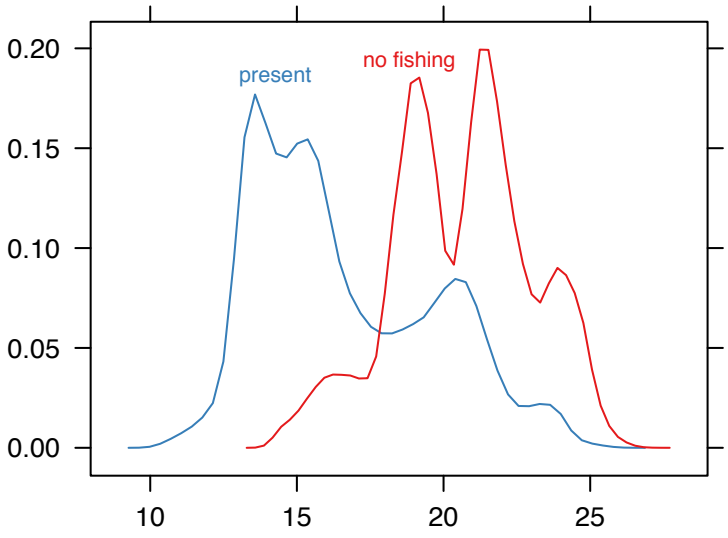


Maui



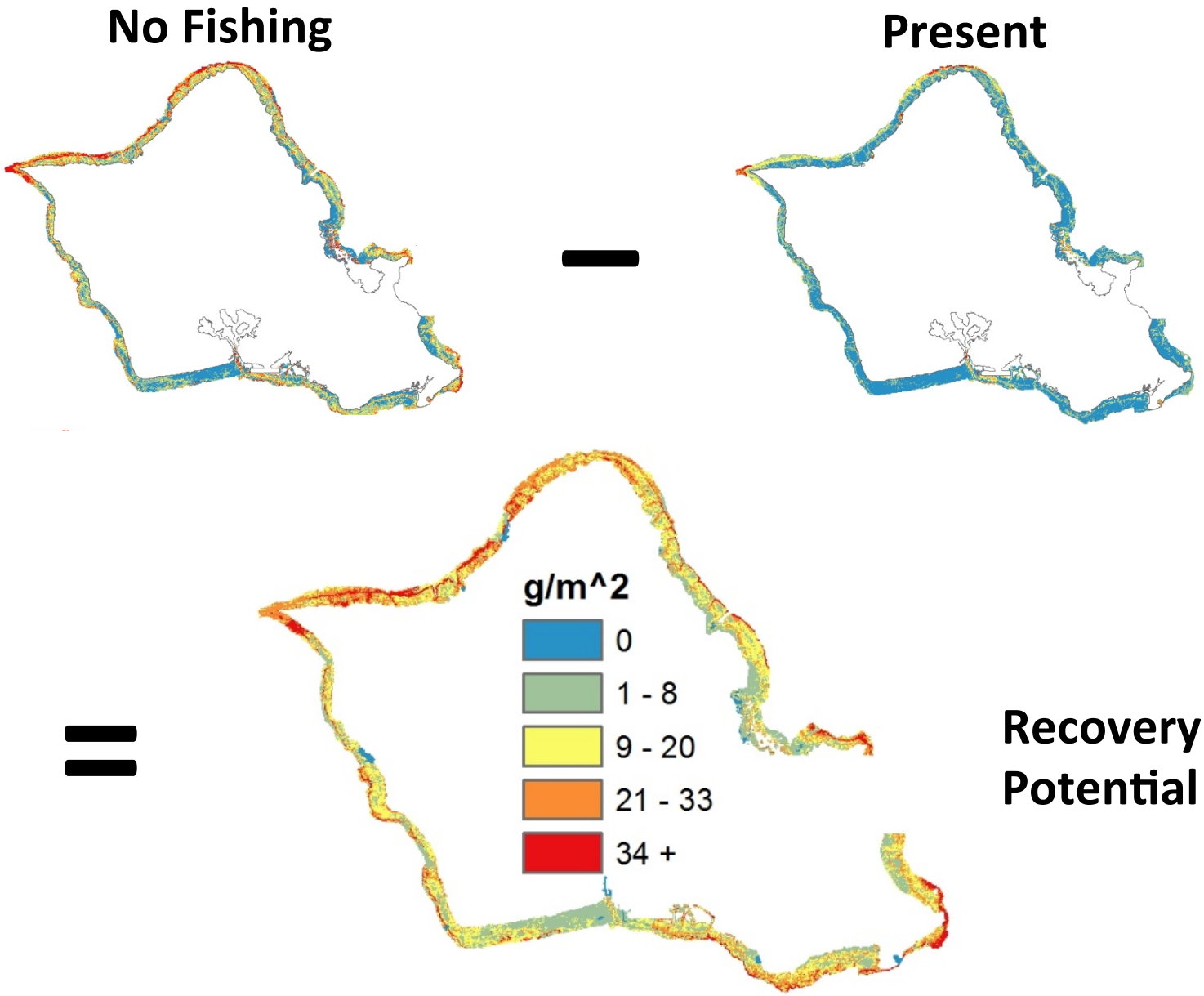
Biomass (g/m²)

Maui

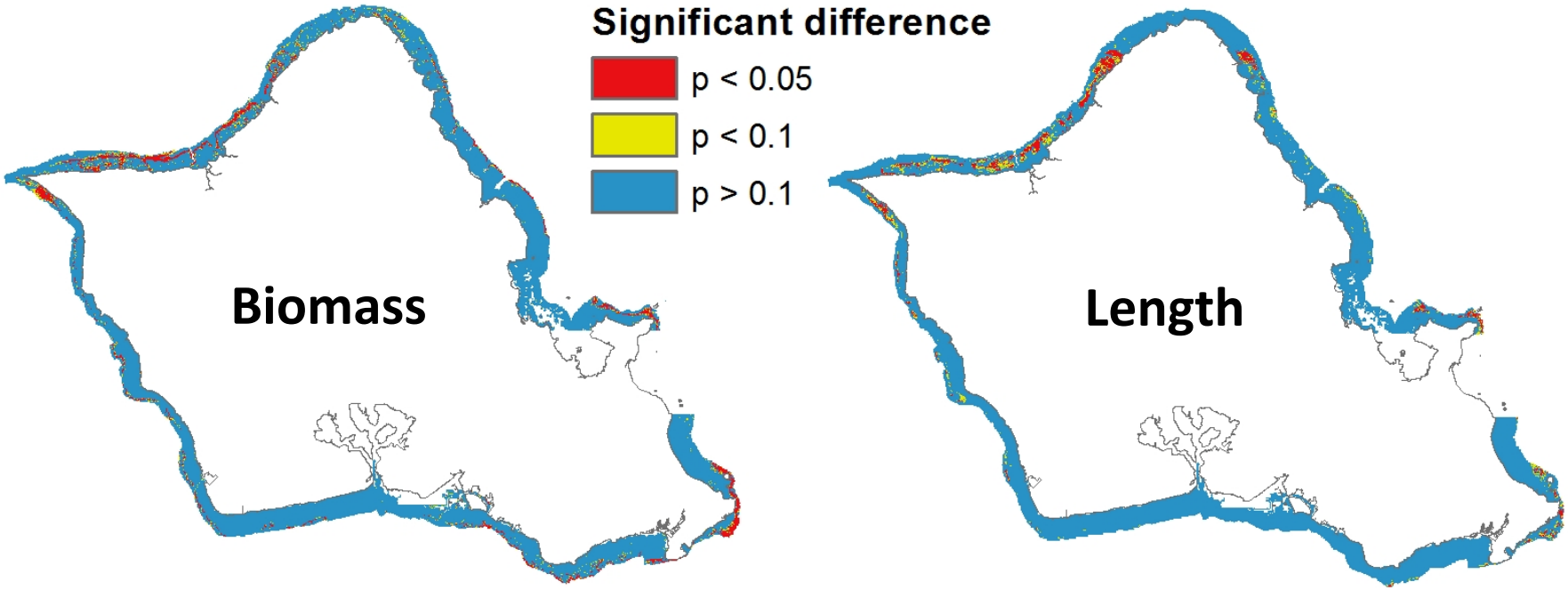


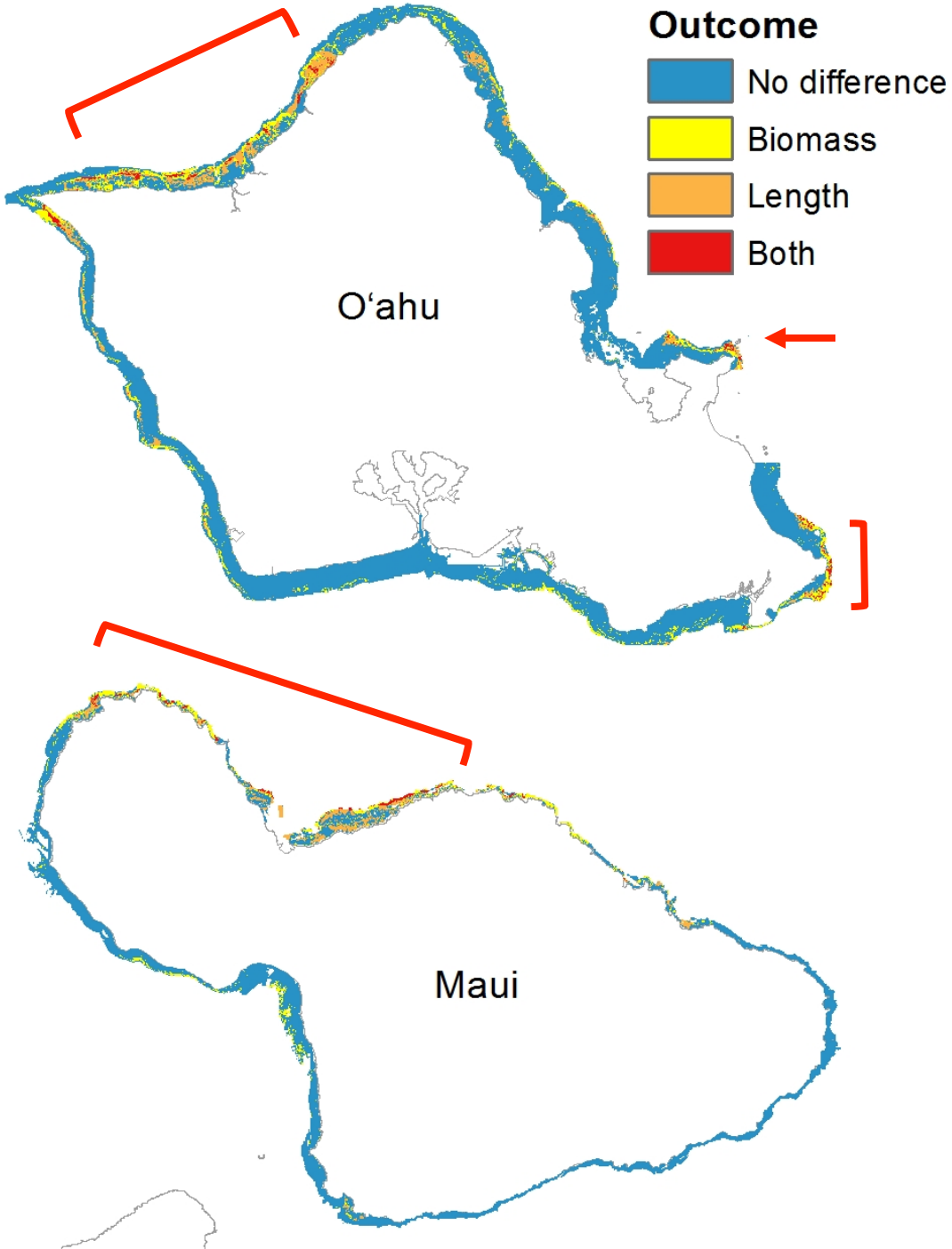
Length (cm)

Recovery Potential



Management Prioritization





- Areas located on North shores – high wave exposure
- Oahu:
  - Biomass +88%
  - Length +42%
- Maui:
  - Biomass +82%
  - Length +40%

Summary…

- Low levels of fishing pressure have large impacts on targeted fish populations
- High reef structure, high wave power, and deeper waters are key habitat conditions
- Currently targeted fish found in areas far from humans
- With fishing removed they become more widely dispersed among key habitats

Management Implications

- Maps under current fishing levels show areas with healthy fish populations
- Maps with fishing pressure removed identify key habitats
- Combining both maps identifies areas with the highest recovery potential
- These areas can be used as starting points for marine reserve selection
- Hawaii 30 x 30 initiative

Vinaka!

- NOAA Biogeography Branch
- Co-authors
- FERL Lab
- Data providers

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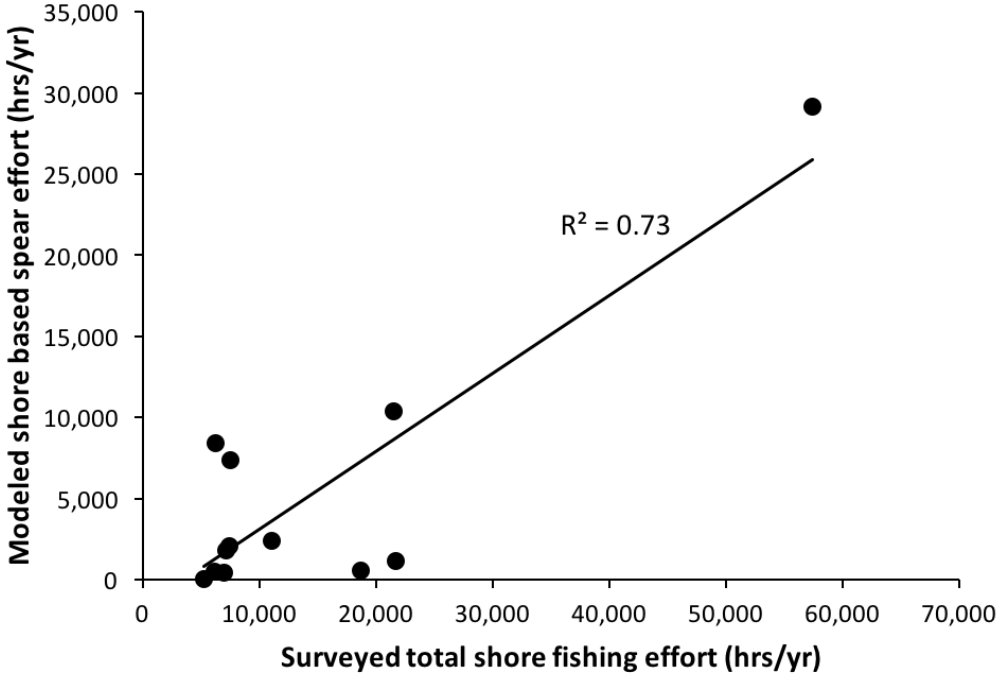
Modeled shore based spear effort (hrs/yr)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
R² = 0.73
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
Surveyed total shore fishing effort (hrs/yr)