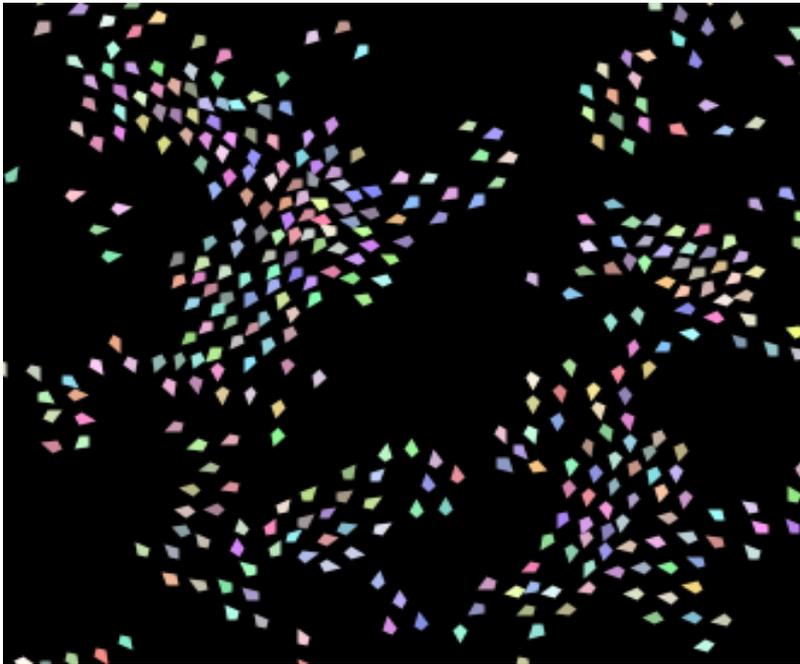


# Are Agent-Based Approaches the Future of Fishery Management?

*The Poseidon Model & ABMs as Assessment Tools*



Steven Saul and Katyana Vert-Pre



POSEIDON



Ocean Conservancy®

**ASU** ARIZONA STATE UNIVERSITY

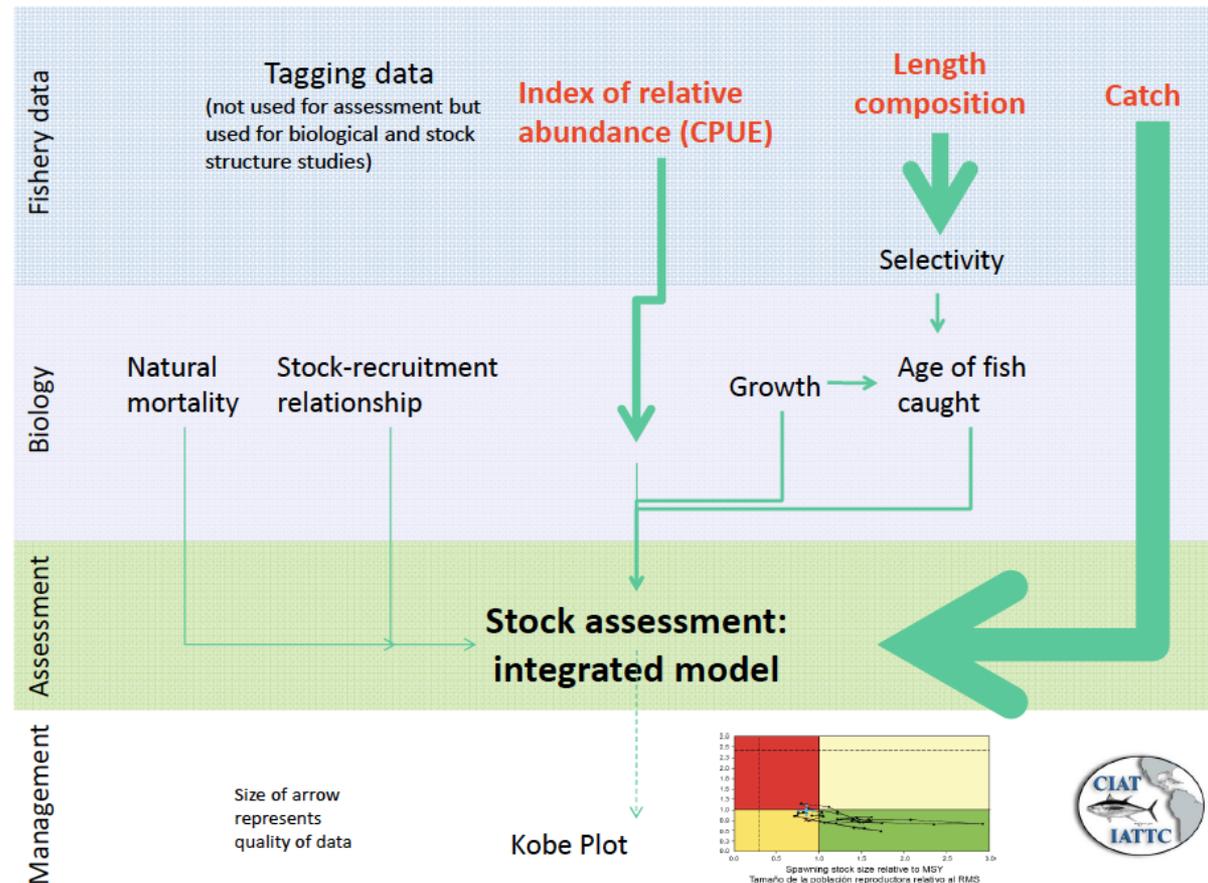
# Objectives

- Agent-based models for fisheries management and assessment.
- The Poseidon model and applications (Eastern Pacific Tuna and Indonesia fisheries management)
- Agent-based models to test stock assessment assumptions: application to Gulf of Mexico reef fish
- Agent-based models as stock assessment infrastructure?
- Pros and cons of ABMs in fisheries

# Agent-Based Models and Fisheries

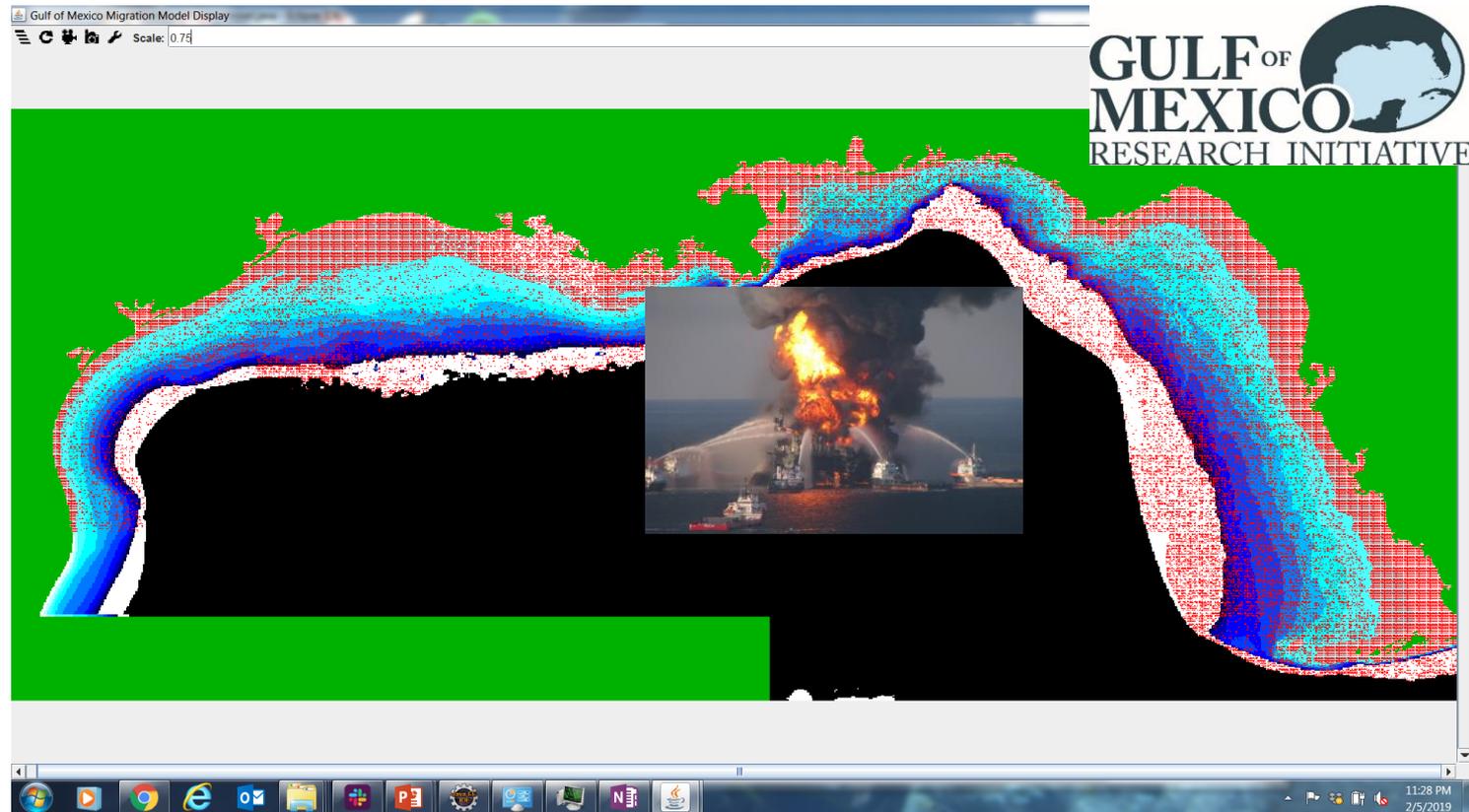
- ABMs can be inserted into any step in the process to improve the quality of an assessment and explore management.

*“What I cannot create, I do not understand.”  
-Richard Feynman.*



# ABM Applications in Fisheries

- Topic specific studies (i.e. turtle bycatch)
- Human-natural coupling in fisheries
- Socioeconomic research (community resilience)
- Management exploration (i.e. DISPLACE)



# Poseidon

POSEIDON is a coupled **agent-based fleet and ecosystem model**, an improved operating model for management strategy evaluations and similar studies.

- Simulates vessel behavior and fishery outcomes
- Uses machine learning and analytical tools to determine the "best" policies, indicators, and management levers
- Emphasizes the human and spatial dimension

P Process based

O Ocean system

S Simulator for

E Evolving

I Integrated

D Domains and

O Operational

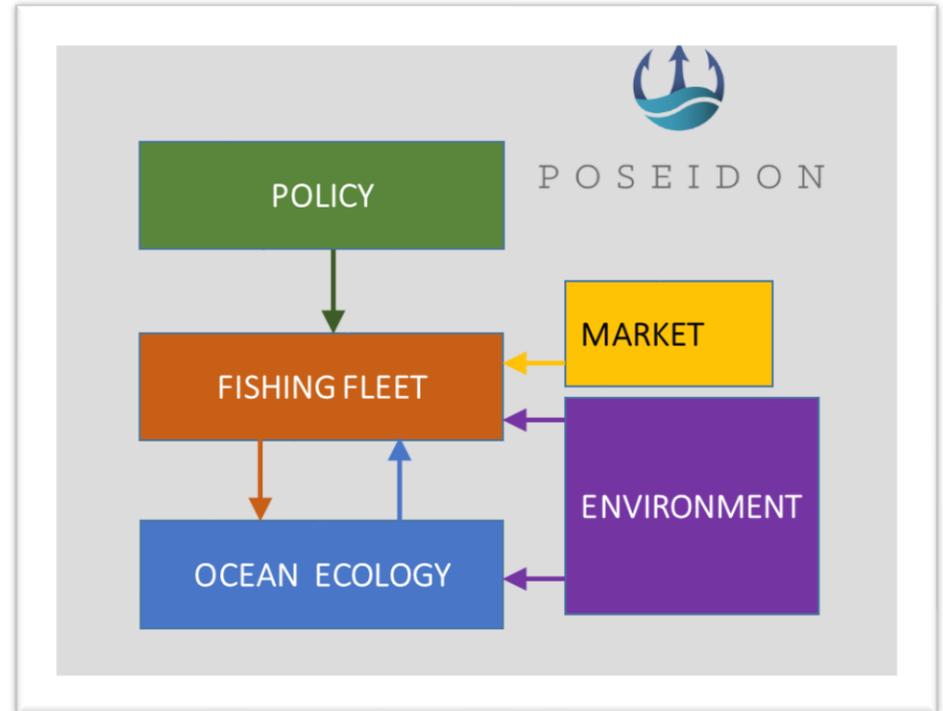
N Needs

# Poseidon Applications



# Poseidon

- Looks at the impact of market forces, governance systems, and enforcement capacity.
- Study fisher behavior to improve the agent behavior algorithms, understand fisher behaviors and motivations, and how they respond to policy.
- Understand how fish population dynamics respond to the above.



# Poseidon

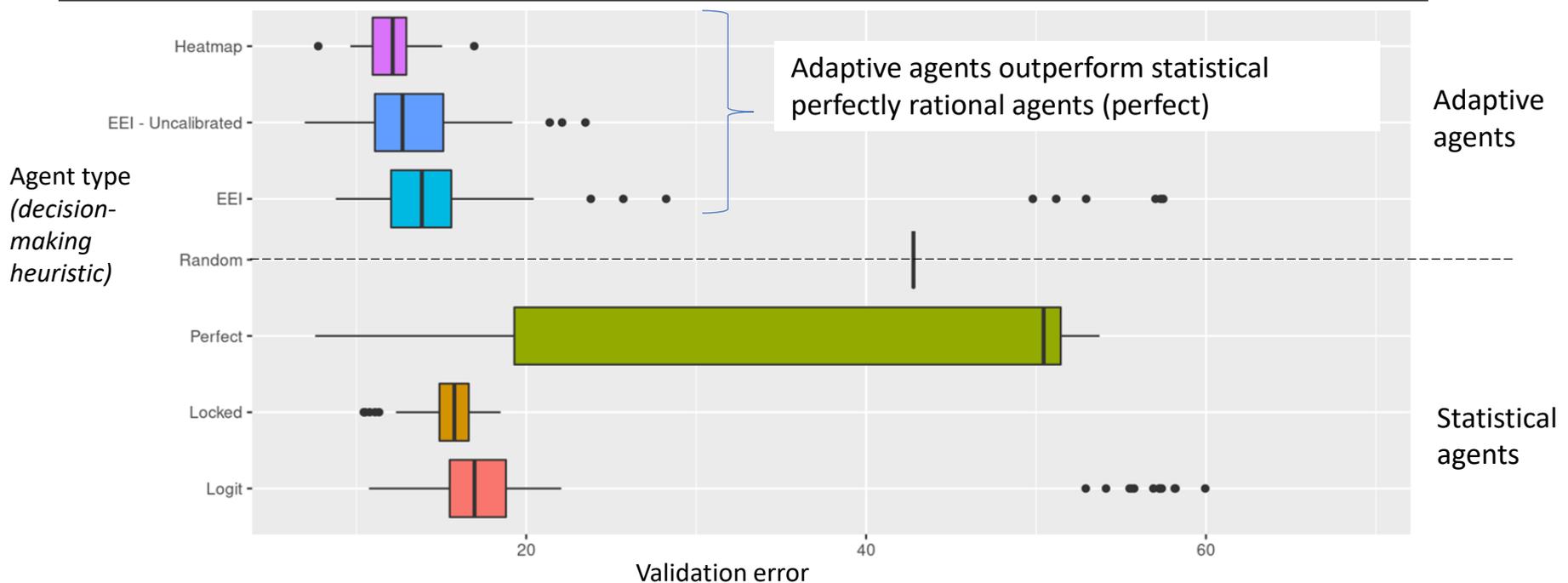
- Fisher behaviors governed by user selected **machine learning algorithms**.
- **Simulates choices of individual vessels** in response to the availability and location of fish, management policies, prices, and costs.
- **Optimizer iterates model to find the policy or combination of policies that maximizes desired management objectives**.
- **Vessel behaviors are adaptive** and respond to state conditions.
- Running simulations under a range of conditions allows us to:
  - Understand how policies will play out.
  - Develop harvest strategies for successful management.
  - **Avoid unintended consequences of proposed policies**.

# Poseidon Agent Learning

In our West Coast Groundfish analysis – we show that simple adaptive agents work as well or better than statistical agents

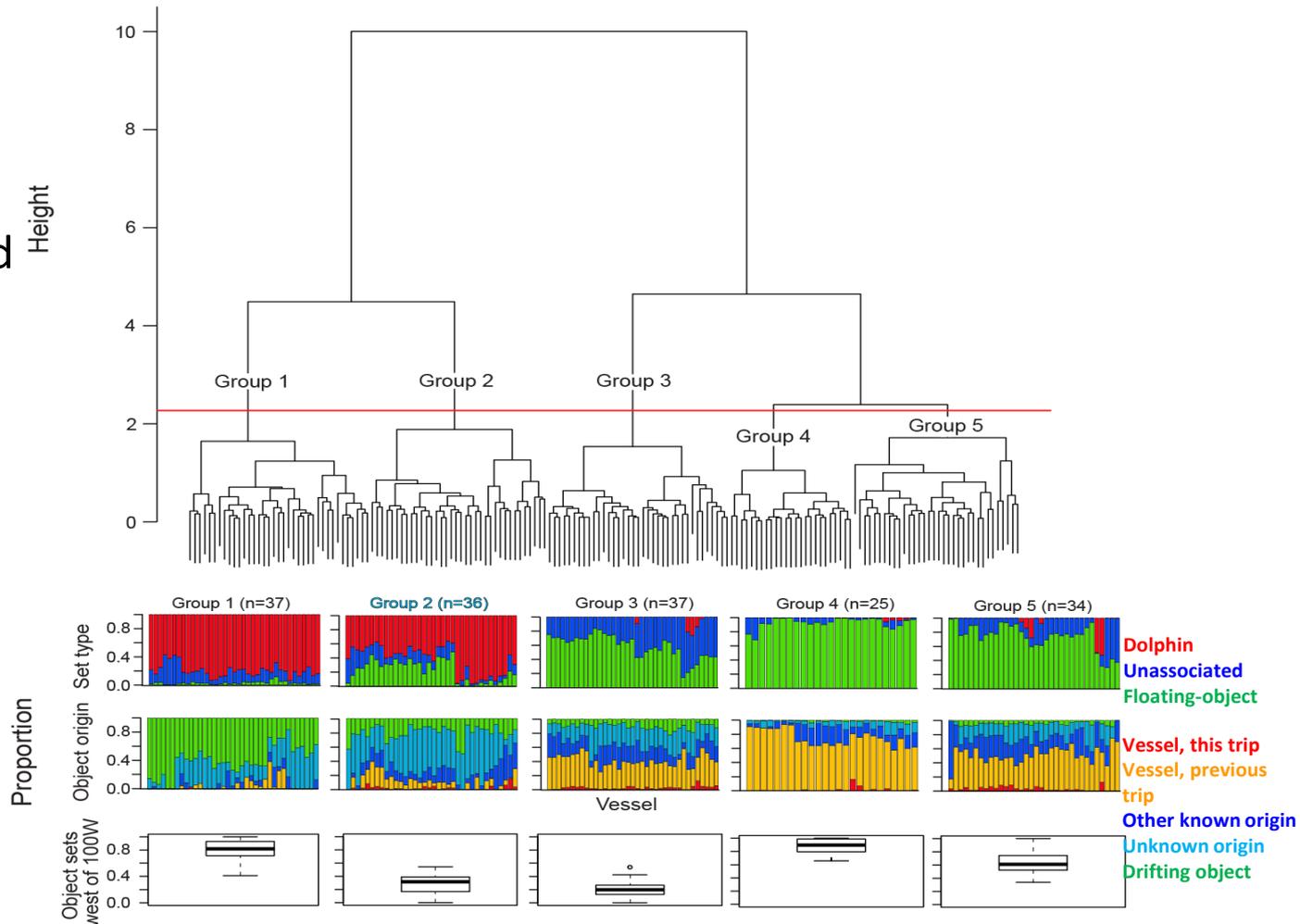
Validation error based on model predictions of fishing patterns for 2015

% validation error



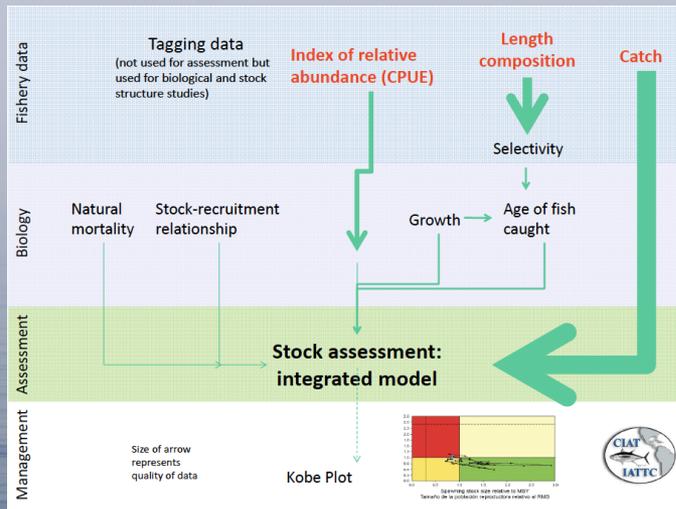
# EPO Tuna and Poseidon

- Poseidon implementation addressing FAD management in EPO in partnership with IATTC.
- Stock assessment doesn't account for the changes in behavior observed in EPO fishery.
- Poseidon useful to better understand FAD dynamics.

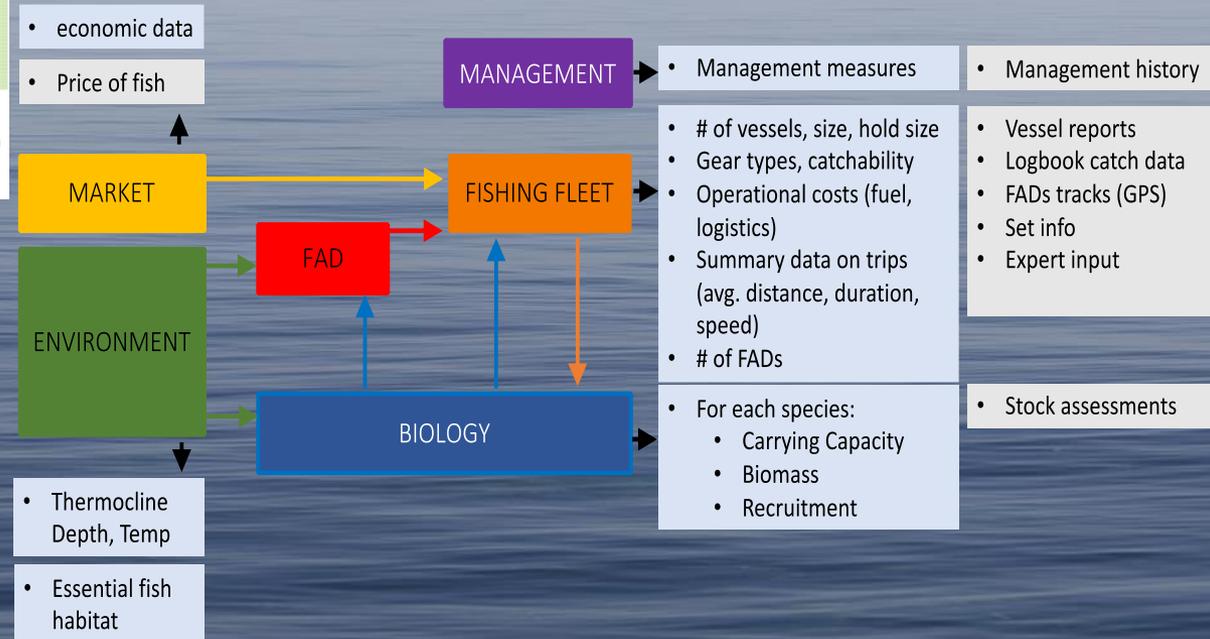


# Poseidon and Stock Assessment

## Stock assessment



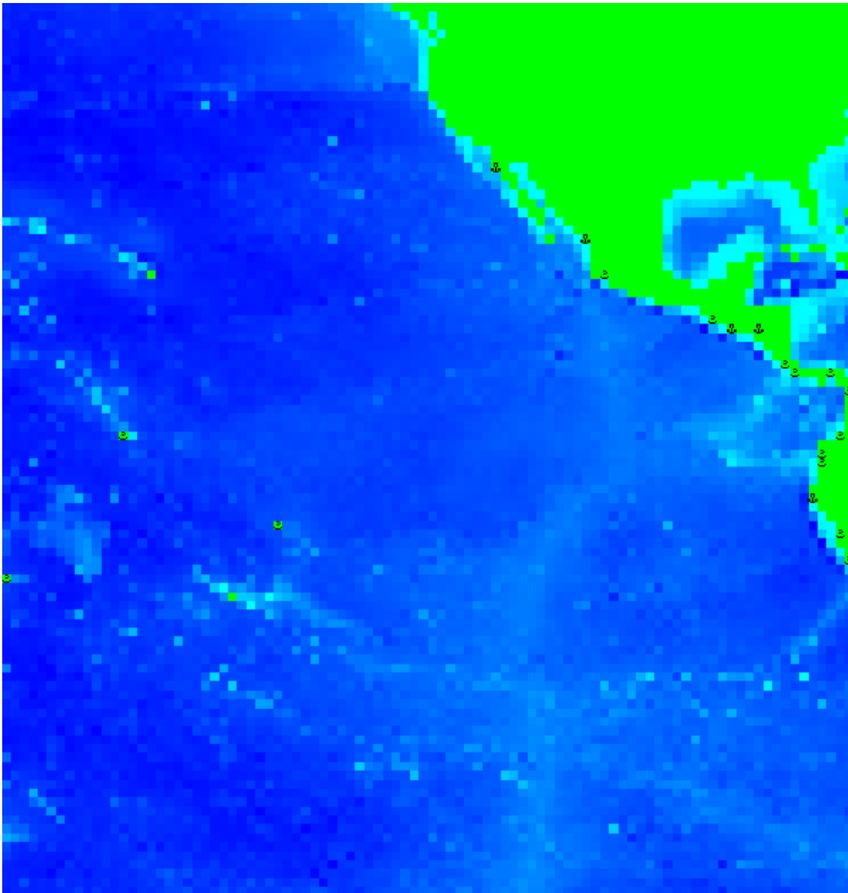
## Poseidon



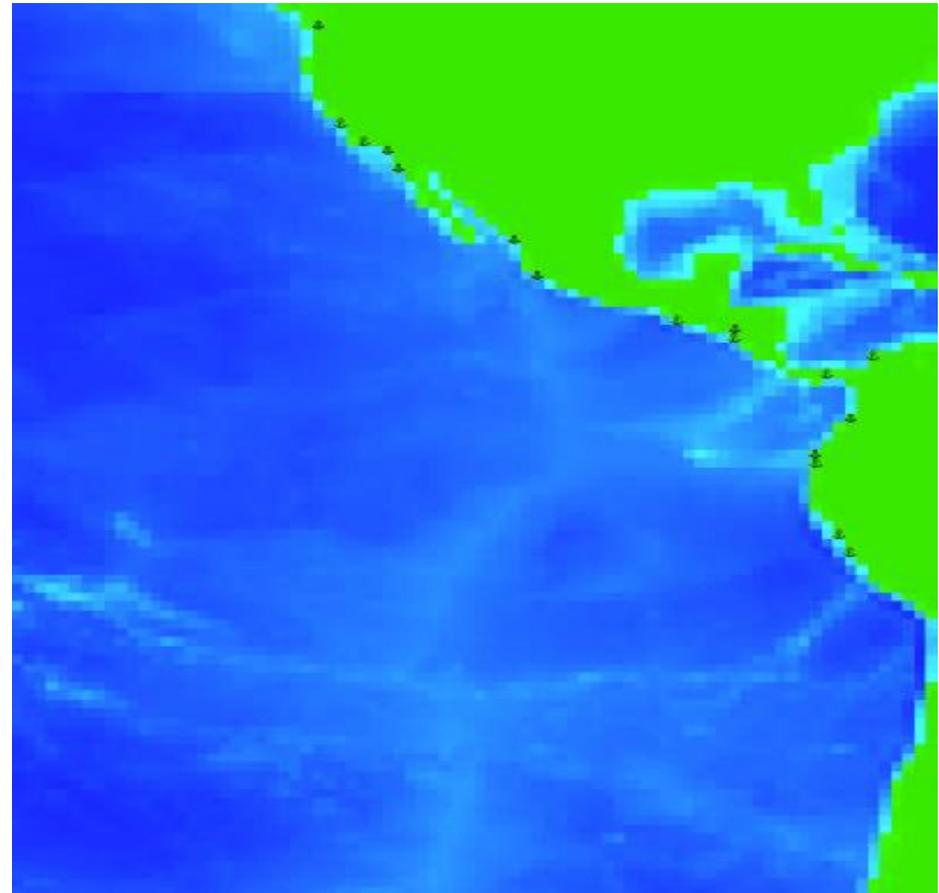
# EPO Tuna and Poseidon

*In progress....*

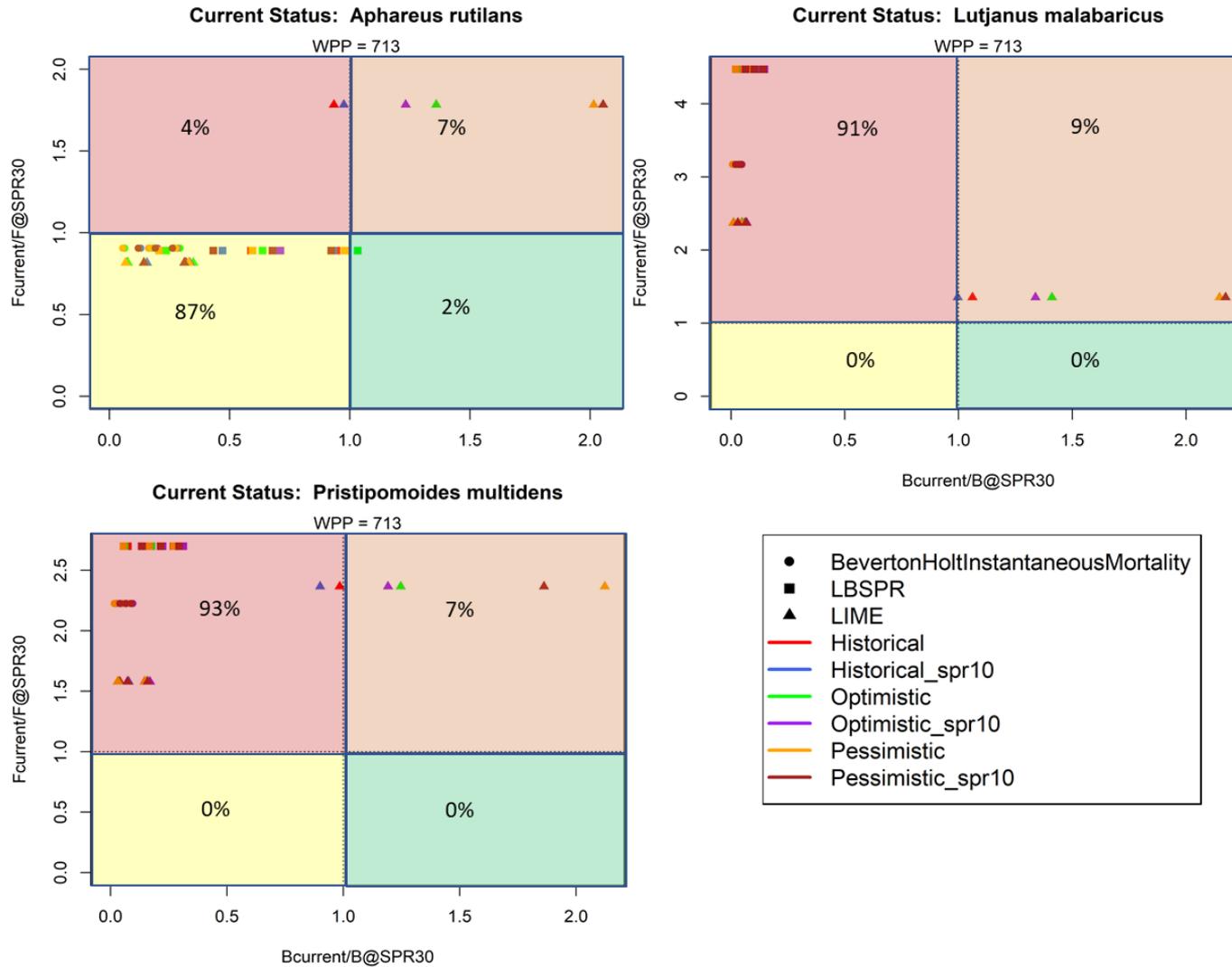
FAD Movement



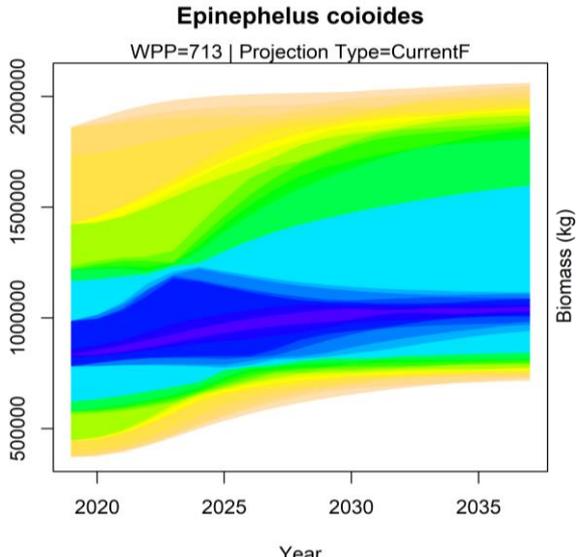
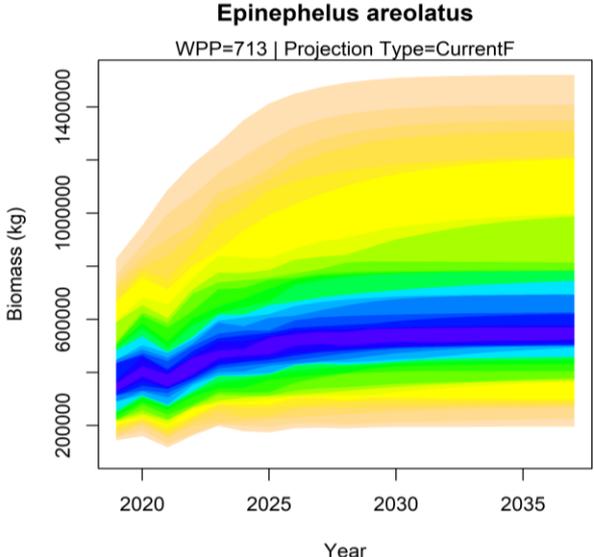
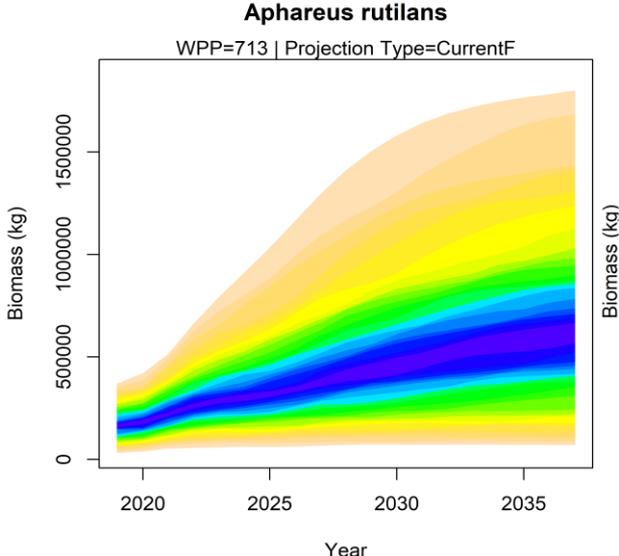
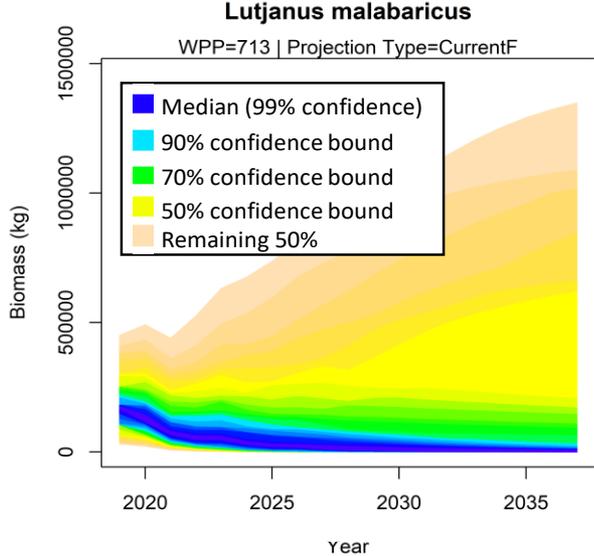
Boat Movement



# Poseidon as Policy Simulator: Indonesia



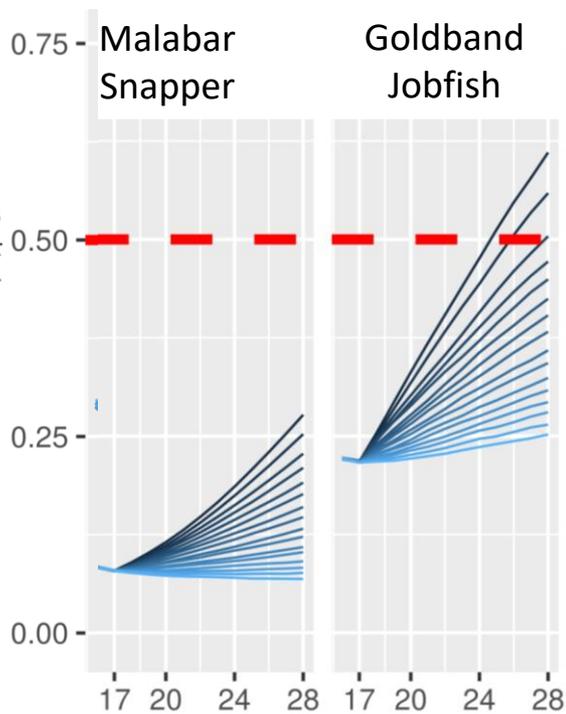
# Poseidon as Policy Simulator: Indonesia



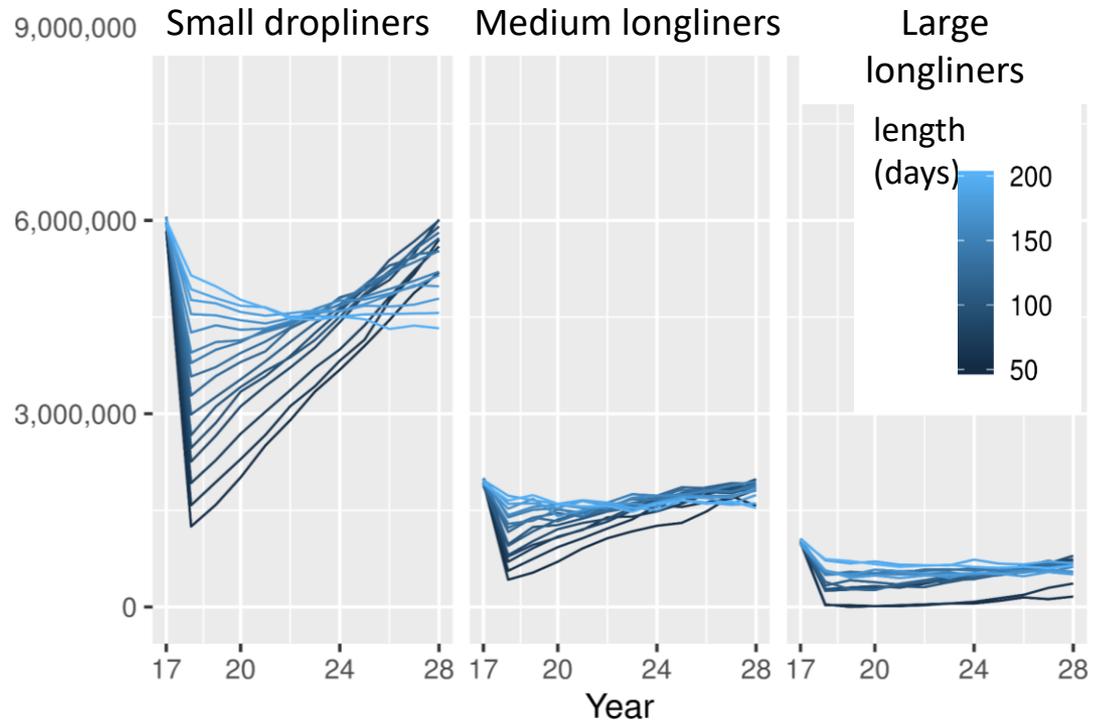
# Poseidon as Policy Simulator

Test impact of policies

## Biomass



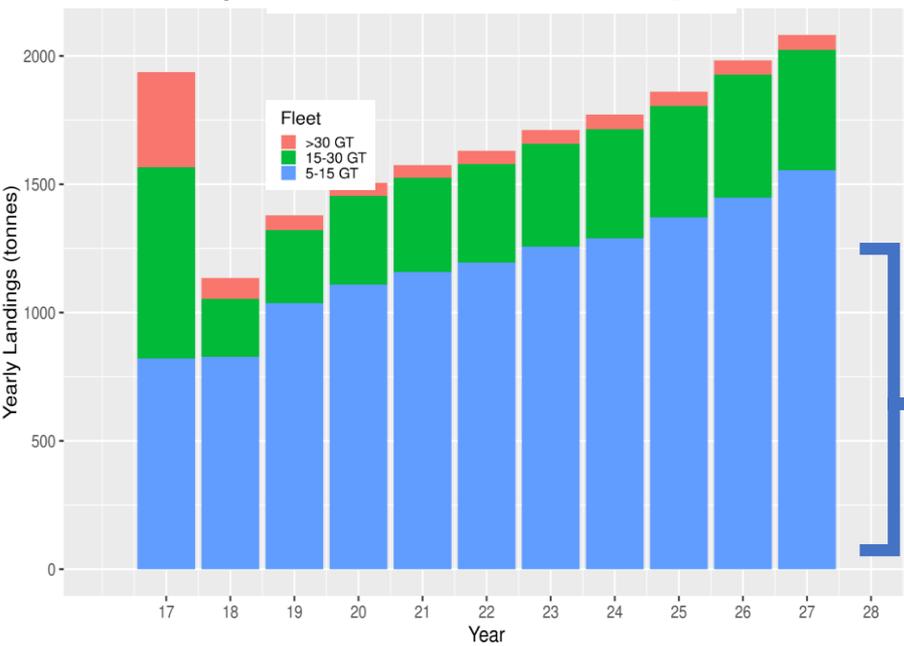
## Landings by boat type



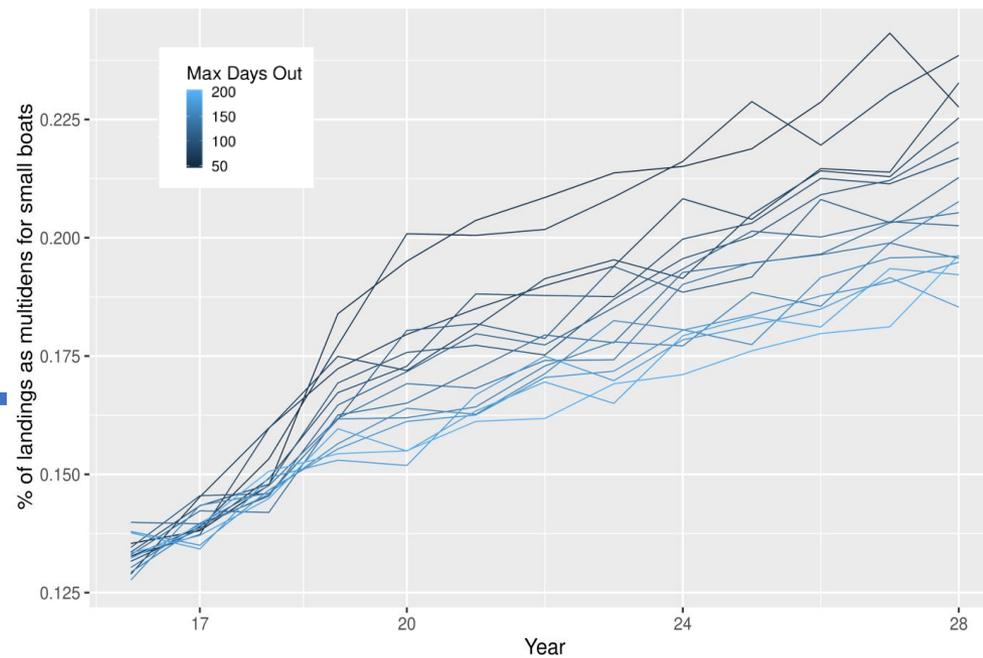
# Poseidon as Policy Simulator

## Policy and multiple fleets interactions

### Goldband landings



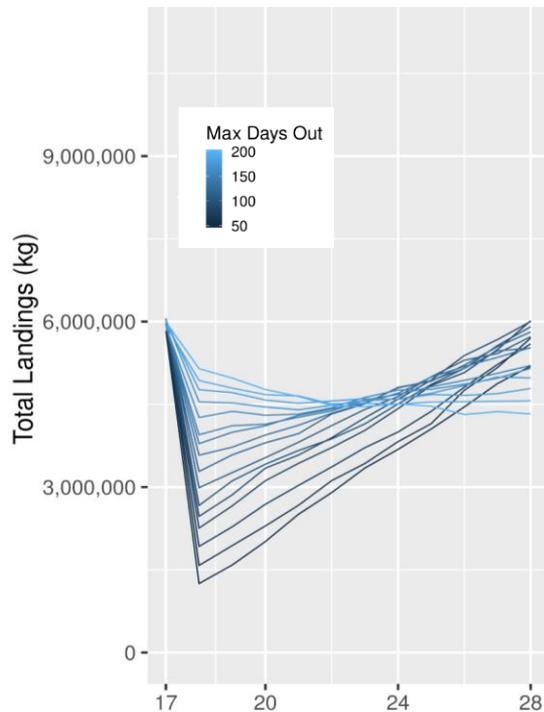
### Share of goldband catch – small boats



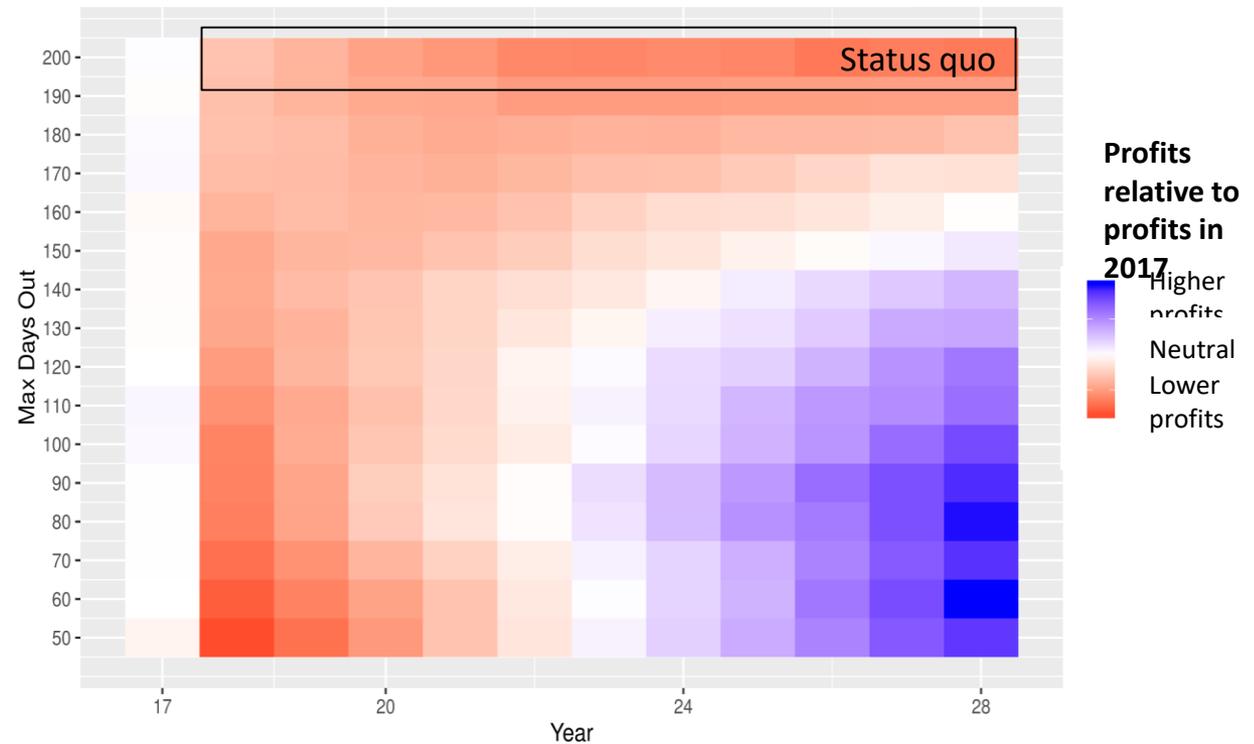
# Poseidon as Policy Simulator

Assess socio-economic impact

## Landings – small boats

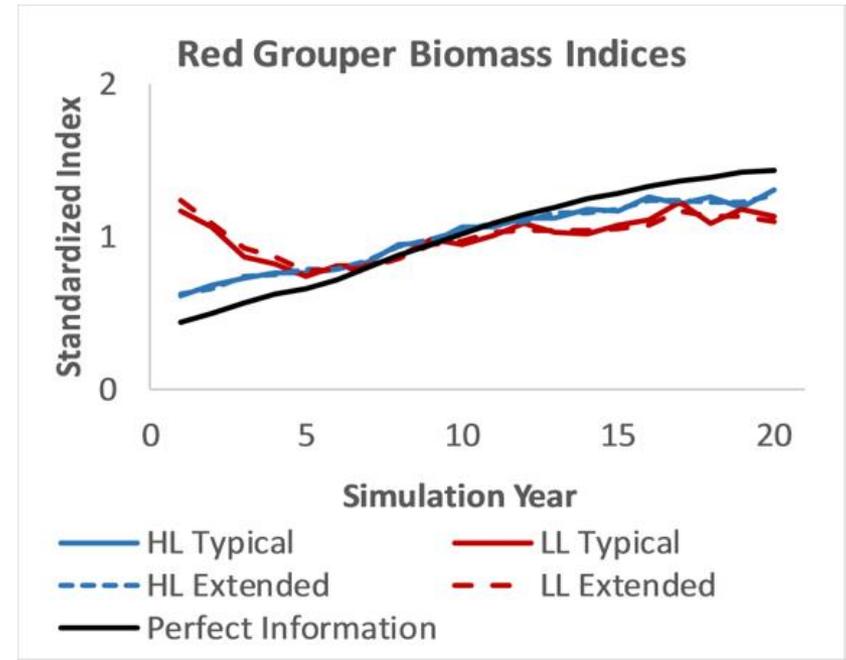
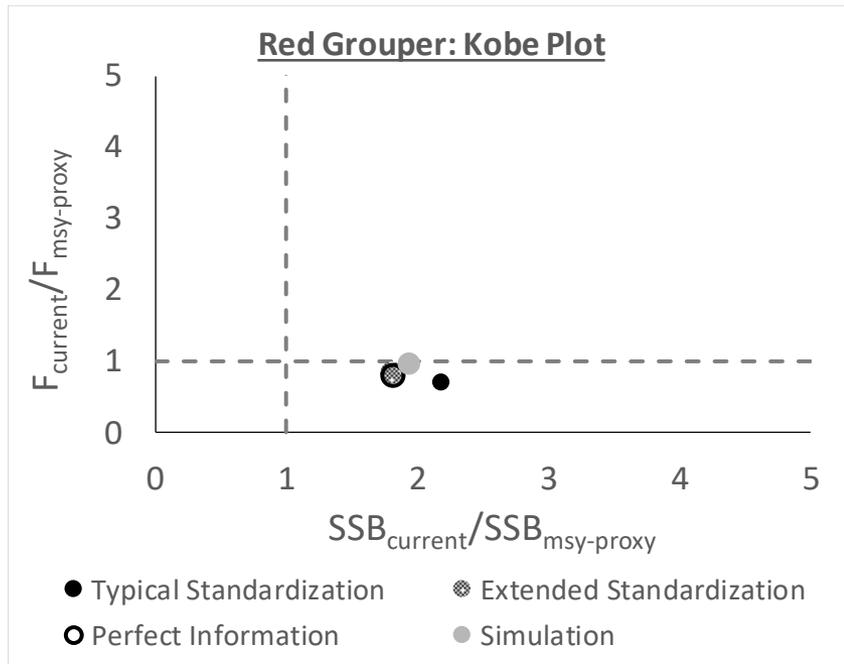


## Small boat profits, vs. pre-policy



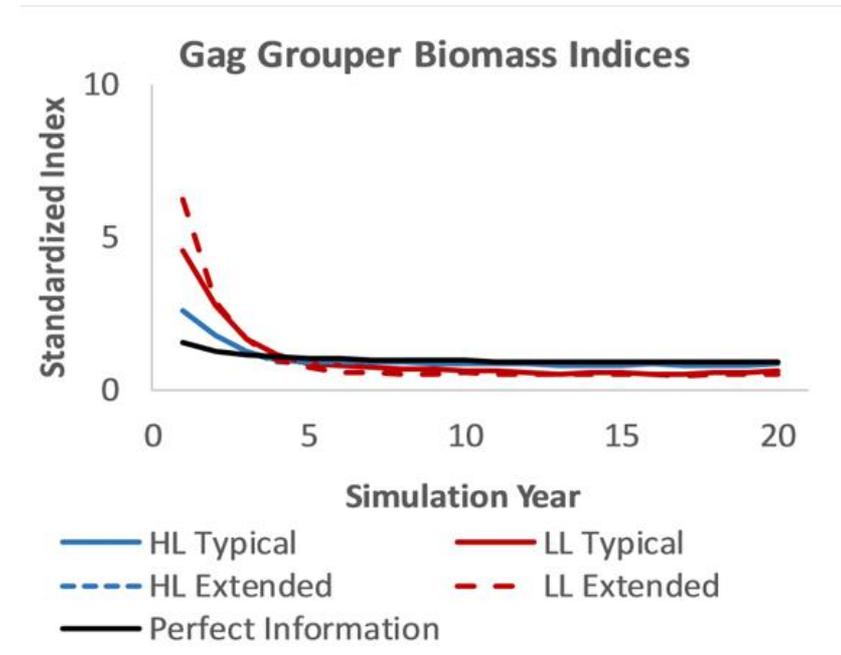
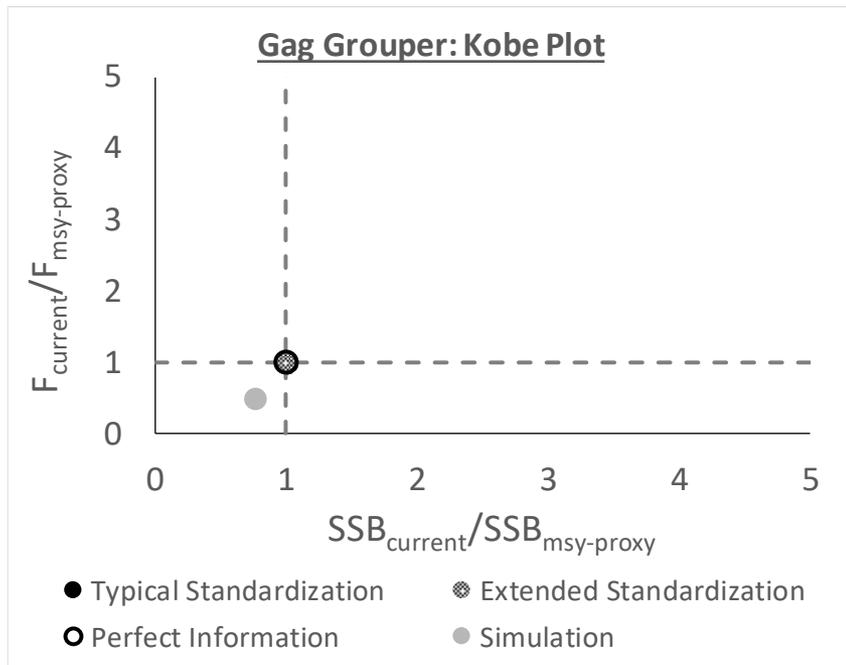
# ABM as Tool to Test Stock Assessment Assumptions

*Does fisher behavior bias our single species assessments through CPUE indices?*



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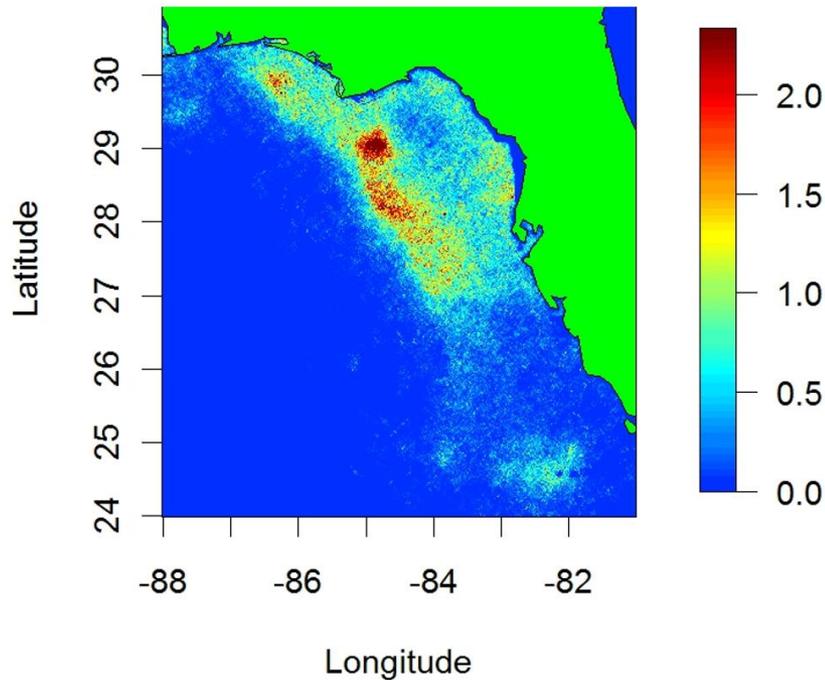


# ABM as Tool to Test Stock Assessment Assumptions

*Does fisher behavior bias our single species assessments through CPUE indices?*

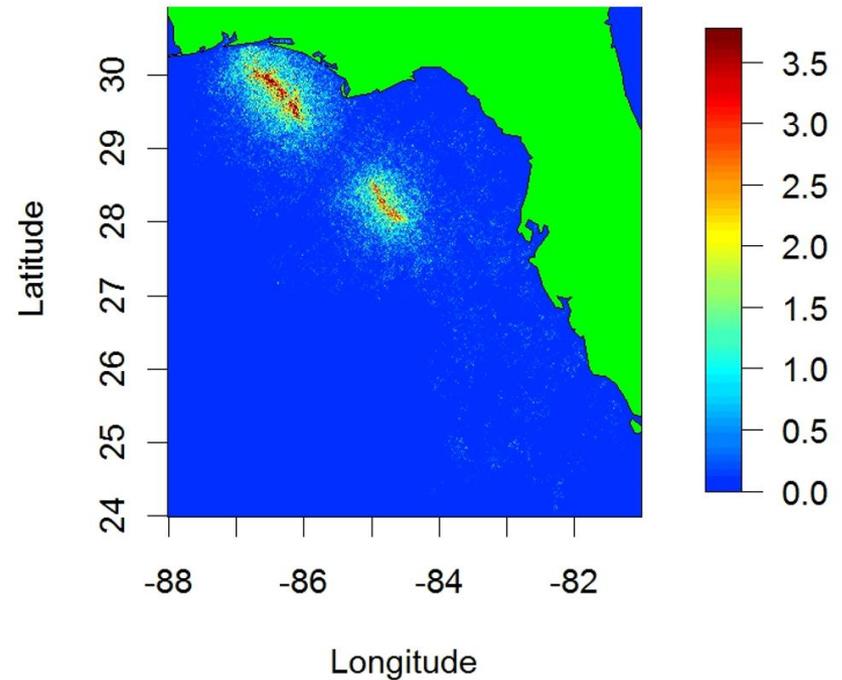
## Fishing Effort: Handline

*Average Number of 24-Hour Periods in Each Grid Cell per Year*



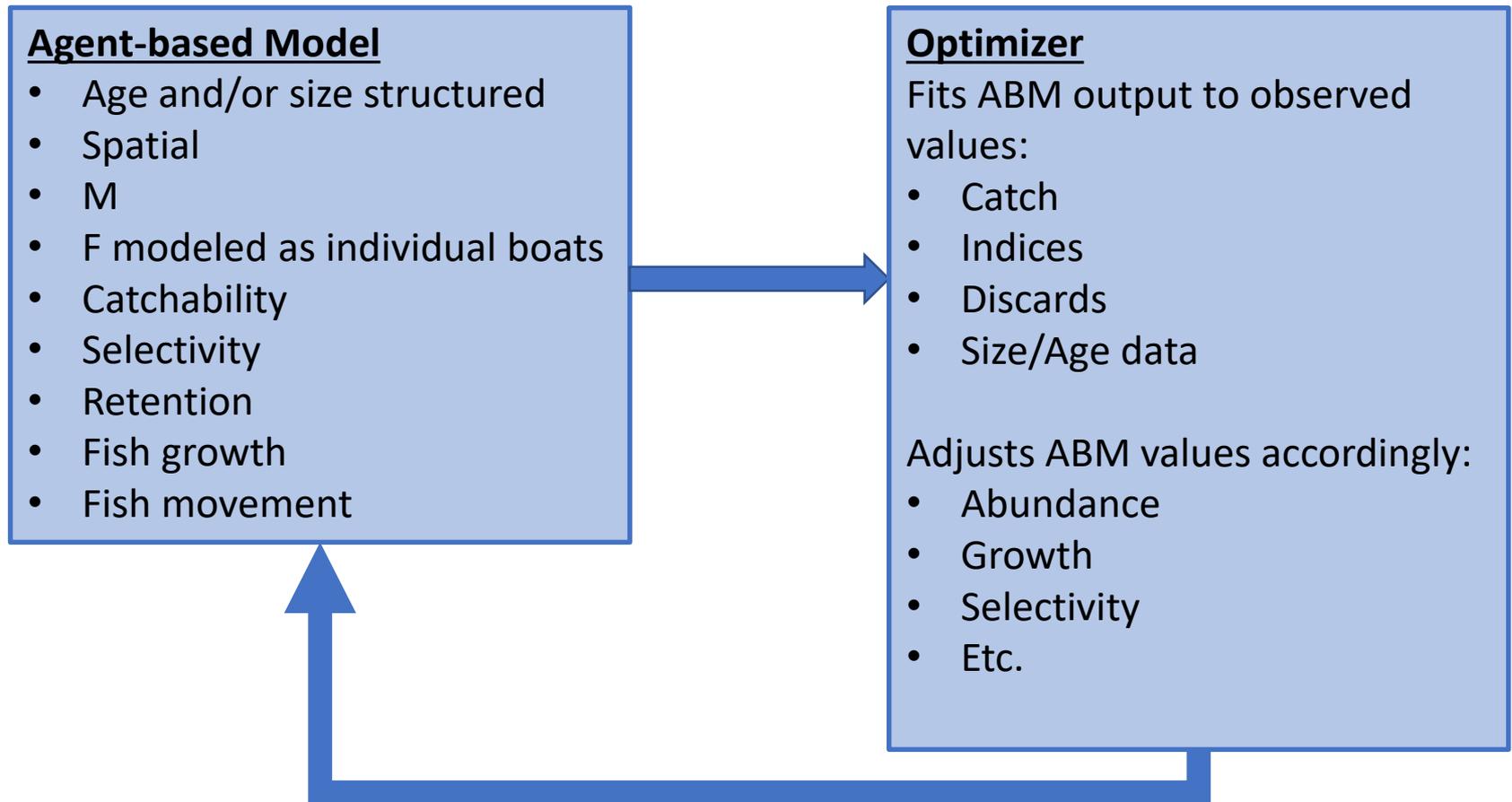
## Fishing Effort: Longline

*Average Number of 24-Hour Periods in Each Grid Cell per Year*



# Can an ABM Serve as an Assessment Tool?

## *Theoretical Framework*



# ABM as Assessment Model

## Pros

- Explicitly incorporate fisher behavior into the assessment
- Fisher behavior adaptive
- Relax statistical assumptions
- Nuanced Spatial component
- Multidisciplinary
- Presented to managers and stakeholders as dynamic tool in real time

## Cons

- Longer run time
- Computational needs
- Multidisciplinary – takes more people to collaborate
- More expensive perhaps
- Longer to build model because more detail
- ABM expertise limited

*ABMs such as Poseidon can also serve as great projection tools post assessment to test policies!*

# Summary

- Agent-based models have many places in fisheries science and stock assessment.
- The Poseidon model is ideally suited in a projection capacity and explore/find through optimization different policy combinations post assessment.
  - Multi species, multi fleet, multi area problems, together with temporal and spatial policies, can be considered.
- Agent-based models could serve as stock assessment infrastructure, but with a “wrapper” of sorts to fit to empirical data.