

# Sustainable Sardine Fisheries

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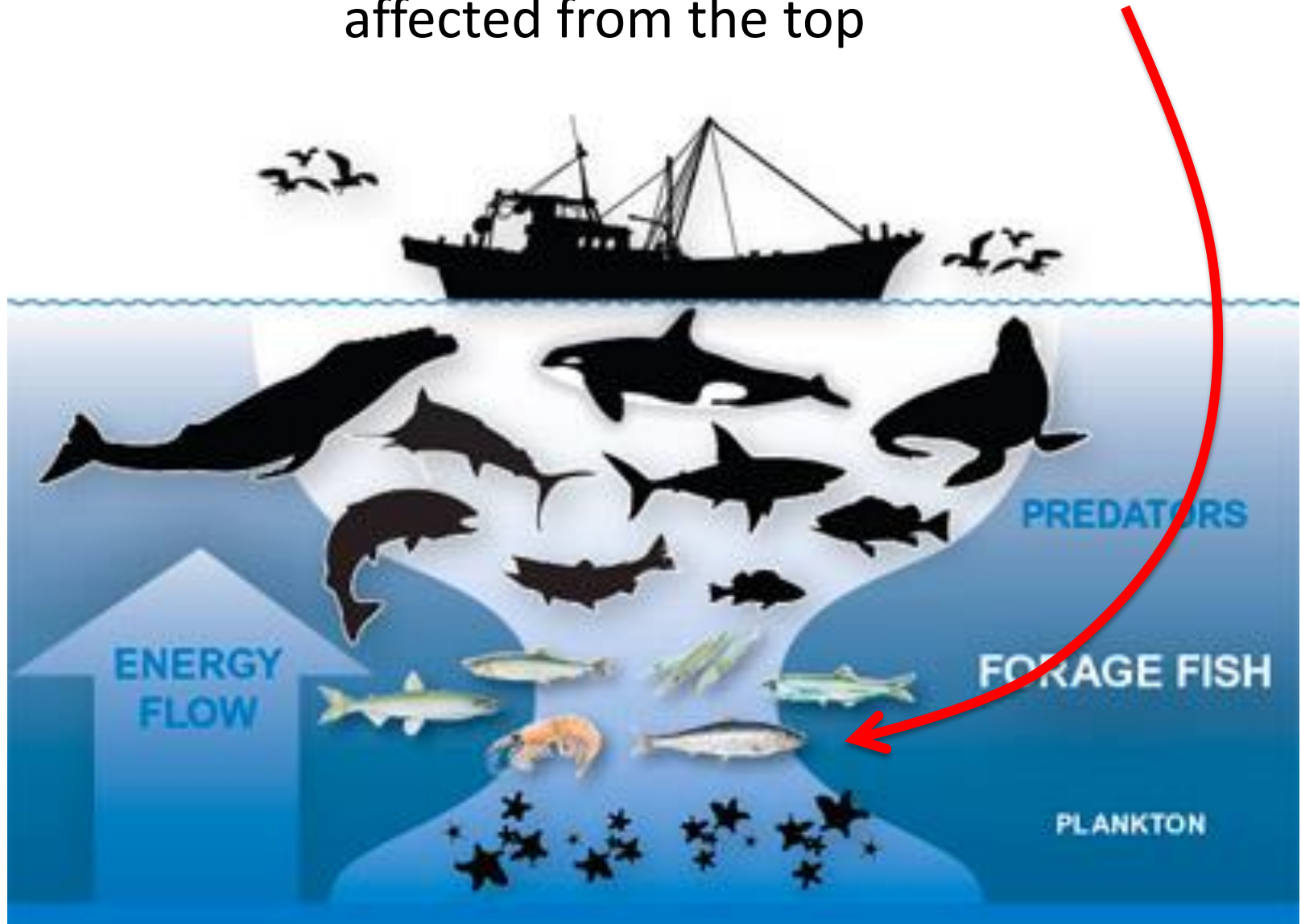


# Sardine production (2015)

## BFAR Statistics

- Commercial (25%) – 260,000 MT
- Municipal (11.2%) – 113,000 MT
  
- Post Harvest Industries
  - Canned and bottled sardines
  - Dried fish

Sardines are found low in the food chain making it sensitive to environmental changes and also affected from the top



upwelling      circulation      sea temperature      ENSO

monsoons      rainfall      river discharge

# Sardine abundance fluctuates

over-fishing      management policies      industry demand

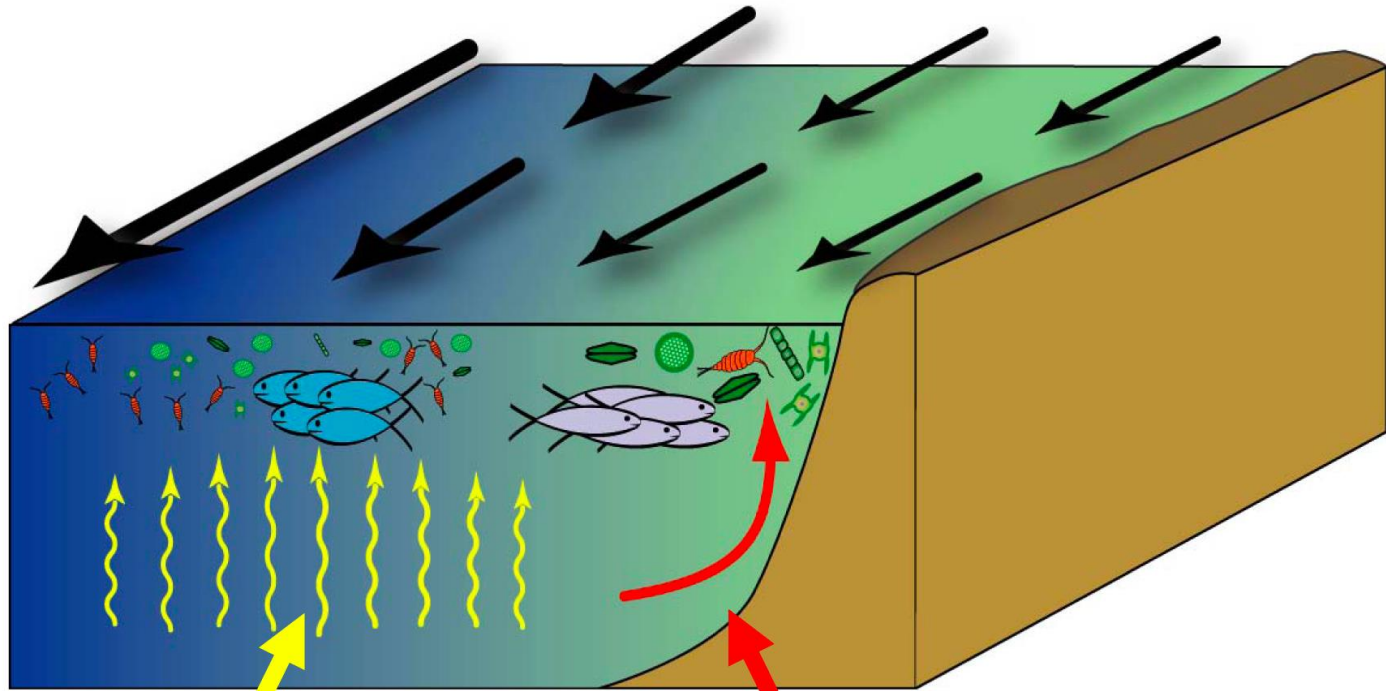
food availability      predation      regime shift

# Sardine distribution related to plankton distribution

- Food predominantly plankton
- Plankton biomass highest in areas where both lights and nutrients are available at the surface
- Sources of nutrients:
  - River runoff
  - Subsurface waters in the ocean where nutrients can accumulate
- Nutrients from below can be brought up to the surface through upwelling and intense mixing



# Types of upwelling

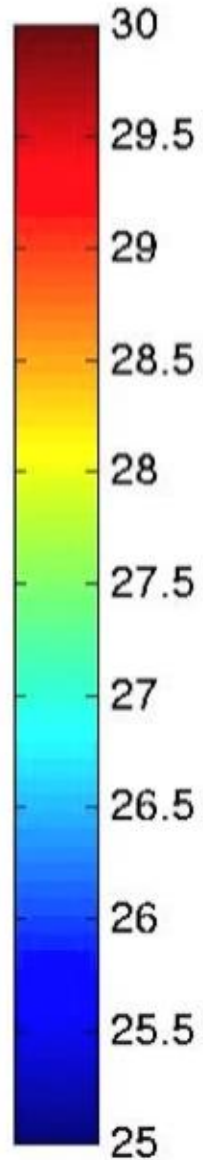
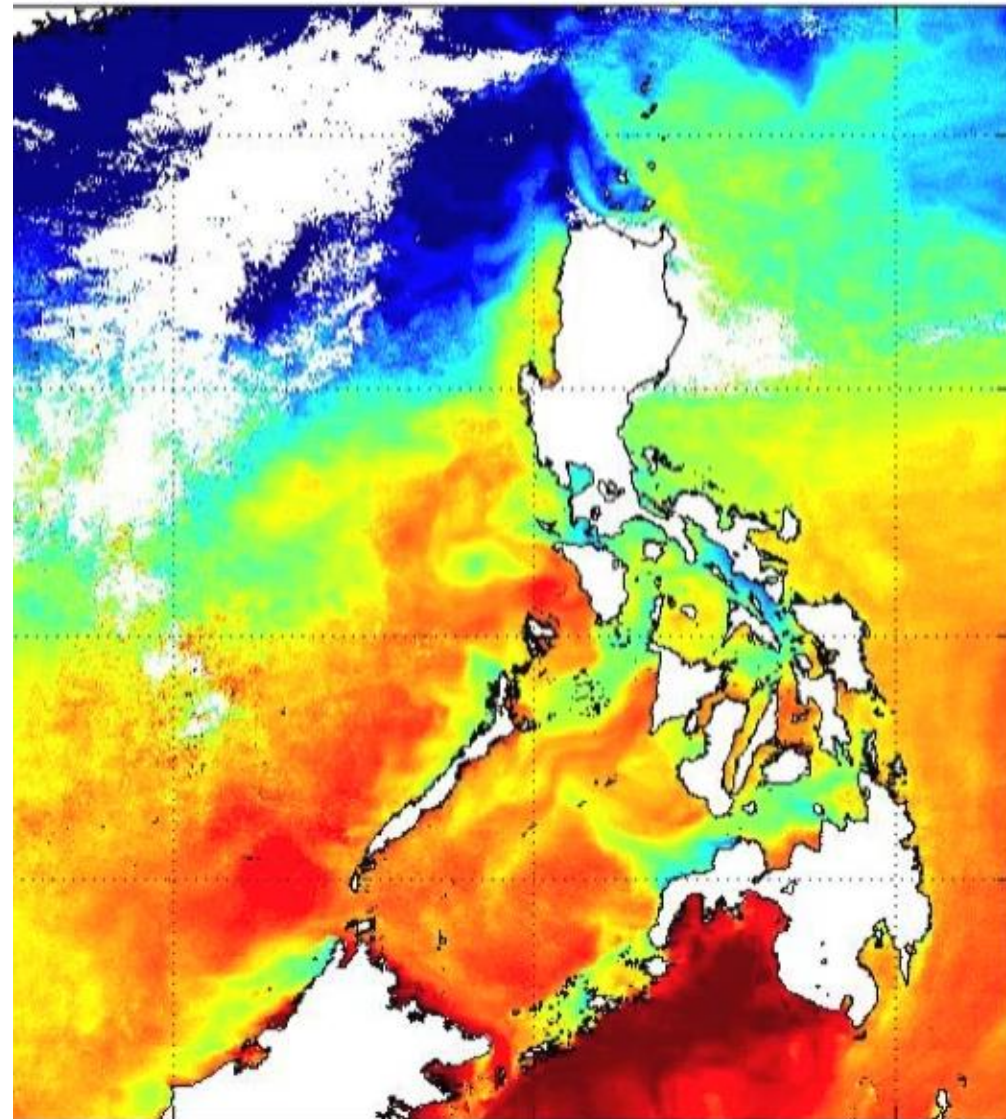


Wind stress curl upwelling:  
**sardine**

Coastal boundary upwelling:  
**anchovy**

Rykaczewski et al, 2008.

Jan 1 2016



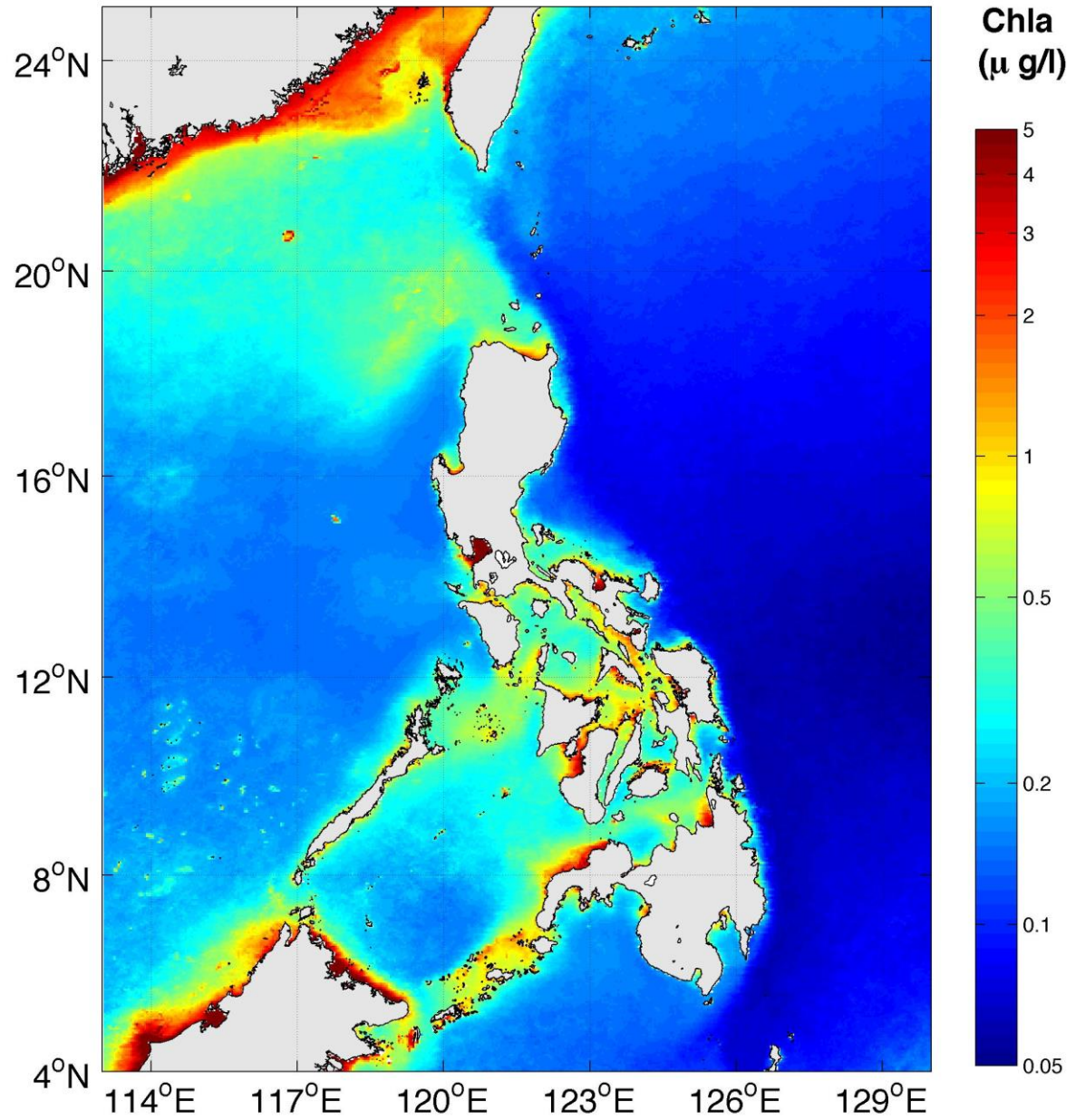
114°E

120°E

126°E

Areas with upwelling or strong vertical mixing identified by cooler sea surface temperatures and high chlorophyll a

# MODIS SMI4 Chlor a : DJF 2001-2015

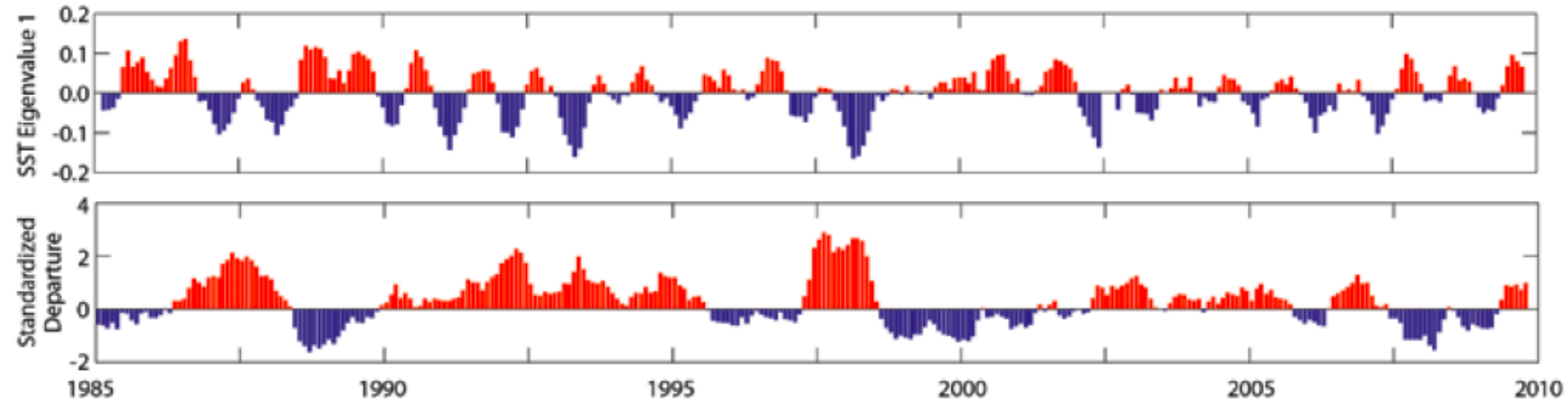




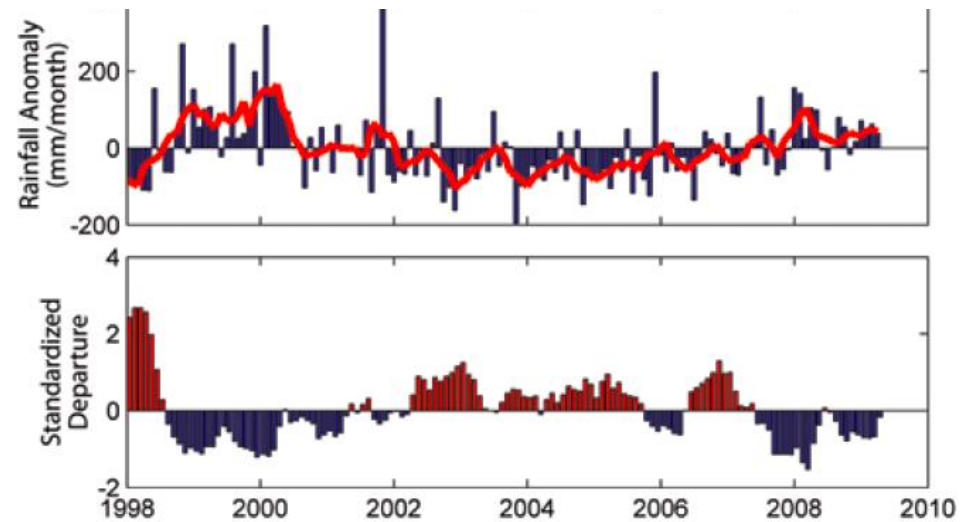
# What do we need to sustain the sardine fisheries?

- Understanding sardine abundance as influenced by:
  - Environmental variability
  - Sardine biology
  - Fishing effort spatial and temporal variability

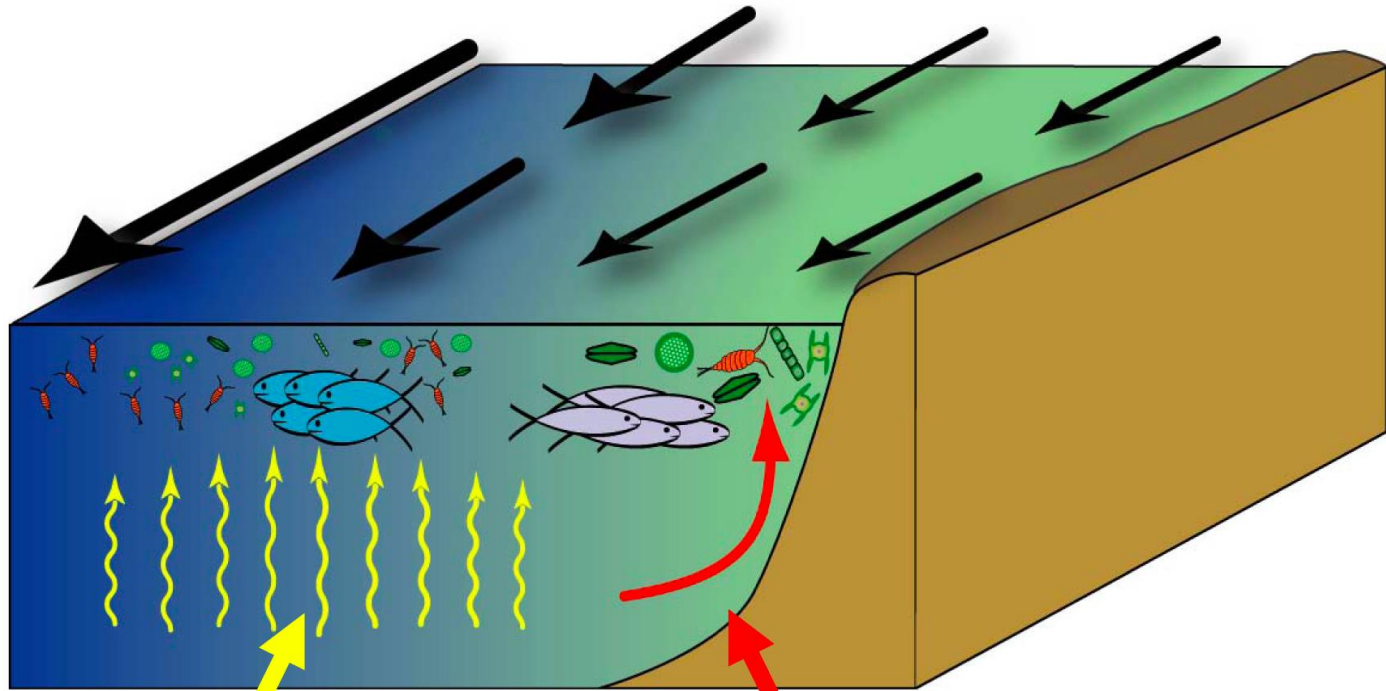
# ENSO Variability



Upwelling intensity increases during El Nino, decreases during La Nina



# Types of upwelling

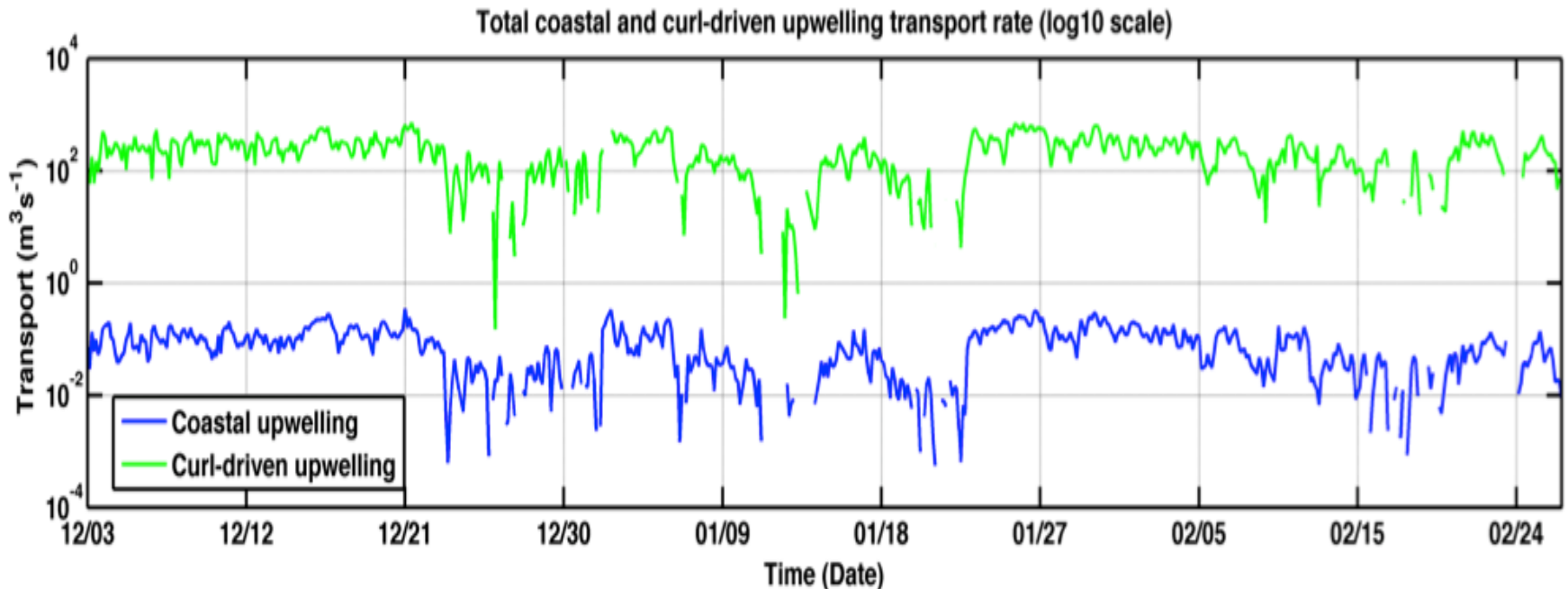
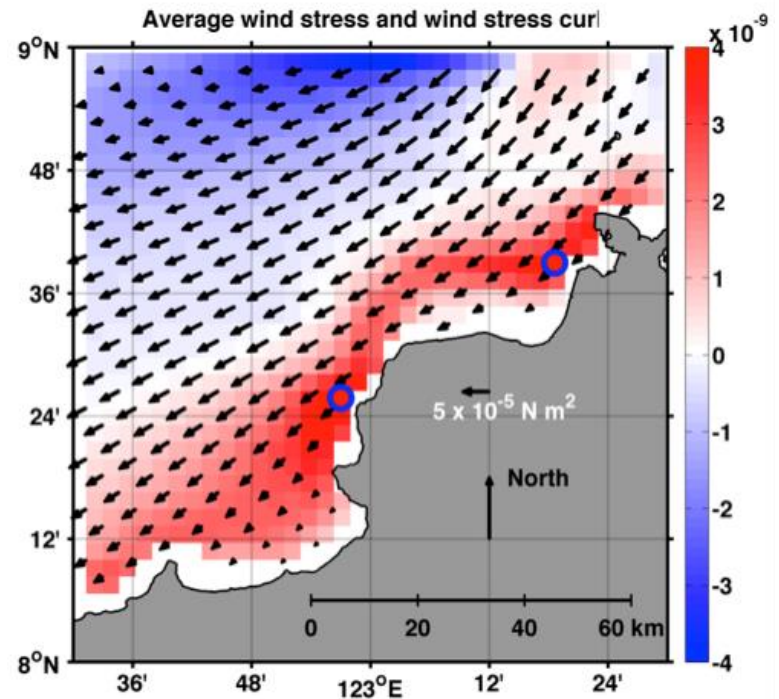


Wind stress curl upwelling:  
**sardine**

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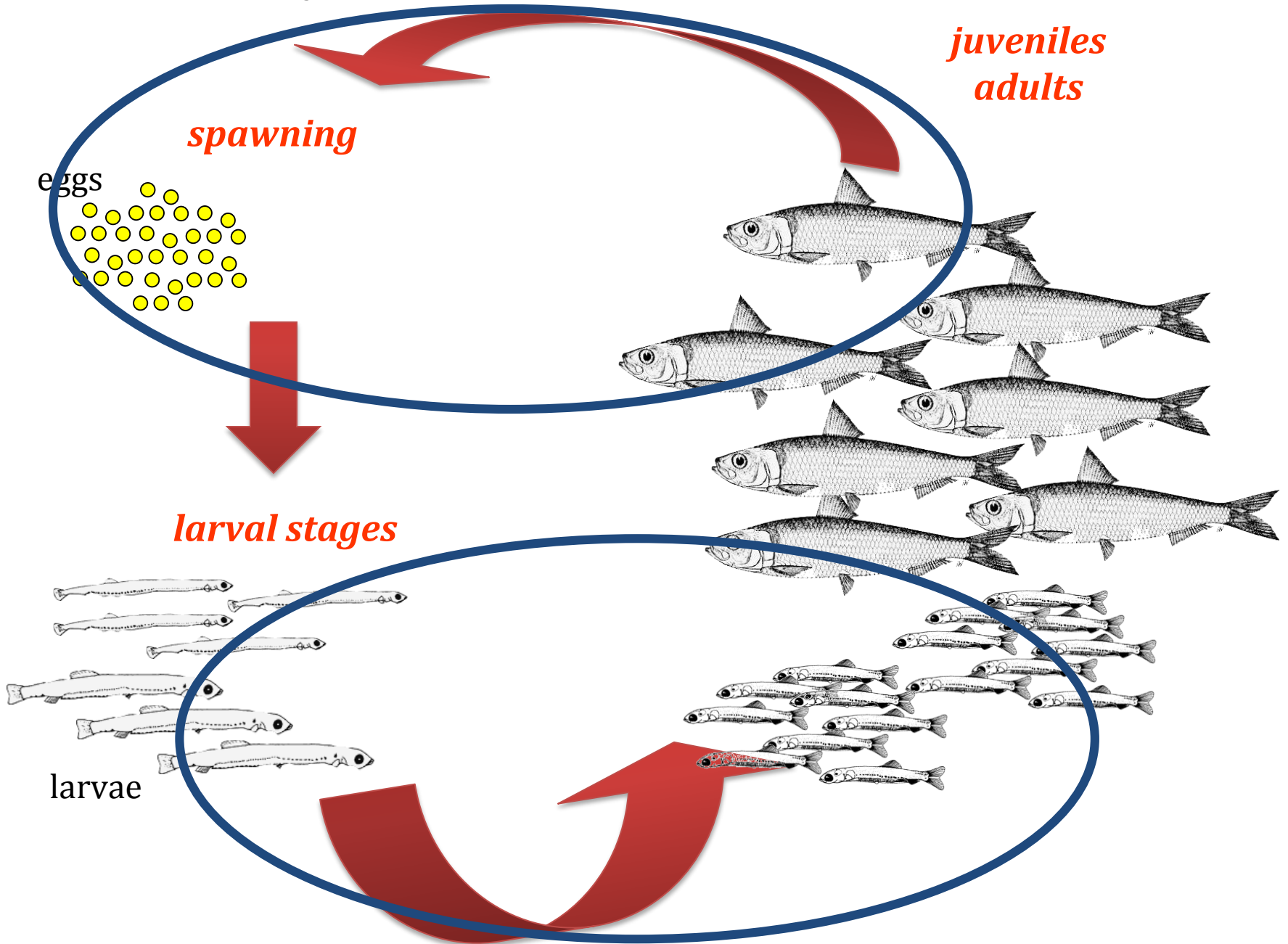
Rykaczewski et al, 2008.

# Curl vs Coastal Upwelling in Dipolog and Sindangan Bay

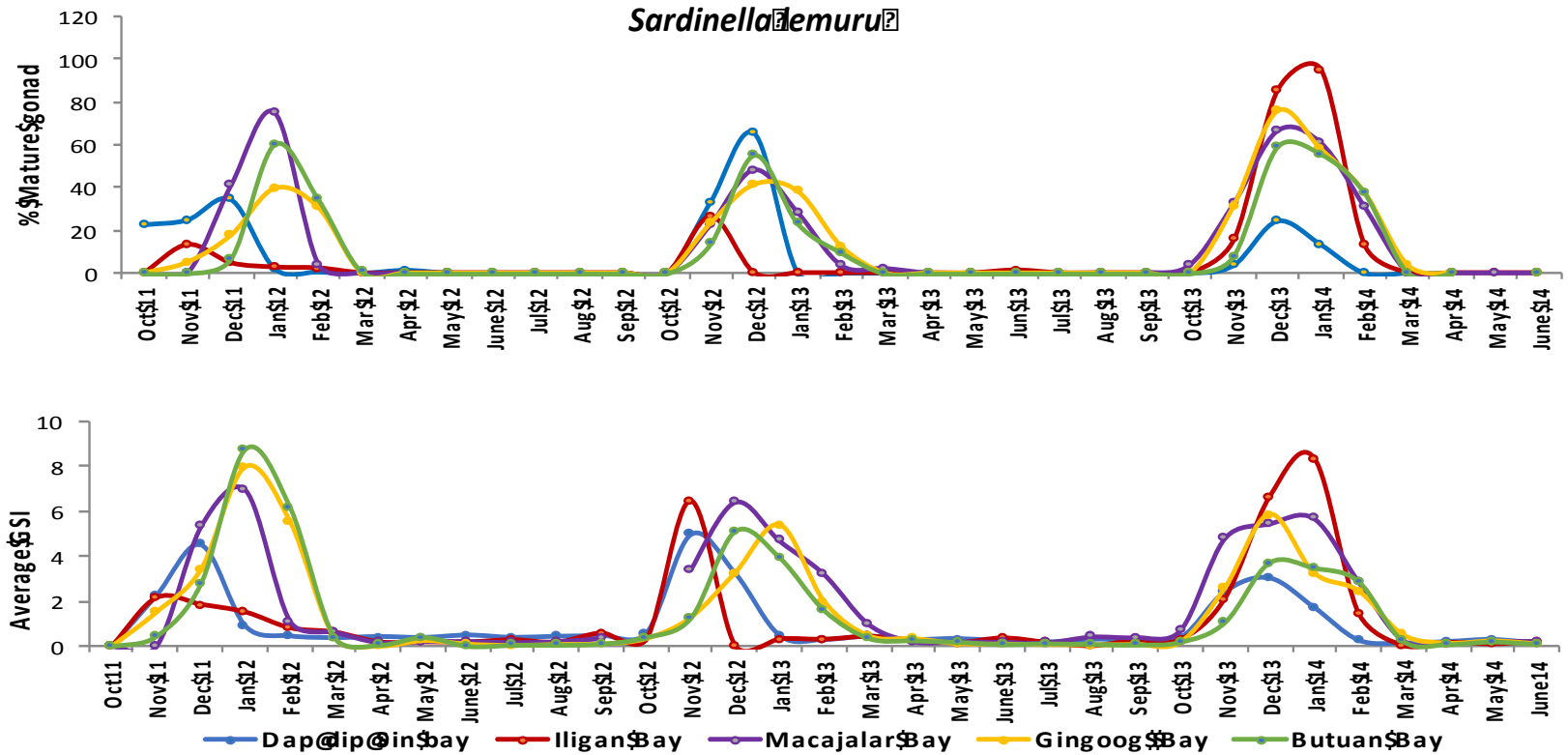




# Sardine Life Cycle

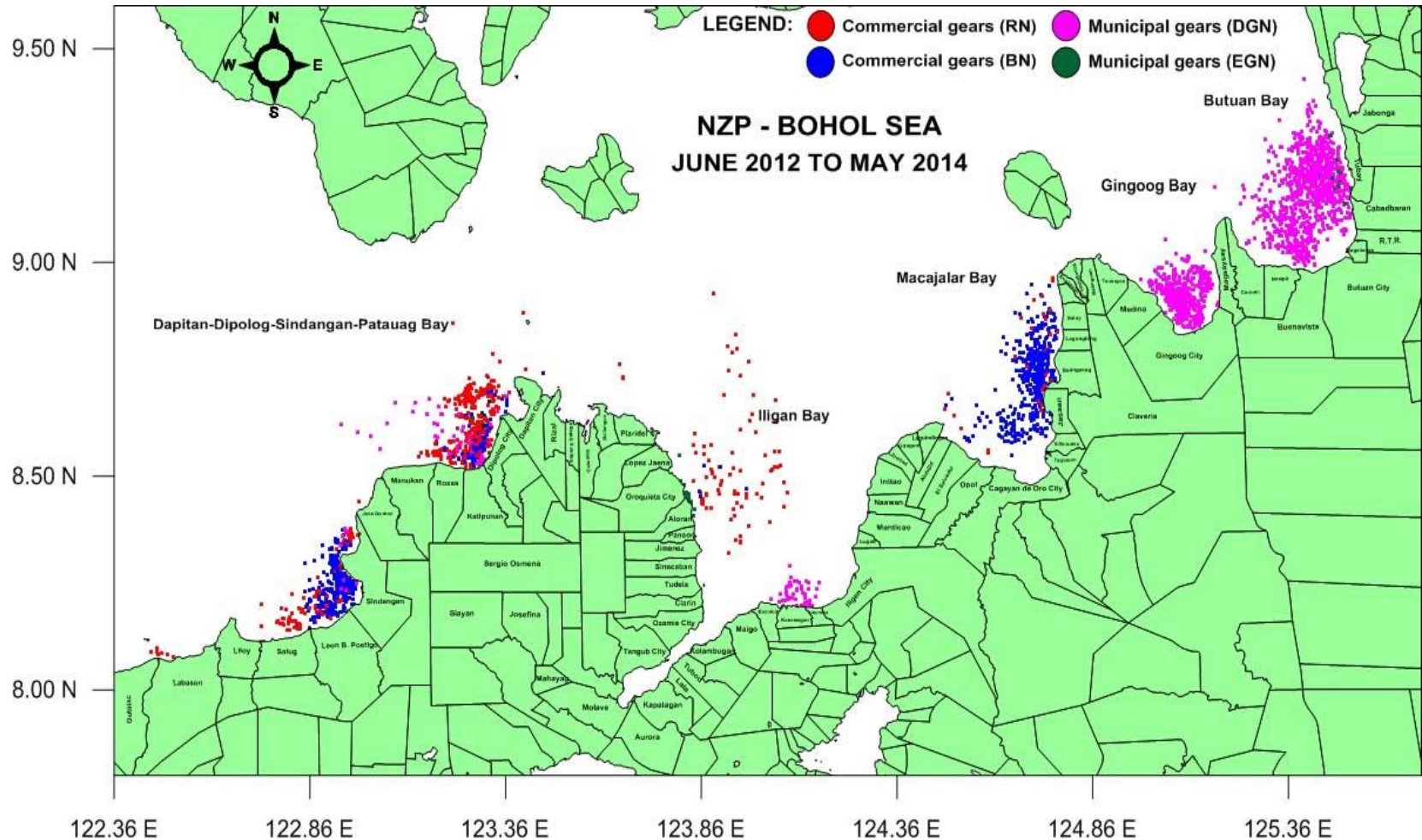


# Catch monitoring provides information on spawning and production

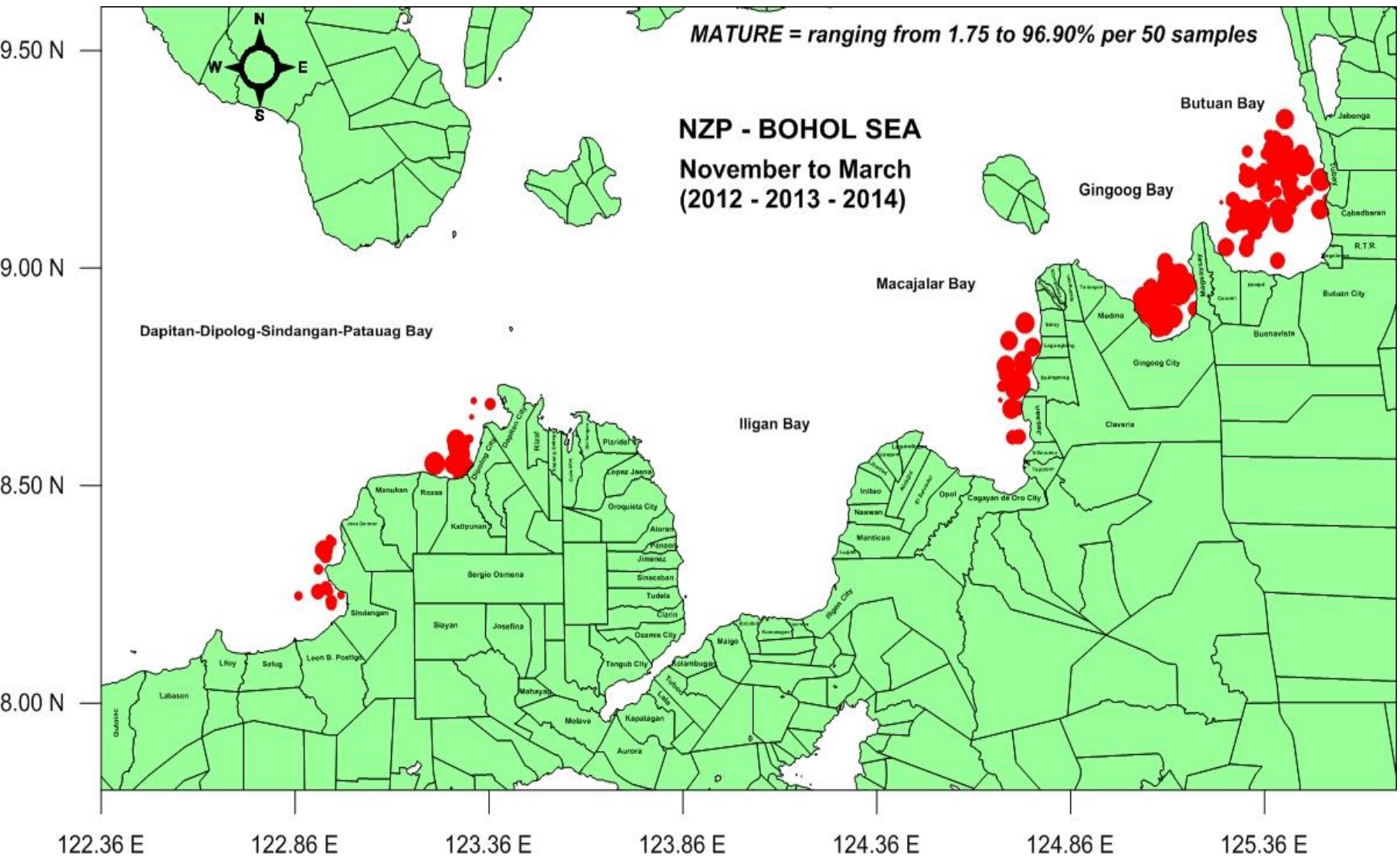


# Mapping fishing effort through RSVP

## Research on Sardines Volunteer Program



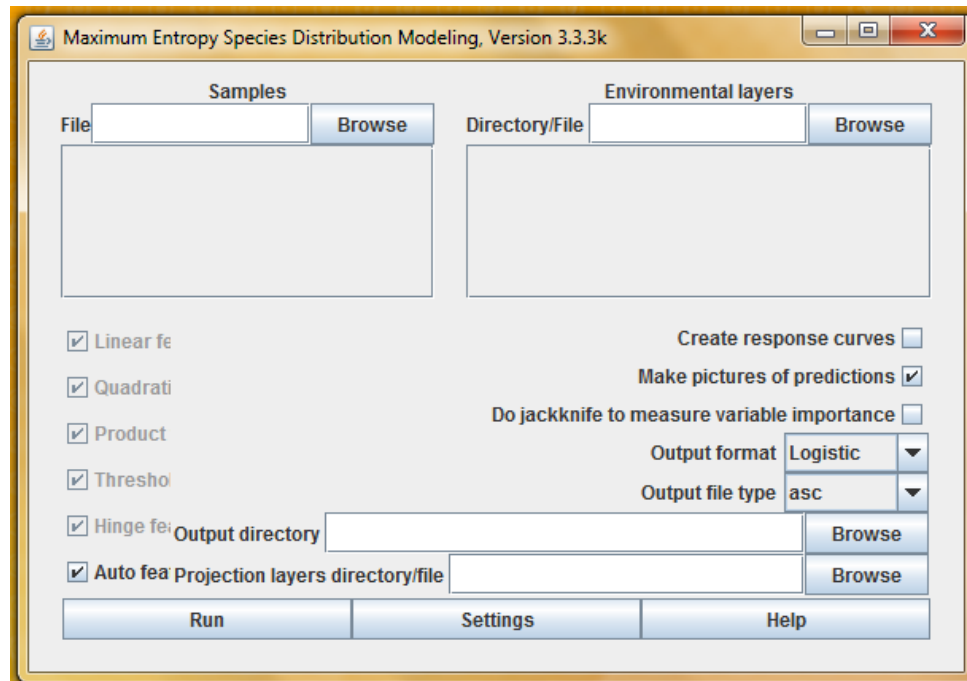
# Identifying spawning areas for more targetted management interventions





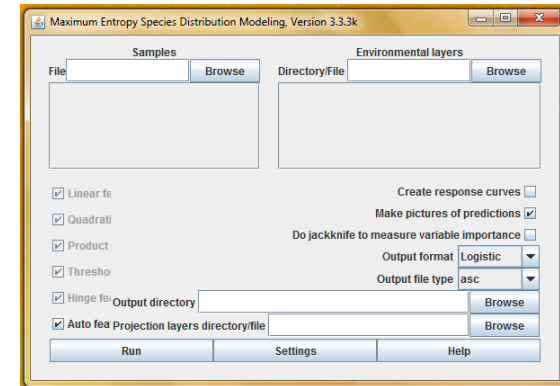
# Habitat Index

- Measure of habitat suitability
- Maximum Entropy Model (MaxEnt) by Phillips et al., 2006



# Habitat Index

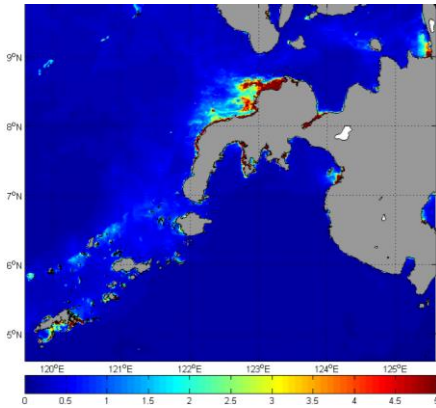
➤ MaxEnt estimates the potential habitat suitability of a species



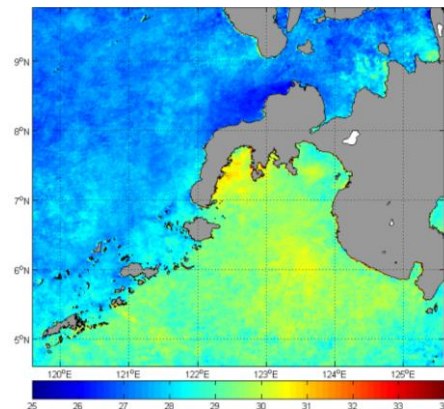
➤ Statistically relate known spatial locations (RSVP) with SST and food availability (Chl-a)

# Habitat Index

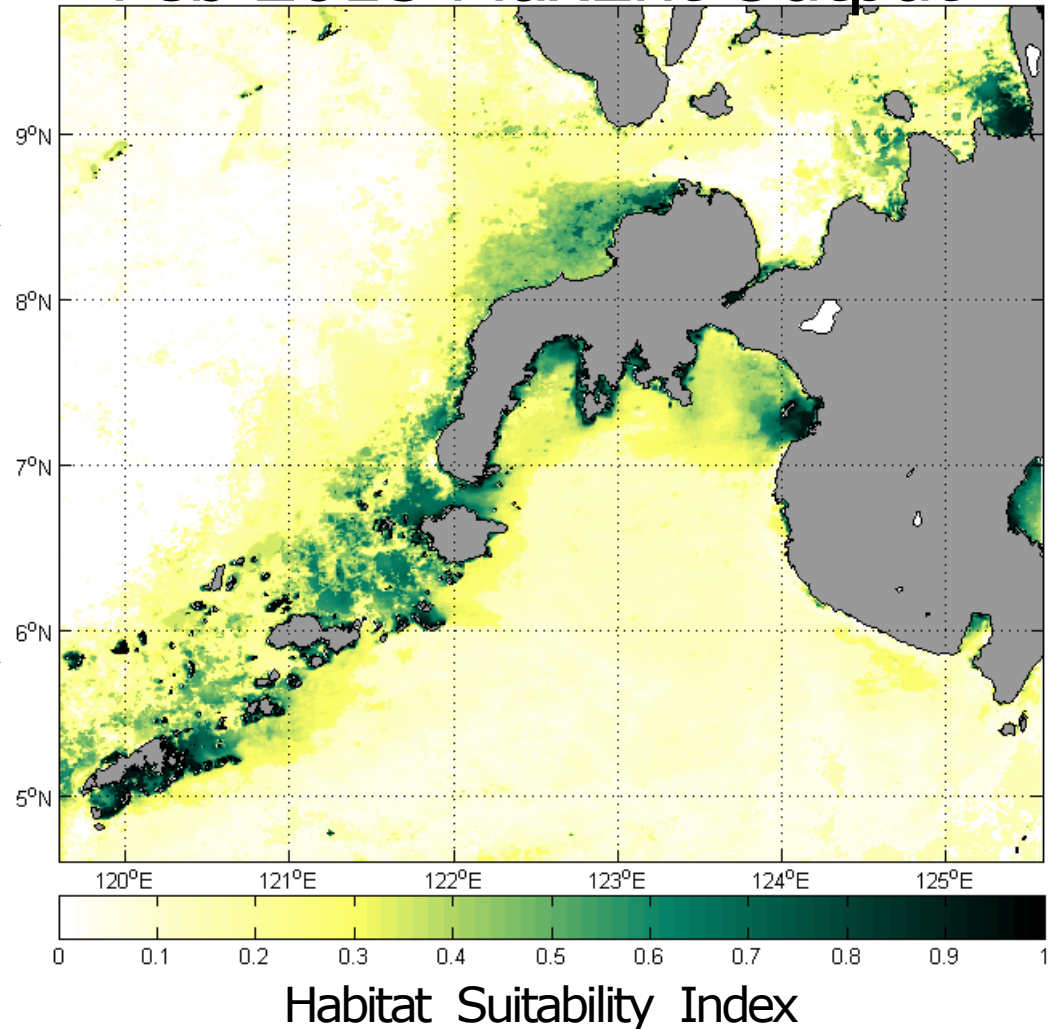
Chlorophyll-a



Sea Surface Temp.



Feb 2013 MaxEnt Output



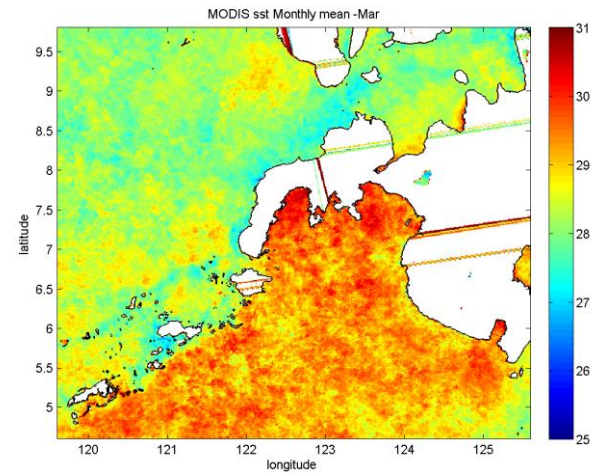
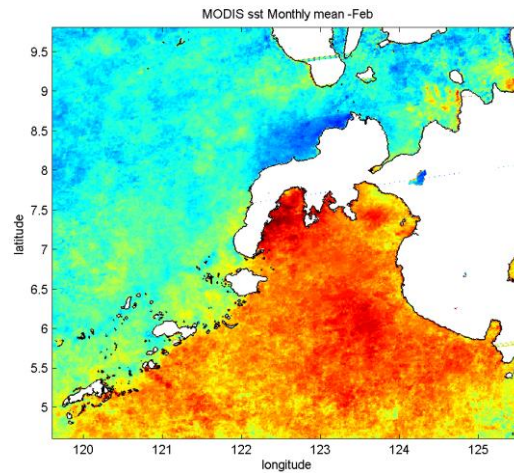
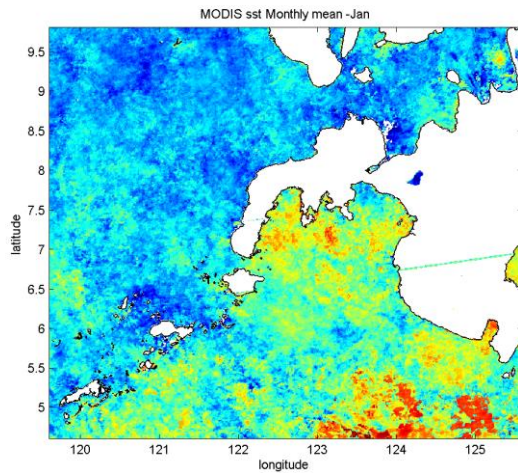
# 2013 Monthly SST

showing upwelling in the northern Zamboanga and very sharp SST difference between Sulu and Sulawesi Sea

**Jan**

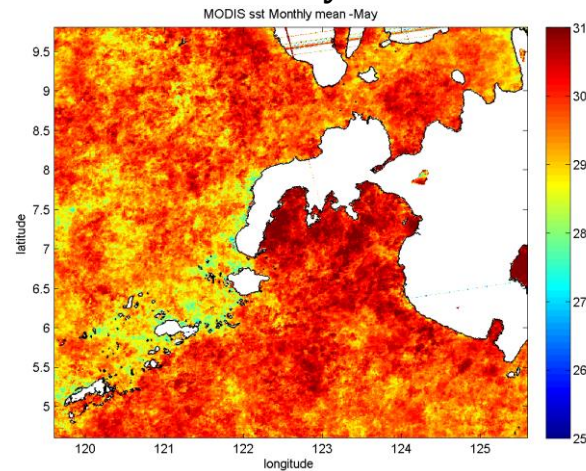
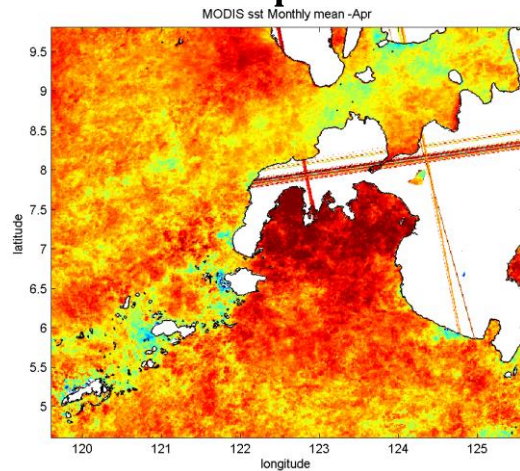
**Feb**

**Mar**



**Apr**

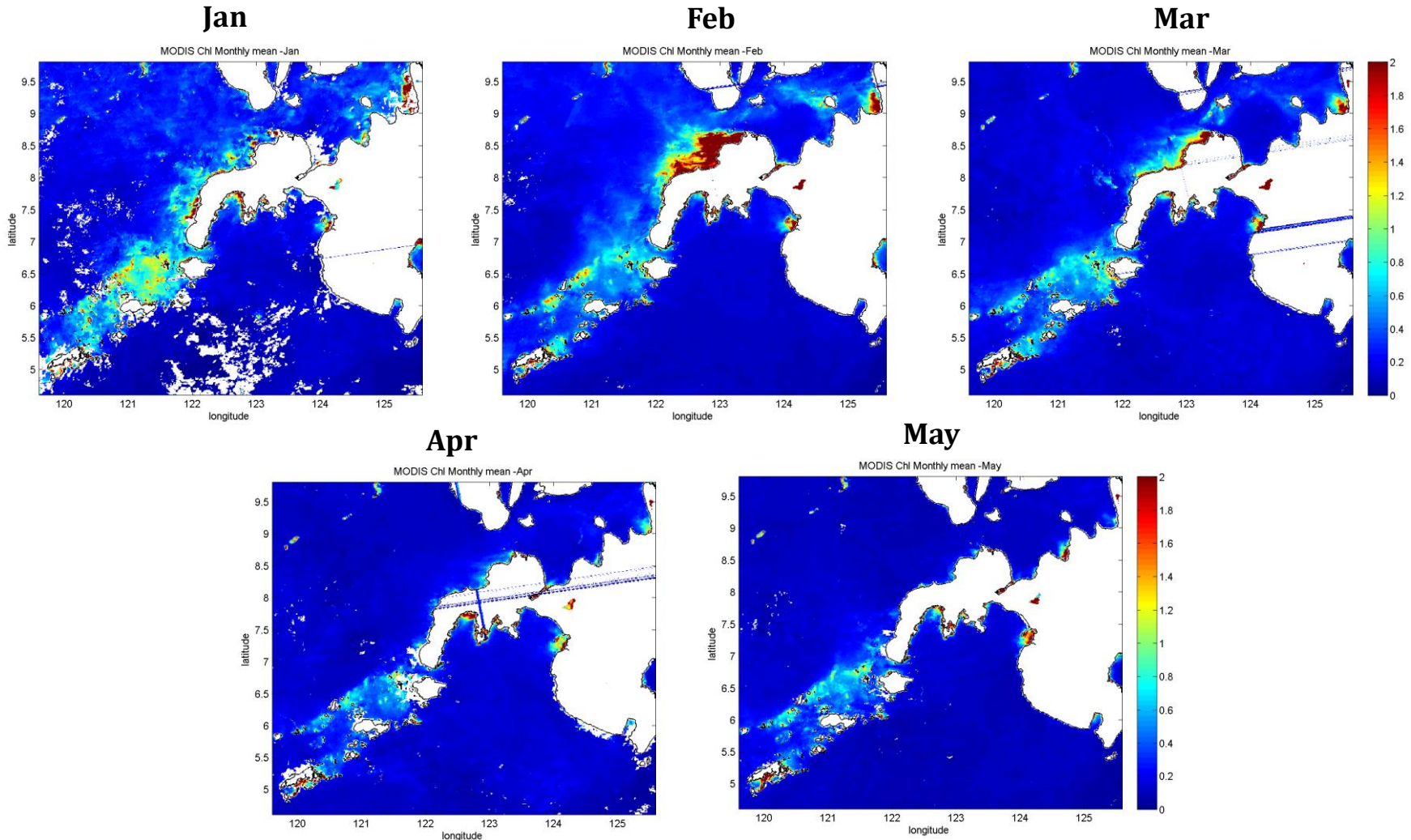
**May**





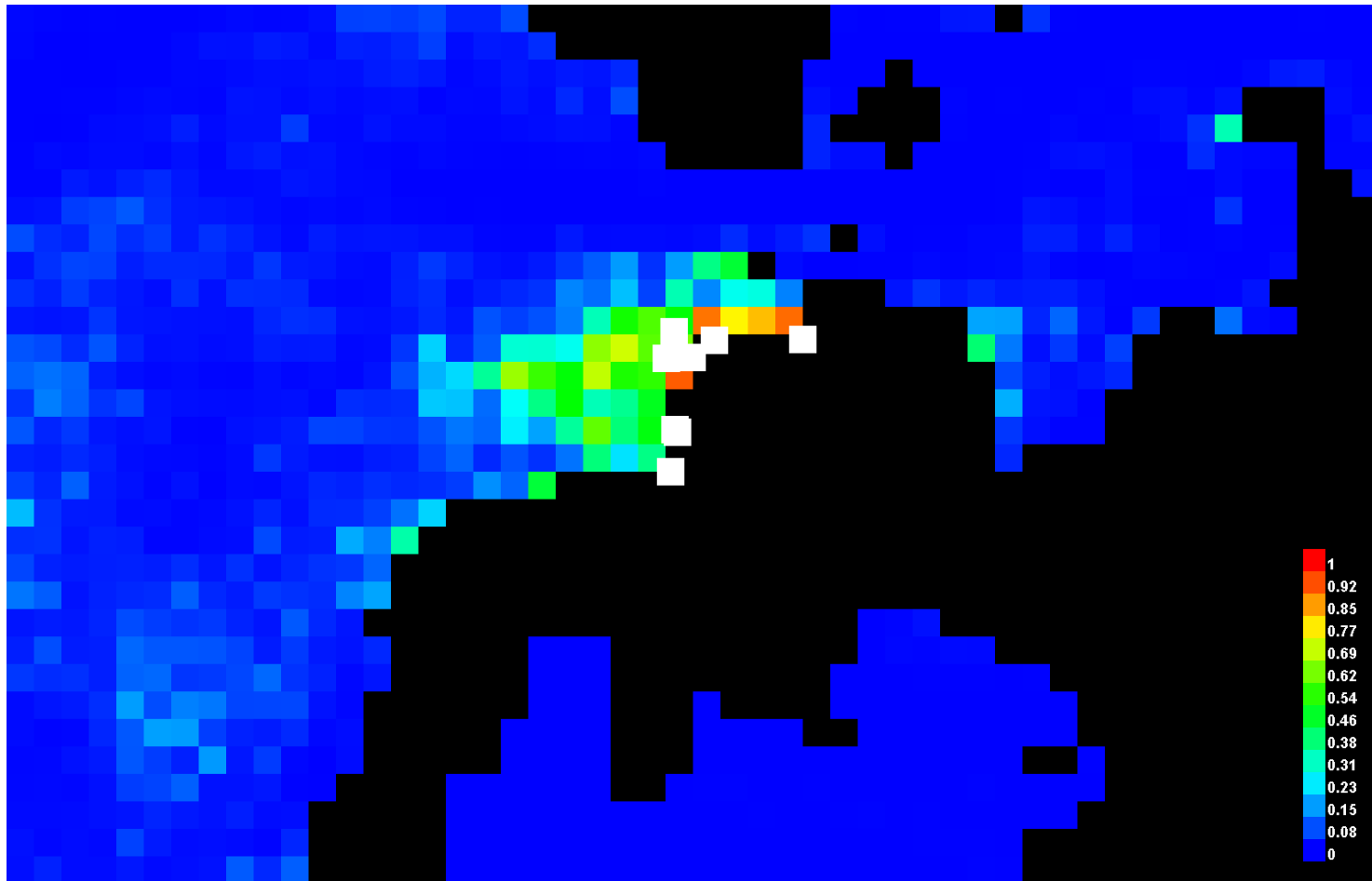
# 2013 Monthly Chlorophyll data showing peak upwelling in Feb 2013

Elevated chlorophyll limited to northern Zamboanga Peninsula. High values along Sulu Archipelago mostly due to reflection of shallow bottom.



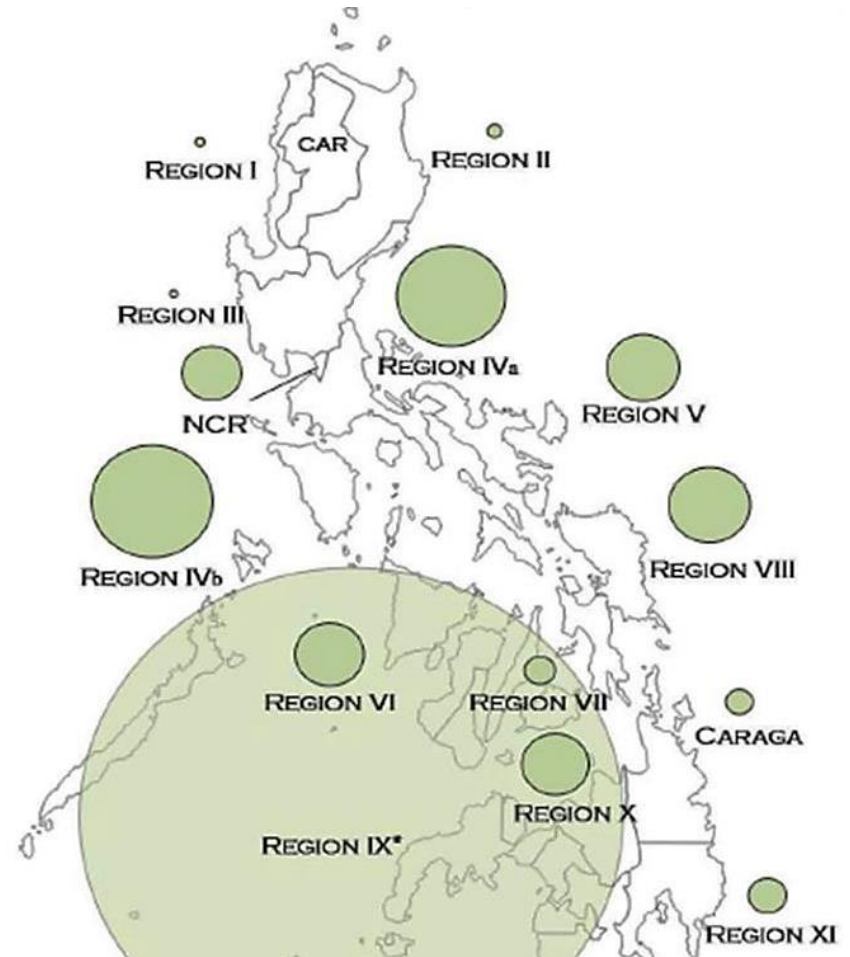
# Feb 2013 : SST, Chl, Currents (MODIS + HYCOM)

## Predicted suitable habitats for sardines



# Challenges to a nationwide scaling up of the habitat preference model

- Absence or inaccessible spatial fish catch and effort data
- Presence data based on fish catch only. No available fishery-independent data



# Environment

**HYCOM  
Global Ocean  
Circulation**

**Habitat Index  
based on MODIS  
Chlorophyll &  
Sea Temperature**

# Sardine Biology

**Movement**  
4th order Runge-Kutta  
method with Extended  
Kinesis swimming

Spatiotemporal  
Location

**Spawning**

**Growth**  
based on age-size  
equations and field  
sampling information

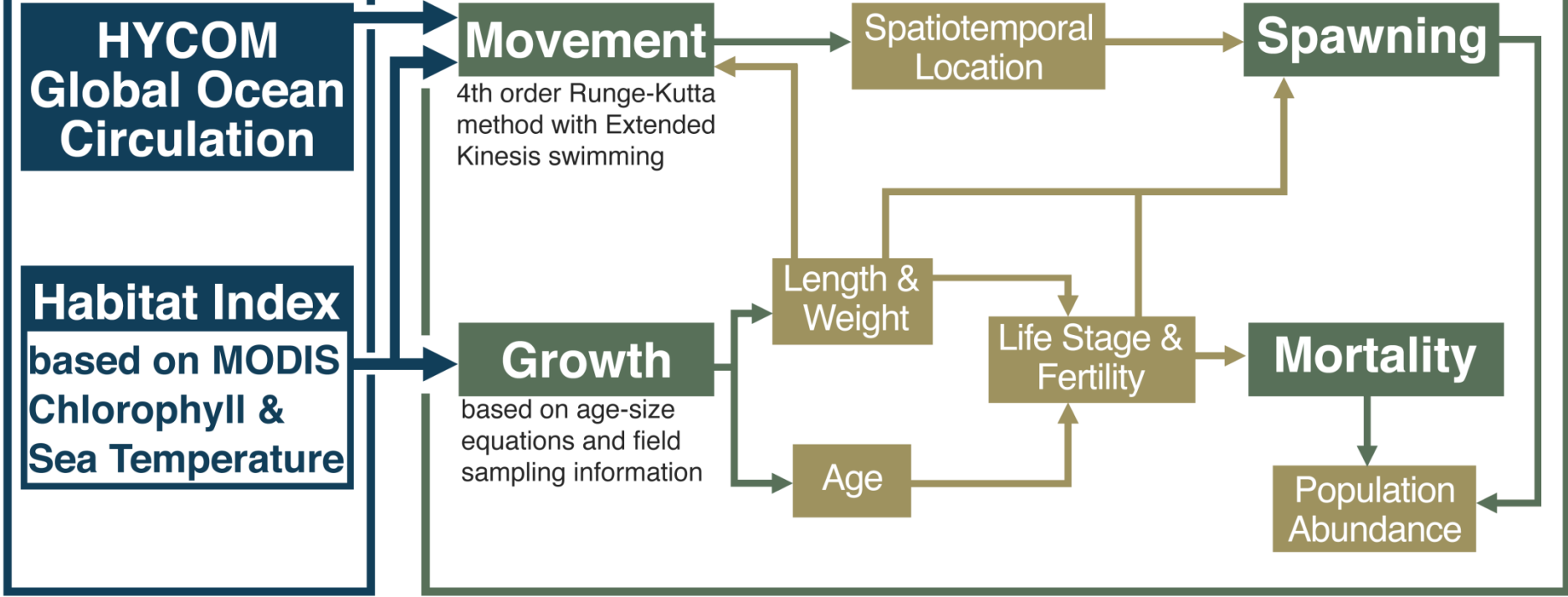
Length &  
Weight

Life Stage &  
Fertility

**Mortality**

Age

Population  
Abundance





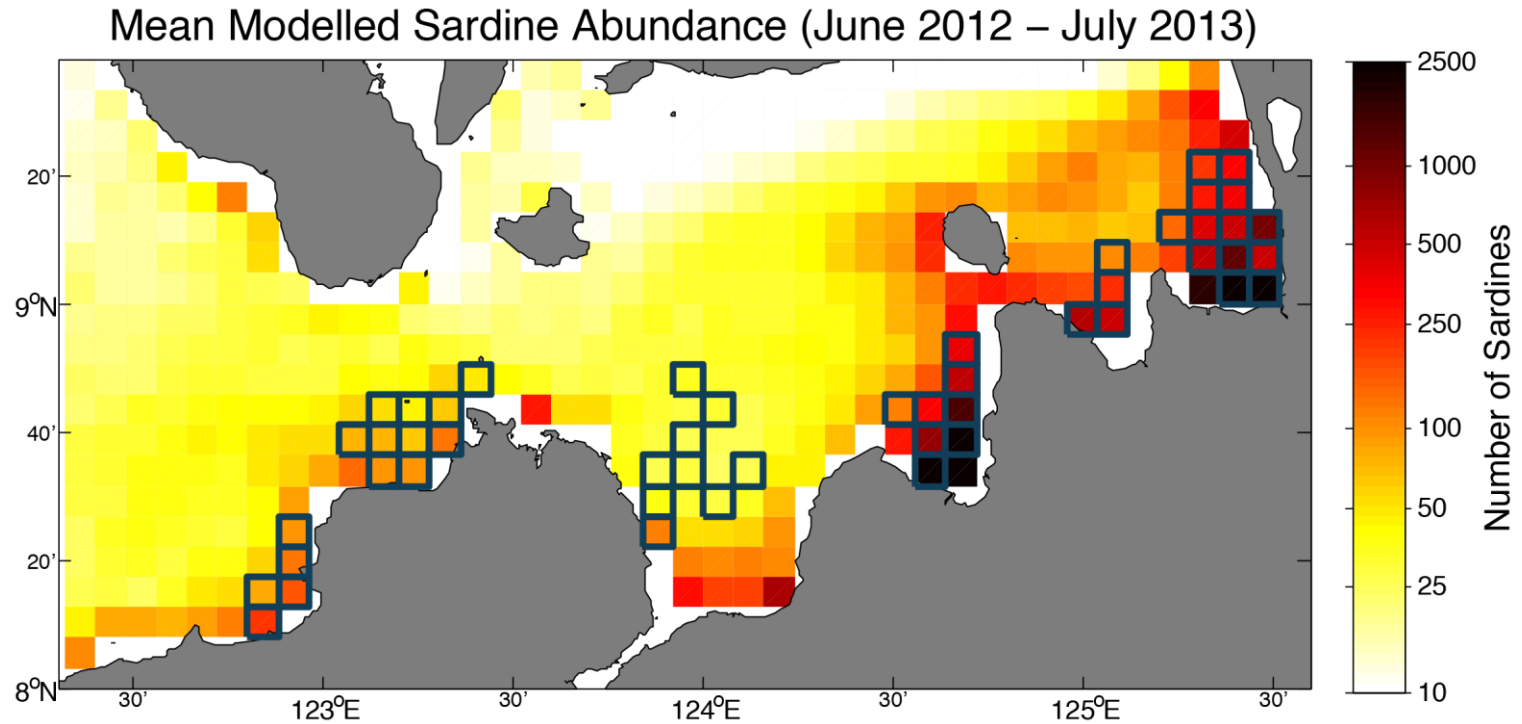
Track Sardines  
& Environmental Conditions

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graph TD; A[Track Sardines & Environmental Conditions] --> B[Understand Biophysical Interactions]; B --> C[Management tool to protect fisheries];
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Understand  
Biophysical Interactions

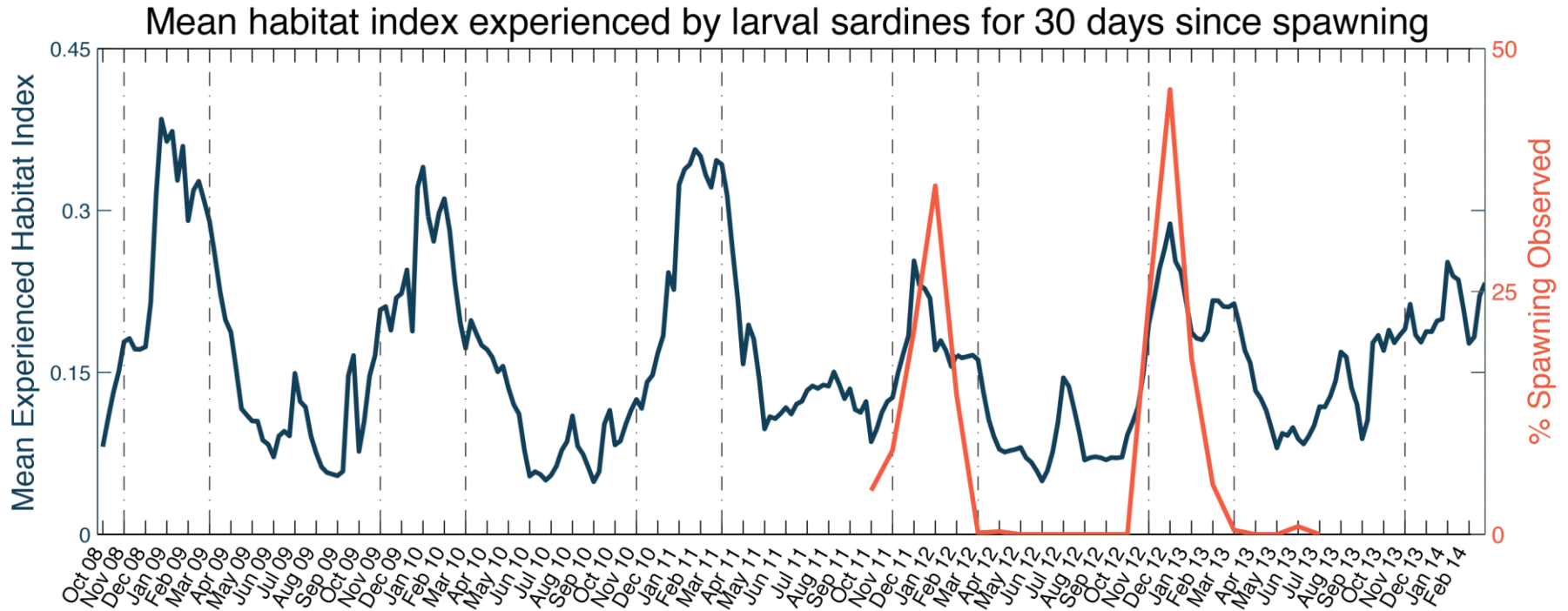
Management tool  
to protect fisheries

# Spatial Validation



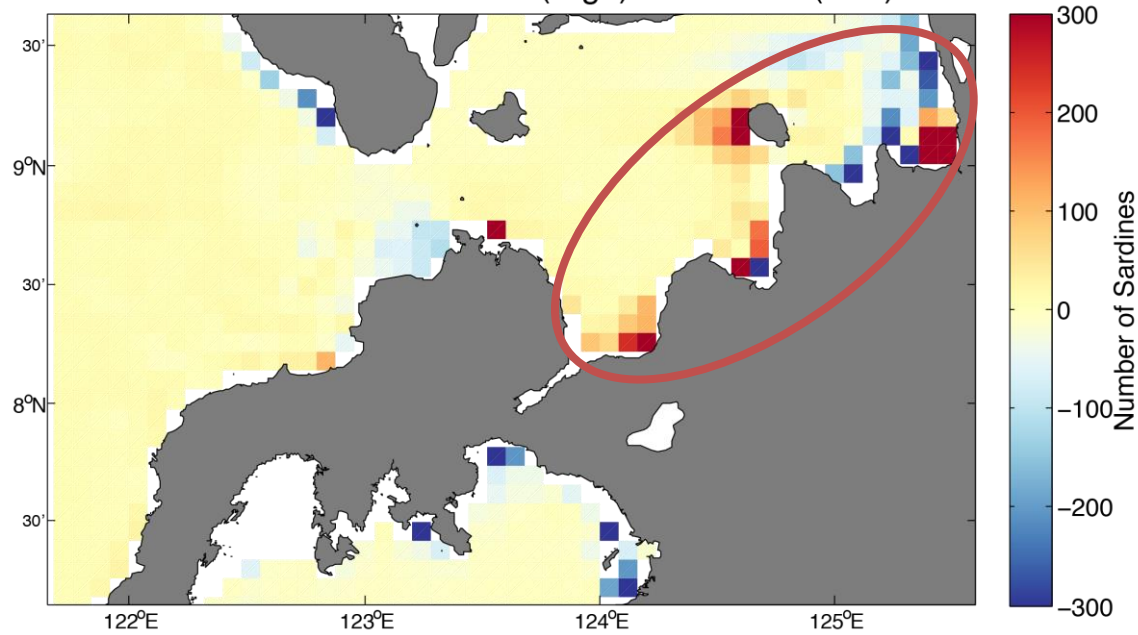
High concentration of agents in boxed cells where sardines have been caught show that the model can reproduce observed field distribution.

# Spawning Timing



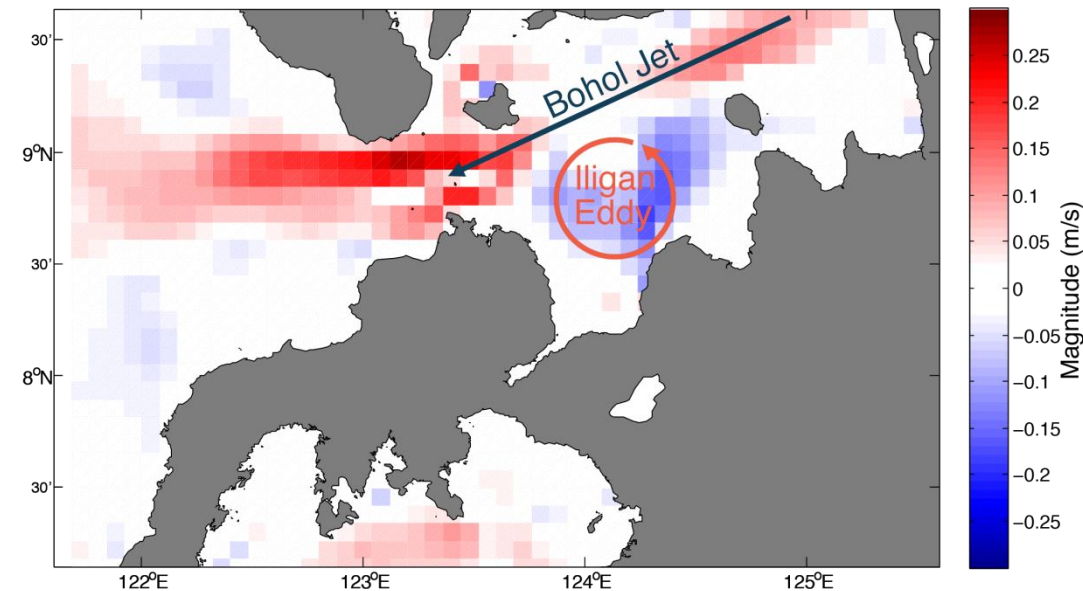
Peak of experienced optimal habitat coincides with peak of observed spawning trends suggesting that spawning is strategically timed.

Quarter 2 Abundance: 2013(High) minus 2011(Low)



Generally, more sardines are located within the bays for 2013 relative to 2011.

Quarter 2 Currents: 2013 minus 2011



The stronger Bohol jet and weaker Iligan eddy in 2013 may have increased retention within the bays.

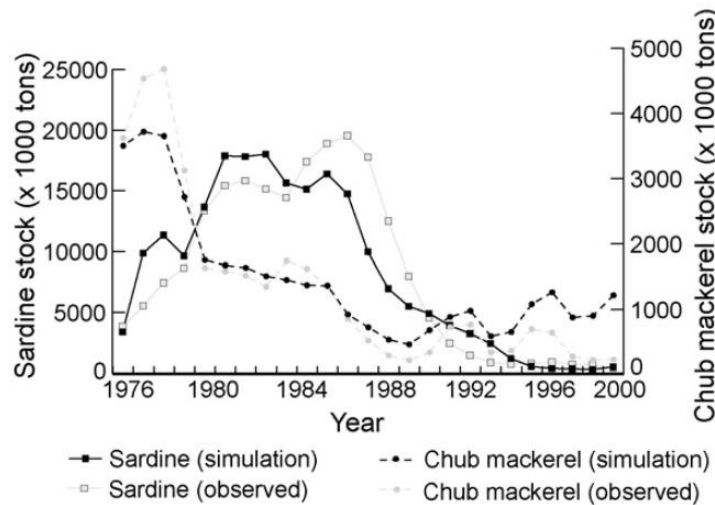


# **Sustaining the sardine fisheries requires more information**

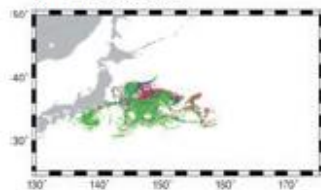
- Egg/Larvae distribution
- Catch Monitoring at specific landing sites (adults, juveniles – lupoy)
- GPS tracking of fishing activities (fishing effort and gonadal index distribution mapping to identify spawning grounds)

# Improving models to help provide tools and refine management strategies

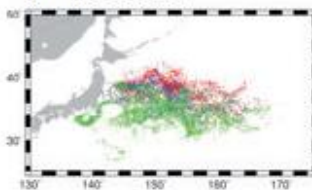
- Reliability of the models rely on availability of data on species catch locations!



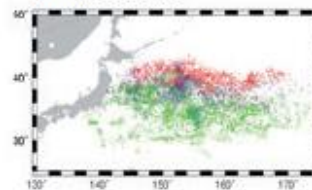
April-spawned cohorts  
(a-3) 30 days



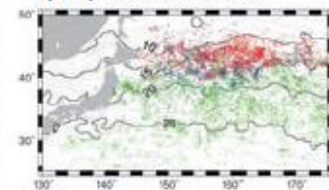
(b-3) 60 days



(c-3) 90 days



(d-3) October 31st



●  $BL_{END} < 7$  cm   ●  $BL_{END} 7-9$  cm   ●  $BL_{END} > 9$  cm

# Daghang Salamat!

