Science, Service, Stewardship

# Investigating California Current petrale sole spawning dynamics and oceanographic recruitment drivers

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10th International Flatfish Symposium

NOAA FISHERIES SERVICE

# Petrale Sole

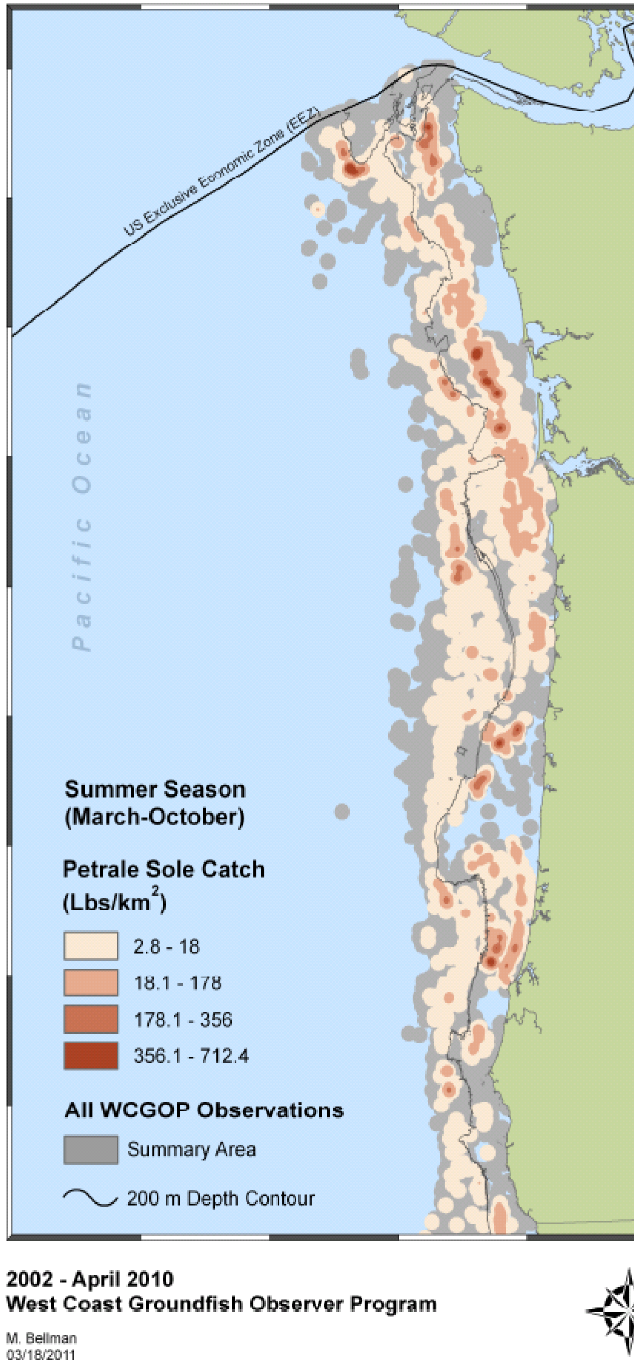
**Widely distributed**
NE Pacific

**Seasonal migration**
onshore – off shore

**Discrete**
winter spawning grounds

**High** site fidelity

**Commercially**
valuable target fishery





# Petrale Sole Stock Status and Recruitment

## 1980s to 2000s

- Minimums in SB
- ≤ 10% of unexploited levels

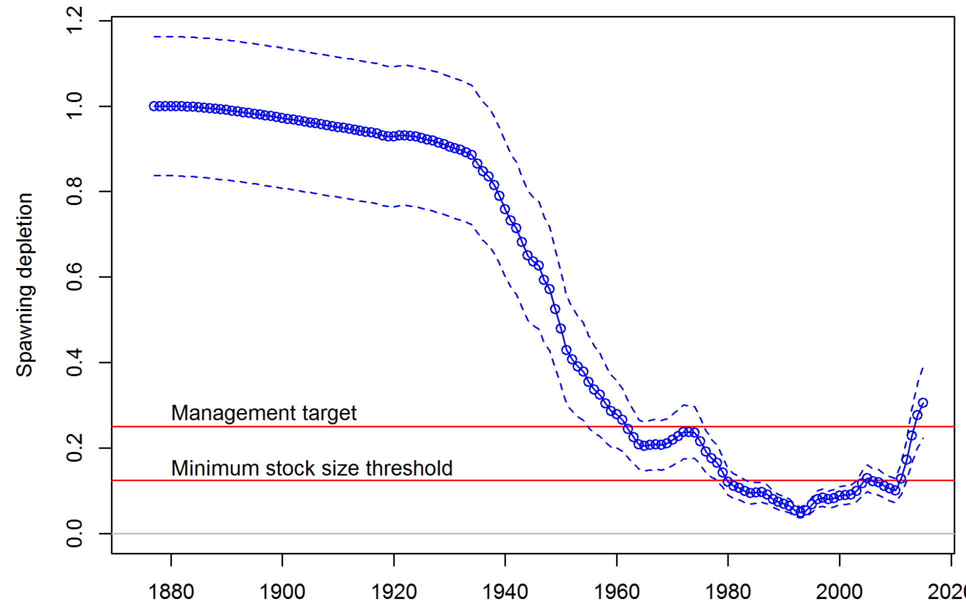
## Few Above Average Recruitments

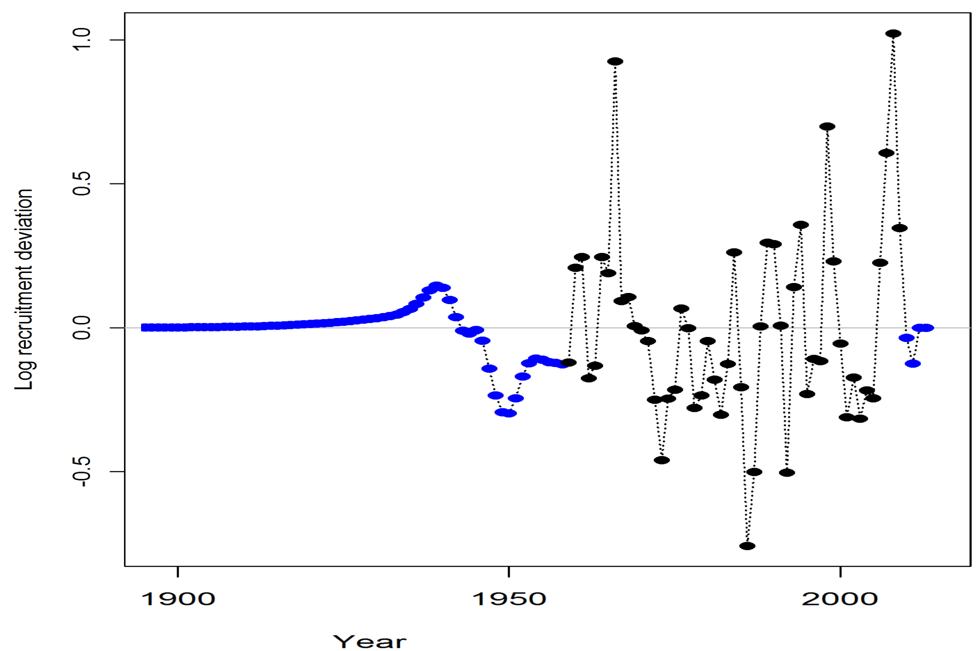
- Support fishery catch
- Followed by a lack of incoming recruits

**What** does fishery data suggest about spawning dynamics?

**What** is driving strong recruitments?

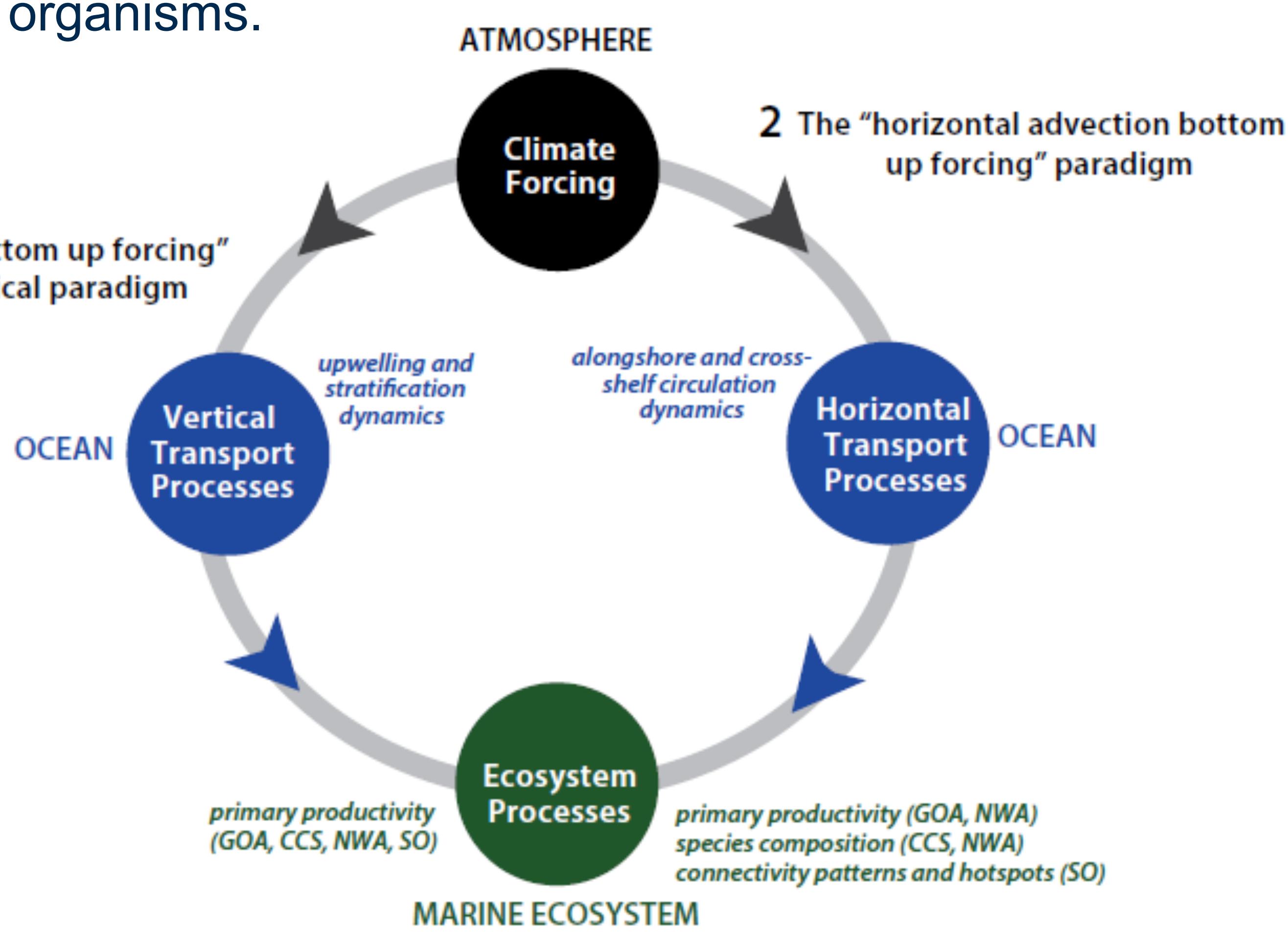
**What** are potential impacts of spawning aggregation fishery on recruitment?



# US GLOBEC:
# The horizontal-advection bottom-up forcing paradigm

Large-scale climate forcing drives regional changes in alongshore and cross-shelf ocean transport, directly impacting the transport of nutrients, water masses, and organisms.




Di Lorenzo, et al. 2013. *Oceanography* 26(4):22–33.

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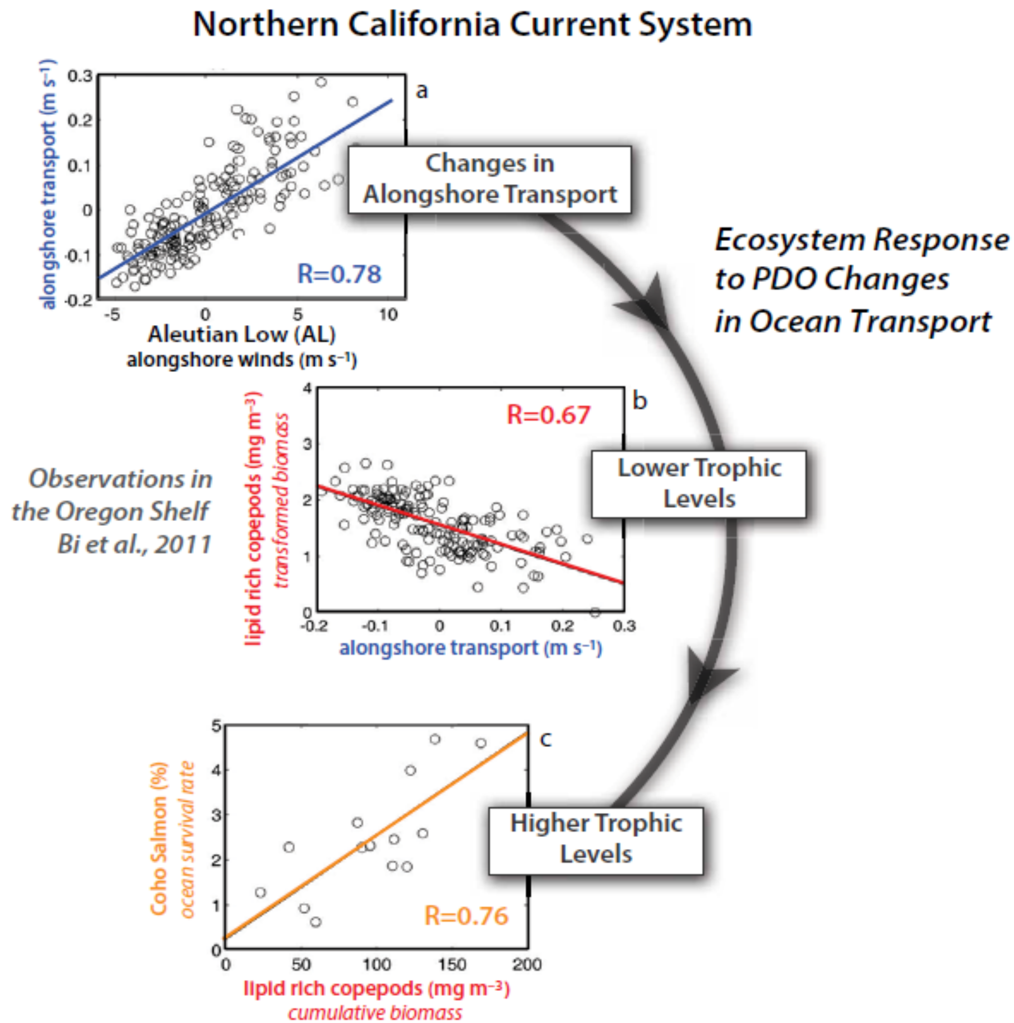


**Goal**

Test the hypothesis that cross-shelf transport of pelagic petrale sole from deep water spawning grounds shoreward towards nursery areas on the continental shelf results in stronger recruitments than transport off-shore away from nursery areas.

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# Approach

**Spatio-temporal modeling** of fishery trawl log-book data

- Spawning aggregation locations, biomass, and density
- Proportion of the stock occupying each spawning ground

**Conceptual life-history model**

- Stage- and spatio-temporally specific

**Test hypotheses**

- Physical variables that influence survival at each life stage

**Biophysical individual-based model driven by ROMS**

- Which spawning grounds contribute to recruitment success?
- Do important spawning grounds change through time?

# Spatio-temporal modeling of fishery trawl log-book data

**Data** 1981-2015

**Filters** for data quality

Top 20% biomass in at least 14 of the years

**Analysis** Package VAST on GitHub (www.FishStats.org)

Delta GLMM

Linear predictors for

1) encounter probability

2) positive catch or catch rates

Catch Weight ~Year + Lat + Lon + vessel

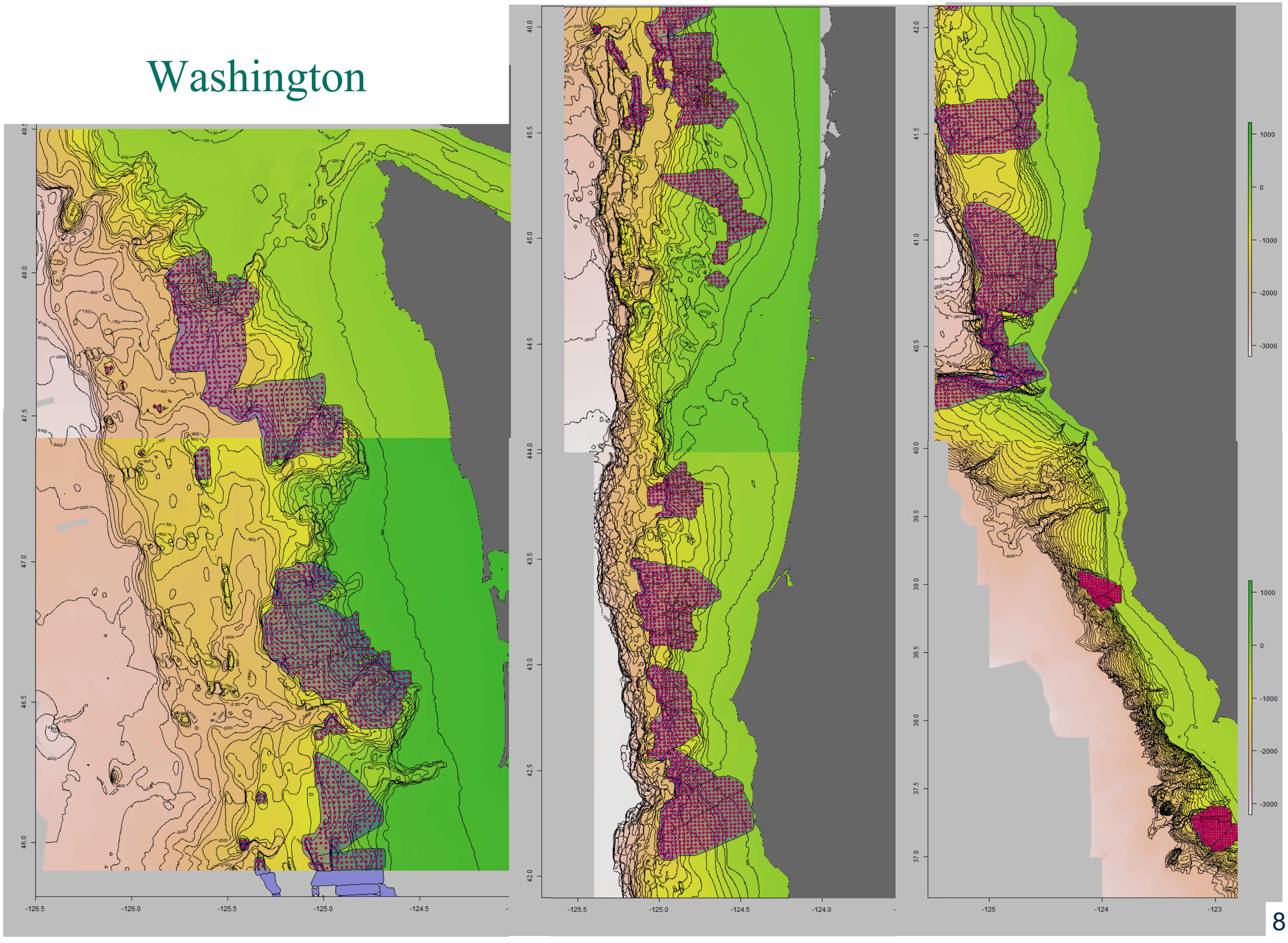
**Identify** 520 unique fishing areas, Static over all years

# Winter Trawl Fishing (Spawning) Grounds

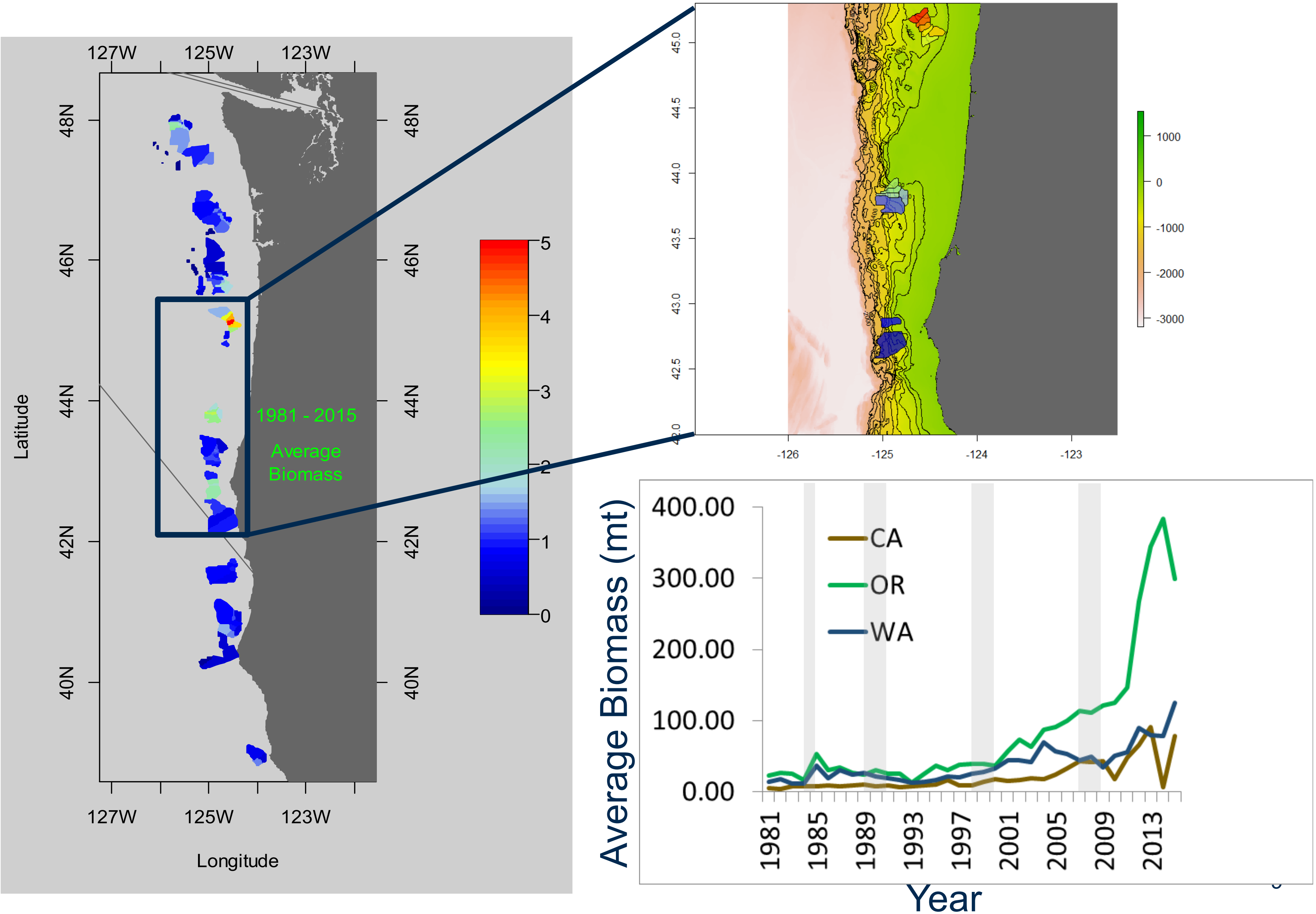
Washington

Oregon

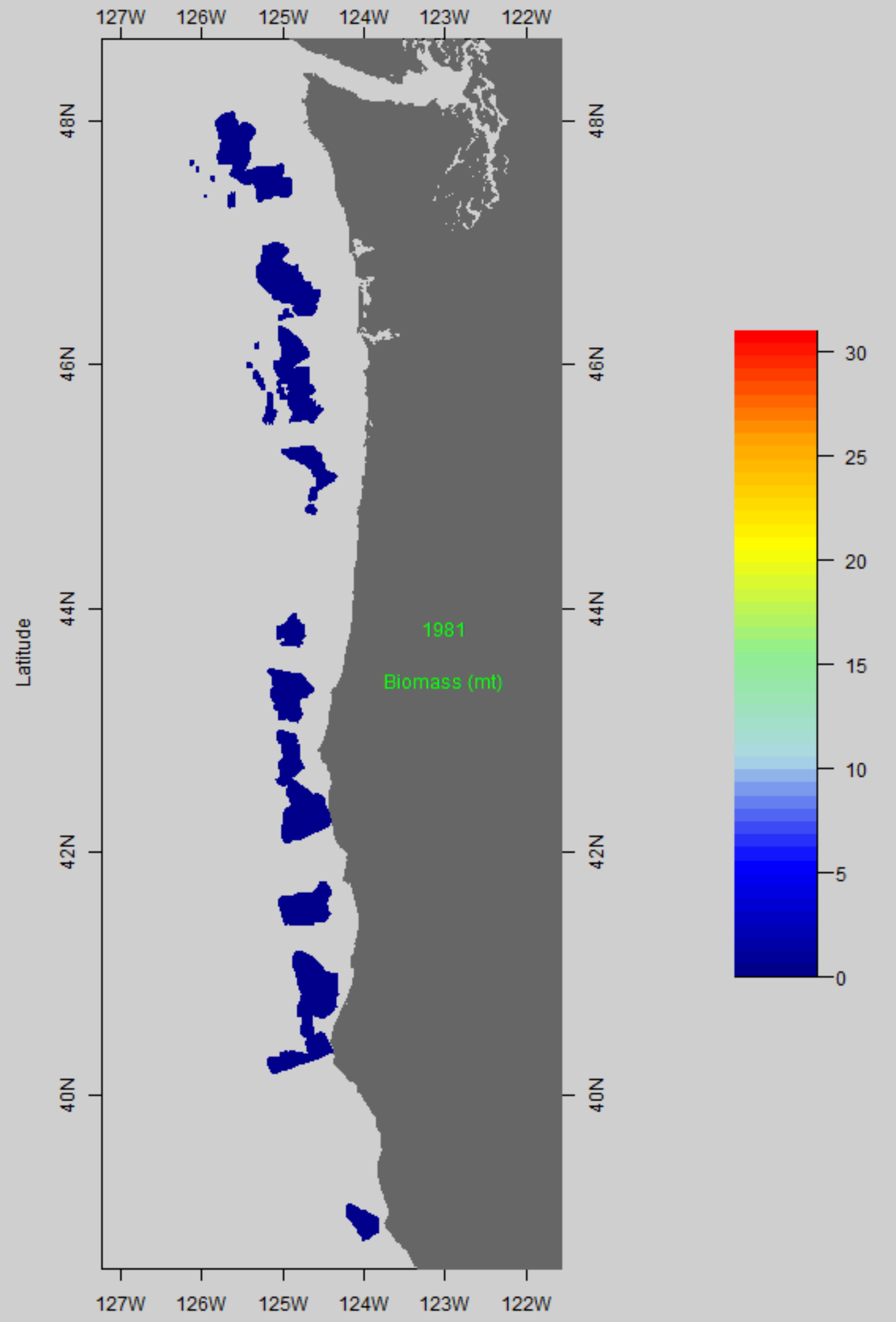
Northern California



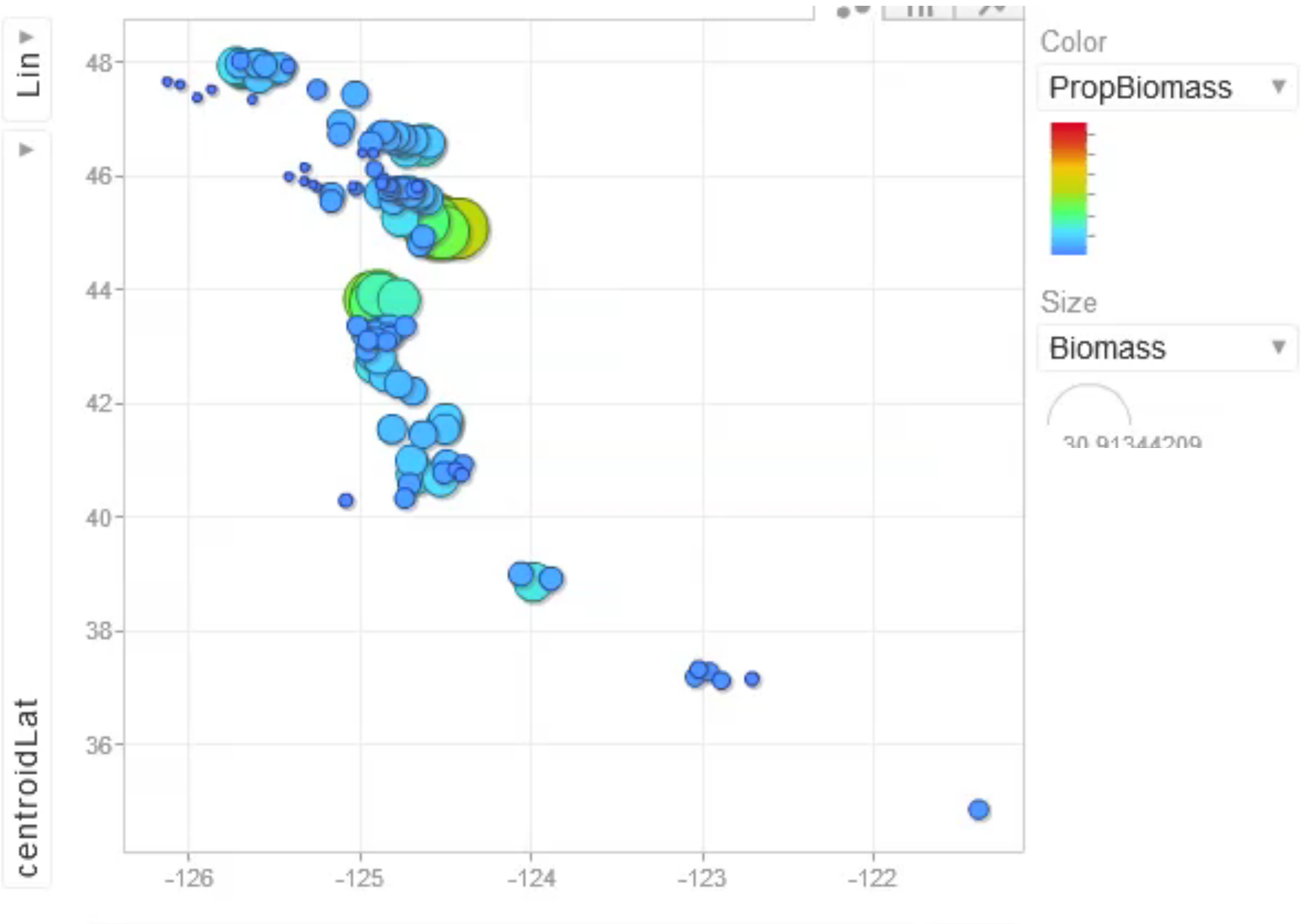
# Spawning aggregation locations and biomass



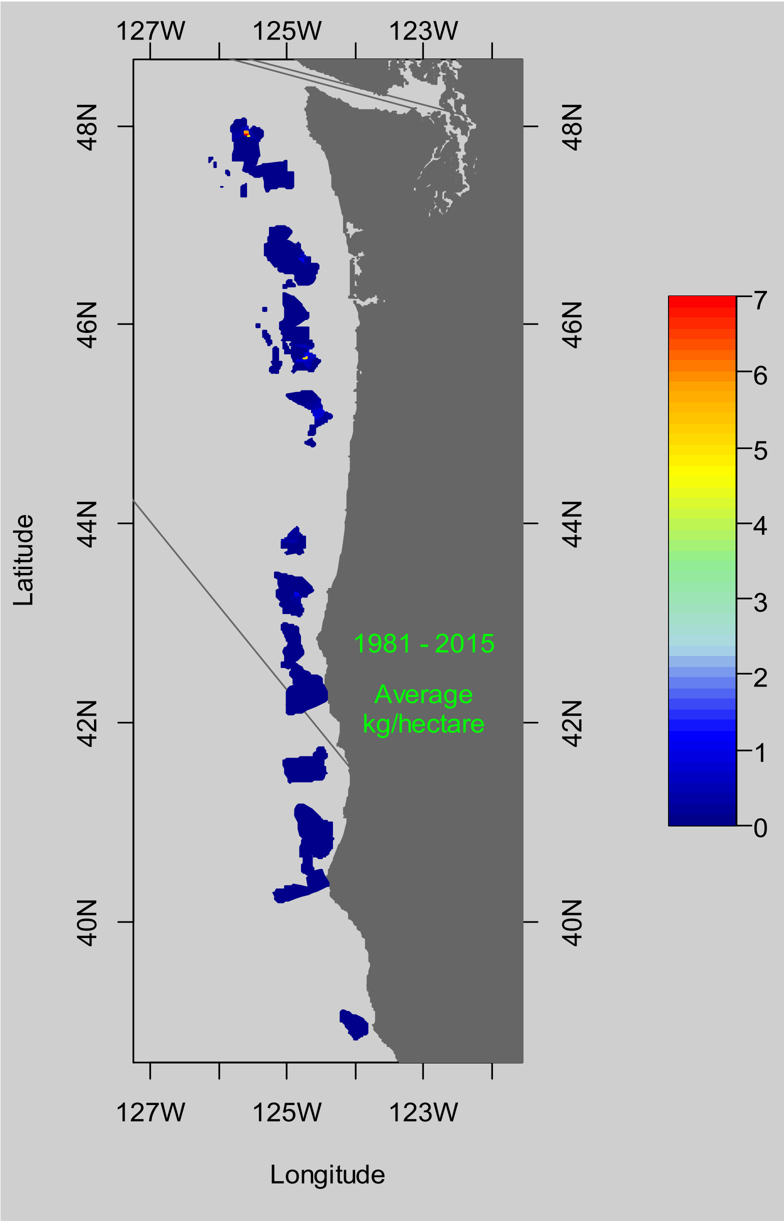
# Spawning biomass over time

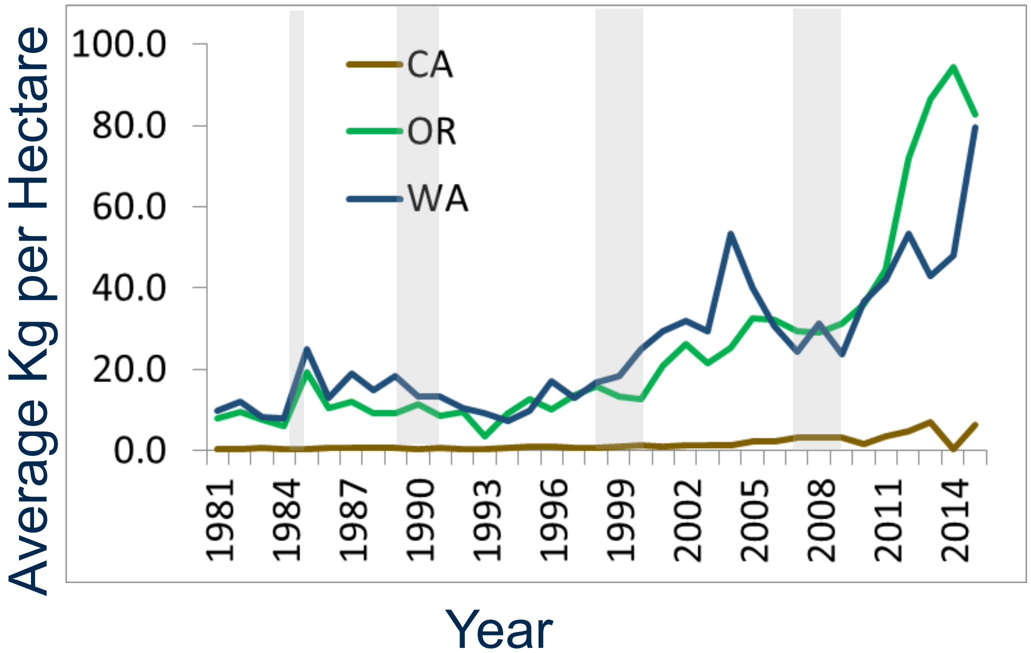


# Biomass During 2015



# Spawning aggregation densities



# Conceptual Life History Model: Oceanographic Recruitment Drivers

Conceptual life-history

↓

Make hypotheses

↓

Fit a bunch of models (glms)

↓

↓

Model selection with AICc

↓

Model testing

**Literature search**

# Conceptual Life History Model: Oceanographic Recruitment Drivers

Conceptual life-history

↓

Make hypotheses

↓

Fit a bunch of models (glms)

↓

Residuals = Intercept + various predictors

↓

Model selection with AICc

↓

Model testing

**Make stage specific & spatially specific hypotheses**

- Do not use generalized climate indices like NOI or PDO
- Use ROMS output for oceanic drivers
- ***NO*** Spawning stock biomass (SSB)

# Conceptual Life History Model:

## Preconditioning to benthic juveniles

Lat: 39-48.5 °N
Years: 1981-2015

| Life-history stage | Time period | Depth | Petrale Sole location |
|---|---|---|---|
| *Preconditioning* | May - Oct (Yr 0) | 50-400m with highest occurrence between 50 - 200 m | Bottom |
| *Spawning* | Nov (Yr 0)- Feb (Yr 1) | 250-475 m | Bottom |
| *Eggs* | Nov (Yr 0)- Mid-Mar (Yr1) | MLD-475 m temperatures 4-10 degrees C, salinities 25-30 ppt | Water Column |
| *Early Development* | Mid-Nov (Yr 0)- Mar (Yr 1) | MLD-475 m | Water Column |
| *Larvae (start feeding)* | Dec-April | 0-50 m | Water Column |
| *Pelagic juveniles* | April-August | 0-150 m | Water Column |
| *Benthic Juvenile (Age-0)* | May-September | 10 - 100 m | Bottom |

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Look at one stage

# Conceptual Life History Model:

## Preconditioning to benthic juveniles

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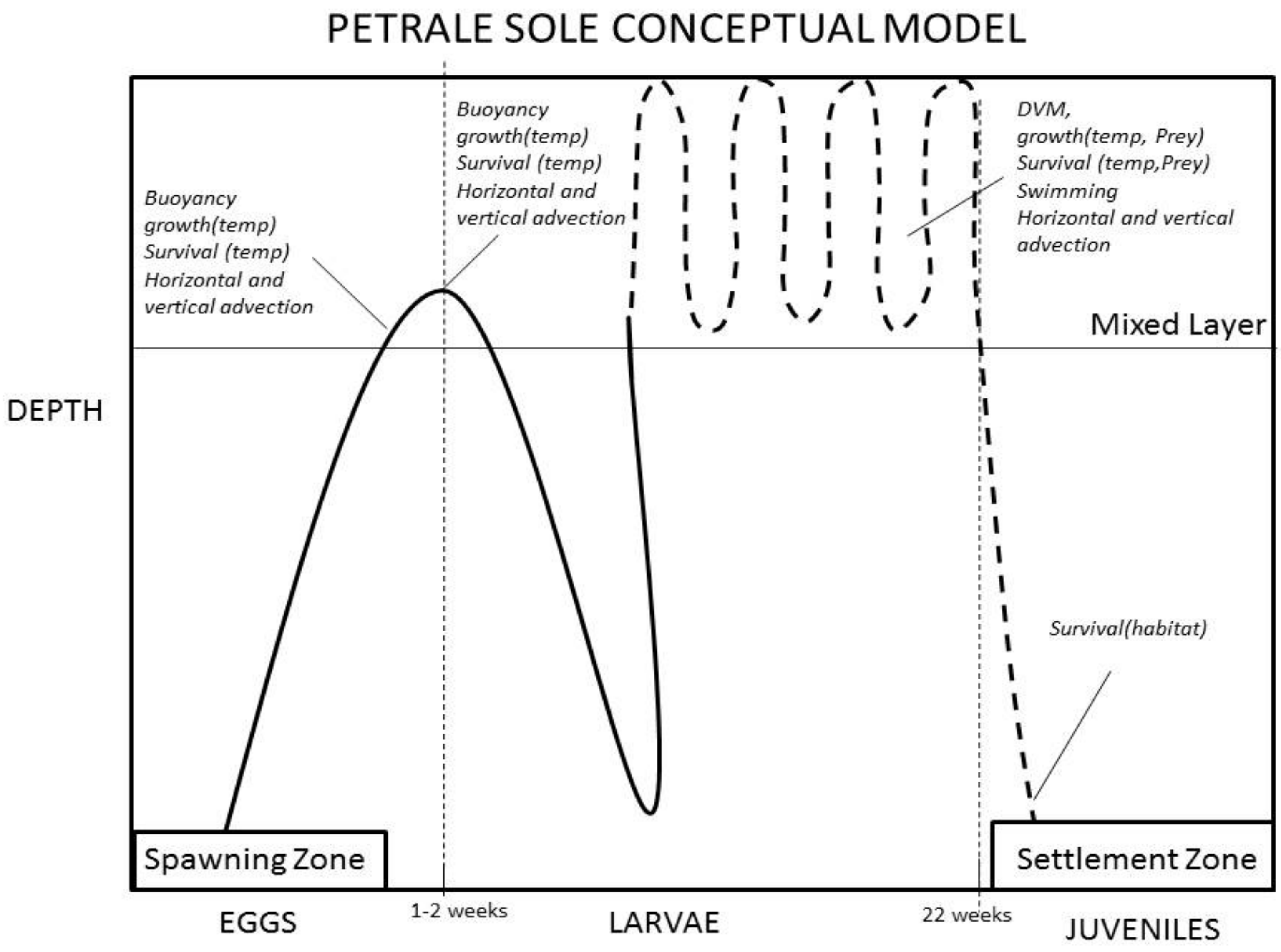
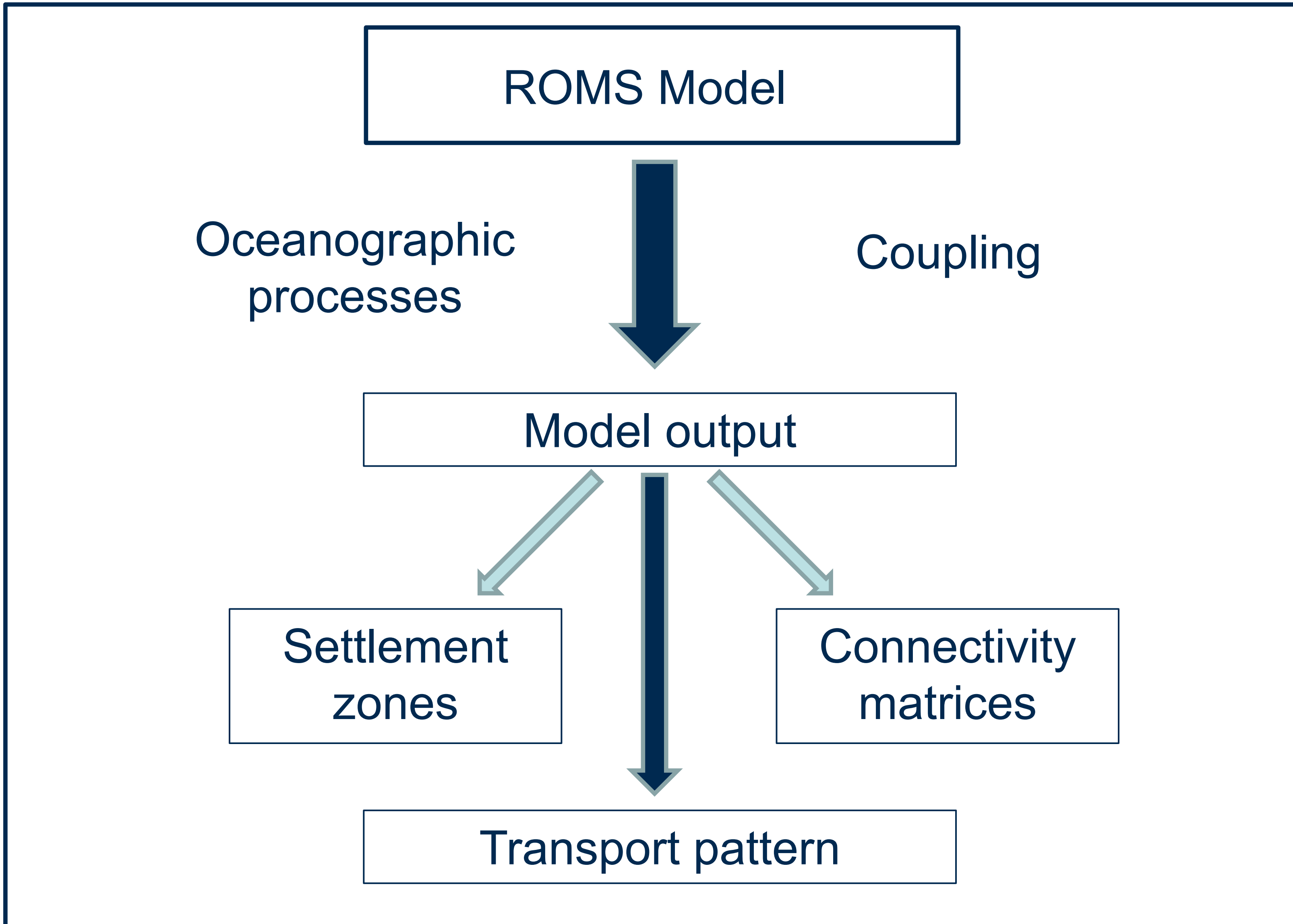
| Hypothesis | Covariates | Depth extent | Longitudinal extent | Data source |
|---|---|---|---|---|
| Transport to settlement habitat affects recruitment | Net long-shore transport | 0-150 m | 80-120 km offshore | ROMS |
| Transport to settlement habitat affects recruitment | Net cross-shelf transport | 0-15 m | 80-120 km offshore | ROMS |
| Growth/Predation hypothesis: | | | | |
| Growth rate is faster in warm water leading to reduced time vulnerable to predators etc | Degree days | 0-150 m | 80-120 km offshore | ROMS |

# Conceptual Life History Model: Individual Based Model



# ROMS Coupled Individual Based Model



# Logbook Modeling Summary:
# What does fishery data suggest about spawning dynamics?

**Identify** 520 discrete spawning grounds

**Low stock size** – low spawning biomass across all spawning grounds

**Increasing stock size** - 13 spawning grounds show large increases in biomass relative to other areas (all off of OR coast)

**Biomass on spawning grounds** - lowest in CA, followed by WA then OR

**Oregon** has ~ 50% or more of the biomass during the time series.

Since 2007 between 55% - 82% of the total spawning biomass is in OR.

**California** - spawning aggregations are much less dense than those in OR and WA

**Spawning aggregation density** - increased steadily with increasing stock size

**Peaks in spawning aggregation** density track strong cohorts in WA.

# Current Work

**Test hypotheses**

Physical variables that influence survival at each life stage

**Biophysical individual-based model driven by ROMS**

Which spawning grounds contribute to recruitment success?

Do important spawning grounds change through time?

The End

Thank You!