Forecasting the spatial distribution of Pacific sardine in the Pacific Northwest

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J-SCOPE project also includes: Bill Peterson, Phil Levin, Jan Newton

http://www.nanoos.org/products/j-scope/

NOAA FATE Fisheries and the Environment

UW Coastal Modeling Group

UNIVERSITY of WASHINGTON

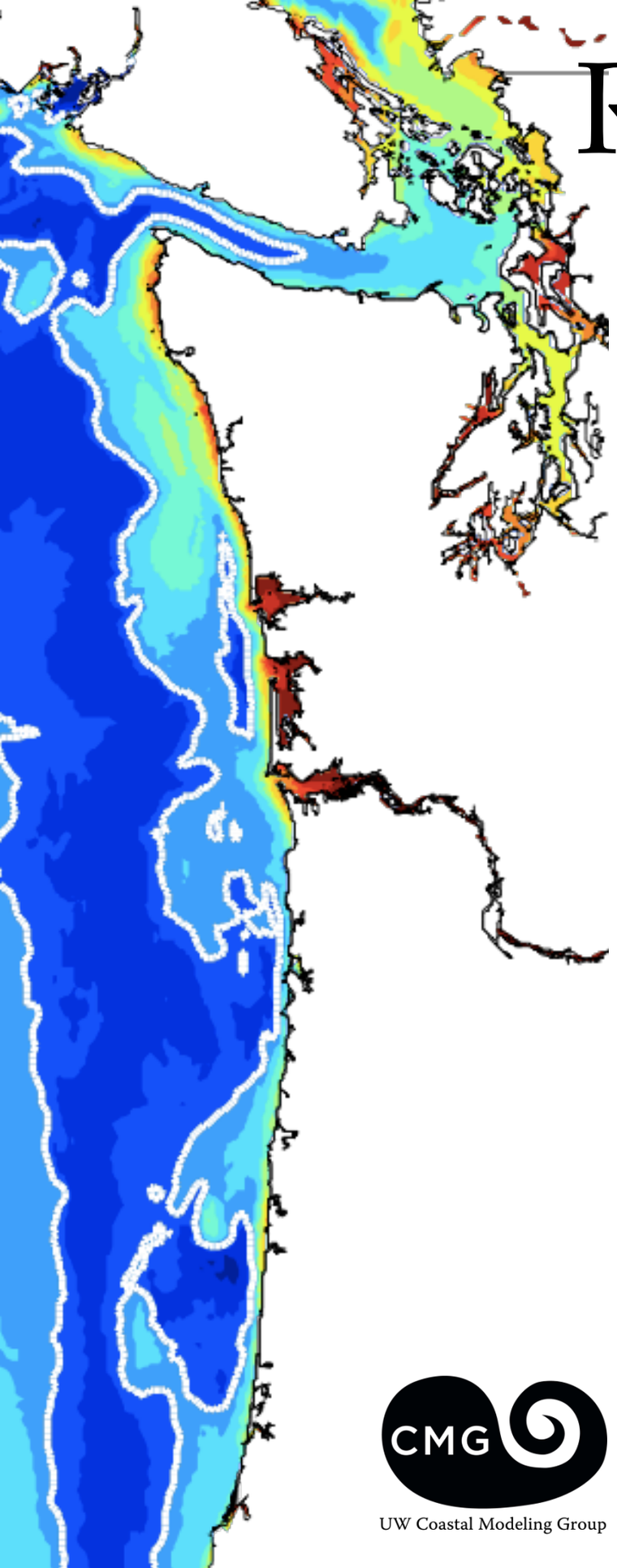
JISAO

NWFSC NORTHWEST FISHERIES SCIENCE CENTER

NANOOS

Goal: forecast up to 6-9 months of California Current ocean conditions

- Climate Forecast System (CFS) for coarse scale (50km) predictions of ocean physics, 6-9 months in advance
- Regional Ocean Modeling System (ROMS) is available to downscale these results



ROMS Model Description

UW Cascadia Model setup

http://faculty.washington.edu/pmacc/cmg/cmg.html

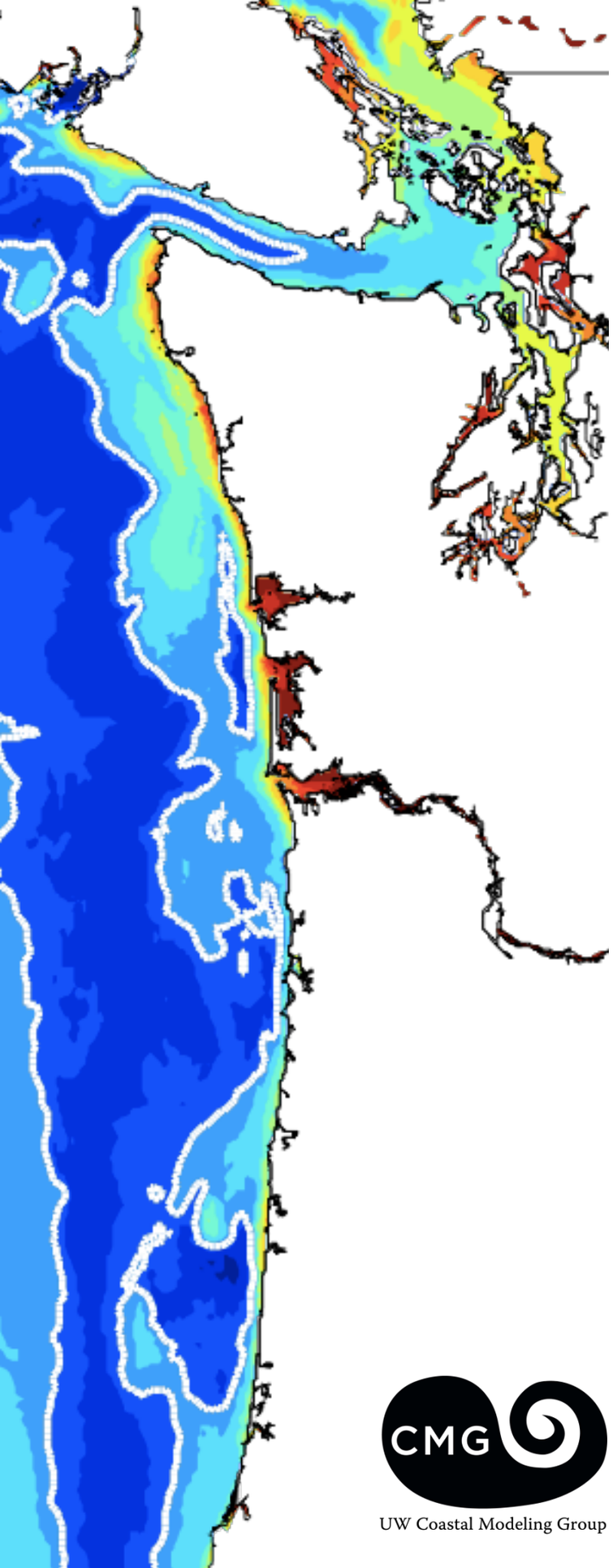
and Siedlecki et al. 2015; Giddings et al. 2014;
Sutherland et al. 2010

Resolution: 40 vertical S-coordinate levels
1.5-4km horizontal resolution, telescoping offshore

Rivers: 17 rivers included with daily discharge
and temperature values from the USGS and
Environment Canada or a Climatology
of discharge values for the forecast

Tides

Boundary Conditions and Atmospheric Forcing:
output from
Climate Forecast System (CFS)



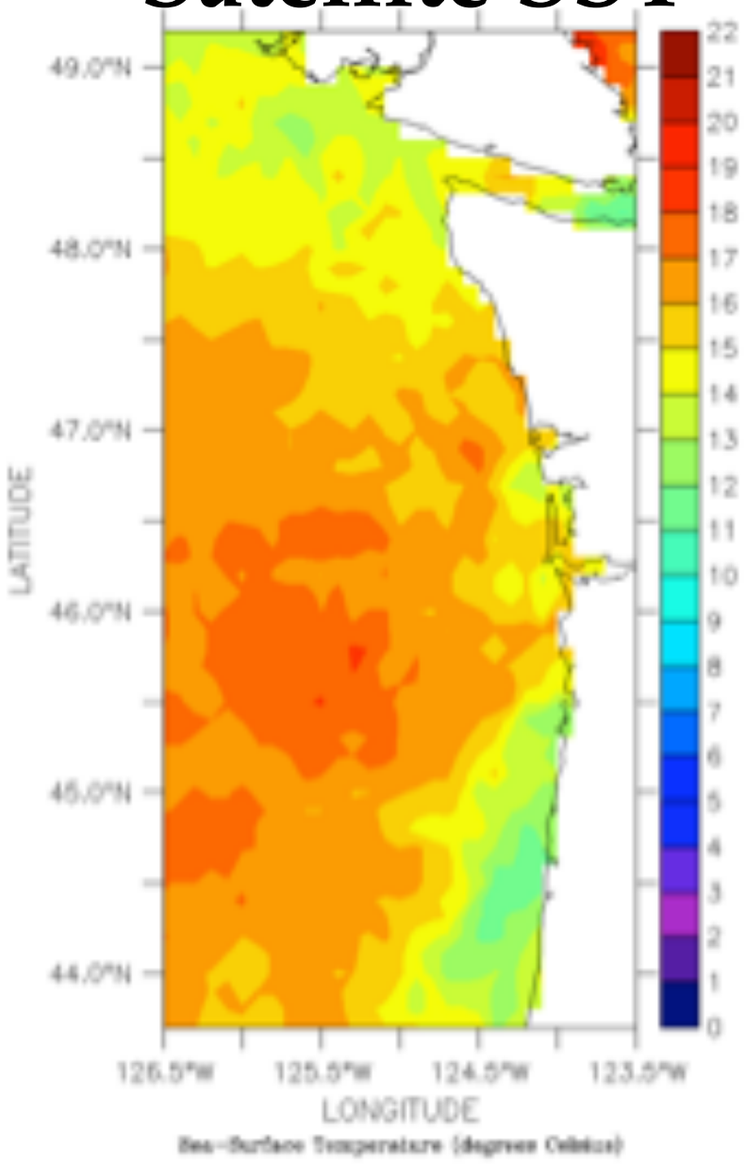
UW Coastal Modeling Group

ROMS Predicts:

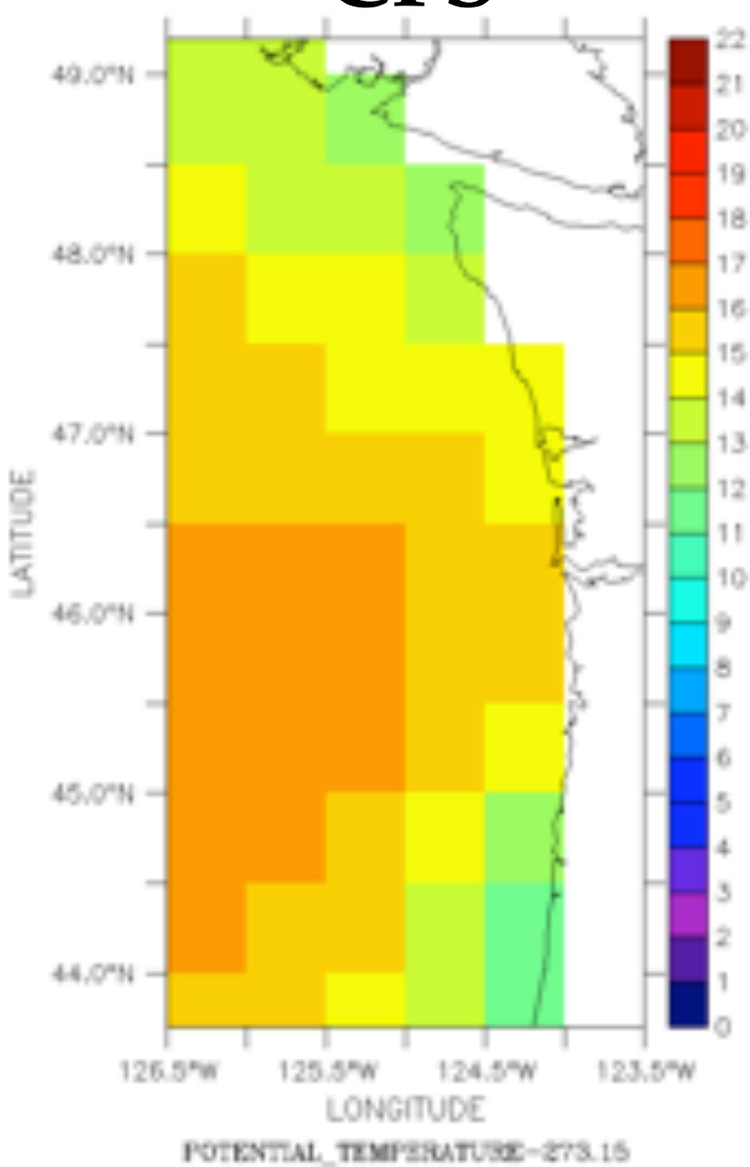
- Temperature, salinity, currents
- Dissolved inorganic nitrogen
- Phytoplankton
- Zooplankton (aggregated)
- Fast and slow sinking detritus
- Oxygen

Downscaled model captures N-S and onshore offshore SST trends

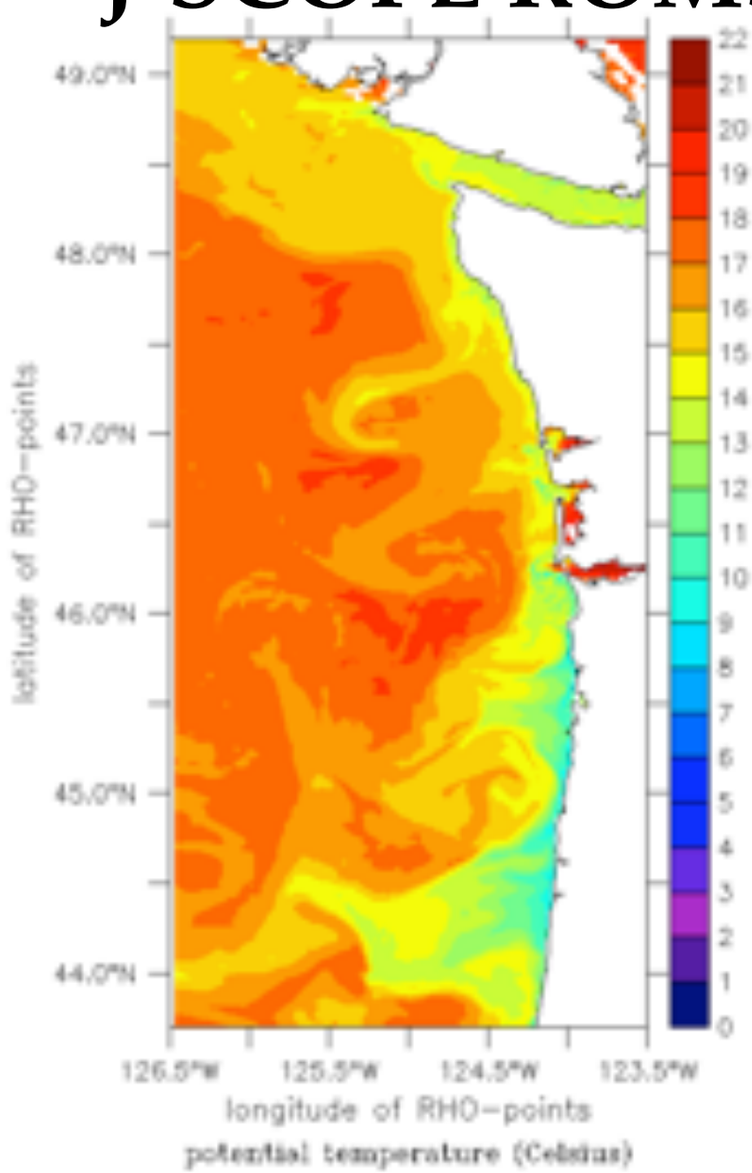
Satellite SST



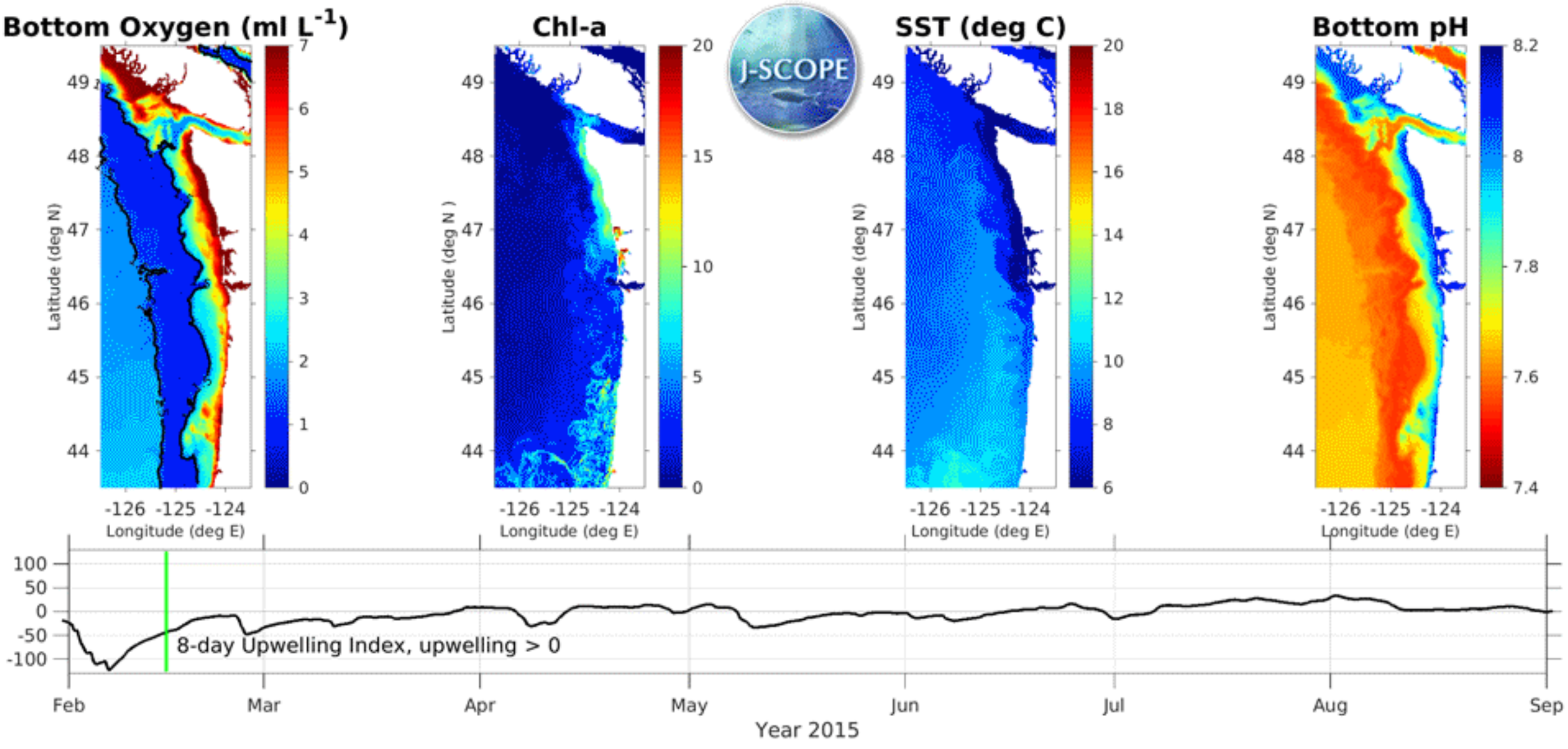
CFS



J-SCOPE ROMS



2015 J-SCOPE Forecast, initialized Jan 15th.
Ensemble also includes initial conditions for Jan 1 and Feb. 1

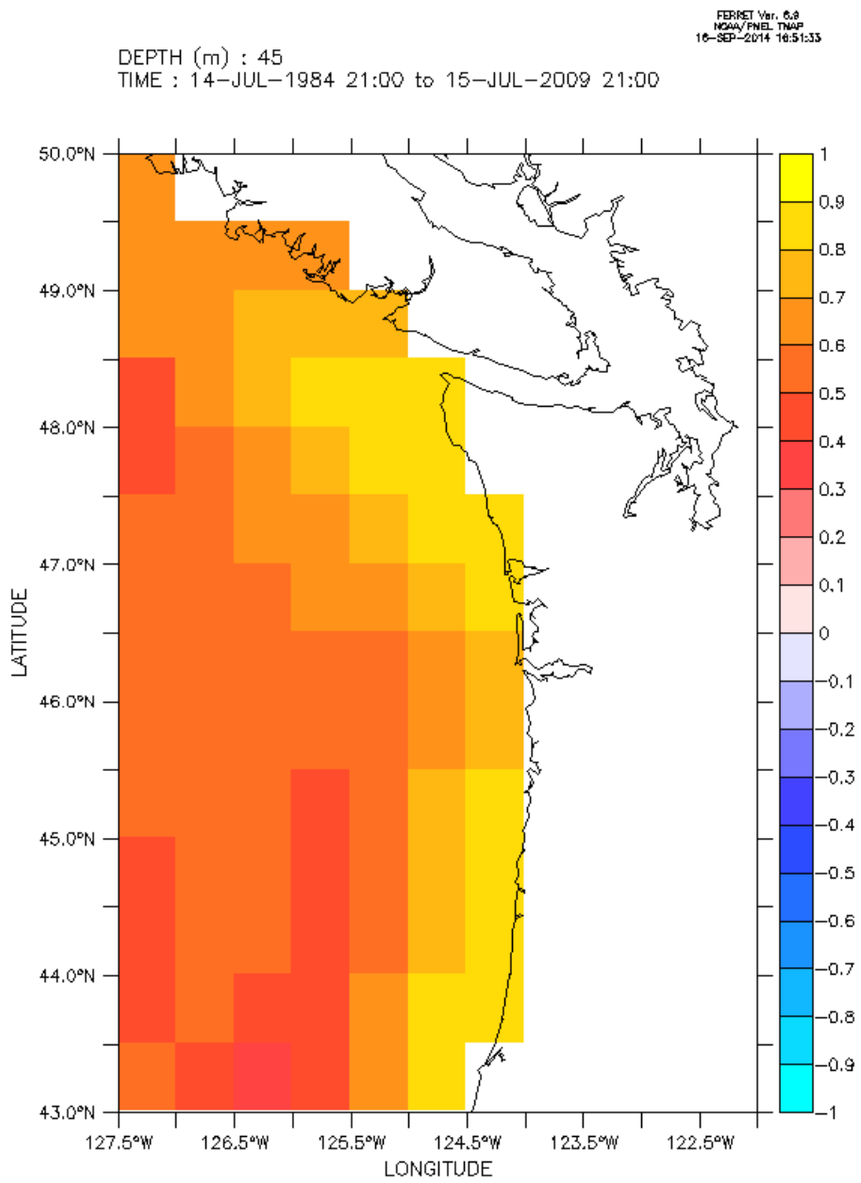


http://www.nanoos.org/products/j-scope/

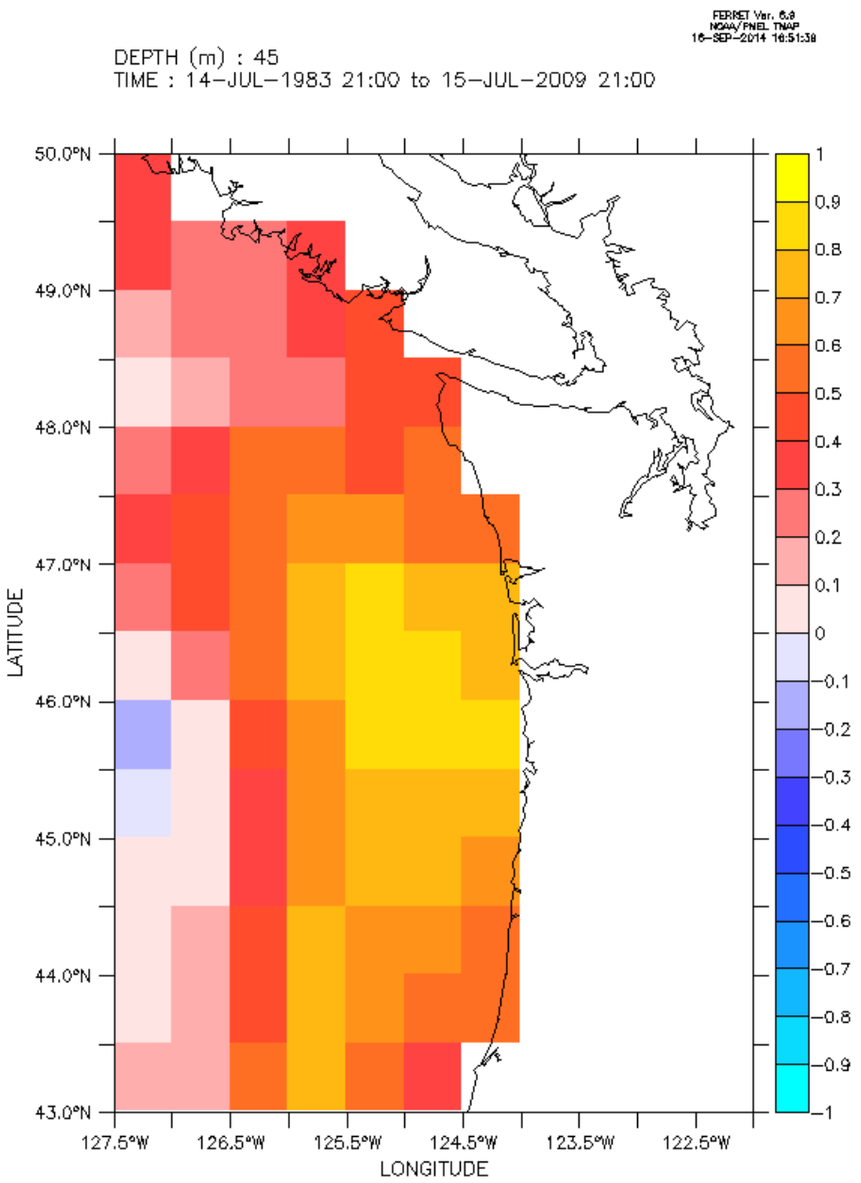
Efforts in 2014-2015

- Model Skill: CFS
- Model Skill: ROMS
- Sardine application

Predictive skill for seasonal Temperature and Salinity change at 45 m depth in J-SCOPE domain

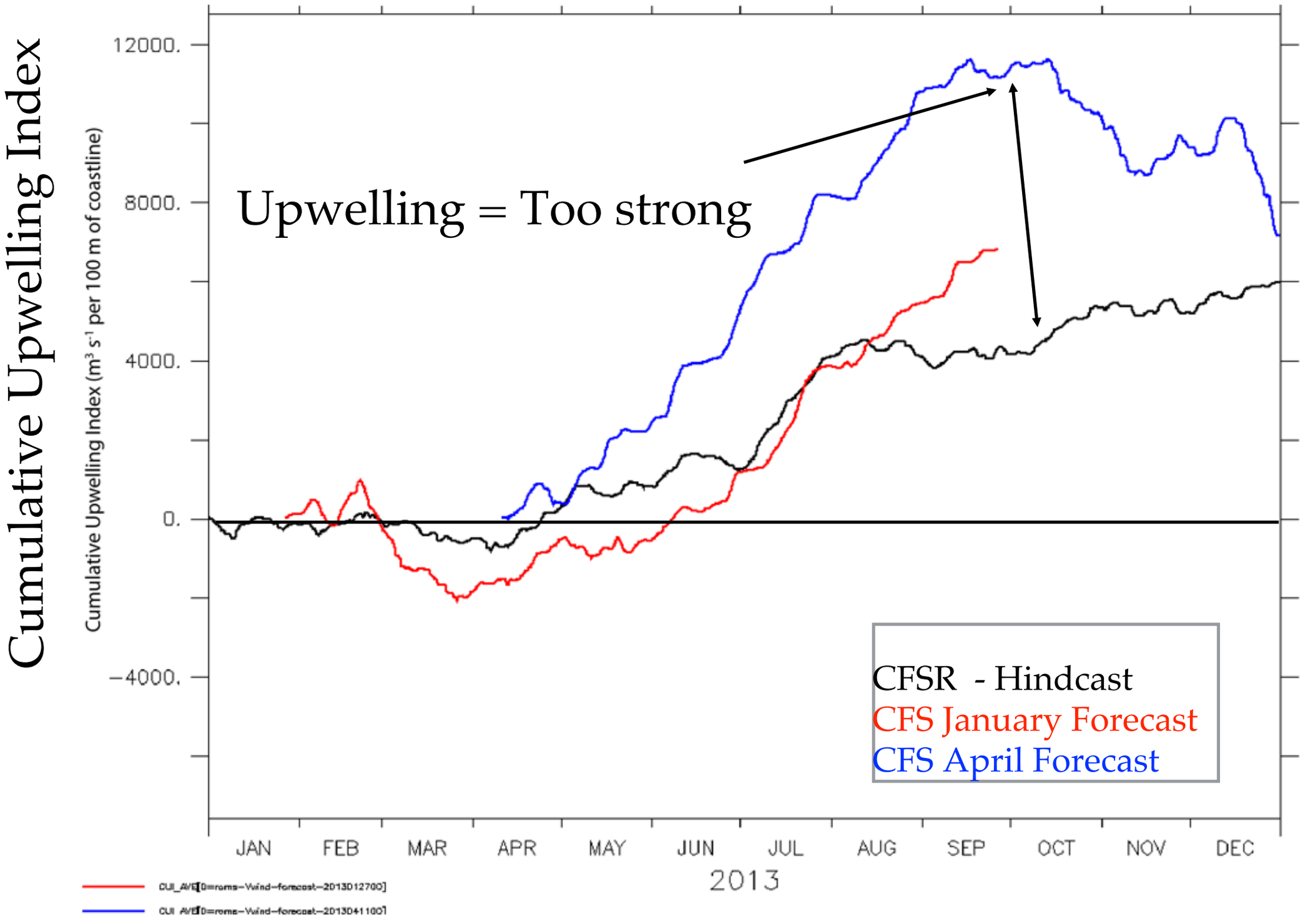


delta T jan–jul



delta S jan–jul

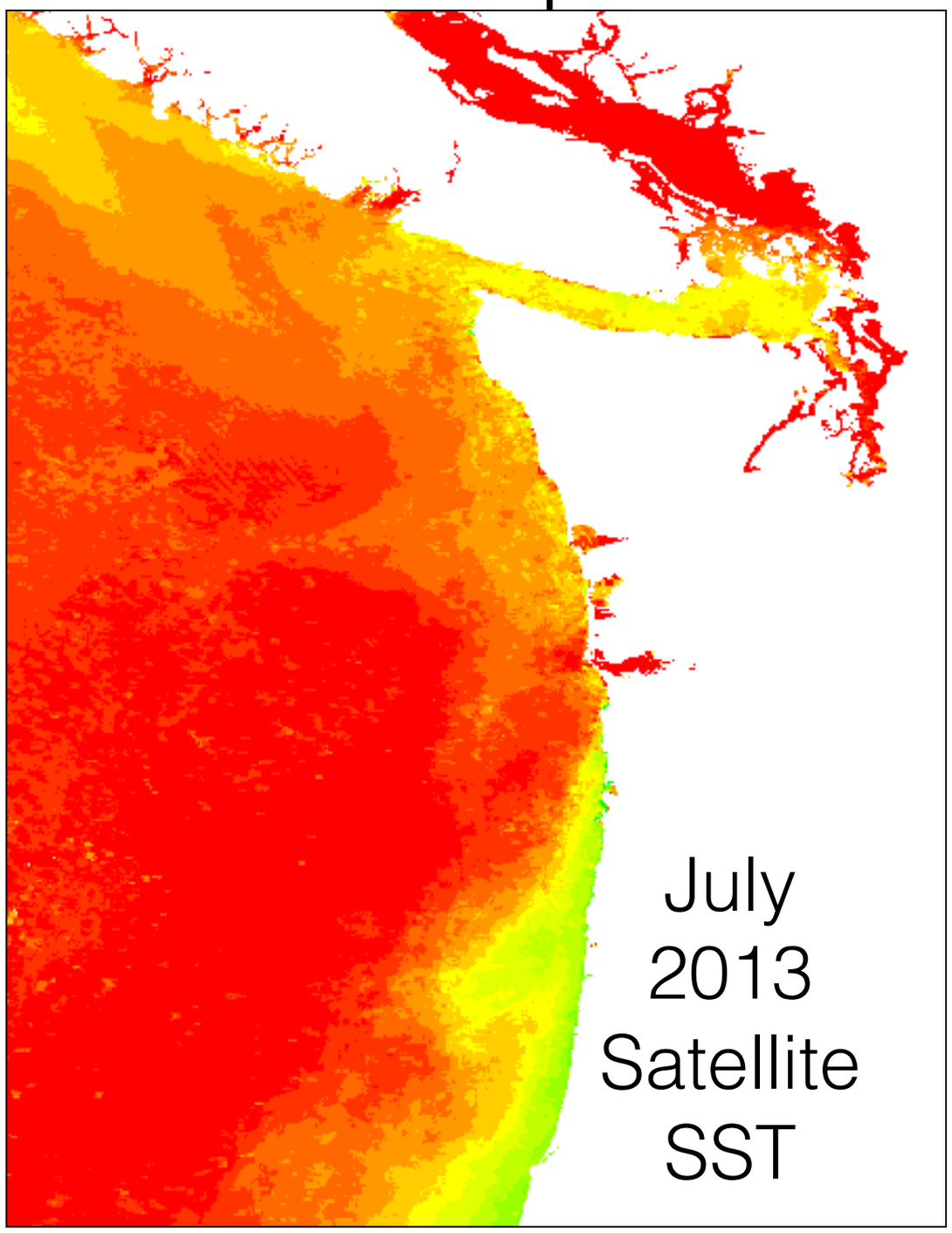
CFS predicted winds have strengths and weaknesses

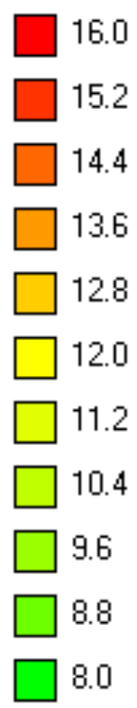


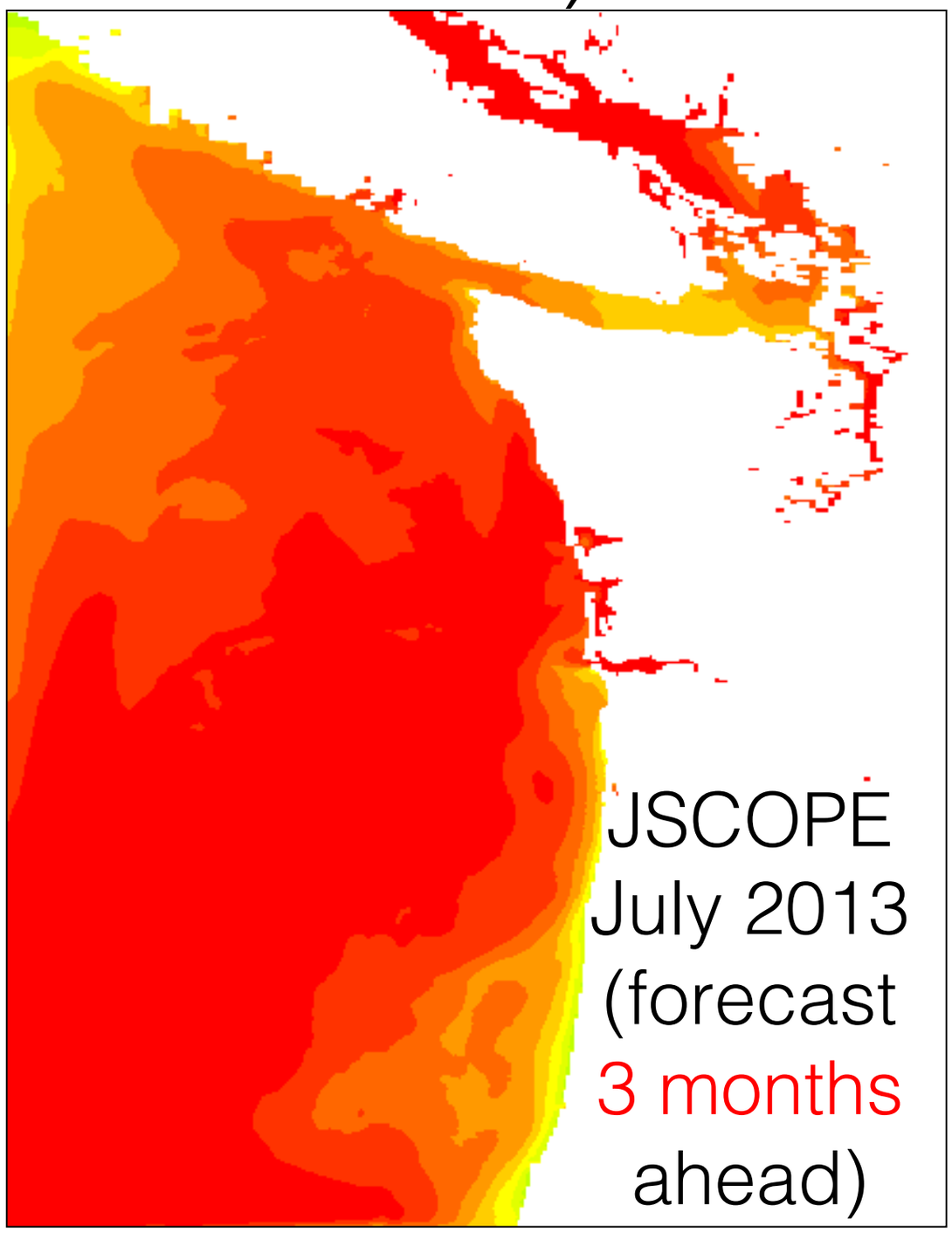
Efforts in 2014-2015

- Model Skill: CFS
- Model Skill: ROMS
- Sardine application

Model Skill: Predicting Monthly Sea Surface Temperature (3 months ahead)



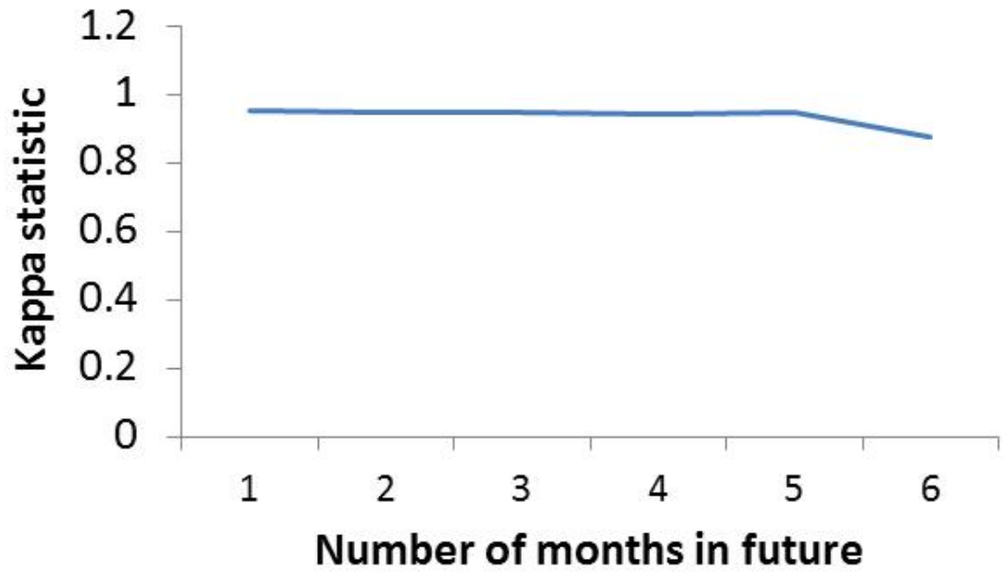




Kappa statistic =0.947, after 1.09 C bias correction.

Model Spatial Skill: Monthly Sea Surface Temperature

- Substantial skill to capture spatial patterns for 1-5 months



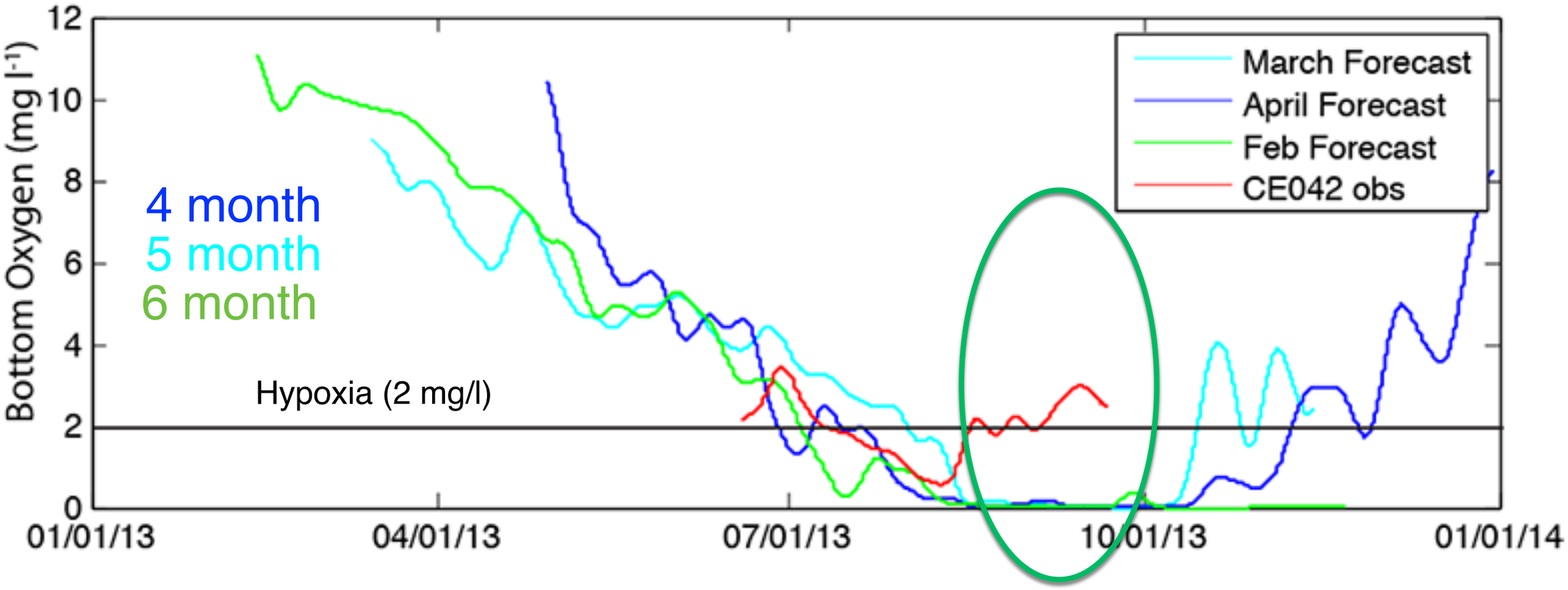
- Spatial skill for SST declines at about 6 months.

- Bias correction must be included – for instance sardine GAM models fitted to ROMS as well as forecast with ROMS

- Biological variables likely harder to predict, but SST is key for many pelagic species

Model Skill: Oxygen in 2013

- Useful for predicting onset of hypoxia, but not return of oxygenated water
- More skill with less lead time
- Winds forecasted too strong and no relaxations late in the season in 2013 (inherited from CFS)



Results for CE042 mooring in 42 meters of water off the Washington shelf ~47 deg N smoothed with a 14 day Hanning window

Efforts in 2014-2015

- Model Skill: CFS
- Model Skill: ROMS
- Sardine application

Will ROMS Ocean Conditions Predict Sardine Density?

Empirical data suggests sardine presence or density driven by:

- Temperature
- Chl *a*
- Salinity
- Wind forcing / Currents / Upwelling rate
- Gradient of sea surface altitude

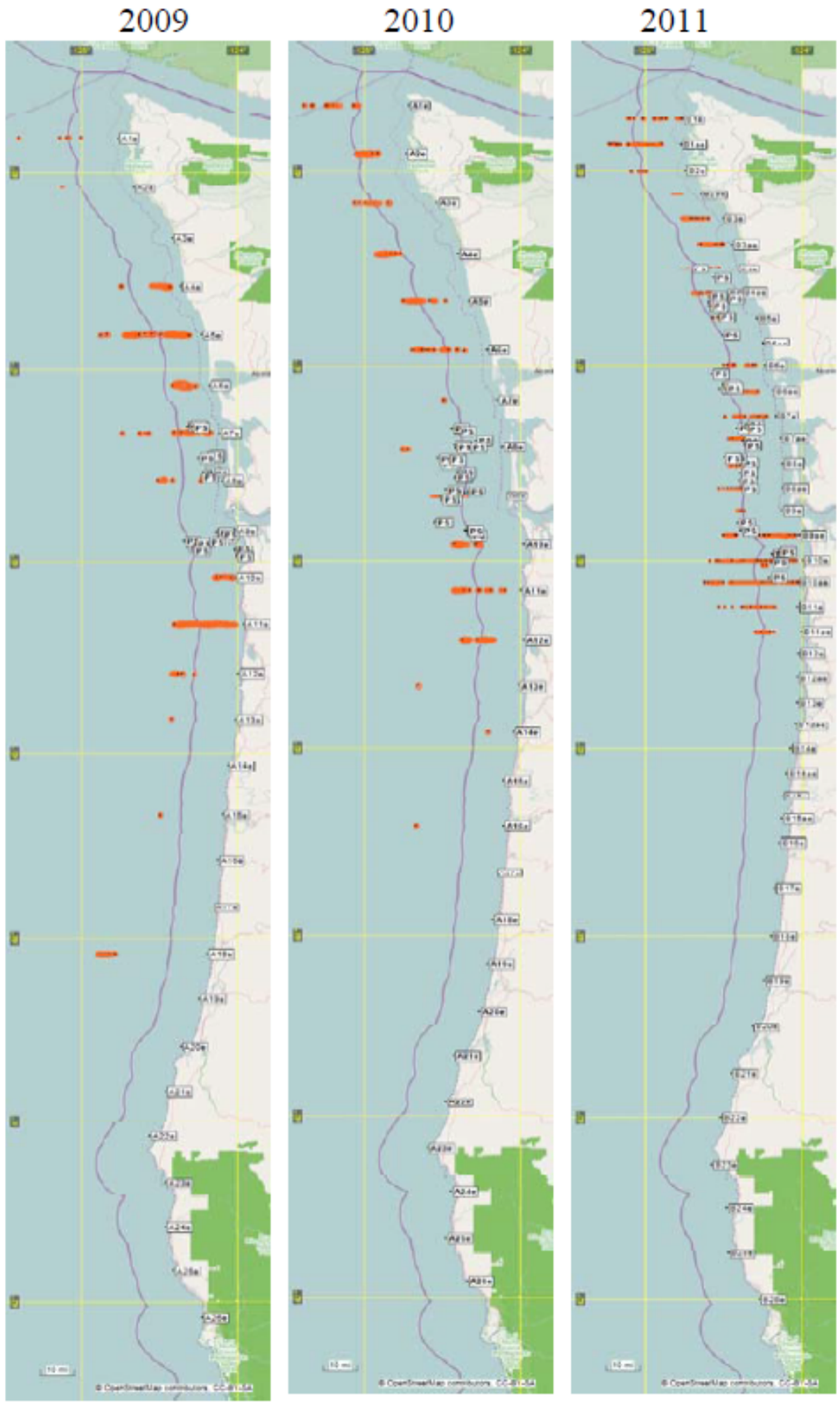
Data: NWSS Aerial Survey

Northwest Sardine Survey (Jagielo et al. 2011)

- Aerial transects; systematic random sampling, photo-documentation, some net sets

- 2961 points, 194 presences in 2009

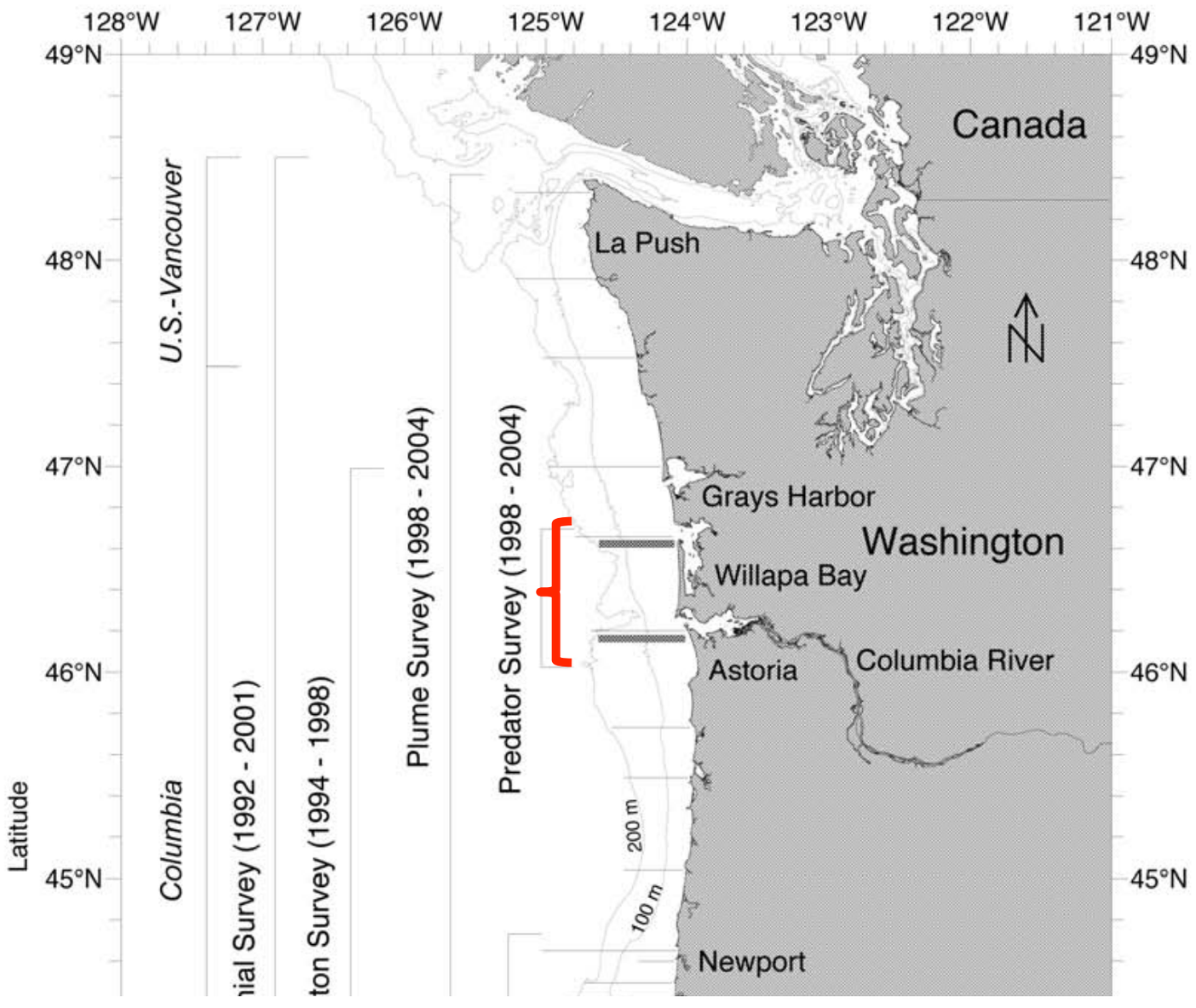
- Here we use presence/ absence only.



Locations of point sets and fish school locations on transects, 2009-2011

Data: Predator Survey

- Night trawl at mouth of the Columbia River
- 84 stations in 2009
- 24 sample days, May 9 to August 25th
- Sardine were absent prior to May 24
- Here we use presence/absence only.

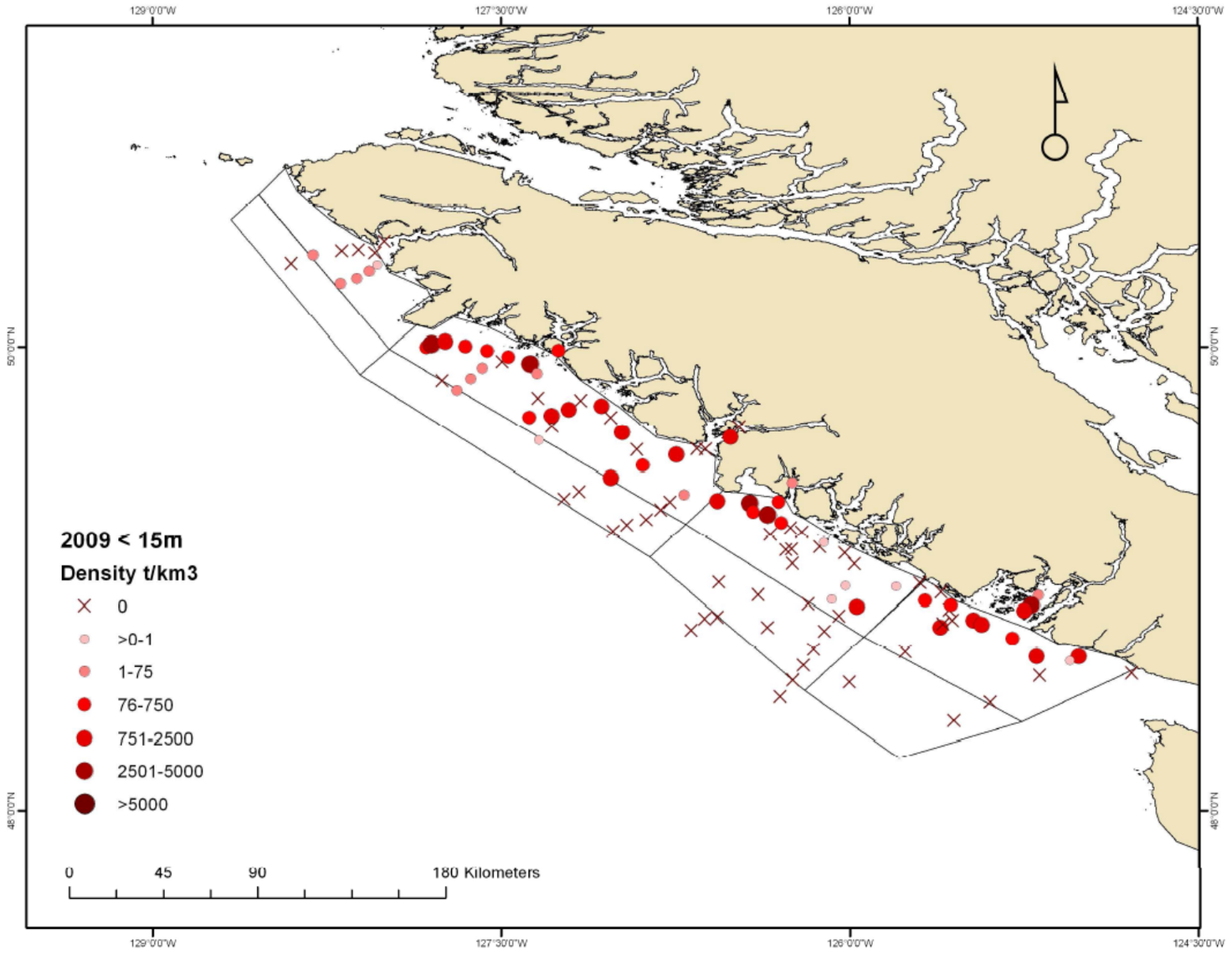


Emmett et al. (2005) CalCOFI Rep. Vol 46

Data: WCVI Survey

West Coast Vancouver Island DFO survey

- Night trawl survey
- 96 sets in 2009 , July 22-August 5th.
- Here we use presence/absence only.

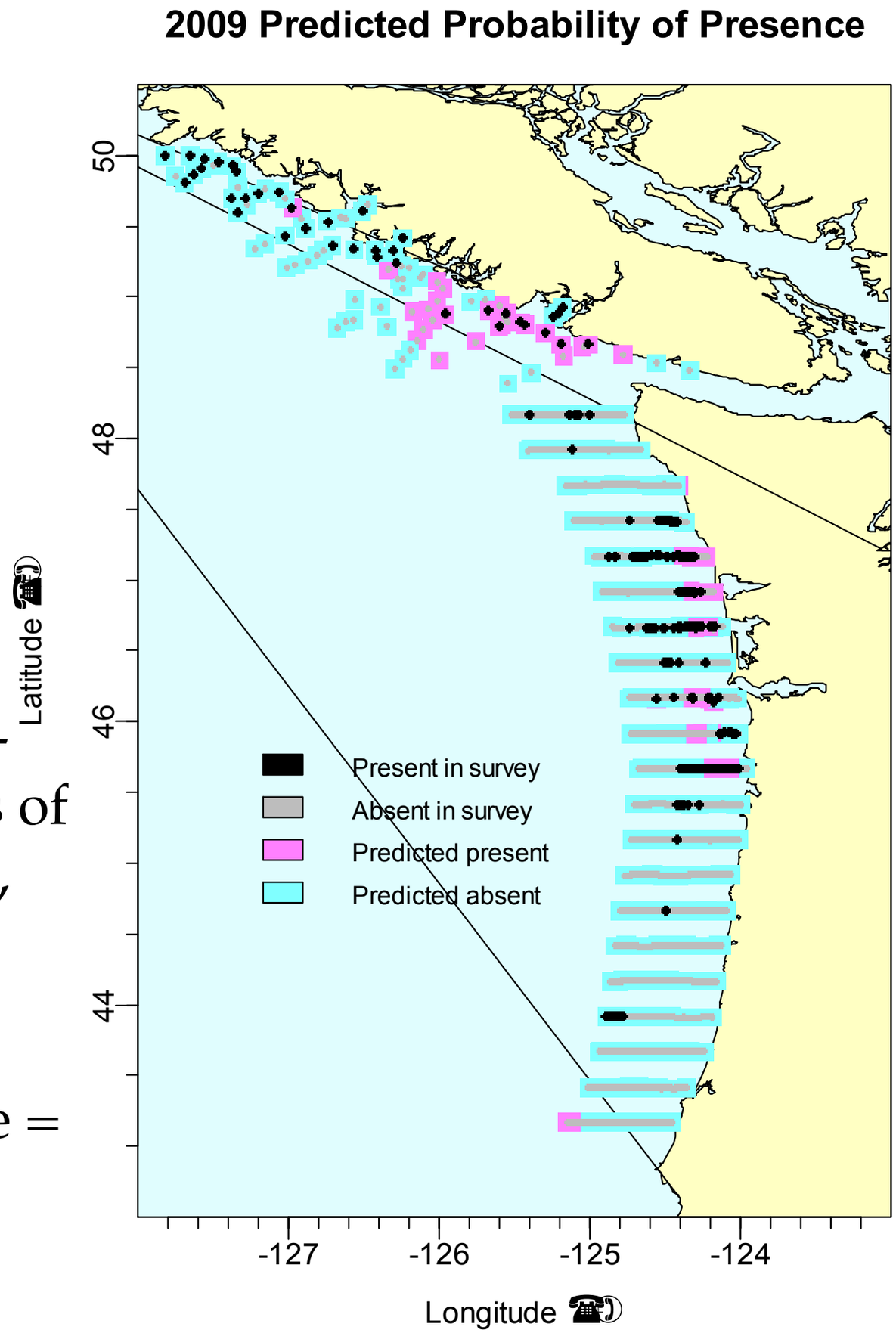


Flostrand et al. (2012)

Empirical relationship using modeled fields to predict sardine presence

Based on a GAM fit to J-SCOPE ROMS predictions of sea surface temperature, Chlorophyll, Salinity

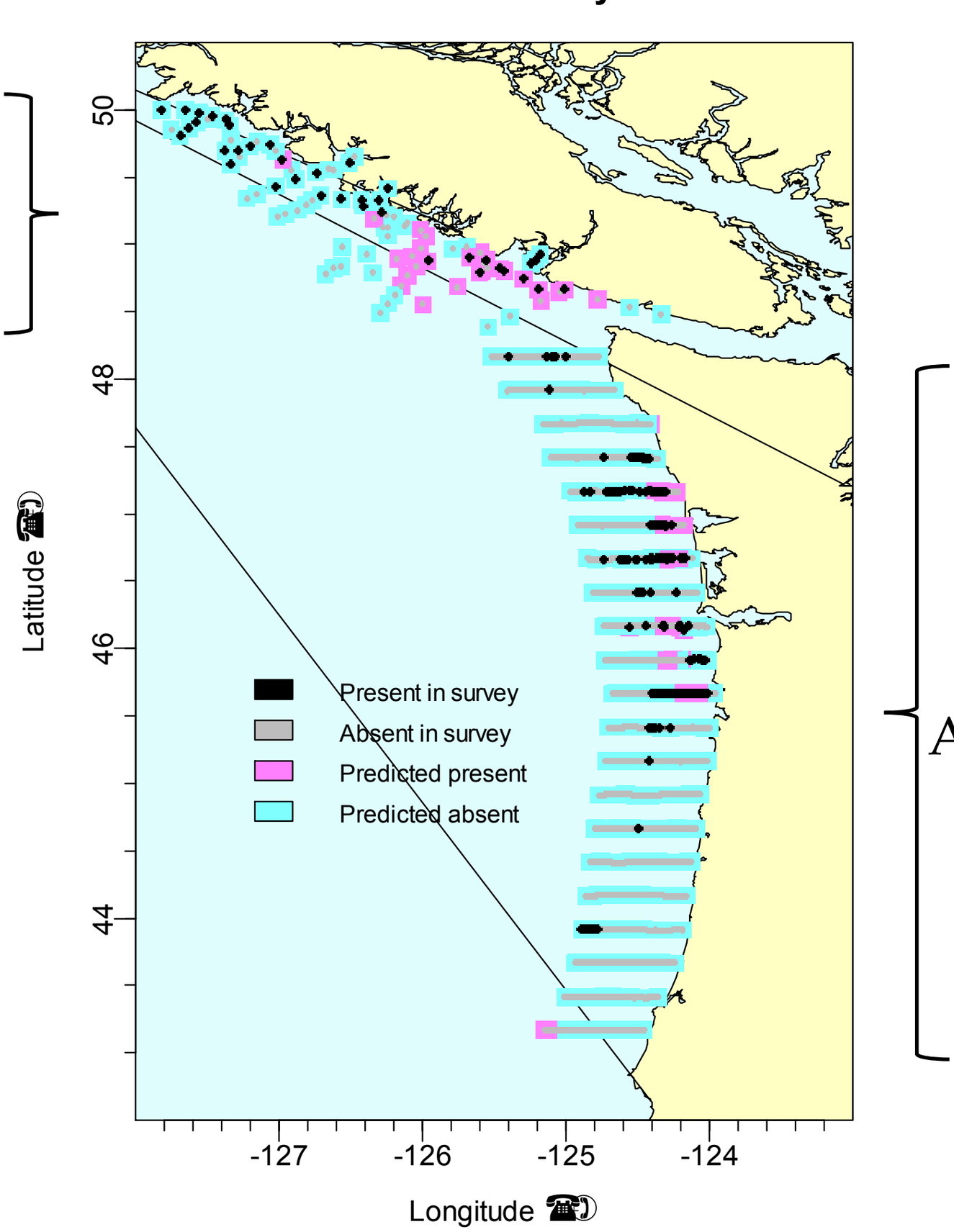
Predictive AUC skill score = 0.78
(range is 0.5—1.0)



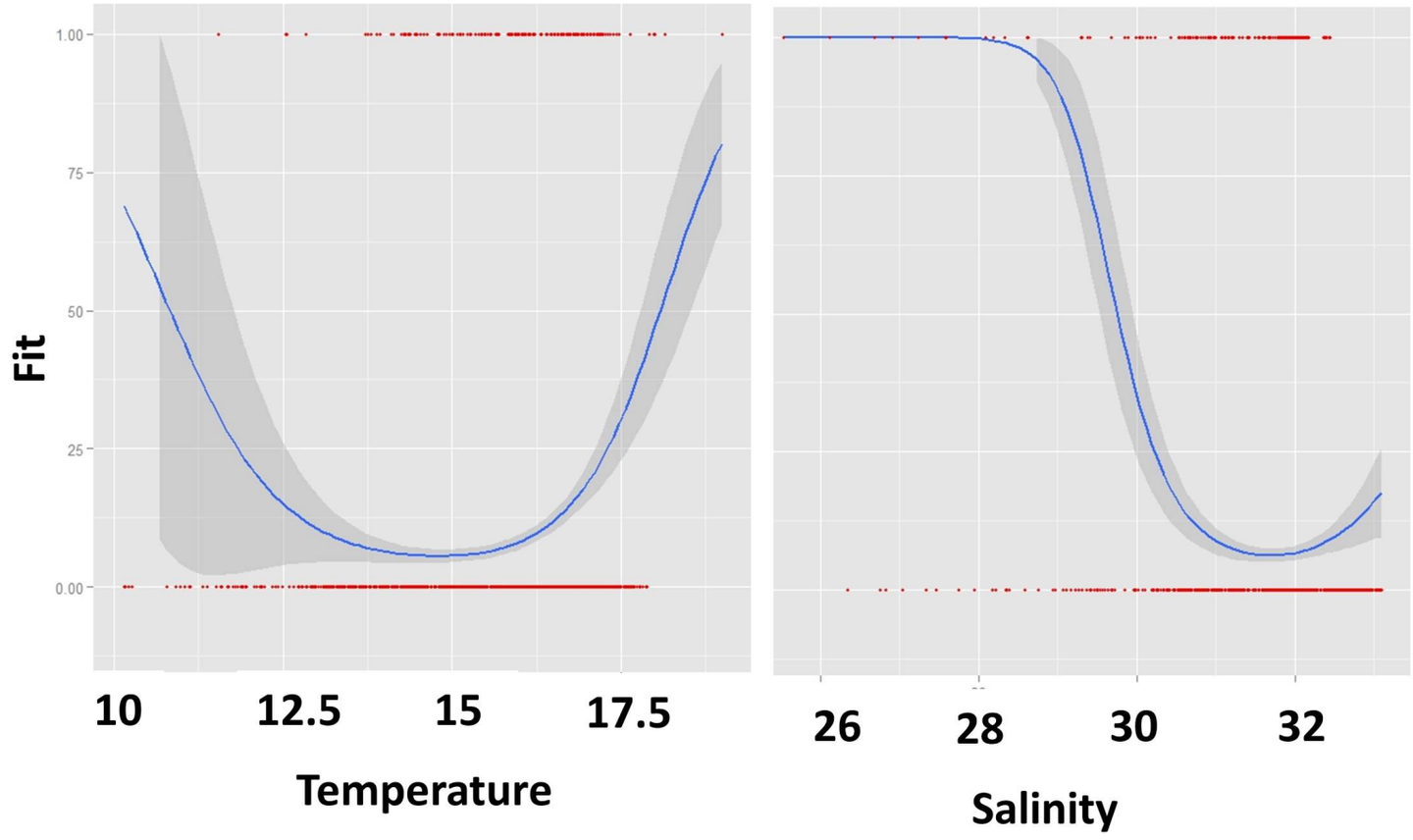
Explanatory AUC

West Coast Vancouver Island: AUC=0.48

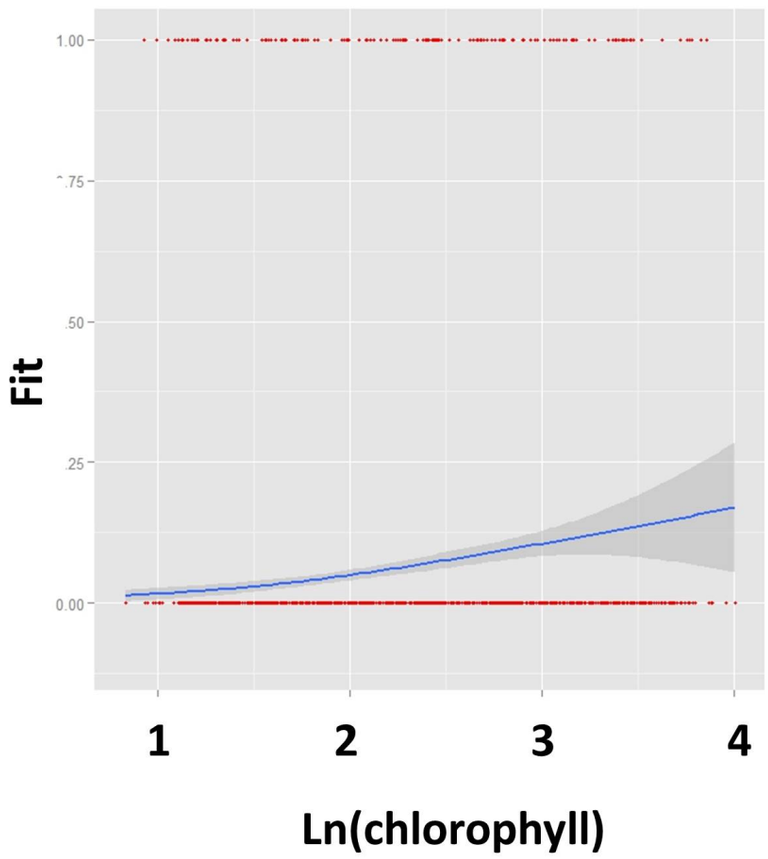
NOAA Predator Survey AUC=0.73



NWSS AUC=0.82



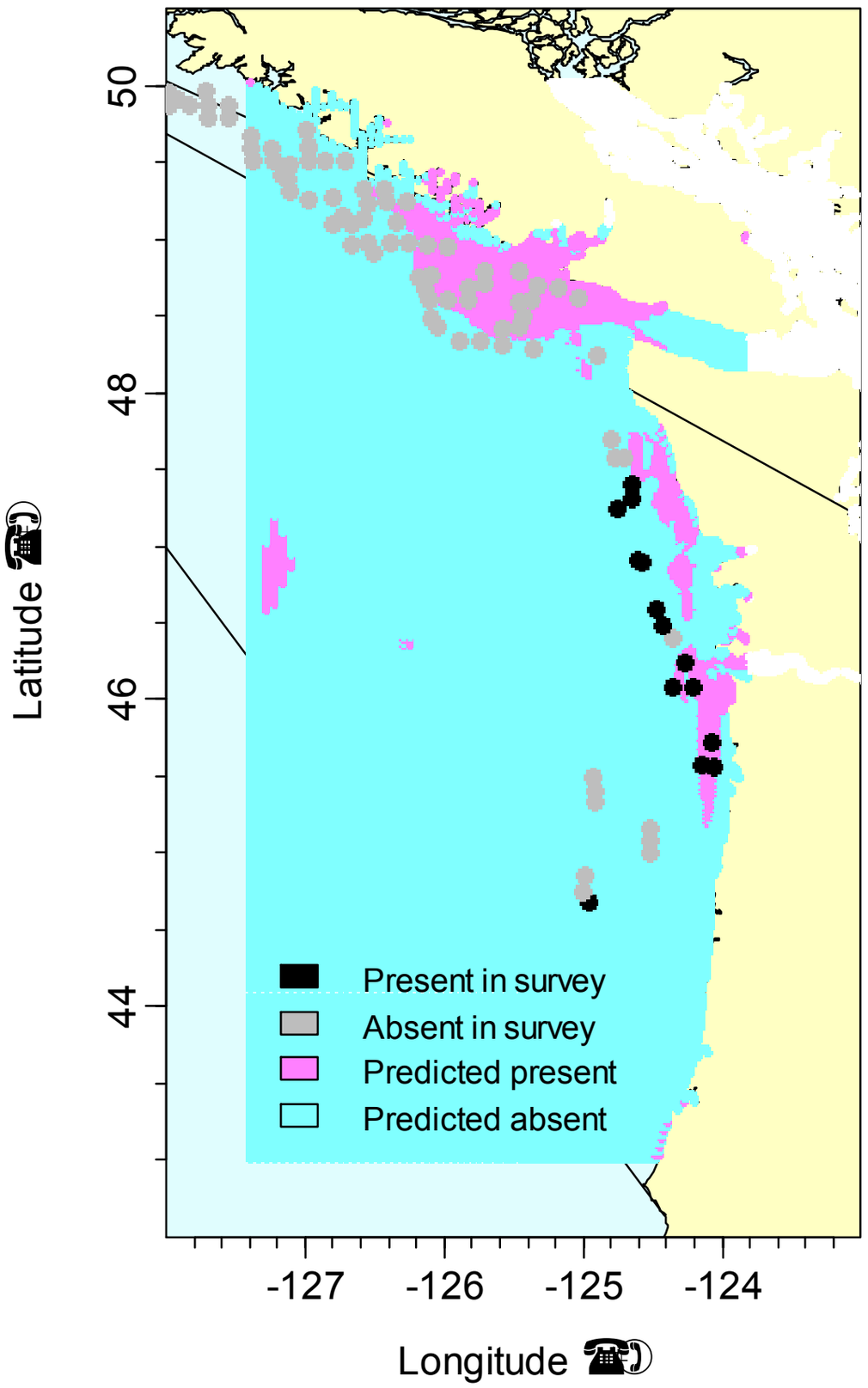
Relationships between sardine and temperature, salinity, and chlorophyll consistent with liter -ature



Key exception is (uncertain) hig h probability at low temperature

Forecasts

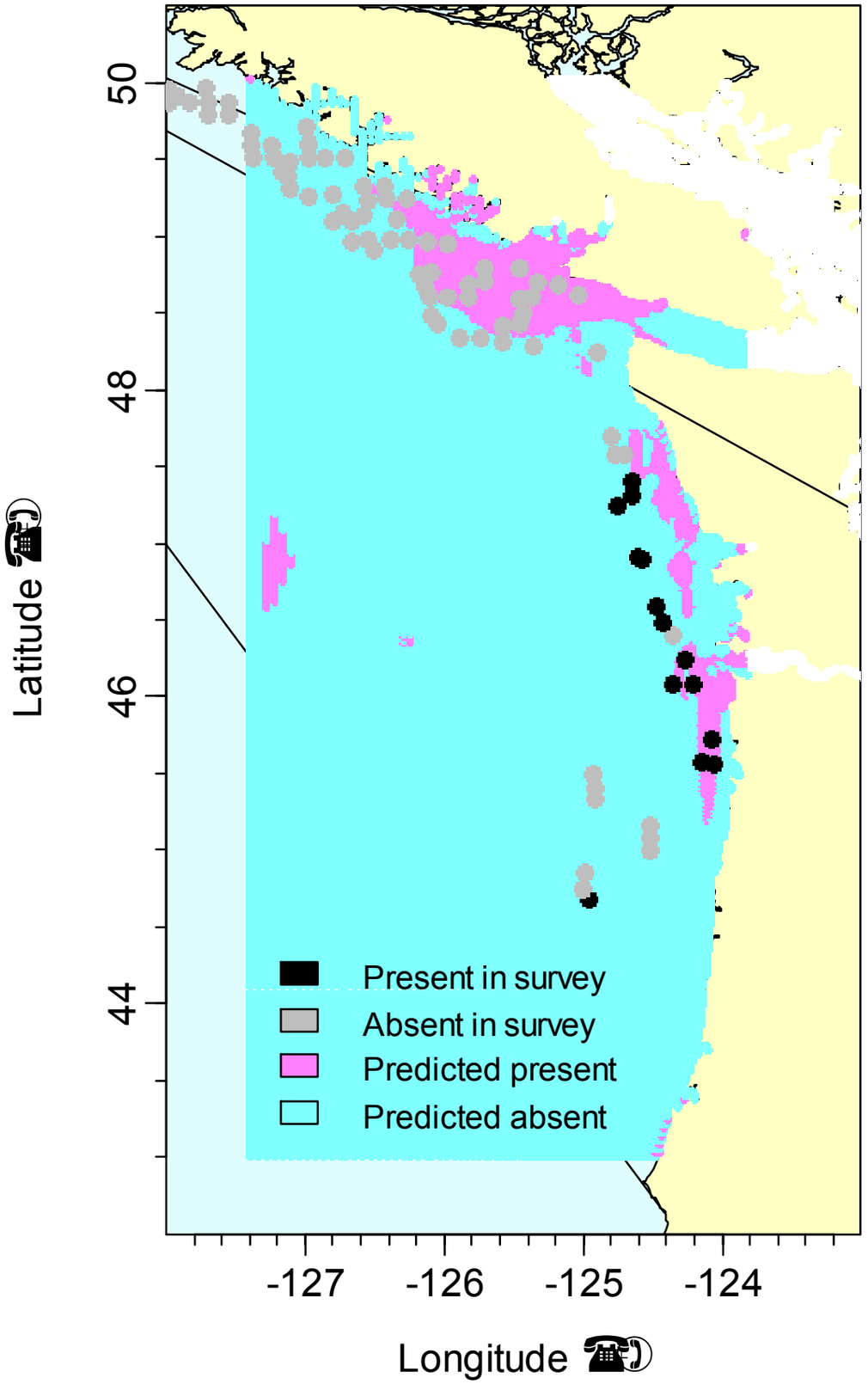
August 2013, Sardine Reforecast



Model correctly predicts sardine off WA and OR, but over-predicts sardine off southern Vancouver Island

AUC skill score = 0.59
(range is 0.5 – 1.0)

August 2013, Sardine Reforecast



No landings

24,000 metric tons of landing
s

Conclusions

1. Successfully coupled CFS to ROMS

2. J-SCOPE ROMS has substantial ability to predict:

   - temperature up to 5 months ahead
   - onset of hypoxia

3. Can predict sardine presence/absence for 2009 (test year) based on temperature, chlorophyll, and salinity

   - Test year (2009) AUC = 0.78, 5 months ahead
   - Forecast (2013) AUC = 0.59, 5 months ahead

Next Steps

- New sardine survey data from SWFSC
- Predictions of SST (albacore tuna)
- Predictions of hypoxia (crab)
- Predictions of transport (salmon)
- Indicators for Integrated Ecosystem Assessment: upwelling, hypoxia, and (from CFS) PDO, ENSO
- Improvements to river input and initial conditions

http://www.nanoos.org/products/j-scope/

Acknowledgements

Funding provided by NOAA Fisheries And The Environment (FATE) program, NOAA NWFSC, and University of Washington College of the Environment