J-SCOPE

J-SCOPE

JISAO's Seasonal Coastal Ocean Prediction of the Ecosystem (J-SCOPE)

The Audacity of an Ocean Prediction System

Nick Bond, Al Hermann, Jan Newton, Samantha Siedlecki (UW)
Isaac Kaplan, Phil Levin, Bill Peterson, Greg Williams (NOAA/NWFSC)

1. **Brief Description of System**

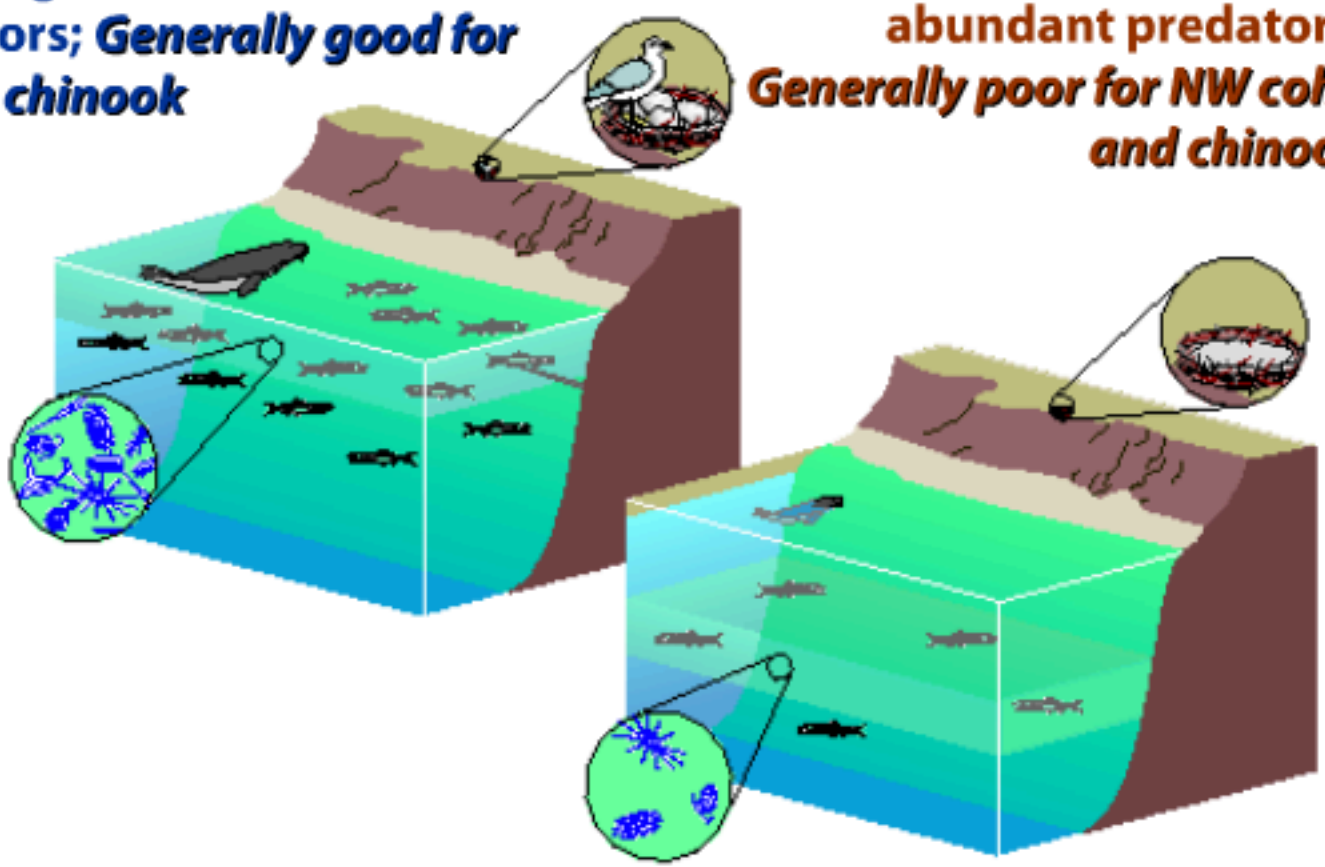
2. **Evaluation of the Accuracy of the Climate Forcing from NOAA's Coupled Forecast System (CFS)**

3. **Results from Some Quasi-operational Runs**

Upwelling food webs in our coastal ocean

Cool water, weak stratification high nutrients, a productive "*subarctic*" food-chain with abundant forage fish and few warm water predators; *Generally good for NW coho and chinook*

Warm stratified ocean, few nutrients, low productivity "*subtropical*" food web, a lack of forage fish and abundant predators: *Generally poor for NW coho and chinook*



Variables used for Coho and Chinook Salmon Forecasts

Ecosystem Indicators	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
PDO (December-March)	15	6	3	11	7	16	10	14	12	9	5	1	13	4	2	8
PDO (May-September)	10	4	6	5	11	15	14	16	12	13	2	9	7	3	1	8
ONI Jan-June	16	2	1	5	12	13	11	14	7	10	3	9	15	4	5	7
46050 SST (May-Sept)	14	8	3	4	1	7	16	13	5	15	2	9	6	10	11	12
NH 05 Upper 20 m T winter prior (Nov-Mar)	16	10	7	9	5	13	14	11	12	4	1	8	15	3	2	6
NH 05 Upper 20 m T (May-Sept)	13	10	12	4	1	3	16	15	7	8	2	5	11	9	6	14
NH 05 Deep Temperature	16	6	8	4	1	9	12	14	10	5	2	7	13	11	3	15
NH 05 Deep Salinity	16	3	7	4	5	13	14	8	6	1	2	11	15	10	9	12
Copepod Richness Anomaly	16	3	1	7	6	12	11	15	13	10	8	9	14	4	5	2
N. Copepod Biomass Anomaly	15	12	7	8	5	14	13	16	9	11	4	10	6	1	2	3
S. Copepod Biomass Anomaly	16	3	5	4	2	11	13	15	12	10	1	8	14	9	7	6
Biological Transition	16	11	7	3	8	12	10	15	14	4	1	2	13	5	9	6
Winter Ichthyoplankton	16	8	2	4	6	15	14	10	13	12	1	9	3	11	7	5
Chinook Juv Catches (June)	15	4	5	13	9	11	14	16	10	8	1	6	7	12	3	2
Coho Juv Catches (Sept)	11	2	1	4	3	6	12	14	8	9	7	15	13	5	10	NA
Mean of Ranks	14.7	6.1	5.0	5.9	5.5	11.3	12.9	13.7	10.0	8.6	2.8	7.9	11.0	6.7	5.5	7.6
RANK of the Mean Rank	16	6	2	5	3	13	14	15	11	10	1	9	12	7	3	8
Principle Component Scores (PC1)	6.58	-2.18	-2.93	-1.56	-2.07	2.19	3.11	4.28	1.00	-0.24	-4.41	-0.96	1.67	-1.40	-2.07	-1.01
Principle Component Scores (PC2)	0.04	0.21	0.42	-1.04	-2.20	-1.73	2.24	-0.73	-1.18	0.15	-0.78	0.58	-0.35	1.24	0.96	2.16
Ecosystem Indicators not included in the mean of ranks or statistical analyses																
Physical Spring Trans (UI Based)	3	6	15	13	4	10	12	16	10	1	5	2	7	9	14	8
Upwelling Anomaly (Apr-May)	7	1	14	3	6	11	10	16	7	2	4	5	12	14	12	9
Length of Upwelling Season (UI Based)	6	2	15	9	1	10	8	16	5	3	7	3	12	14	12	11
NH 05 SST (May-Sept)	10	6	5	4	1	3	16	14	8	12	2	15	9	7	11	13
Copepod Community Structure	16	4	5	7	1	12	13	15	14	10	2	6	11	9	8	3

Bill Peterson, NOAA/NWFSC

	Juvenile Migration Year				Adult Return Outlook	
	2010	2011	2012	2013	Coho 2014	Chinook 2014
Large– scale ocean and atmospheric indicators						
PDO (May – Sept)	🟨	🟩	🟩	🟨	🟡	🟢
ONI (Jan-Jun)	🟥	🟩	🟩	🟨	🟡	🟢
Local and regional physical indicators						
Sea surface temperature anomalies	🟨	🟨	🟨	🟥	🔴	🟡
Coastal upwelling	🟥	🟥	🟥	🟨	🟡	🔴
Deep water temperature and salinity	🟥	🟨	🟨	🟥	🔴	🟡
Local biological indicators						
Copepod biodiversity	🟥	🟩	🟩	🟩	🟢	🟢
Northern copepod anomalies	🟨	🟩	🟩	🟩	🟢	🟢
Biological spring transition	🟥	🟩	🟨	🟨	🟡	🟡
Winter Ichthyoplankton	🟩	🟨	🟨	🟩	🟢	🟡
Spring Chinook Salmon--June	🟨	🟥	🟩	🟩	--	🟢

Key

🟩 good conditions for salmon

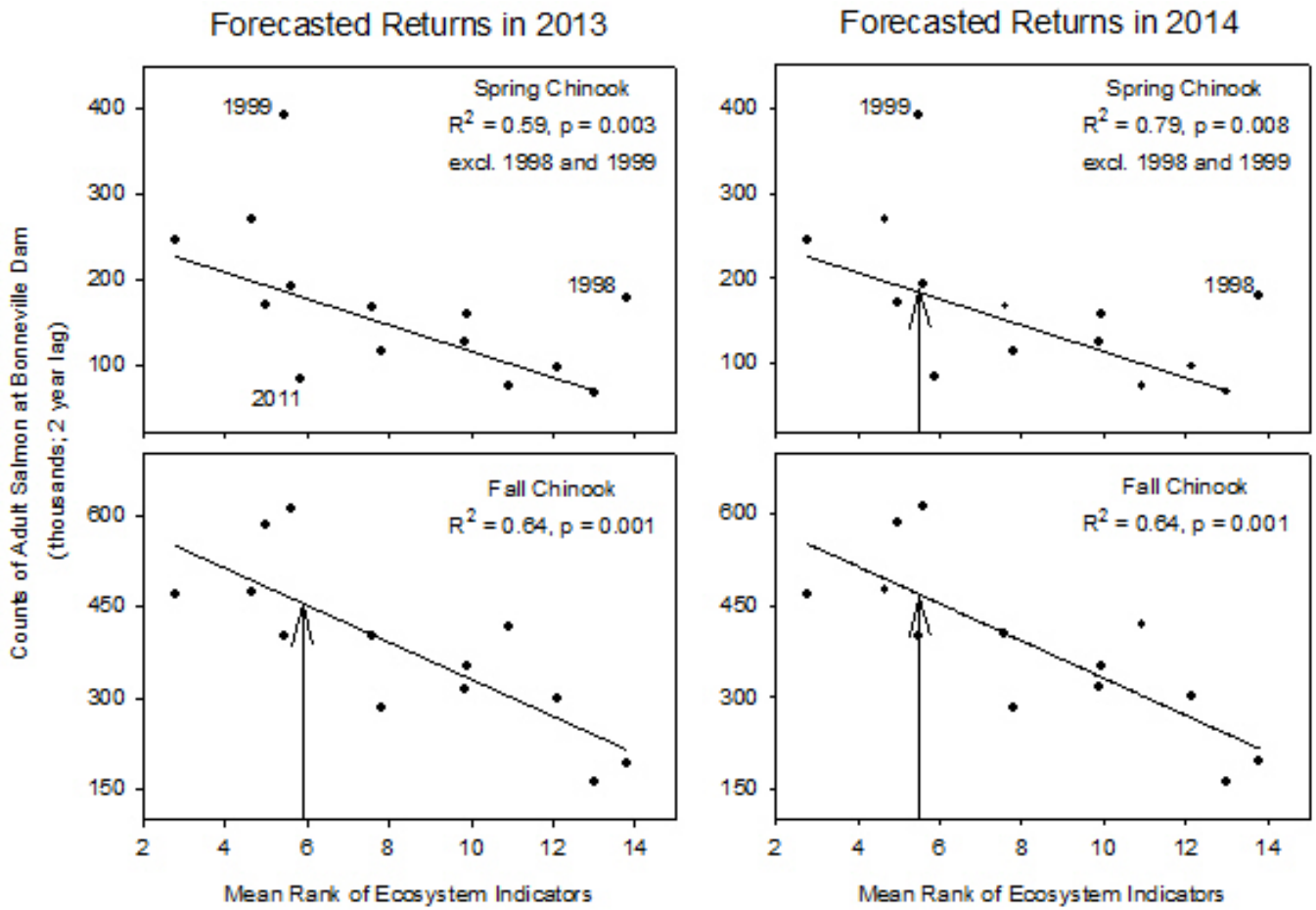
🟨 intermediate conditions for salmon

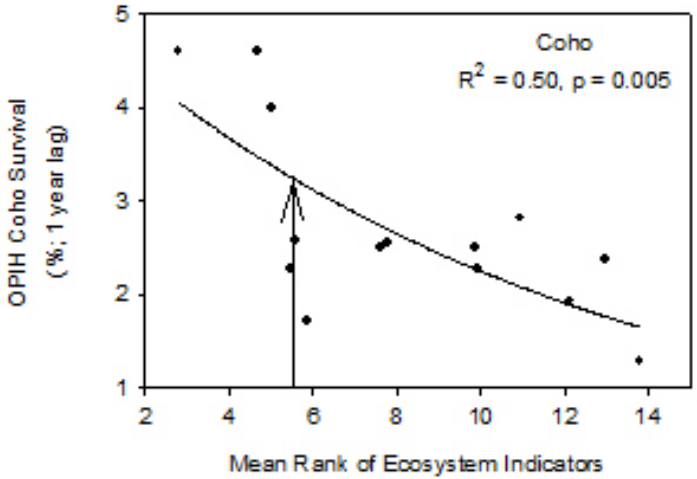
🟥 poor conditions for salmon

🟢 good returns expected

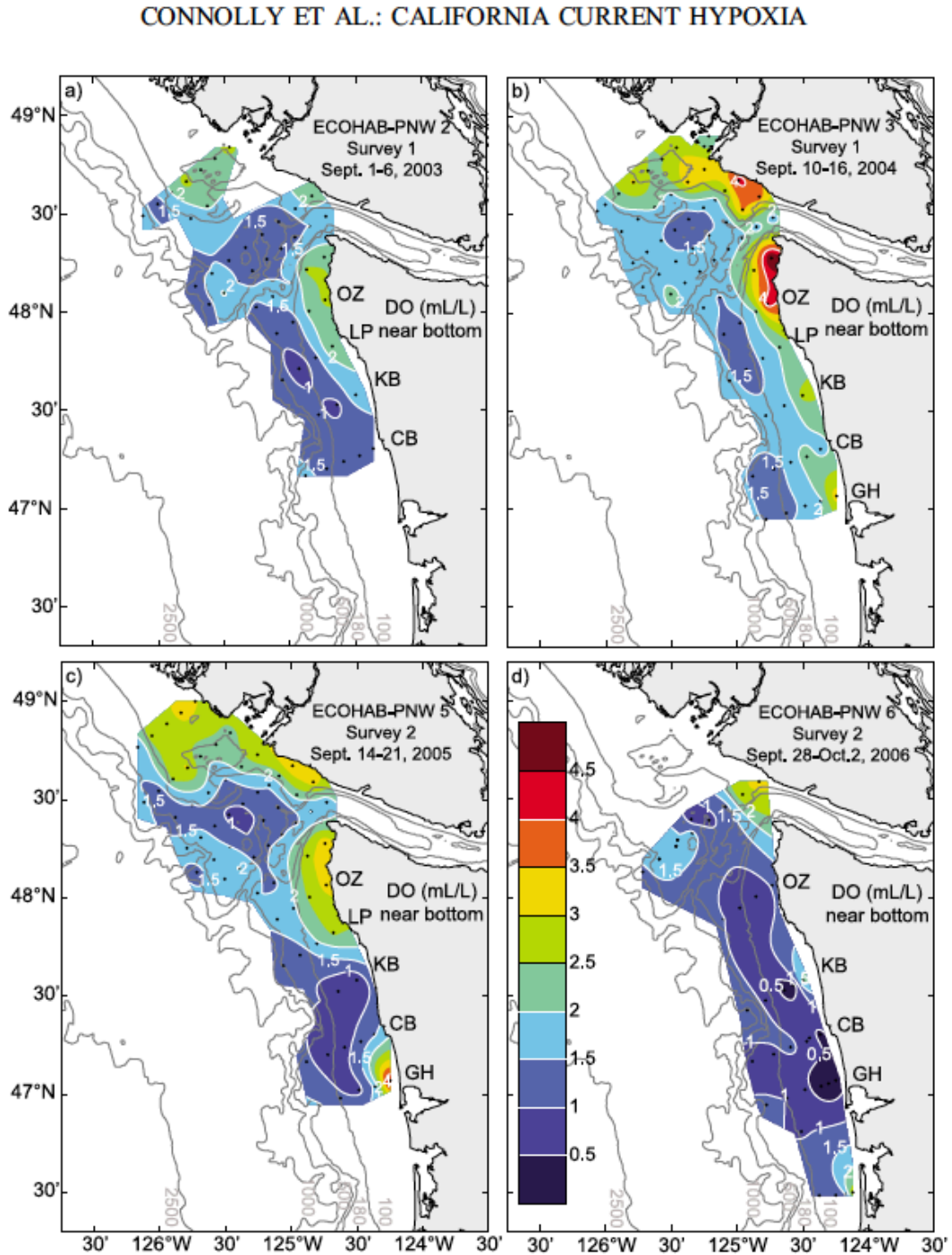
– no data

🔴 poor returns expected


Forecasted Returns in 2013
Forecasted Returns in 2014
Spring Chinook
R^2 = 0.59, p = 0.003
excl. 1998 and 1999
1999
1998
2011
Spring Chinook
R^2 = 0.79, p = 0.008
excl. 1998 and 1999
1999
1998
Fall Chinook
R^2 = 0.64, p = 0.001
Fall Chinook
R^2 = 0.64, p = 0.001
Counts of Adult Salmon at Bonneville Dam
(thousands; 2 year lag)
Mean Rank of Ecosystem Indicators
Mean Rank of Ecosystem Indicators


Coho
R^2 = 0.50, p = 0.005
OPIH Coho Survival
(%; 1 year lag)
Mean Rank of Ecosystem Indicators

Dissolved Oxygen Concentrations: 2003-2006



VOLUME 27 JOURNAL OF CLIMATE 15 MARCH 2014

The NCEP Climate Forecast System Version 2

SURANJANA SAHA,* SHRINIVAS MOORTHI,* XINGREN WU,+ JIANDE WANG,# SUDHIR NADIGA,+ PATRICK TRIPP,+ DAVID BEHRINGER,* YU-TAI HOU,* HUI-YA CHUANG,* MARK IREDELL,* MICHAEL EK,* JESSE MENG,+ RONGQIAN YANG,+ MALAQUÍAS PEÑA MENDEZ,+ HUUG VAN DEN DOOL,@ QIN ZHANG,@ WANQIU WANG,@ MINGYUE CHEN,@ AND EMILY BECKER&

** Environmental Modeling Center, NOAA/NWS/NCEP, College Park, Maryland*
+ I. M. Systems Group, Inc., Rockville, Maryland
 # Science Systems and Applications, Inc., Largo, Maryland
@ Climate Prediction Center, NOAA/NWS/NCEP, College Park, Maryland
& Wyle Lab, Inc., Arlington, Virginia

Elements of Forecast System

- Large-scale atmospheric and oceanic conditions provided by NCEP’s Coupled Forecast System (CFSv2) model
- Dynamical downscaling (~1.5 km grid) with the Regional Ocean Modeling System (ROMS) with a lower-trophic level (NPZD2) module
- ROMS output used in an integrated ecosystem assessment
- Projections publically available on the NANOOS website

Funding for Effort

- Began with support from the Northwest Fisheries Science Center for a post-doc
- Modest funding from Fisheries And The Environment (FATE), a NMFS program supporting research on developing indicators and models for fisheries and ecosystem management
- Leverage from a marine carbon project in the Gulf of Alaska led by Jeremy Mathis of NOAA/PMEL
- Discretionary funds from the Dean of the College of the Environment at the UW (Lisa Graumlich)

For a new Climate Forecast System (CFS) implementation

Two essential components:

A new Reanalysis of the atmosphere, ocean, seaice and land over the 32-year period (1979-2010) is required to provide consistent initial conditions for:

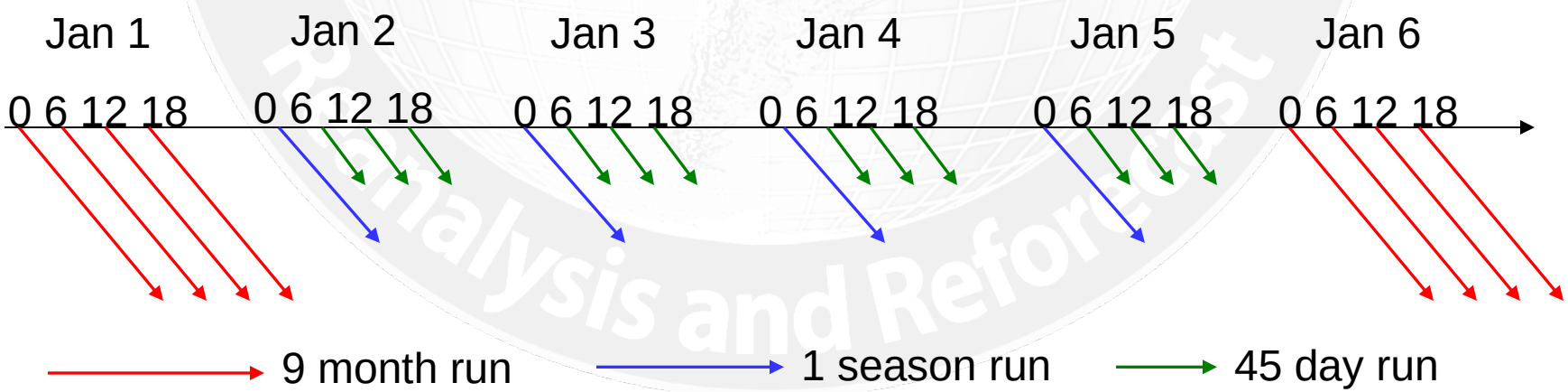
A complete Reforecast of the new CFS over the 29-year period (1982-2010), in order to provide stable calibration and skill estimates of the new system, for operational seasonal prediction at NCEP

For a new CFS implementation (contd)

1. An atmosphere at high horizontal resolution (spectral T574, ~27 km) and high vertical resolution (64 sigma-pressure hybrid levels) for the real time analysis
2. An atmosphere of T126L64 for the real time forecasts
3. An interactive ocean with 40 levels in the vertical, to a depth of 4737 m, and horizontal resolution of 0.25 degree at the tropics, tapering to a global resolution of 0.5 degree northwards and southwards of 10N and 10S respectively
4. An interactive 3 layer sea-ice model
5. An interactive land model with 4 soil levels

Reforecast Configuration for CFSv2 (T126L64)

- **9-month hindcasts initiated from every 5th day and run from all 4 cycles of that day, beginning from Jan 1 of each year, over a 29 year period from 1982-2010. This is required to calibrate the operational CPC longer-term seasonal predictions (ENSO, etc)**
- **In addition, a single 1 season (123-day) hindcast run, initiated from every 0 UTC cycle between these five days, over the 12 year period from 1999-2010. This is required to calibrate the operational CPC first season predictions for hydrological forecasts (precip, evaporation, runoff, streamflow, etc)**
- **In addition, three 45-day (1-month) hindcast runs from every 6, 12 and 18 UTC cycles, over the 12-year period from 1999-2010. This is required for the operational CPC week3-week6 predictions of tropical circulations (MJO, PNA, etc)**



Regional Ocean Modeling System (ROMS)

1.5 km grid spacing

Tides

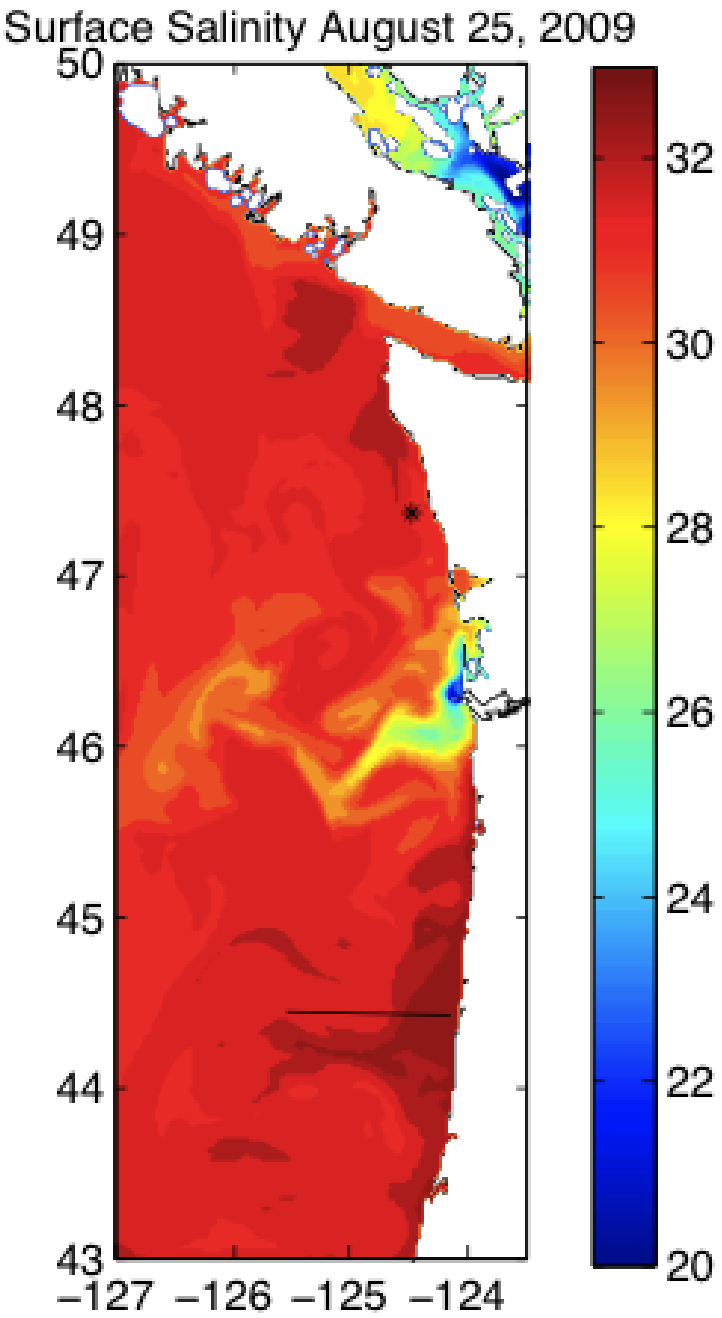
Climatological freshwater runoff

NPZD module from Banas et al. (2009) with additional detrital and oxygen sub-model

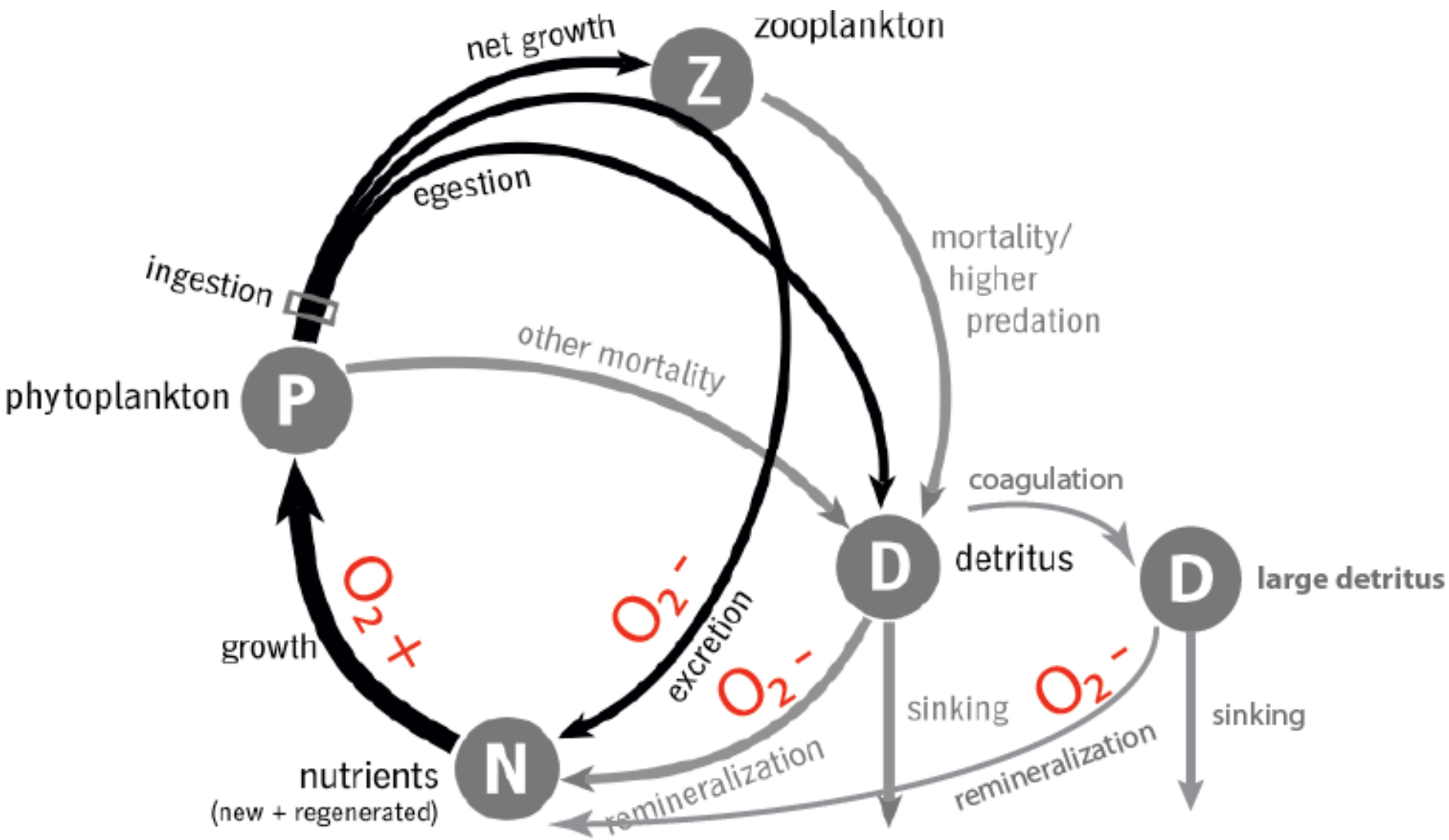
Algorithms using oxygen and temperature to derive pH and aragonite undersaturation

Nitrate and oxygen values for initial and boundary conditions based on CFSv2 salinity and observed relationships

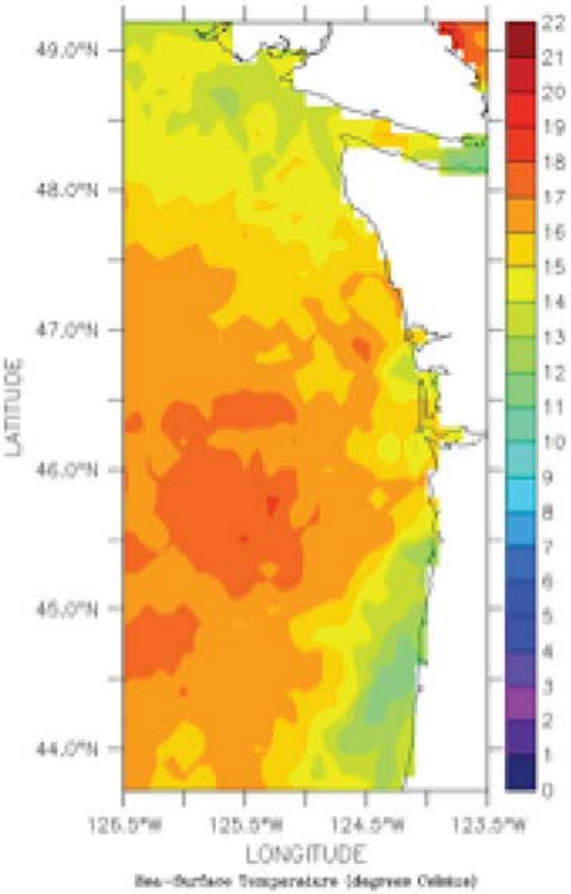
Phytoplankton and zooplankton set as seed stocks at ROMS boundary



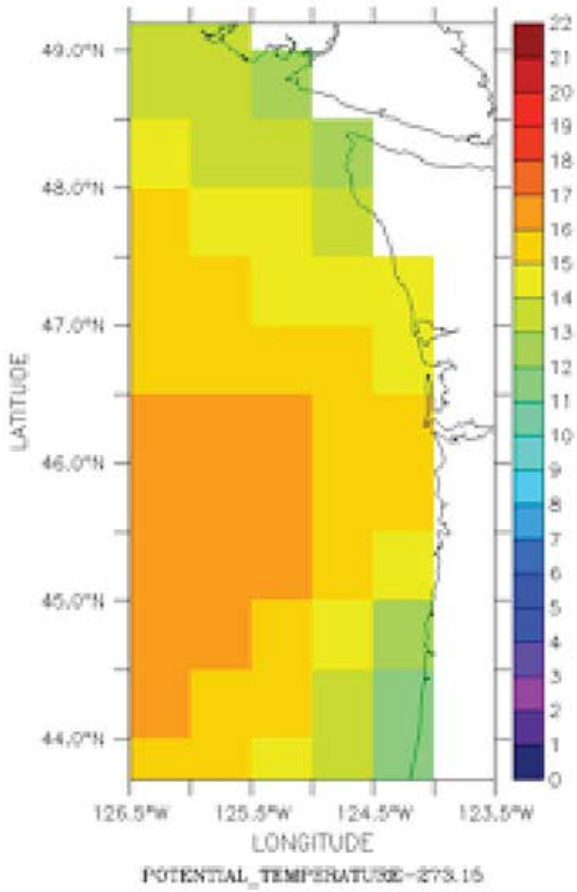
Focus on the biogeochemistry (pH, pCO_2, pO_2); Banas et al. (2009)



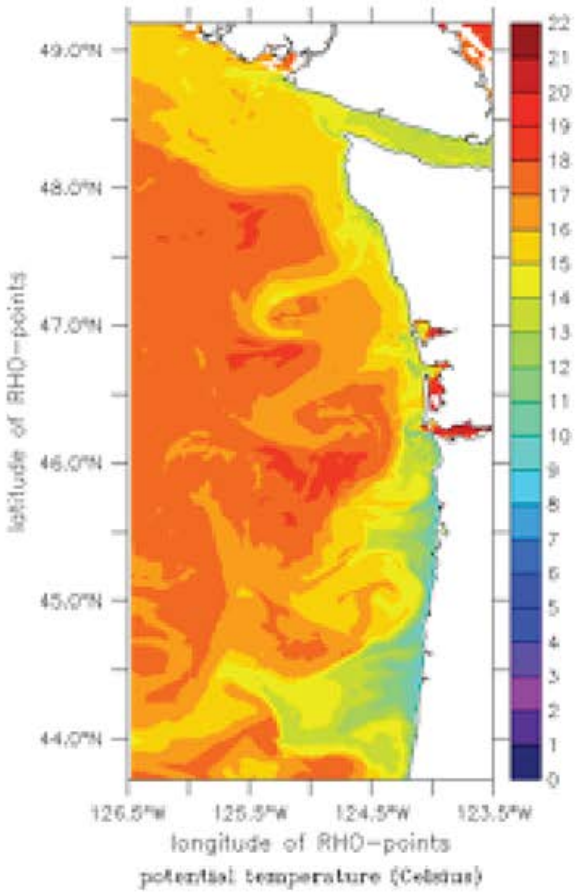
Sea Surface Temperature (SST) on 25 August 2009



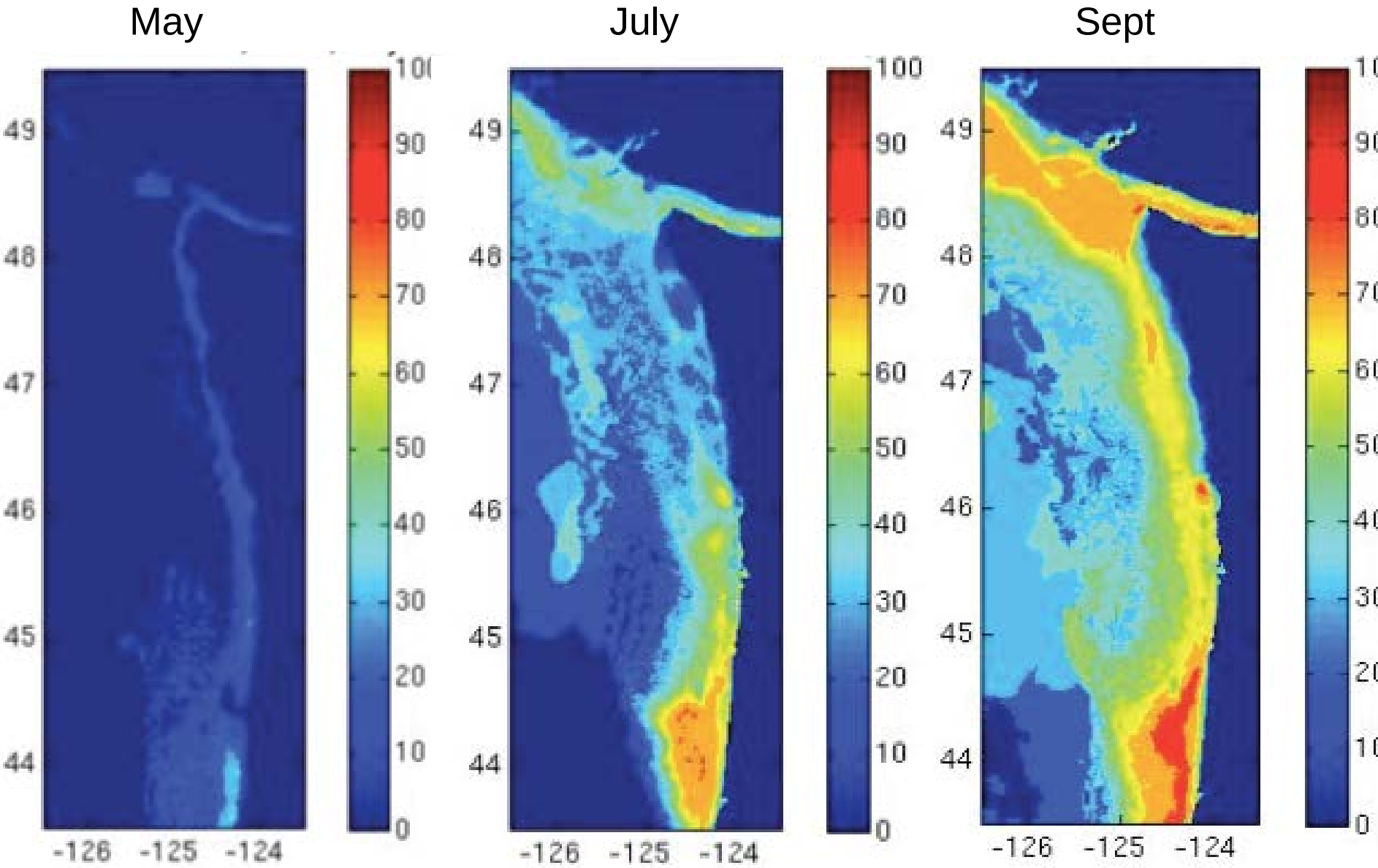
AVHRR (weekly ave.)



CFS



ROMS



Percent of upper 100 m of water column undersaturated with respect to aragonite (from forecasts for 2013)

NANOOS

Welcome to NANOOS, the Pacific Northwest regional ocean observing system of IOOS (Integrated Ocean Observing System). NANOOS is creating customized information and tools with these areas of emphasis:

- Maritime Operations
- Ecosystem Assessment
- Fisheries & Biodiversity
- Coastal Hazards
- Climate

Data Exploration

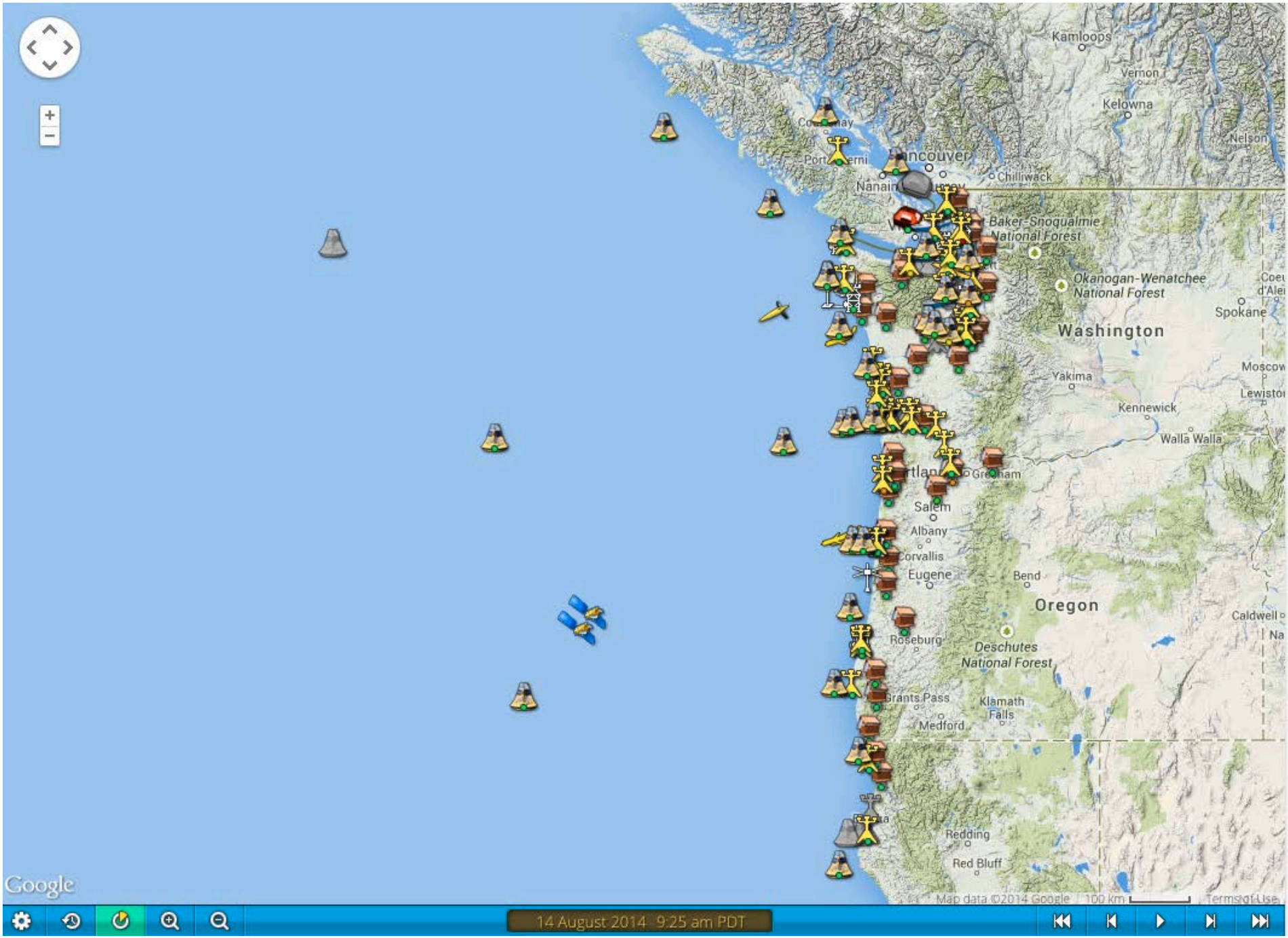
NVS (NANOOS Visualization System) is a web app that provides easy access to observations, forecasts, data, and visualizations.

Ocean Acidification in the Pacific Northwest

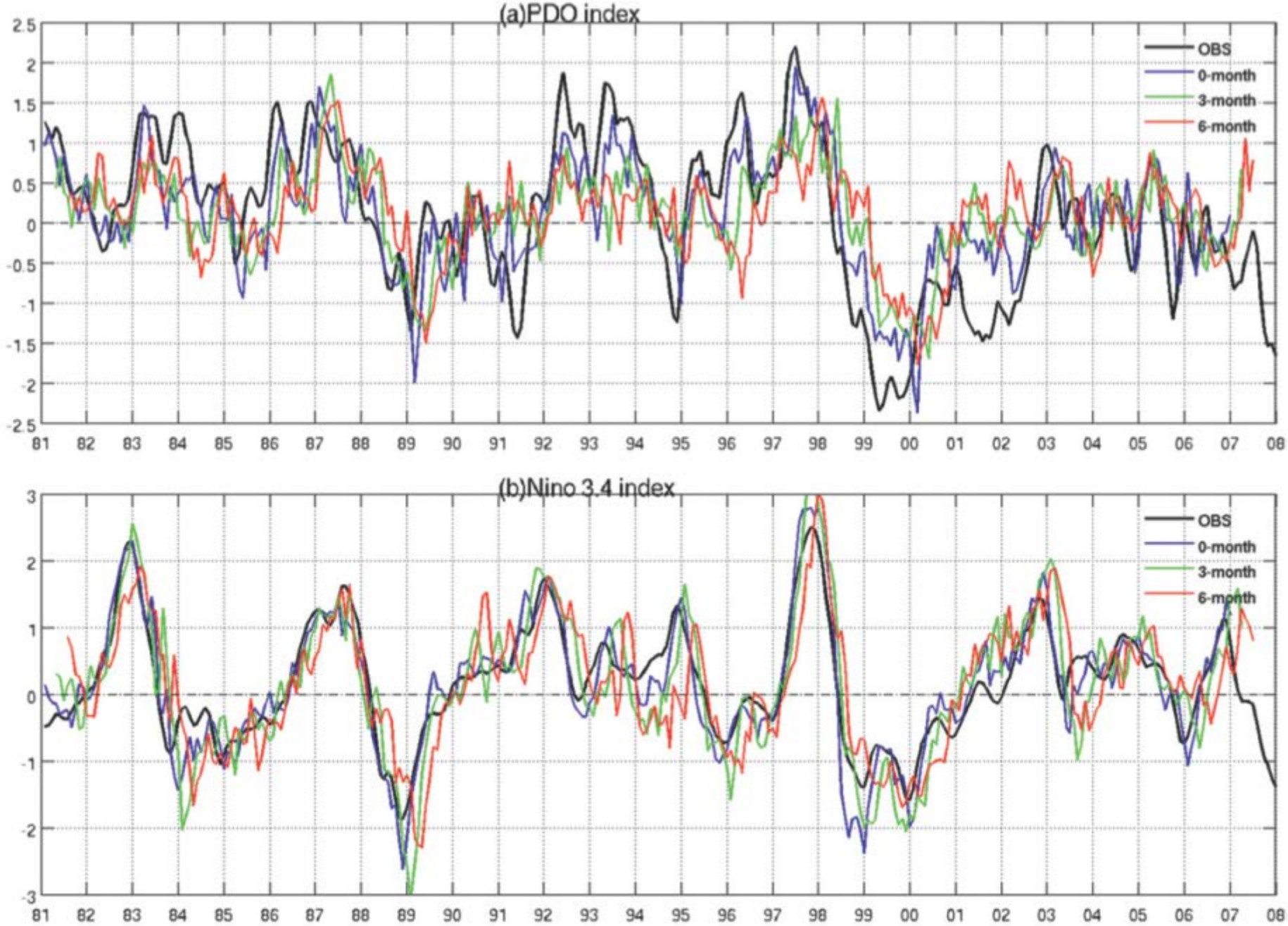
The marine waters of the Pacific Northwest are particularly vulnerable to ocean acidification. NANOOS, with its partners, is collecting and making available ocean acidification related water quality data from sensitive areas along the coast and within Puget Sound.

Visit the OA Page

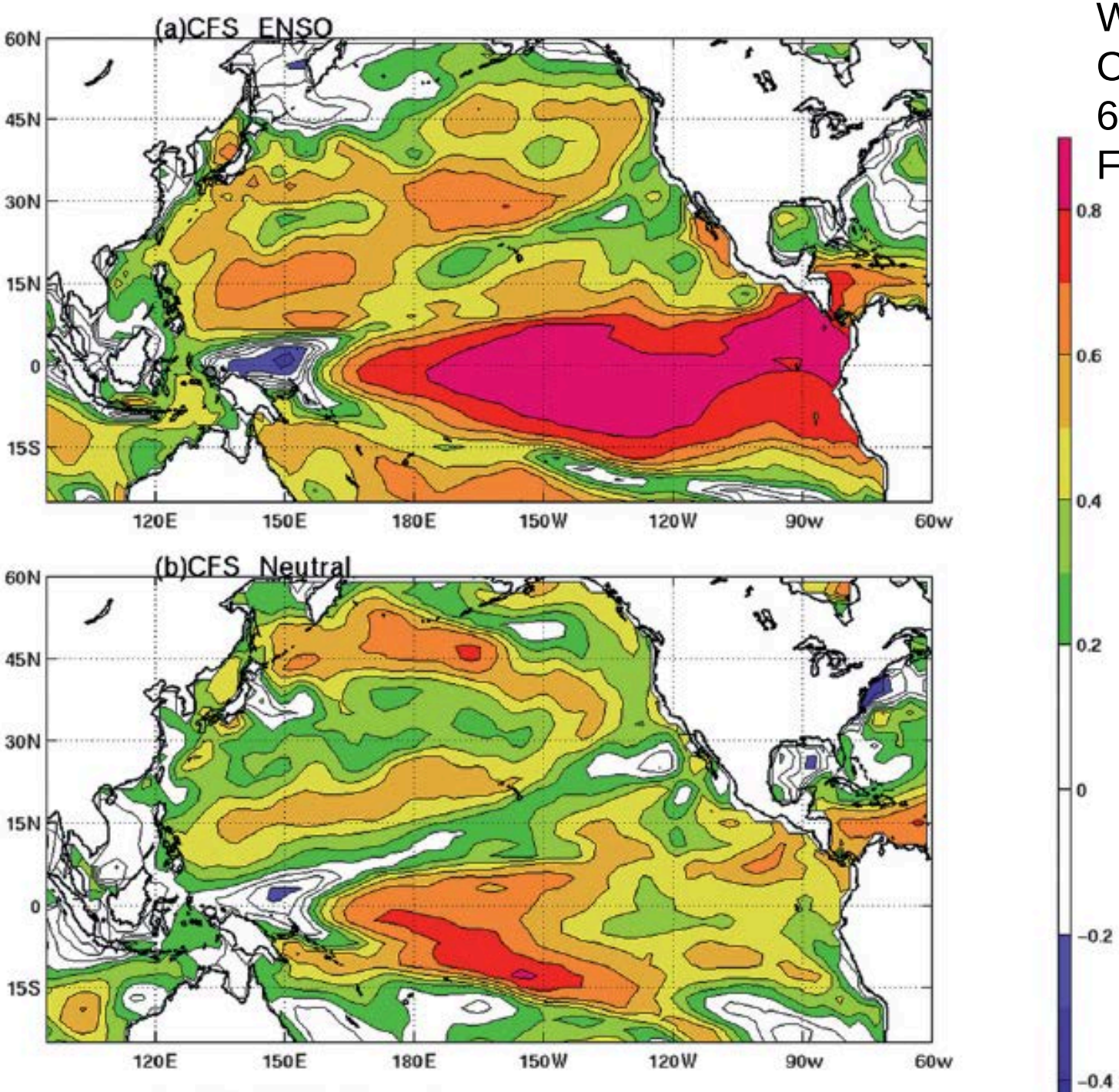
NANOOS and the Shellfish Industry

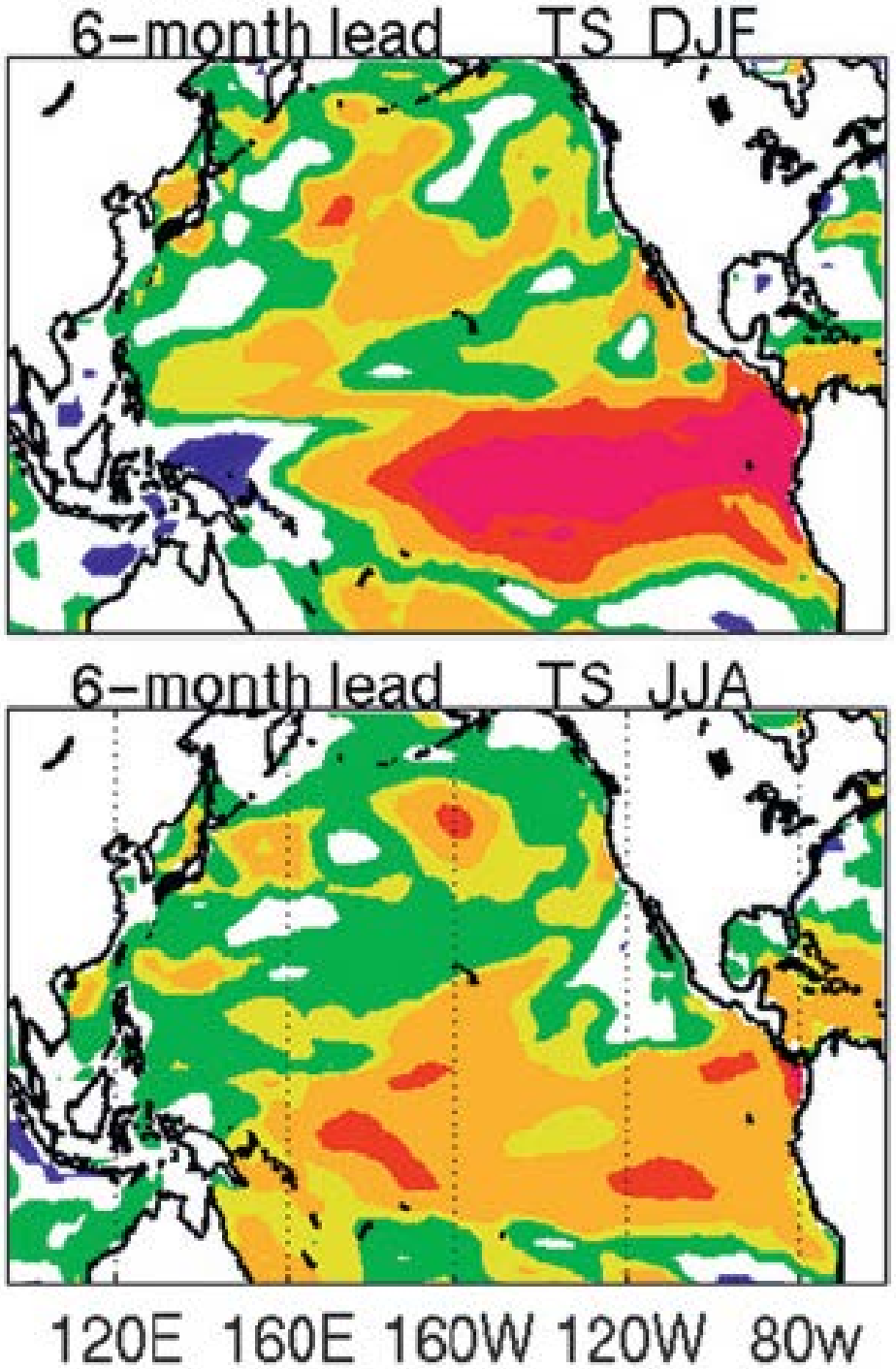

Kamloops
Vernon
Kelowna
Nelson
Chilliwack
Nanaimo
Baker-Snoqualmie National Forest
Okanogan-Wenatchee National Forest
Spokane
Washington
Yakima
Moscow
Kennewick
Walla Walla
Salem
Albany
Corvallis
Eugene
Bend
Oregon
Caldwell
Roseburg
Deschutes National Forest
Grants Pass
Medford
Klamath Falls
Redding
Red Bluff
Google
Map data ©2014 Google
100 km
Terms of Use
14 August 2014 9:25 am PDT

Wen et al. (2012)



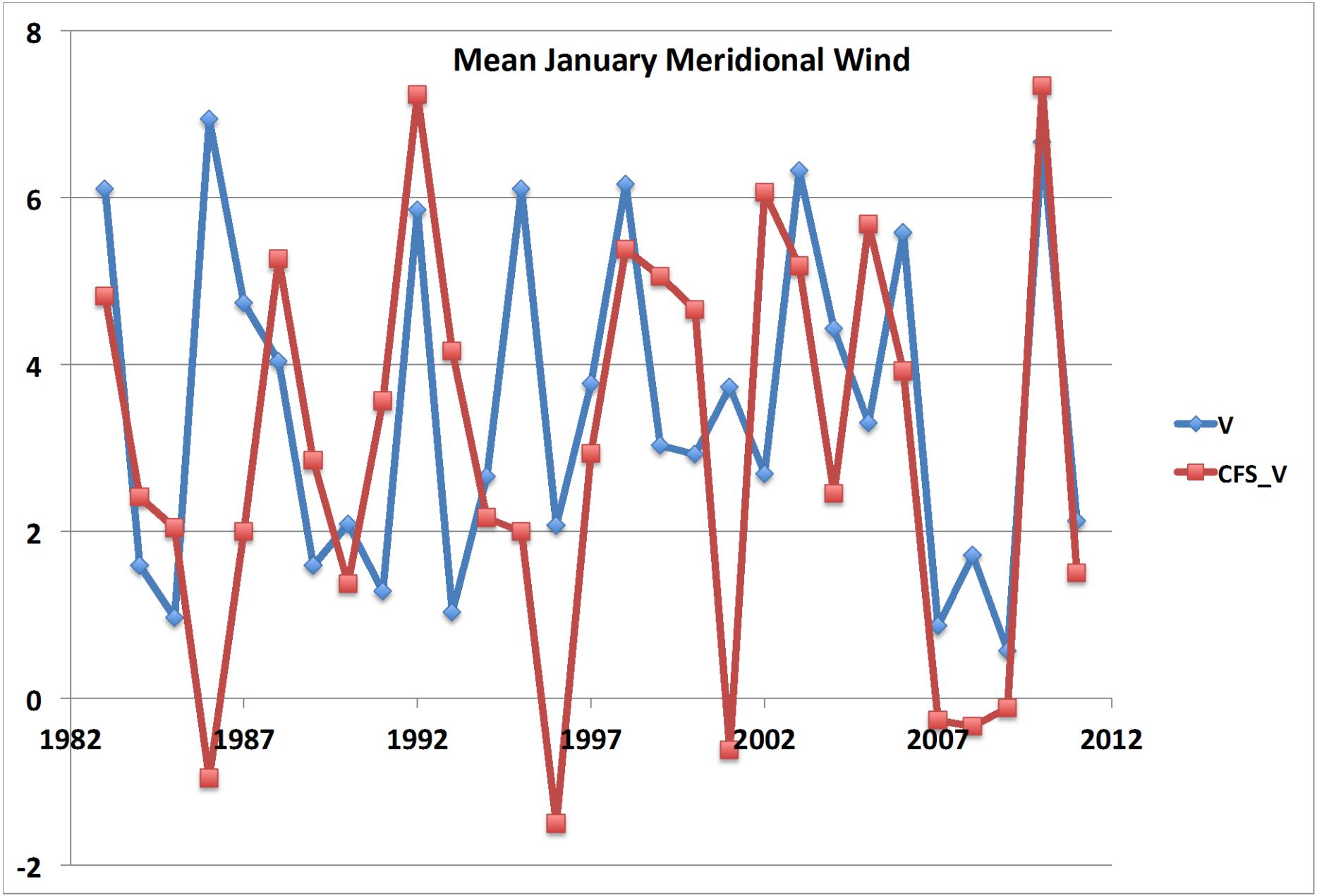
Wen et al. (2012)
Correlation Skill
6-month SST
Forecasts



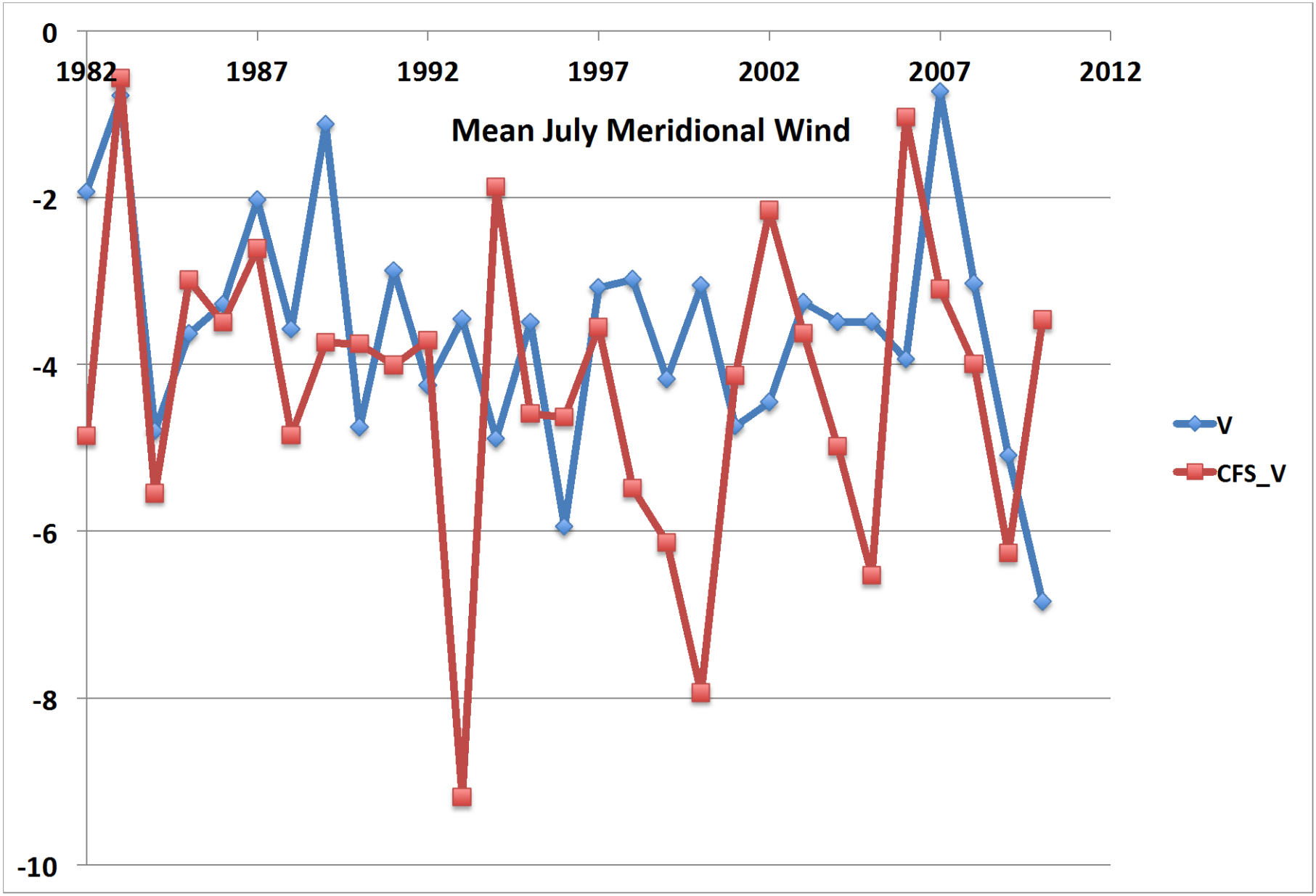


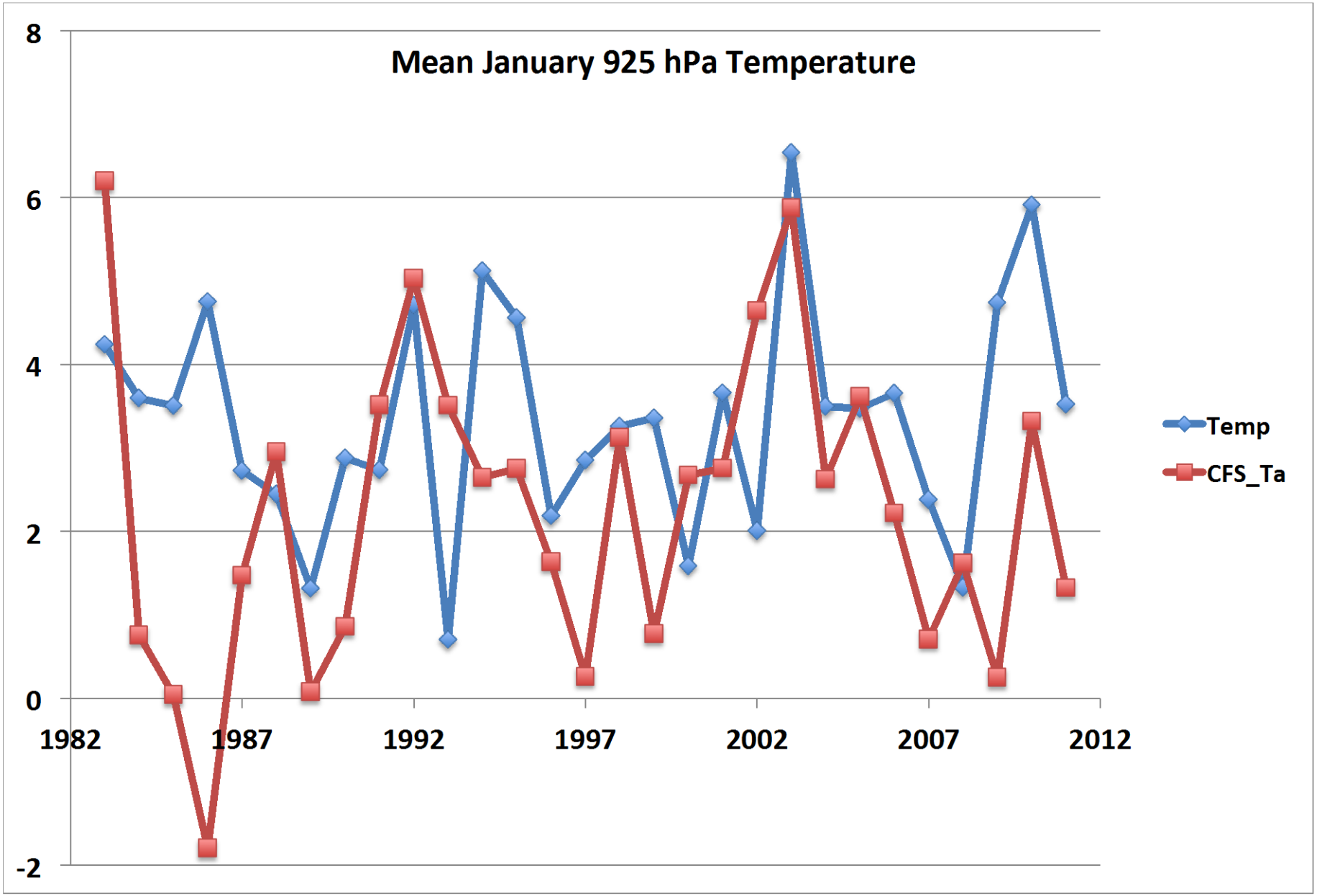
Wen et al. 2012

Seasonality of Correlation Skill in SST Forecasts



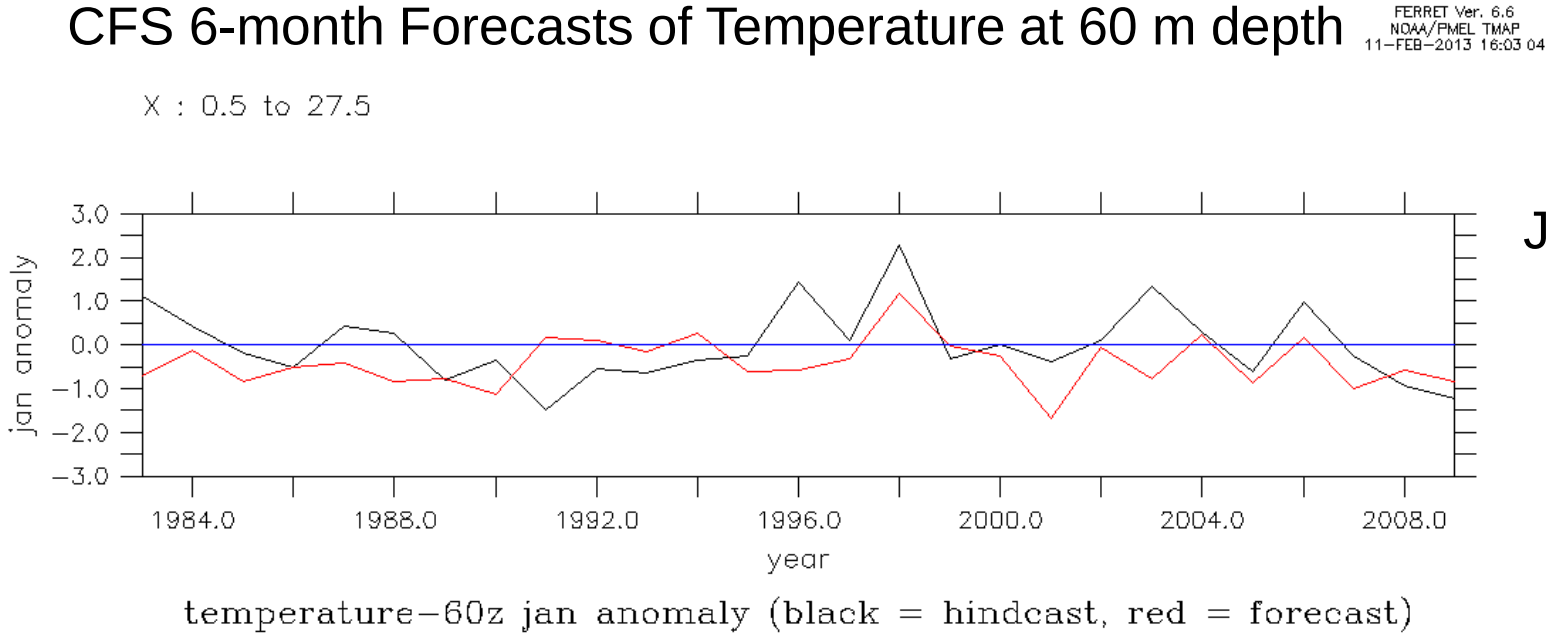
6 month forecasts (initialized previous July) for 43-49 N, 128-124 W


Mean July Meridional Wind
0
-2
-4
-6
-8
-10
1982
1987
1992
1997
2002
2007
2012
V
CFS_V

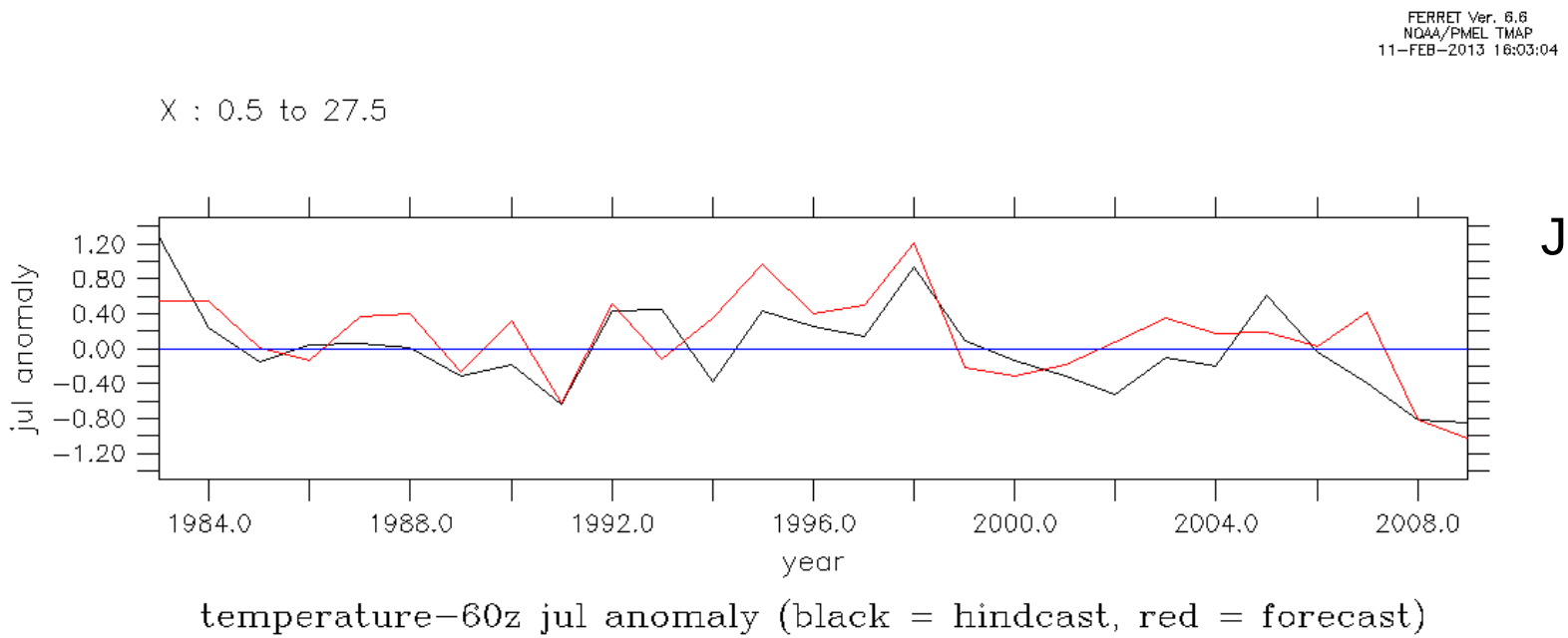


6 month forecasts for 43-49 N, 125-121 W

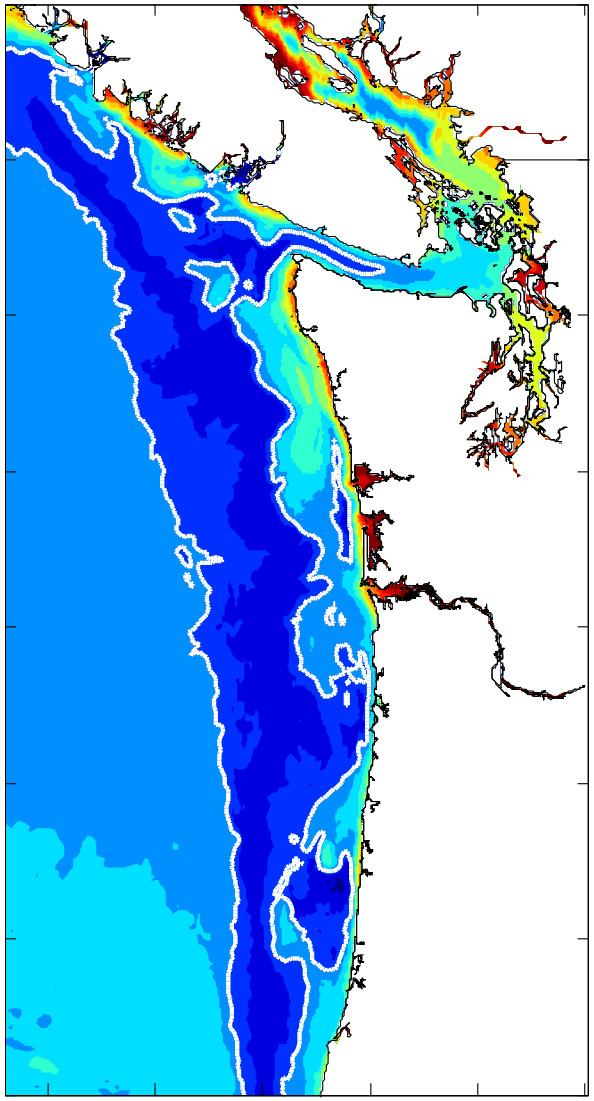
CFS 6-month Forecasts of Temperature at 60 m depth

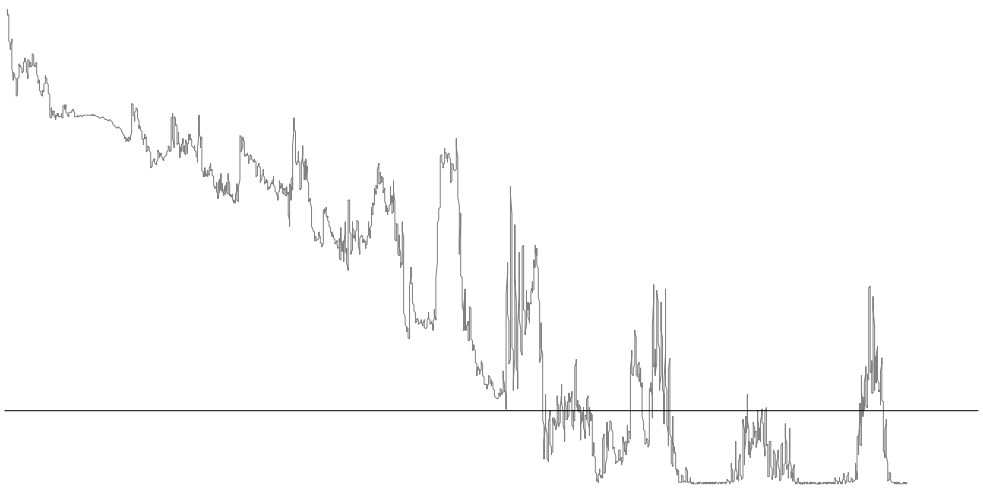


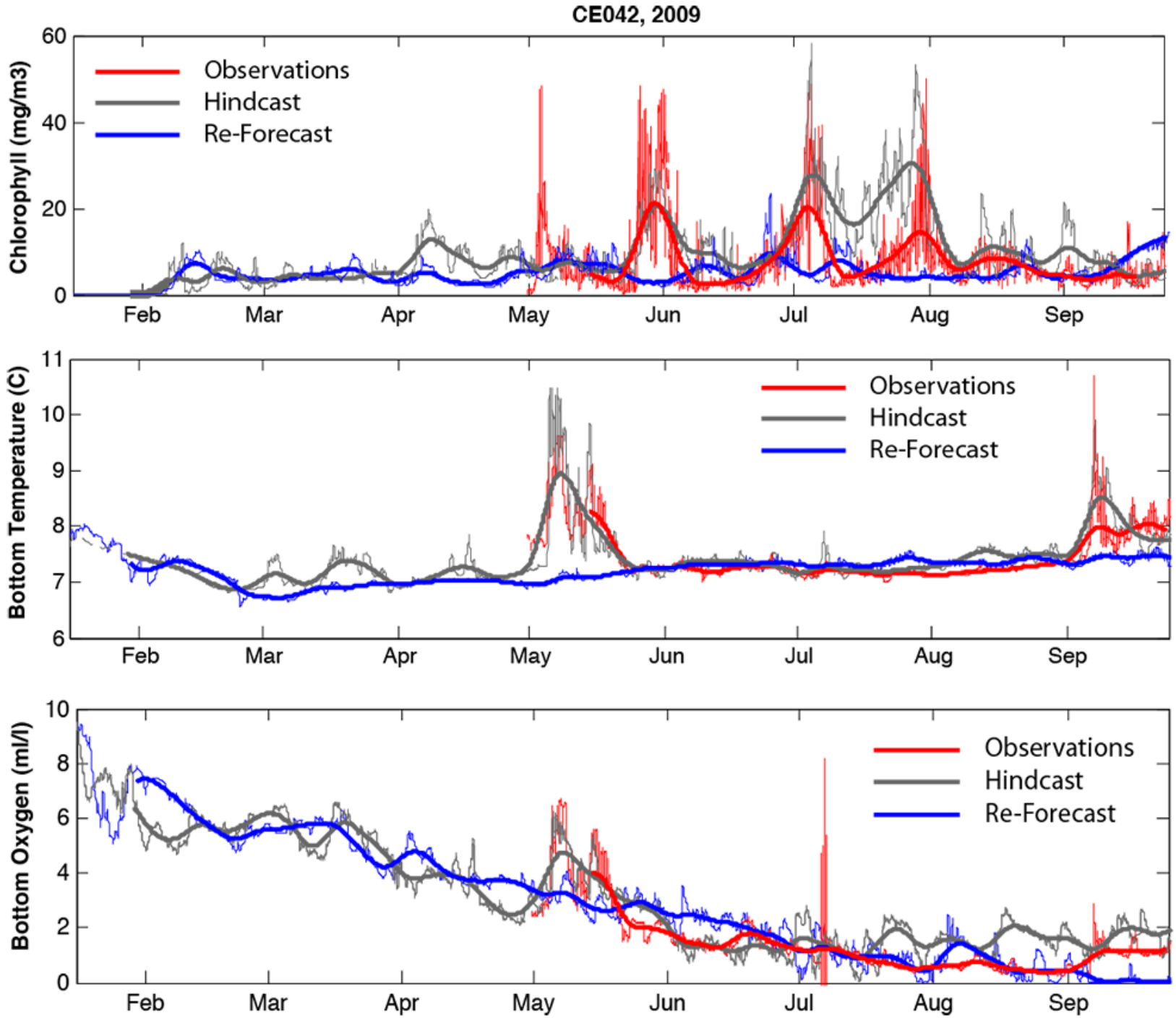
Jan

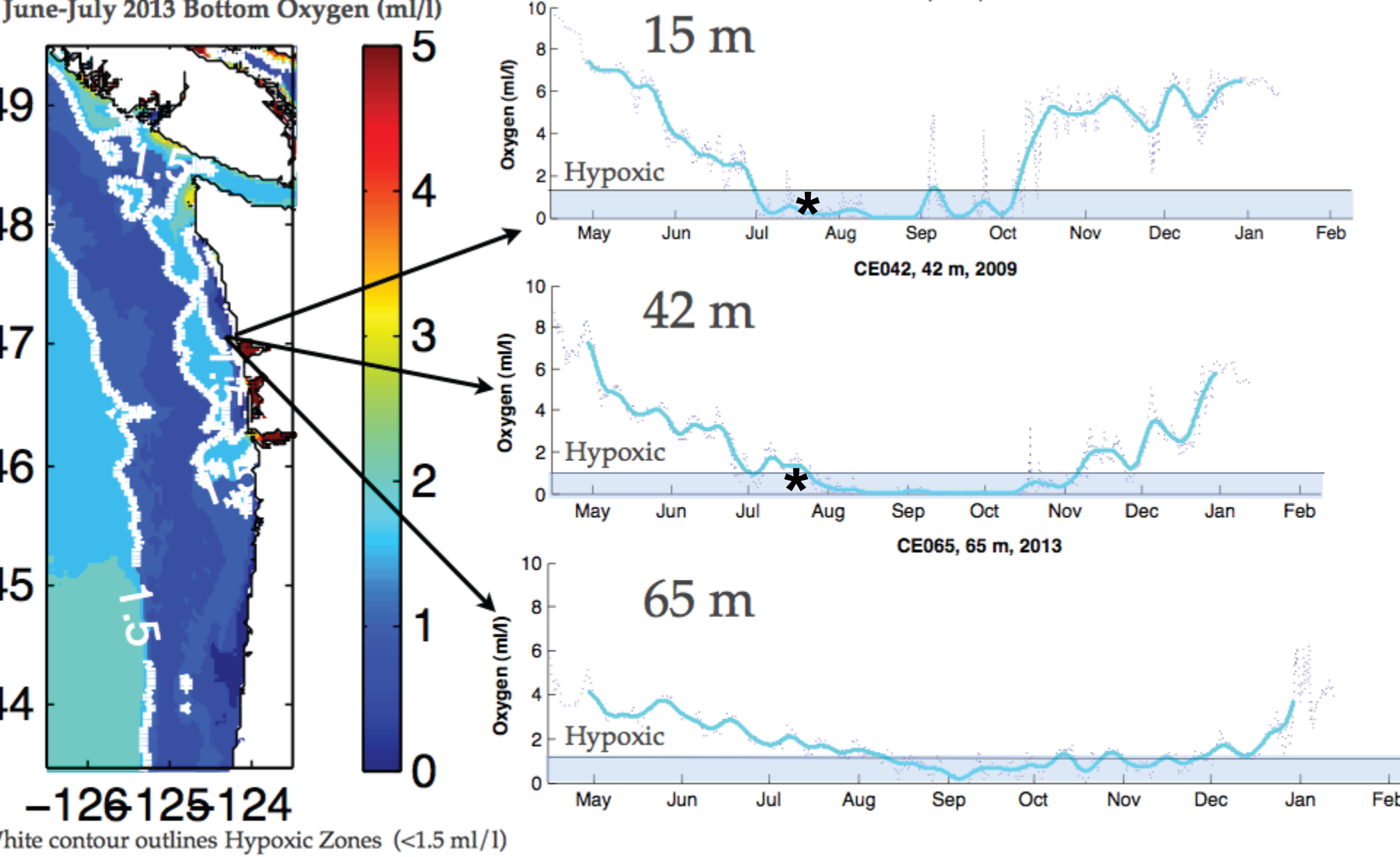


Jul





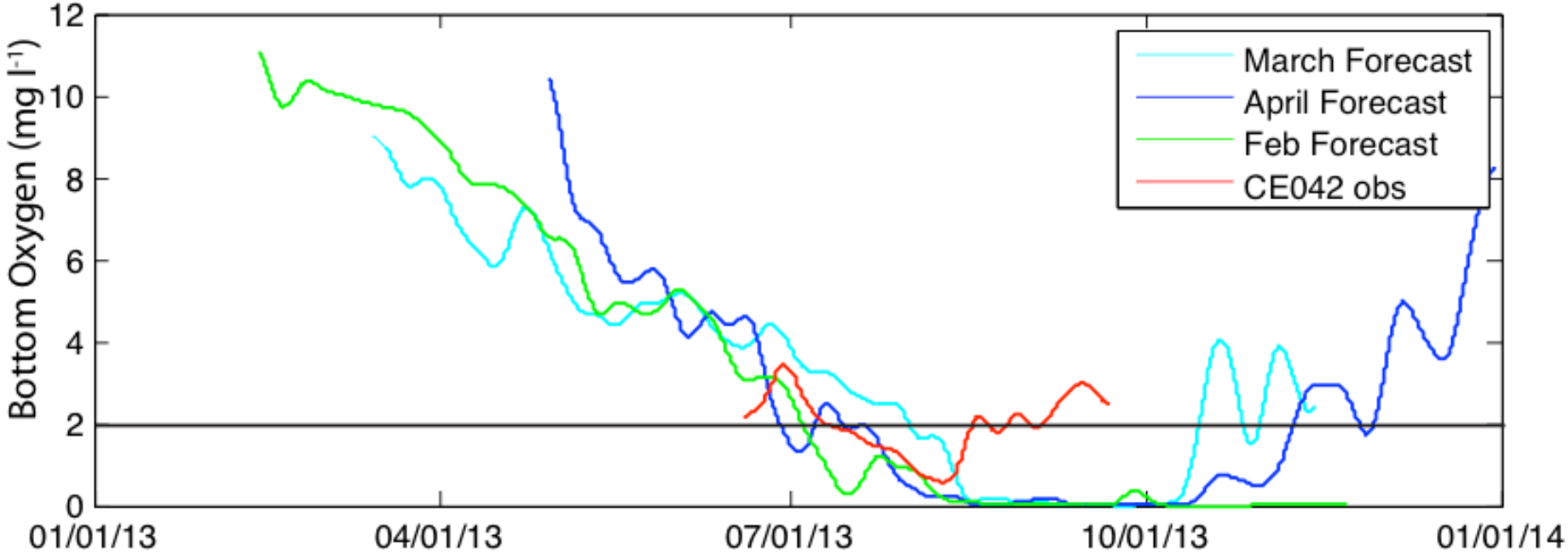

CE042, 2009
Chlorophyll (mg/m3)
Observations
Hindcast
Re-Forecast
Bottom Temperature (C)
Observations
Hindcast
Re-Forecast
Bottom Oxygen (ml/l)
Observations
Hindcast
Re-Forecast
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep



Forecast: Hypoxia begins in July, 2013 for Cape Elizabeth region of WA coast

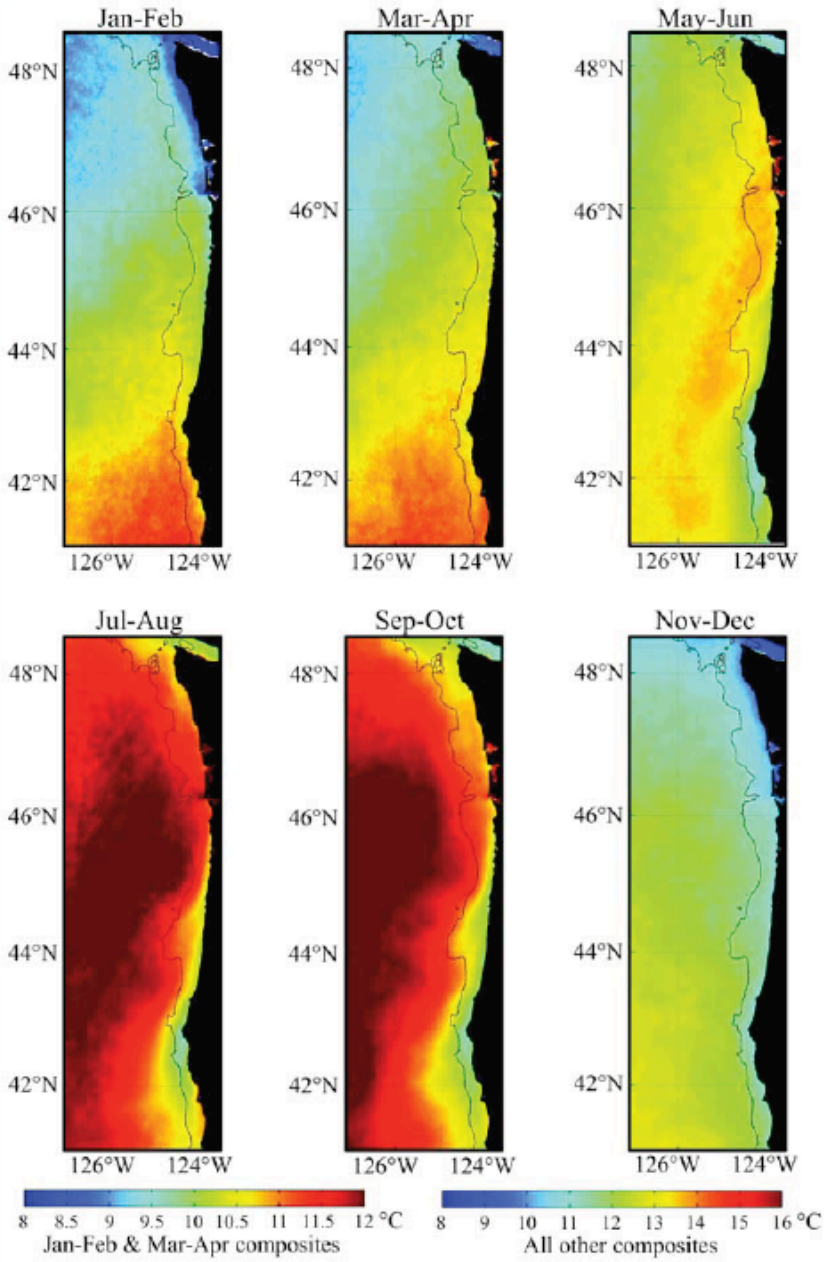
Oxygen model - Siedlecki et al. in prep

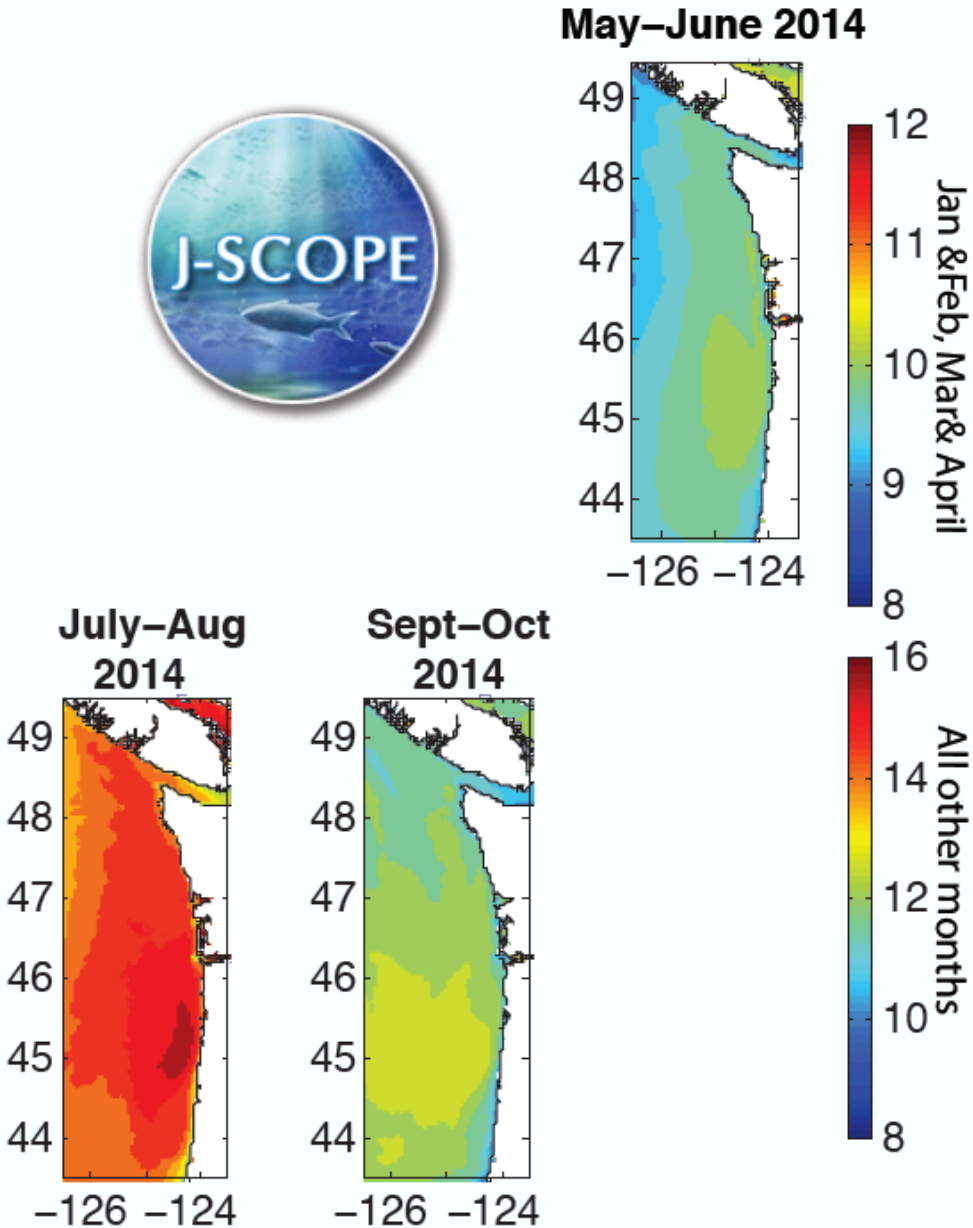
Oxygen Concentrations off the Washington Coast

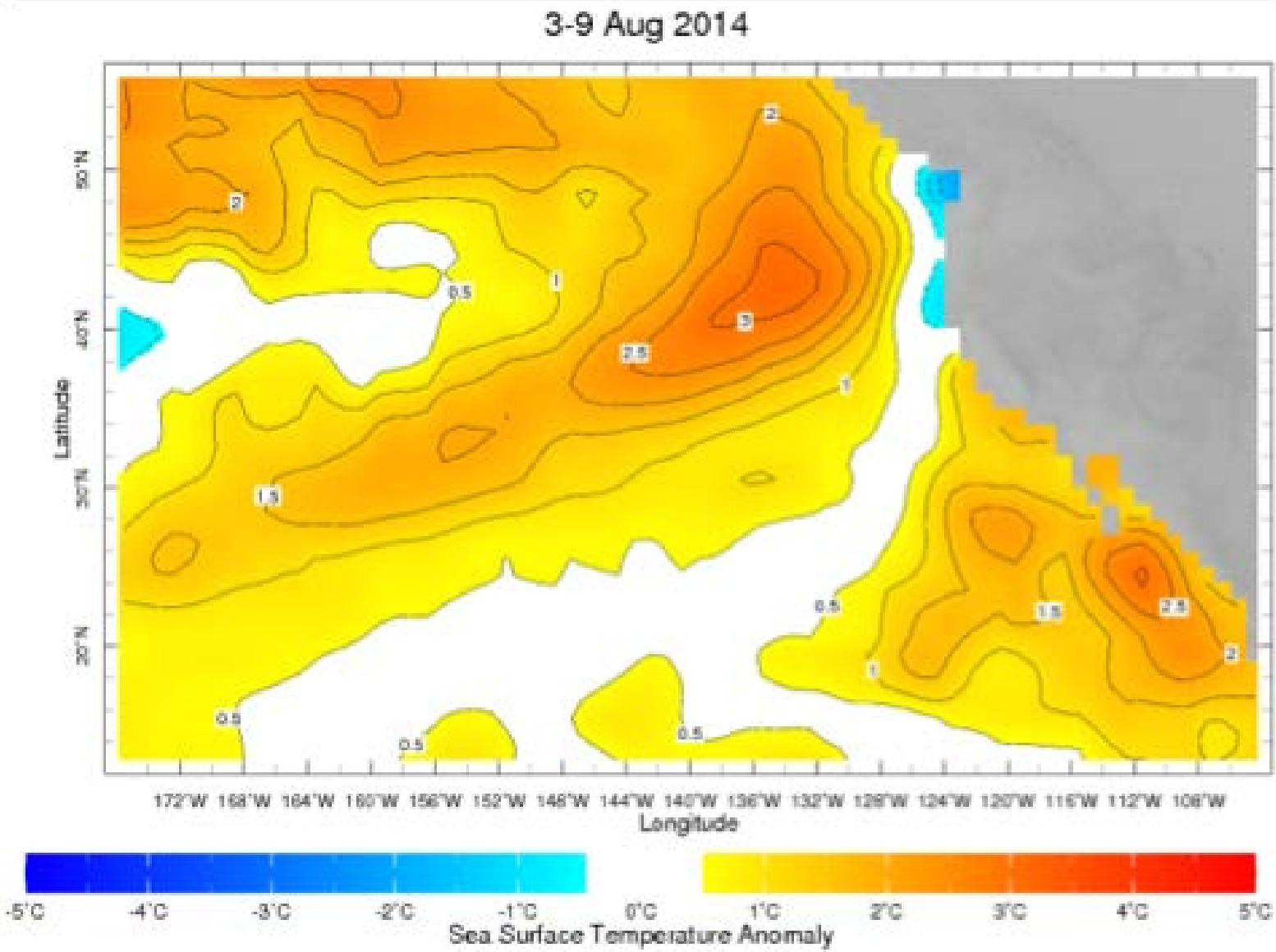


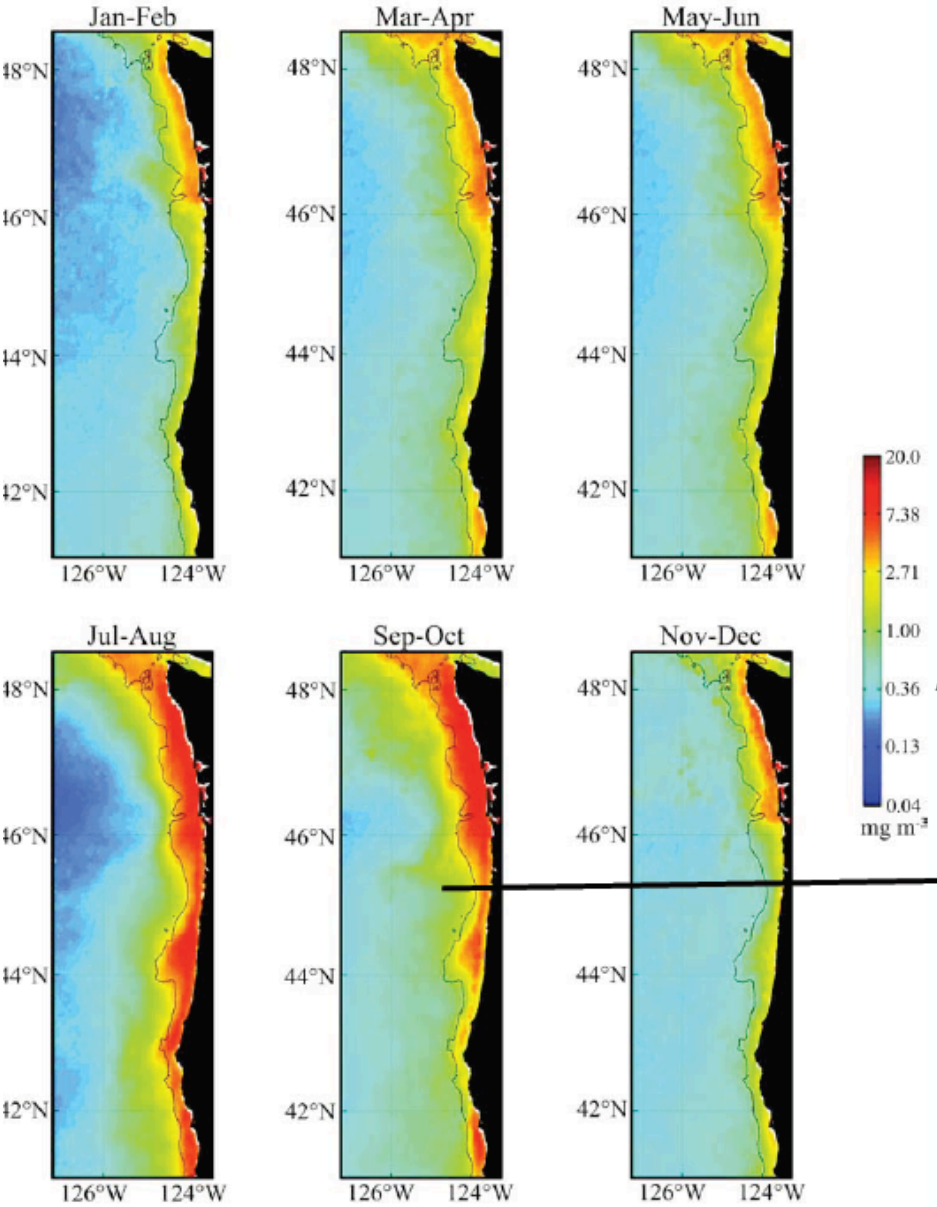
Venegas et al, 2008

SST climatology

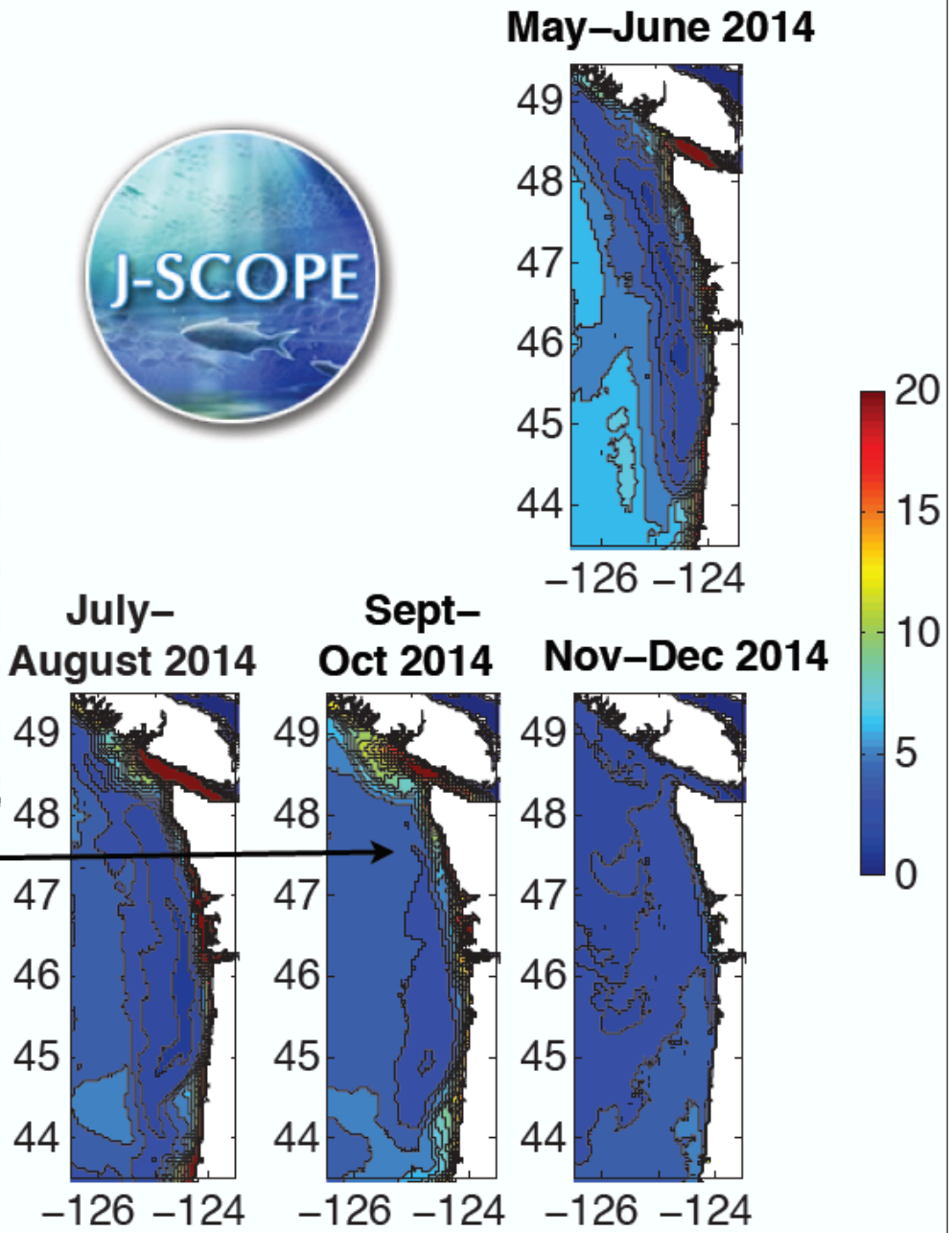





3-9 Aug 2014
Latitude
50°N
40°N
30°N
20°N
172°W 168°W 164°W 160°W 156°W 152°W 148°W 144°W 140°W 136°W 132°W 128°W 124°W 120°W 116°W 112°W 108°W
Longitude
-5°C -4°C -3°C -2°C -1°C 0°C 1°C 2°C 3°C 4°C 5°C
Sea Surface Temperature Anomaly



Venegas et al, 2008

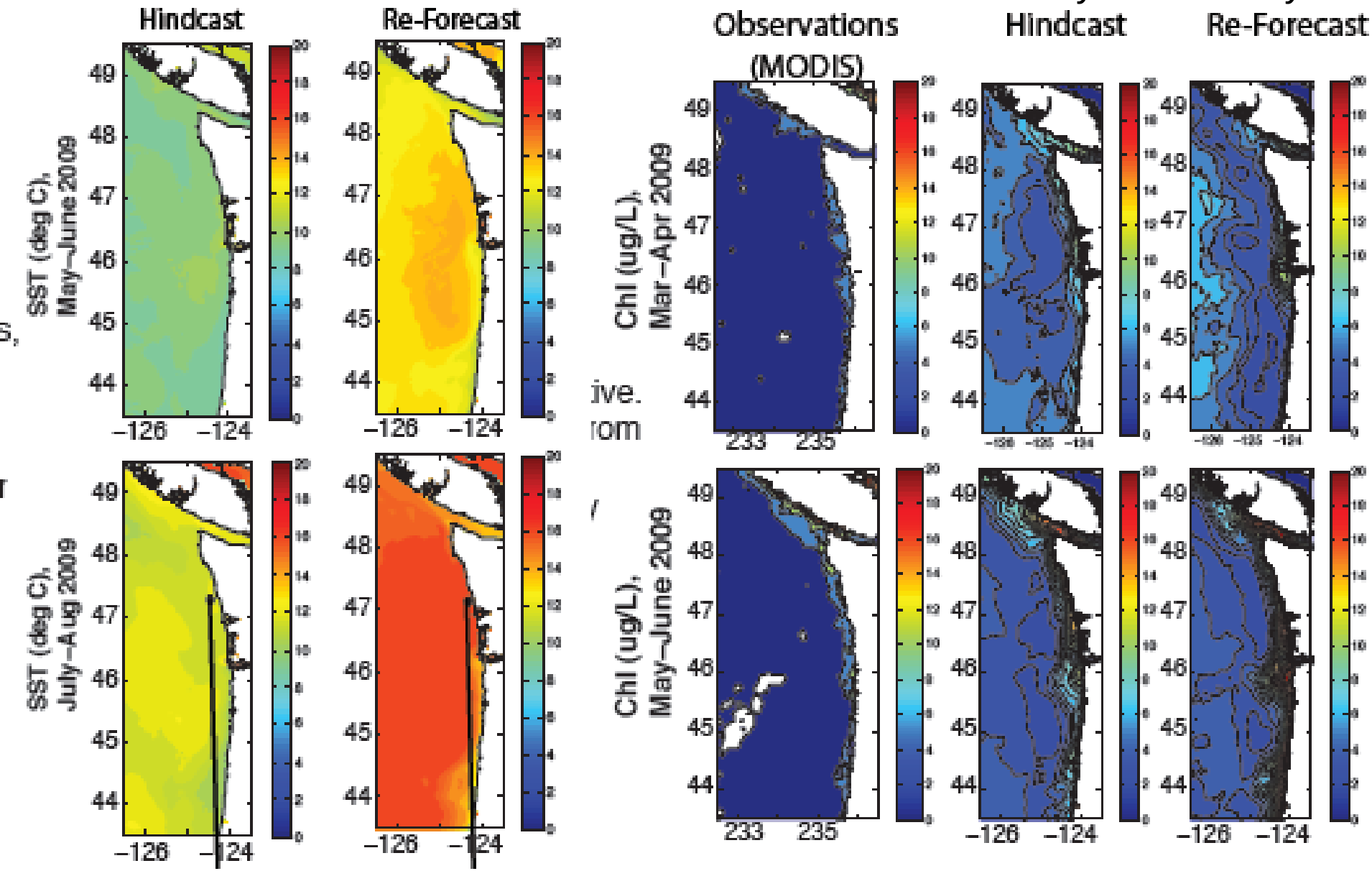


Surface Chl Climatogy

Sept 2014 is higher than average but closer to the coast

Too Warm

Too Much Primary Productivity



Systematic Errors from ROMS Simulations

Recurring Problems

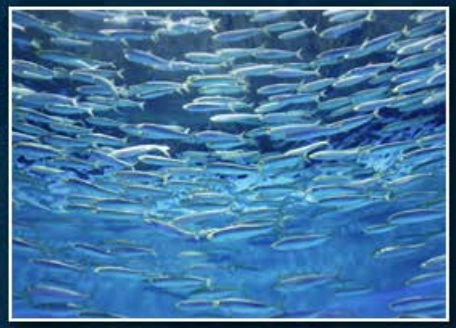
- Under-representation of summer cloud cover resulting in greater upper ocean warming than observed
- Upwelling seems to persist too long into the autumn season (seasonality in wind forecasts from the CFSv2?)
- Drawdown of oxygen persists past the end of summer (enhanced primary production in ROMS?)

J-SCOPE

JISAO Seasonal Coastal Ocean Prediction of the Ecosystem

An ecosystem is: "The functional unit of a biological organization interacting with the physical environment such that the flow of energy and mass leads to a characteristic trophic structure and material cycles." ~ Odum, 1969.

NOAA further defines the environment as "the biological, chemical, physical, and social conditions that surround organisms. When appropriate, the term environment should be qualified as biological, chemical, and/or social" (Murawski and Matlock 2006).

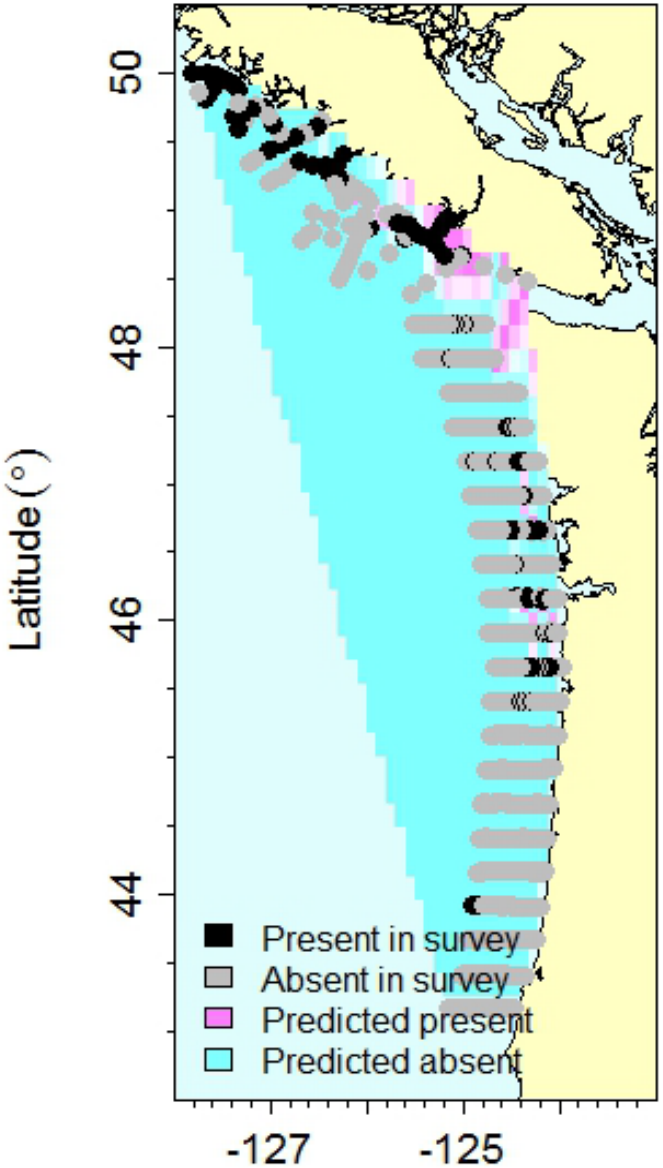


The J-SCOPE forecasts are developed to support the California Current Integrated Ecosystem Assessment. Integrated Ecosystem Assessments (IEAs) are a framework for informing ecosystem-based management, which aims to take into account interactions among ecosystem components and managed sectors, as well as cumulative impacts of a wide spectrum of ocean-use sectors (Rosenberg and McLeod 2005). IEAs are a synthesis and quantitative analysis of information on relevant natural and socioeconomic factors, in relation to ecosystem management objectives (Levin et al. 2009).

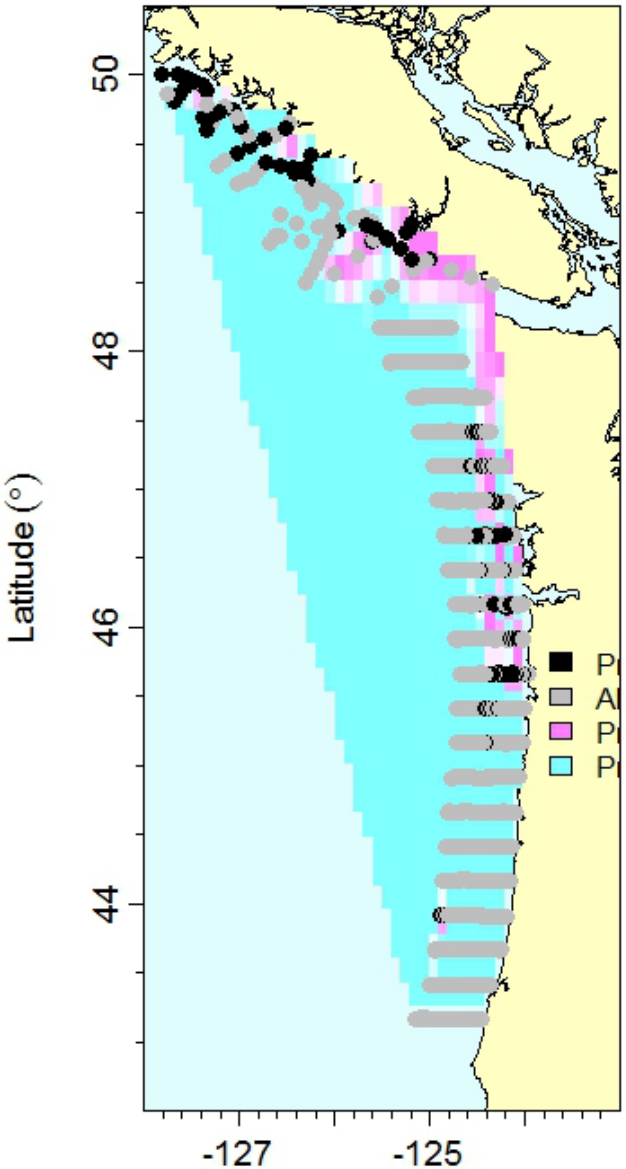
In the context of the California Current IEA, JSCOPE provides short term (six to nine month) forecasts of ocean condition that are testable and relevant to management decisions for fisheries, protected species and ecosystem health. Results will directly inform the IEA process, and will forecast indicators requested by the Pacific Fishery Management Council.

Predicted vs. Observed Presence of Sardines in 2009 based on ROMS re-forecasts of T, Salinity, Chl, O2 (Kaplan et al.)

Simple Model



Complex Model



Final Remarks

- With support from NOAA's National Marine Fisheries Service, a seasonal prediction system (J-SCOPE) has been developed for the coastal waters of the PNW
- Projections based on mesoscale output from ROMS forced by the CFSv2 global coupled model
- Will be used in a quasi-operational sense for integrated ecosystem assessment and for projections of salmon returns
- **Quality of CFS forcing** – Positive skill for surface winds and sub-surface ocean temperatures; less reliable for low-level air temperature & cloud cover
- **Issues** – Neglect of mesoscale atmospheric effects; complexity of biochemistry; # of ensemble members