Flow-Topography Interaction and its Influence on Ecosystem Dynamics in the Northern California Current System

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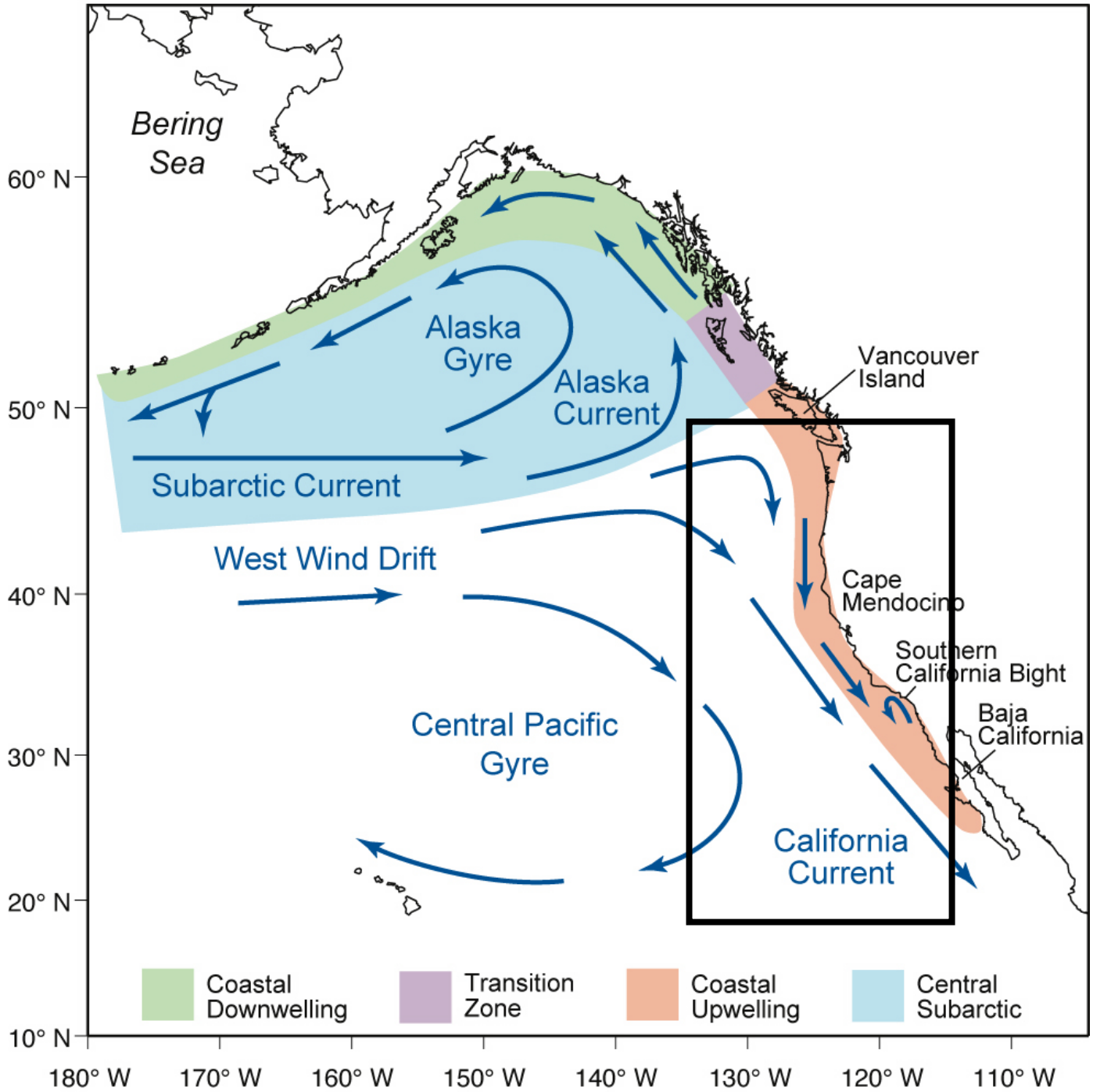
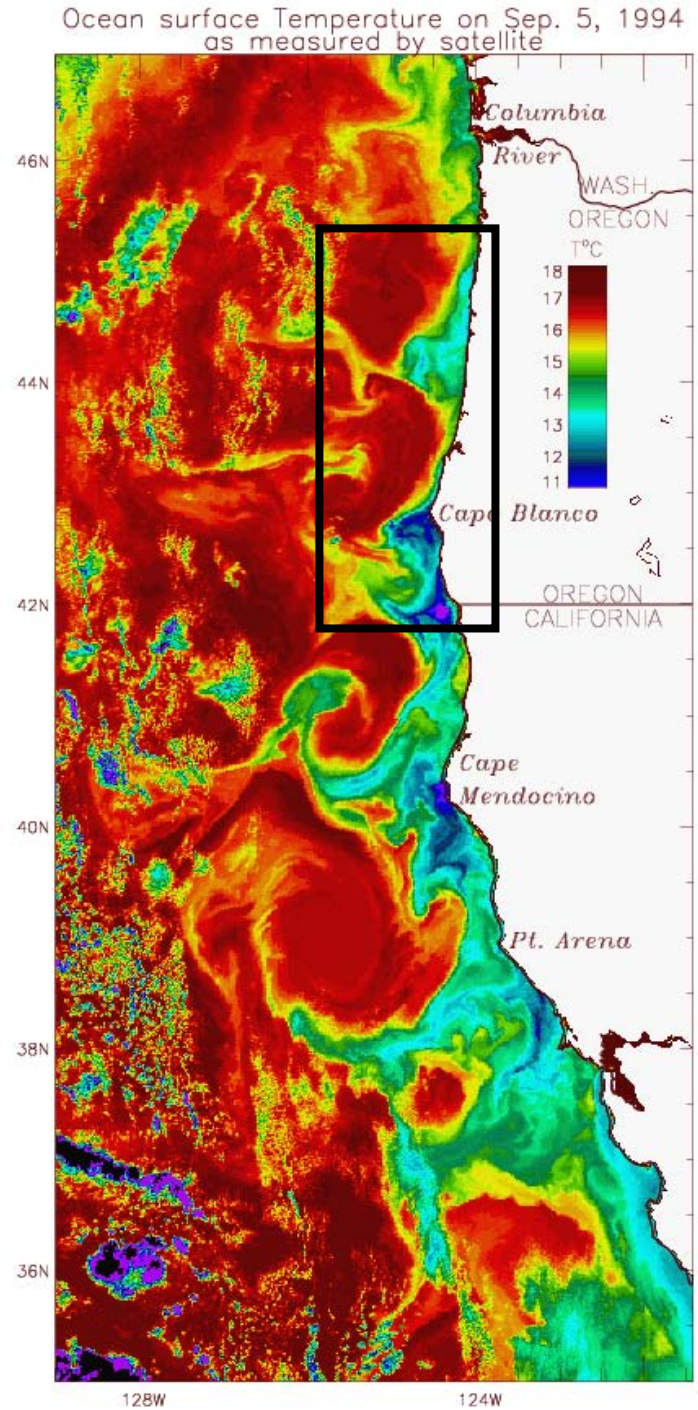
- Flow-topography interaction
- Ecosystem response
  - localized enhanced productivity (new bioacoustics inversion)
  - hypoxia
- Flow-topography dynamics ("recipe" to assess interaction)
- Interannual variability

Courtesy of J. Bane (UNC)

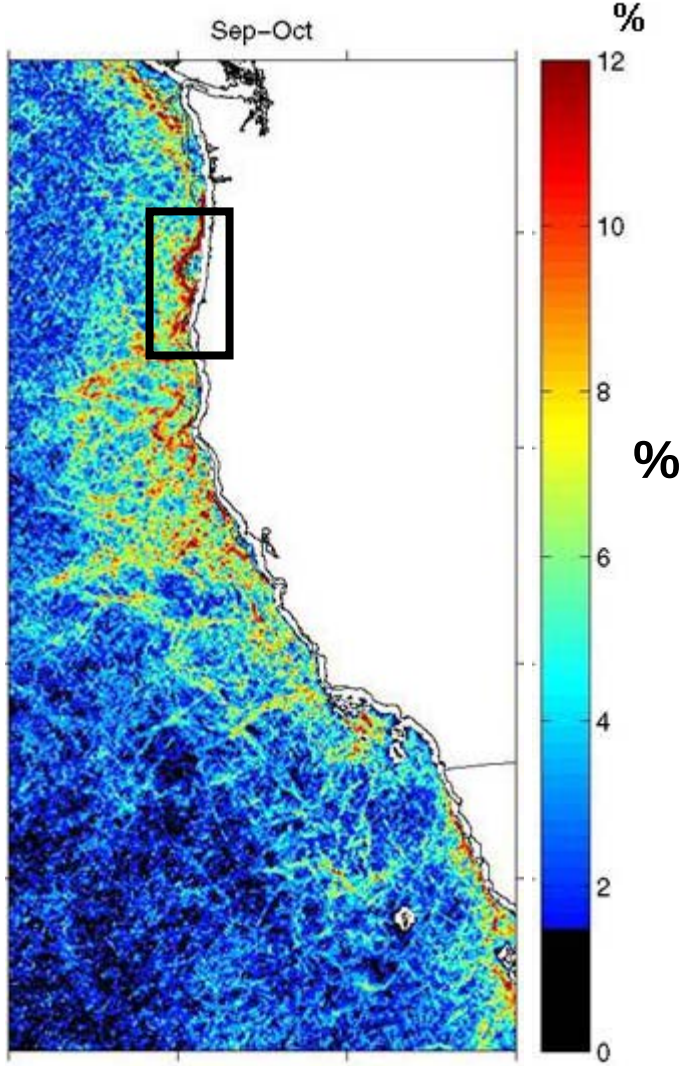

Bering Sea
60° N
50° N
40° N
30° N
20° N
10° N
180° W
170° W
160° W
150° W
140° W
130° W
120° W
110° W
Alaska Gyre
Alaska Current
Subarctic Current
West Wind Drift
Central Pacific Gyre
California Current
Vancouver Island
Cape Mendocino
Southern California Bight
Baja California
Coastal Downwelling
Transition Zone
Coastal Upwelling
Central Subarctic

California Current upper-ocean response



Heceta Bank & Cape Blanco

GOES surface frontal probability



Mavor, Castelao and Barth (in prep.)

Field work in the northern California Current System

Northeast Pacific Program

U.S. GLOBEC

GLOBAL OCEAN ECOSYSTEMS DYNAMICS

College of Oceanic & Atmospheric Sciences

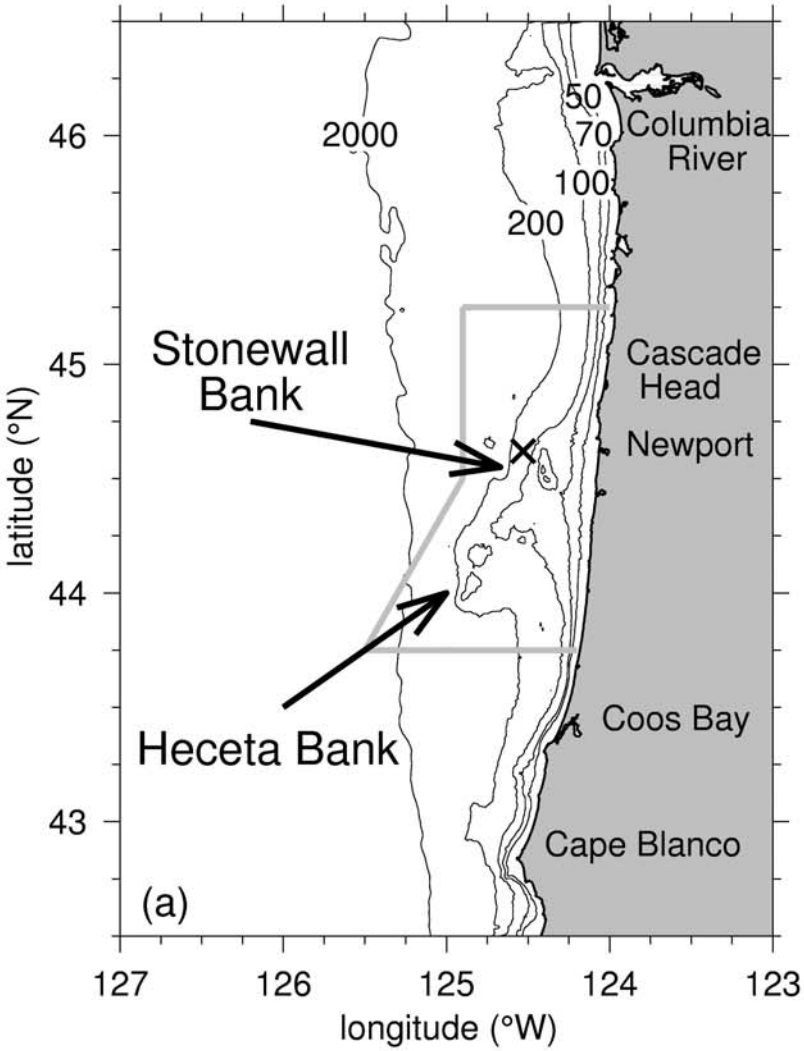
OREGON STATE UNIVERSITY

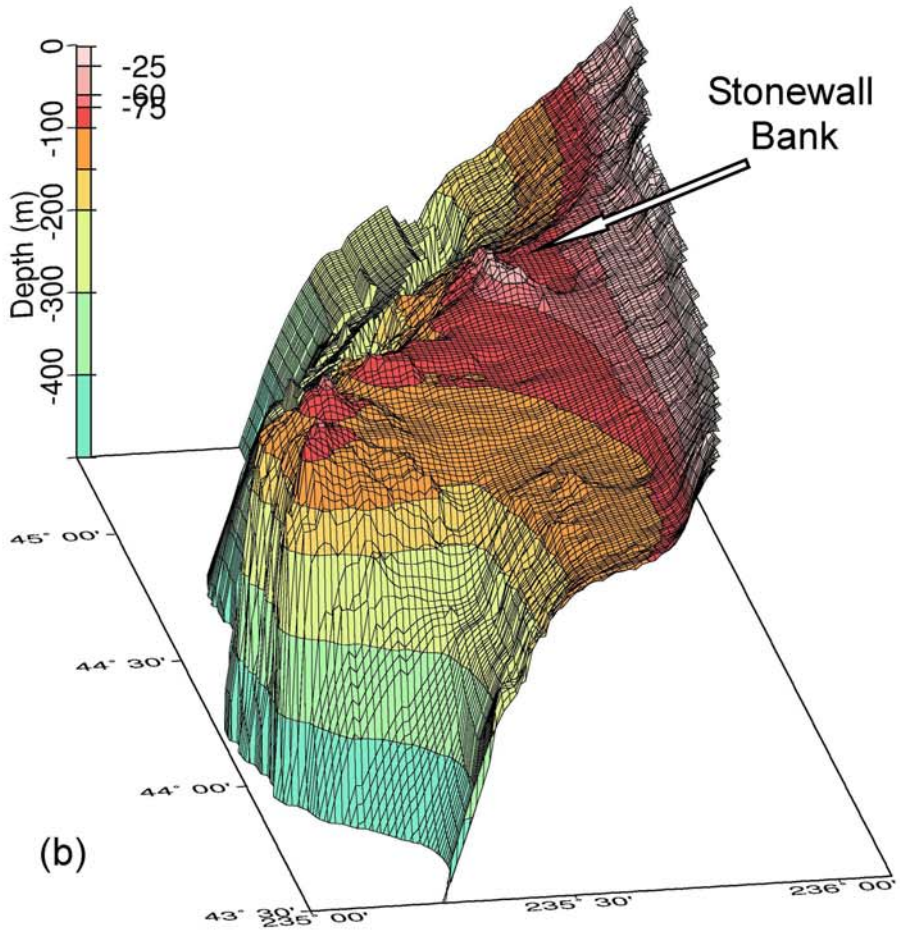
OSU • UNC • LDEO

COAST

Coastal Ocean Advances in Shelf Transport

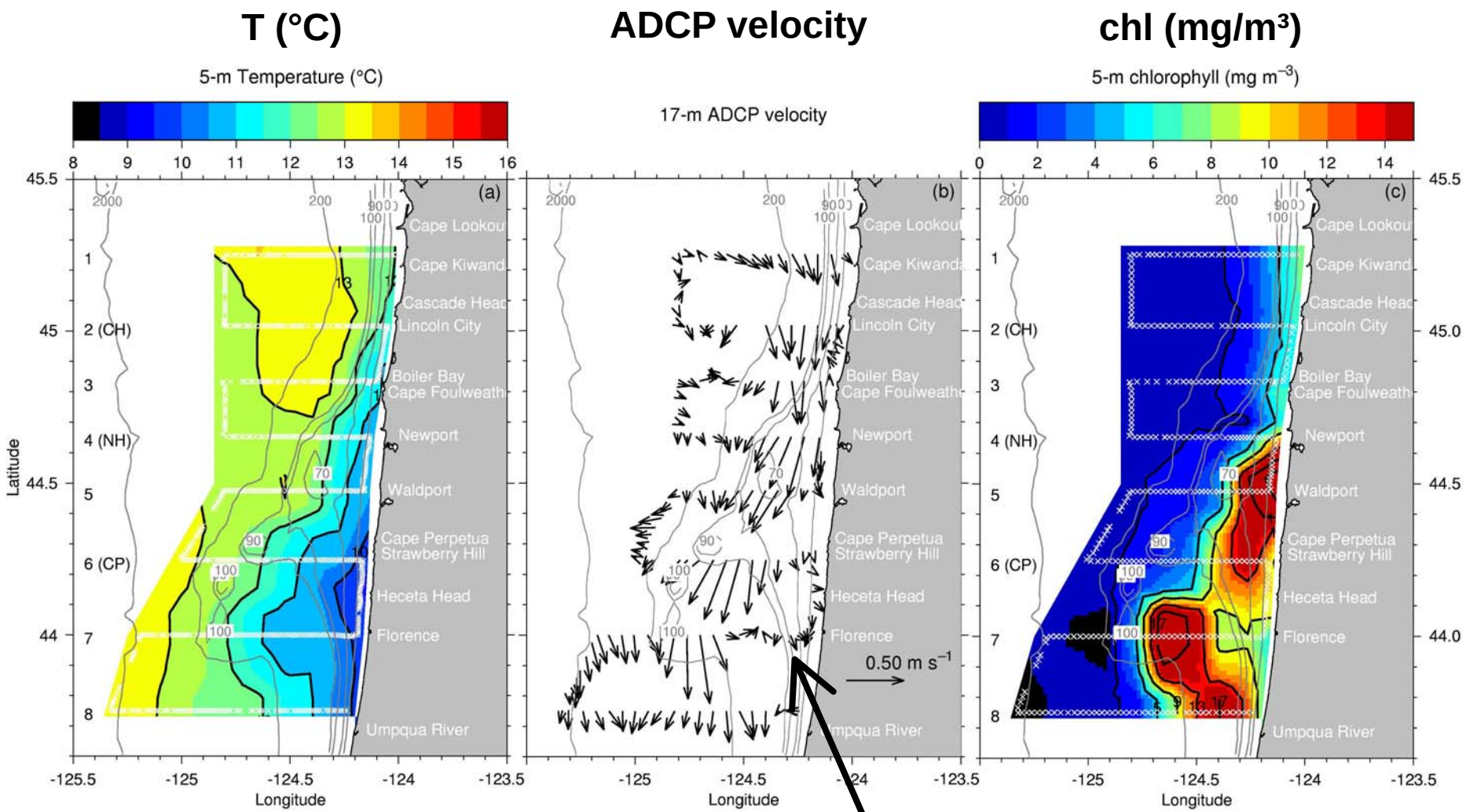
Flow-topography interaction off Oregon





Barth et al. (2005)

Heceta Bank deflects coastal upwelling jet offshore



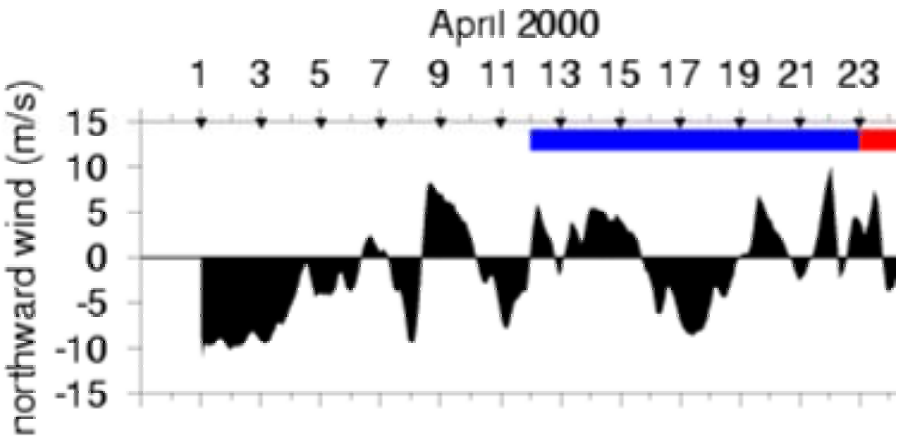
29 May – 1 June 2001

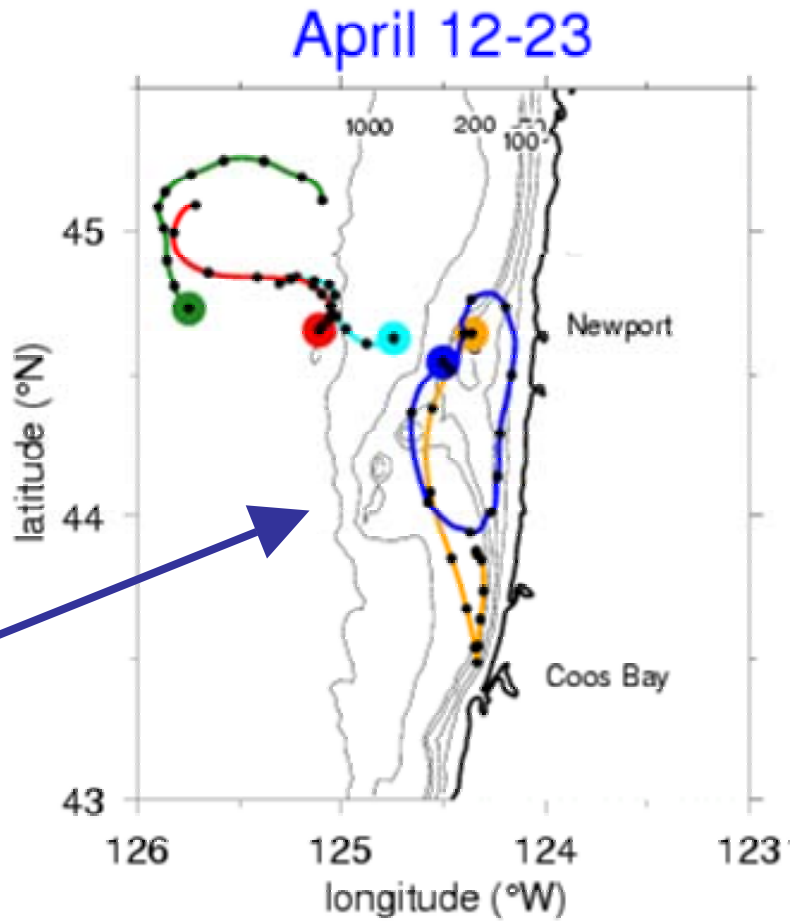
low-velocity inshore

Barth et al. (2005)

Time-variable winds leads to recirculation around Bank

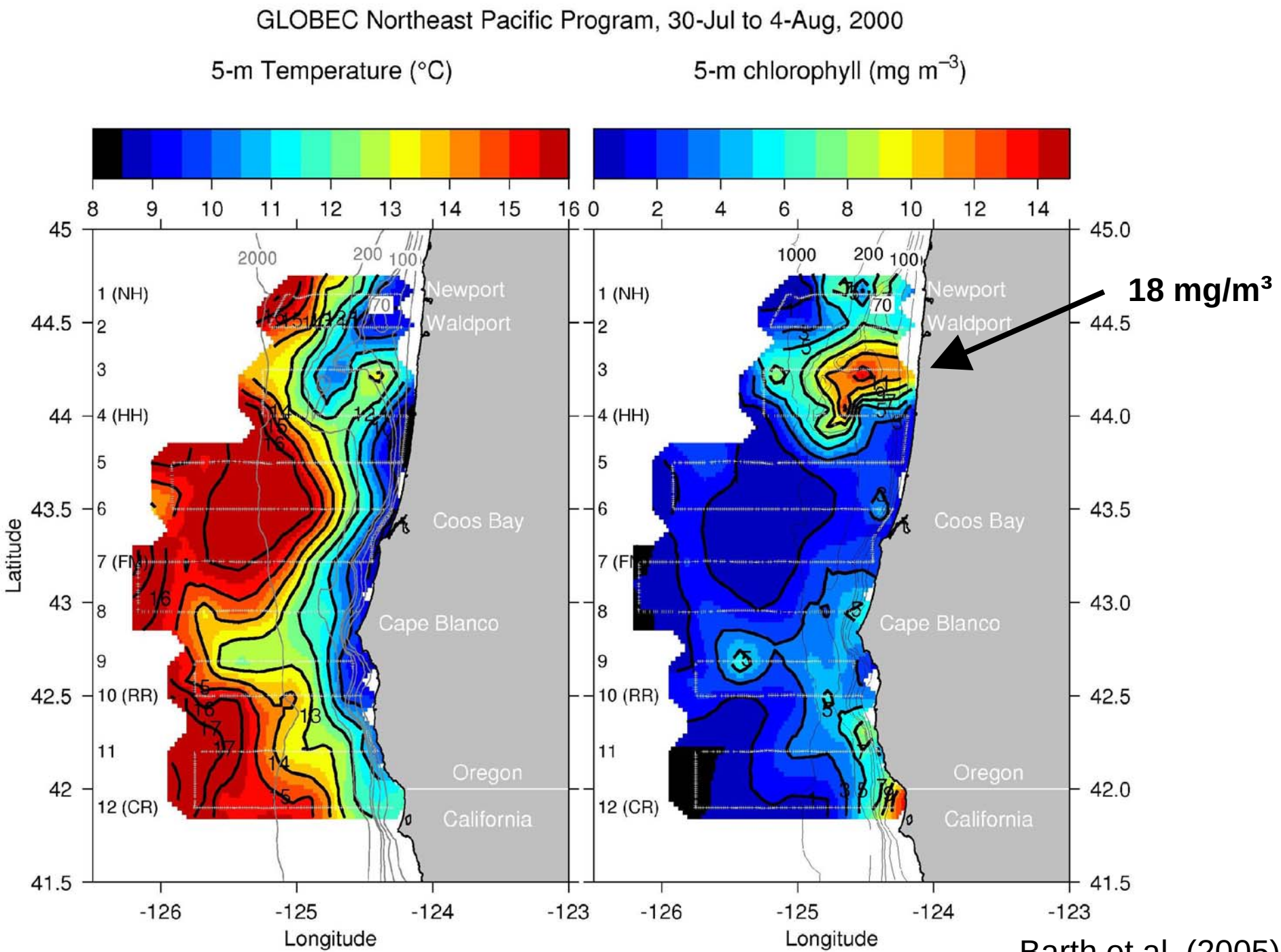
retention & growth





11-day recirculation

Barth et al. (2005)



Barth et al. (2005)

GLOBEC NEP, August 2000

65

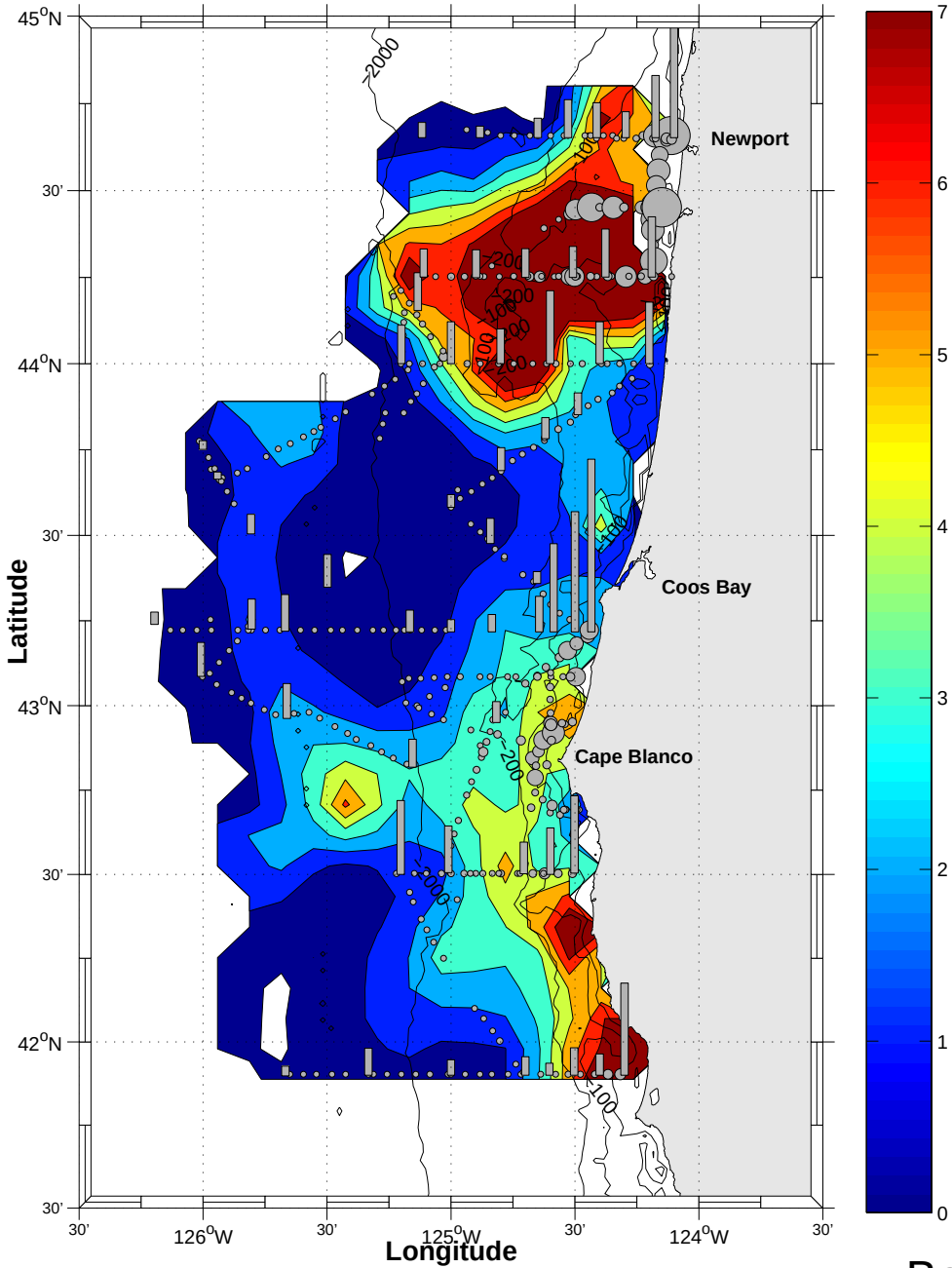
Copepods (mg/m³)

Courtesy of Bill Peterson (NOAA)

170

Birds (kg/km²)

Courtesy of David Ainley (HTH Inc.)



chlorophyll (mg/m³)

Batchelder et al. (2002)

GLOBEC NEP, August 2000

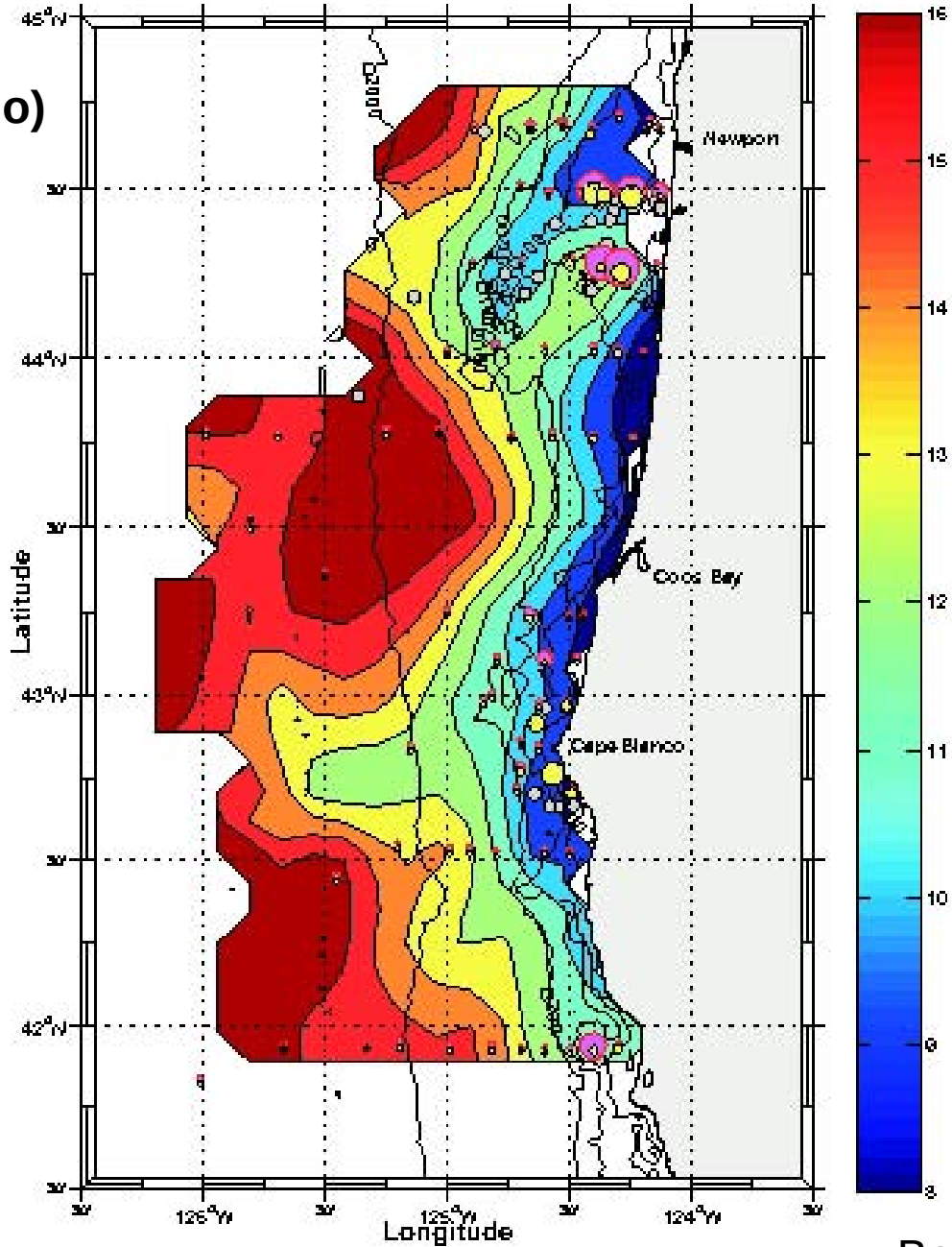
Salmon (chinook & coho)

Courtesy of Ric Brodeur (NOAA)

10 fish per trawl

Humpback whale sightings

Courtesy of Cyndy Tynan (NOAA/WHOI)

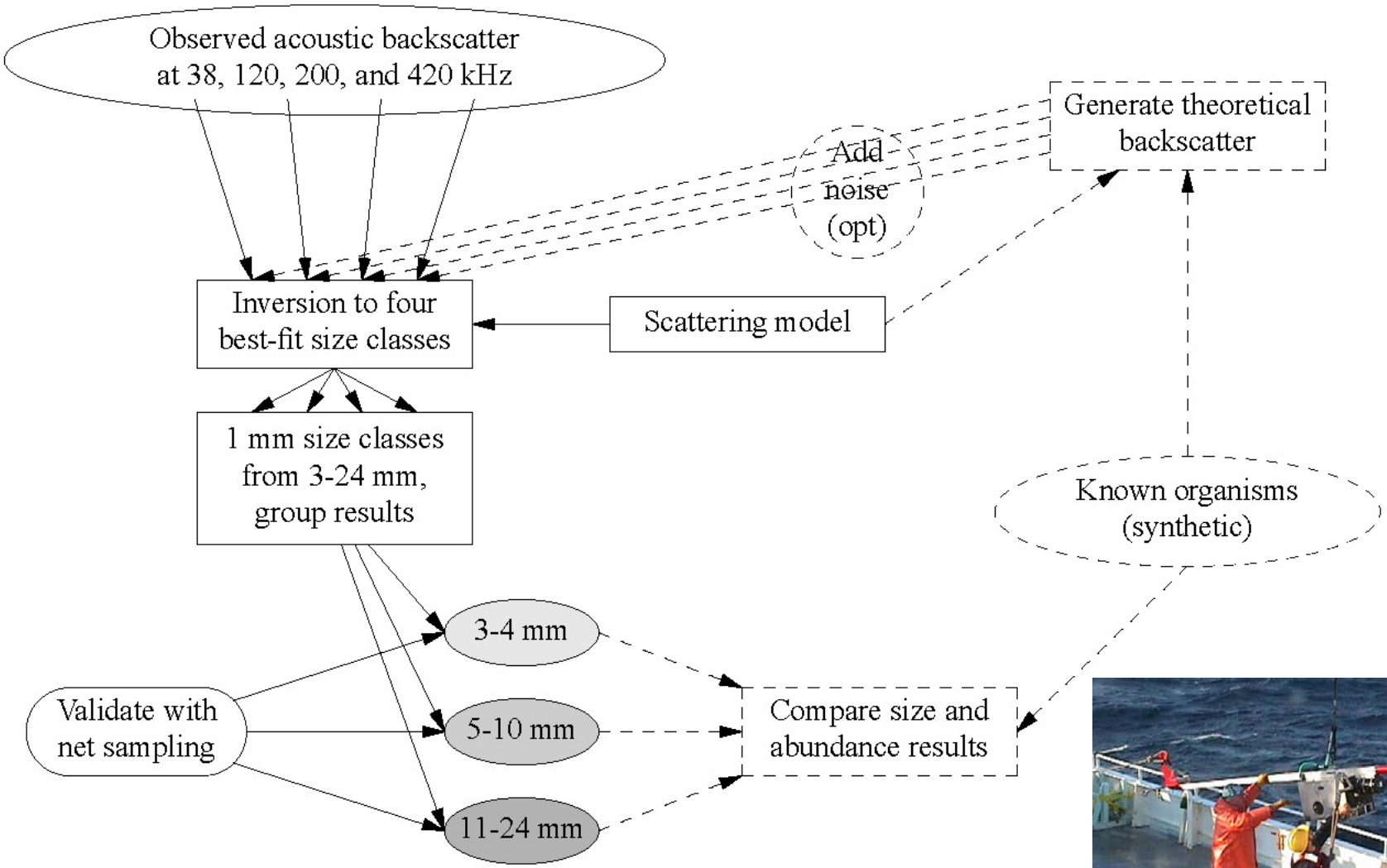


temperature (°C)

Batchelder et al. (2002)

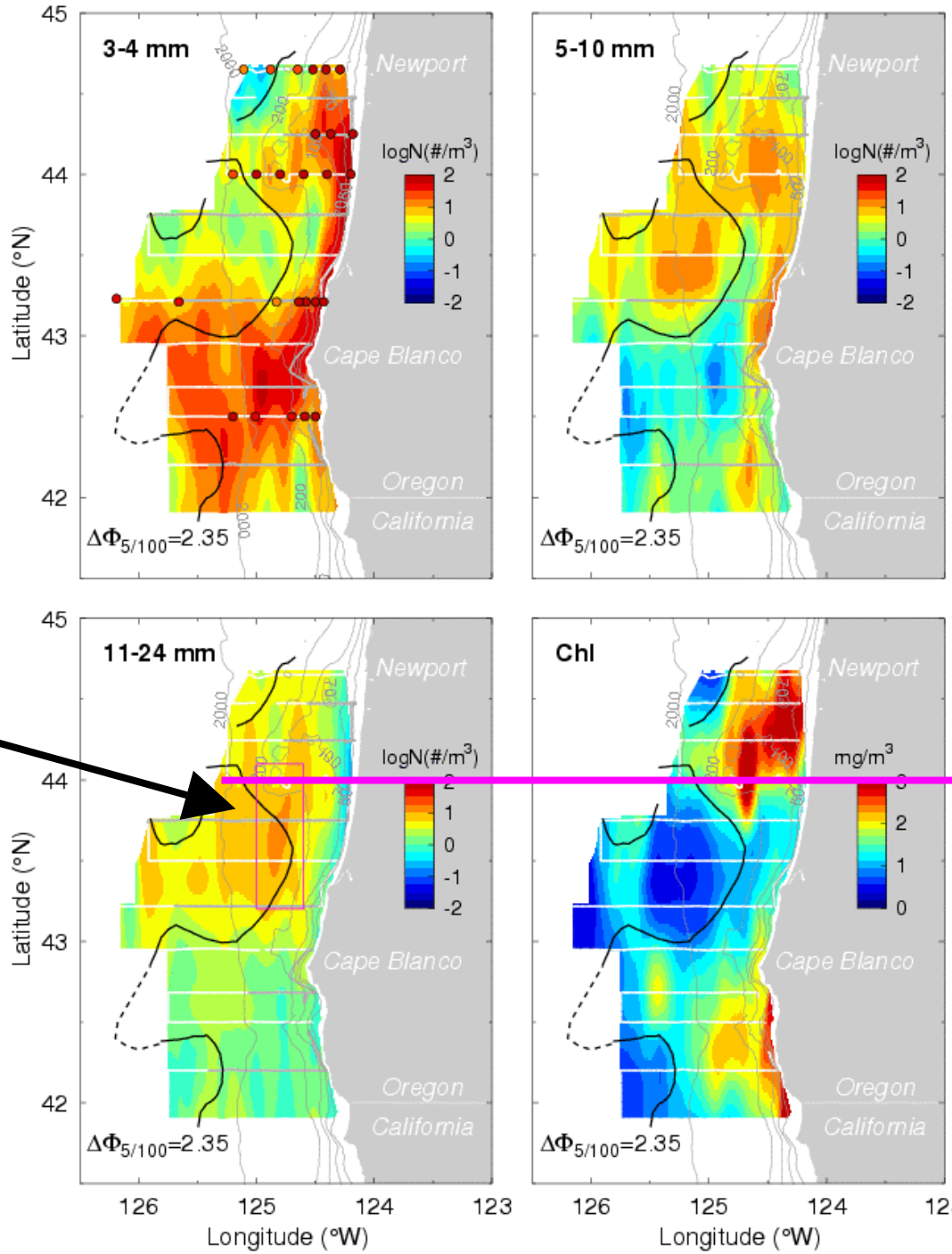
Bioacoustic estimation of zooplankton

Improved multi-frequency bioacoustics inverse method: Linear Programming instead of Non-Negative Least Squares, leads to **correlation with nets of 0.74** rather than 0.39



Pierce et al. (2005)

small zooplankton follow mesoscale flow/hydro field



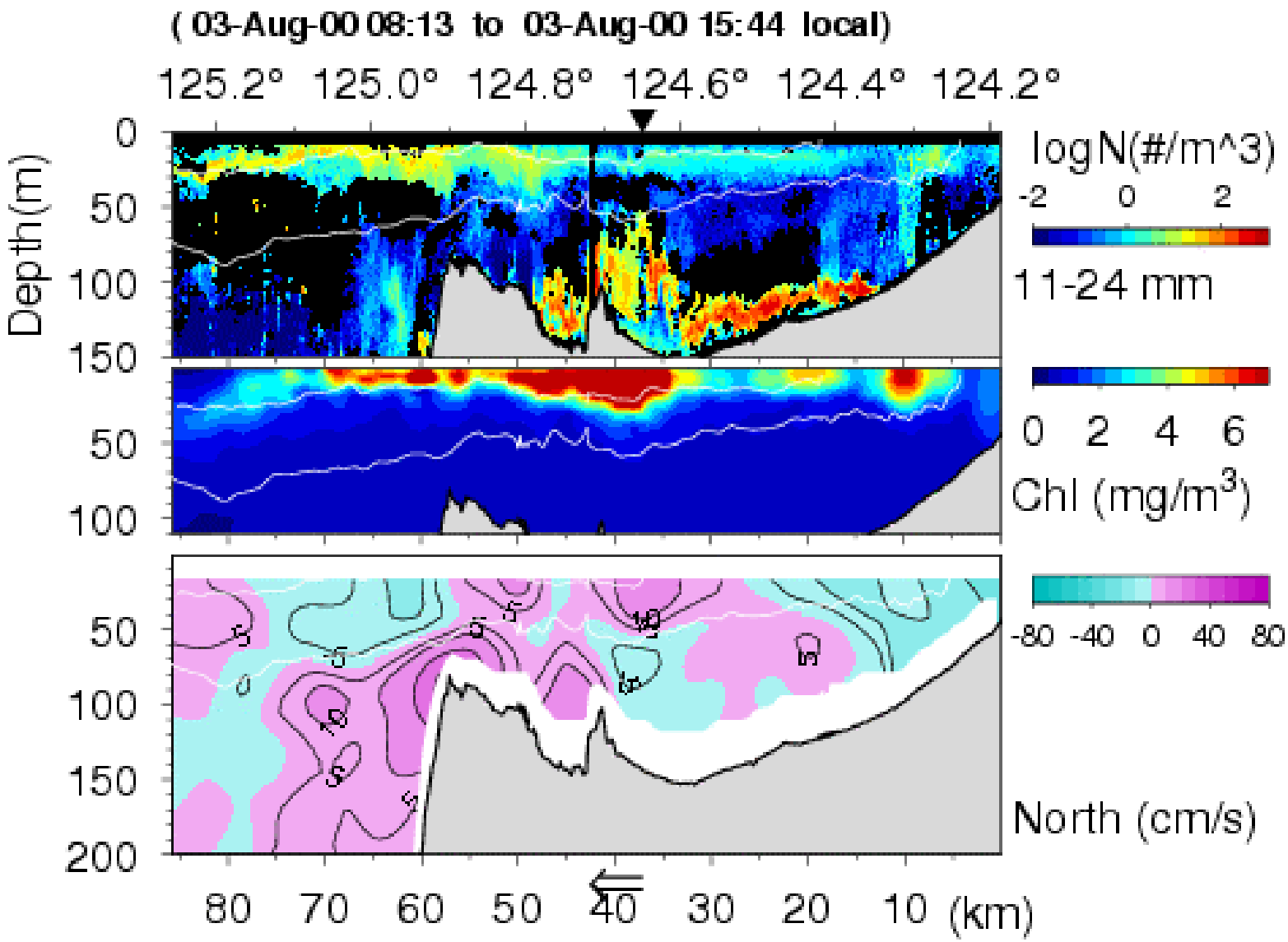
Depth-averaged abundance 30-Jul to 4-Aug 2000

euphausiid patch over bank

44N

Pierce et al. (2005)

“Euphausiids” along 44.0°N



Pierce et al. (2005)

Hypoxia off the central Oregon coast

Normal Inner-Shelf Rockfish Community

July 2002

D. Fox (ODFW)

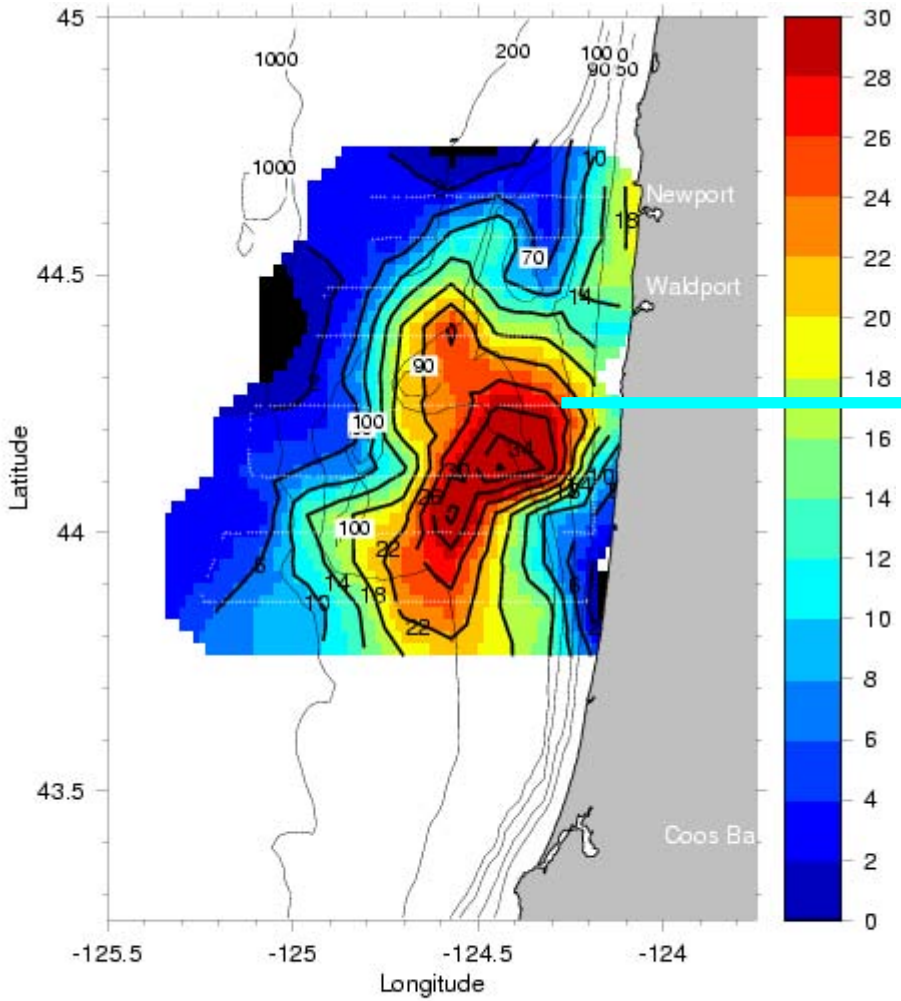
J. Lubchenco (OSU)

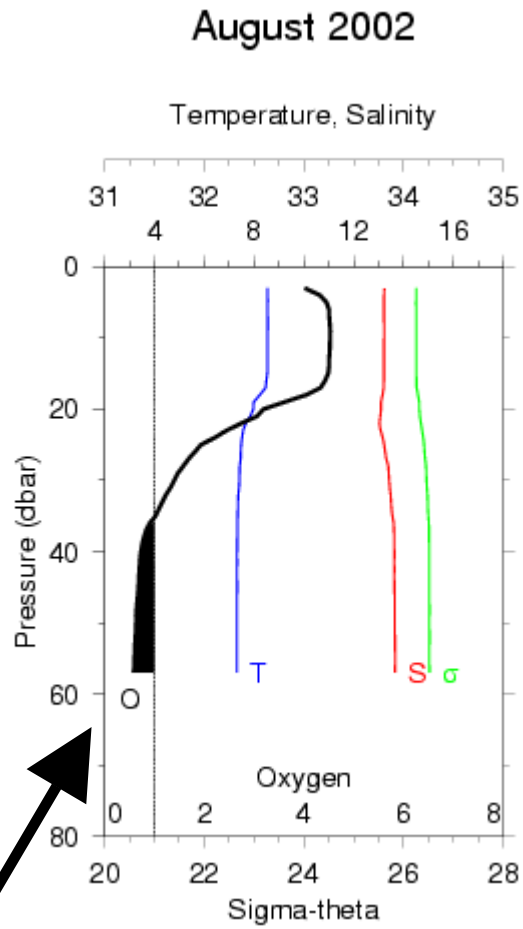
Grant McOmie/katu.com

©Elizabeth Gates

Ecosystem Response to Flow-Topography Interaction

GLOBEC NEP, 9-11 August 2002
5-m chlorophyll (mg/m³)





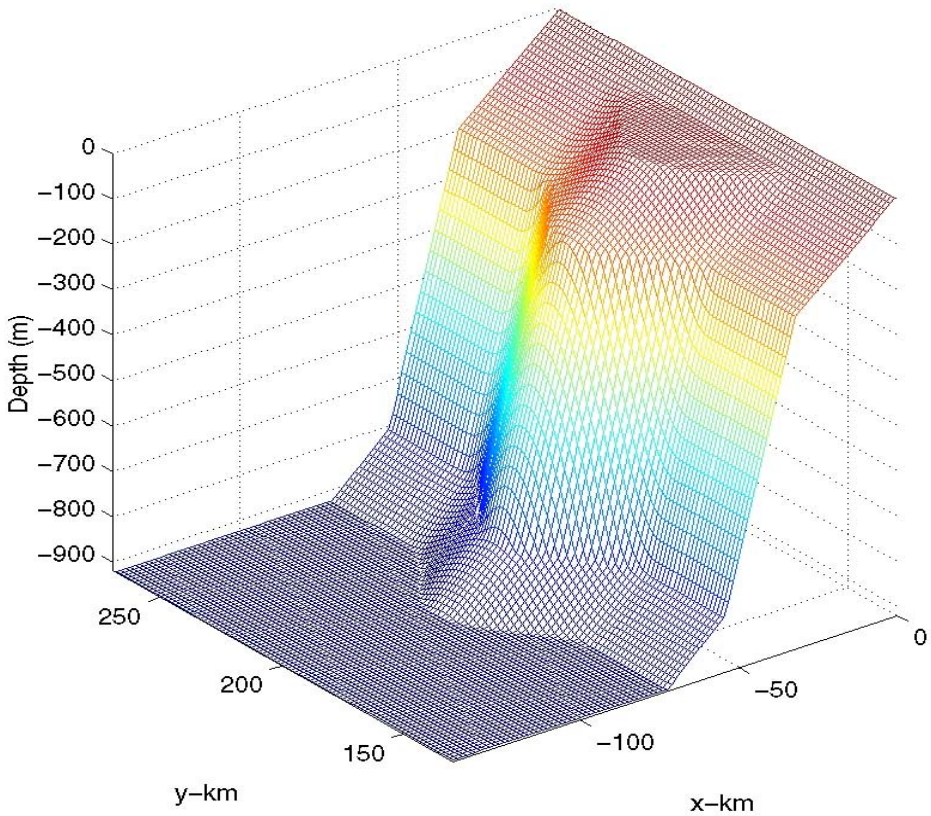
hypoxic

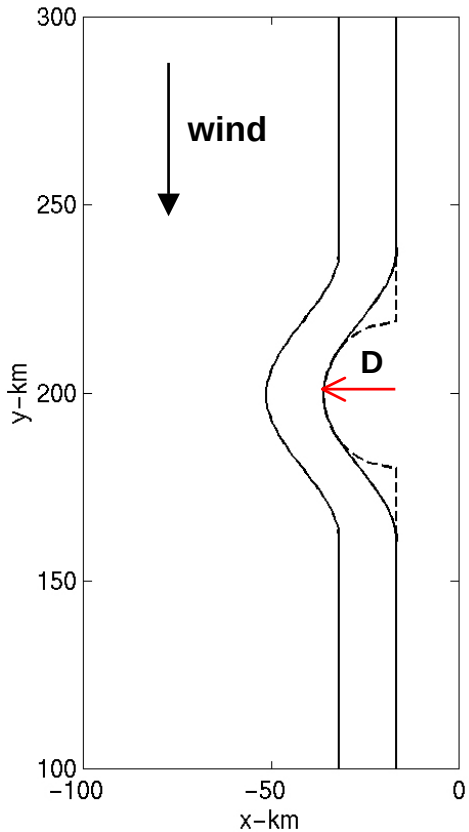
Grantham et al. (2004)

Flow-Topography Dynamics

Numerical Model

- Princeton Ocean Model (POM)
- Domain:
  - Extension: 250 x 400 km
  - Resolution: 1.5 km
  - Vertical resolution: 31 σ-layers
  - N-S: periodic; W: open





Castelao & Barth (in press, JPO)

- **Several topographies used, differing in the value of D**

$$Bu = \frac{N^2 H^2}{f^2 D^2} \sim \frac{Rossby\ radius^2}{bank\ radius^2}$$

- **Model forced by constant winds**

$$Ro = \frac{\left| \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y} \right|}{f} \sim \frac{nonlinear\ terms}{Coriolis\ acceleration}$$

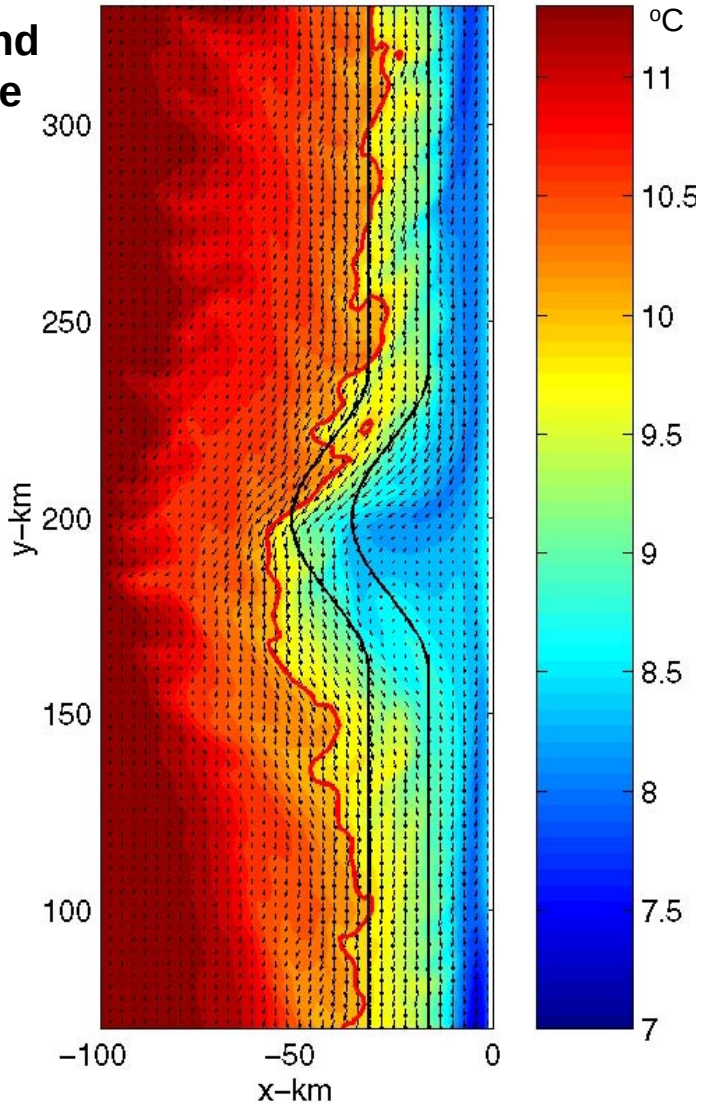
Castelao & Barth (in press, JPO)

Flow response to steady upwelling favorable winds

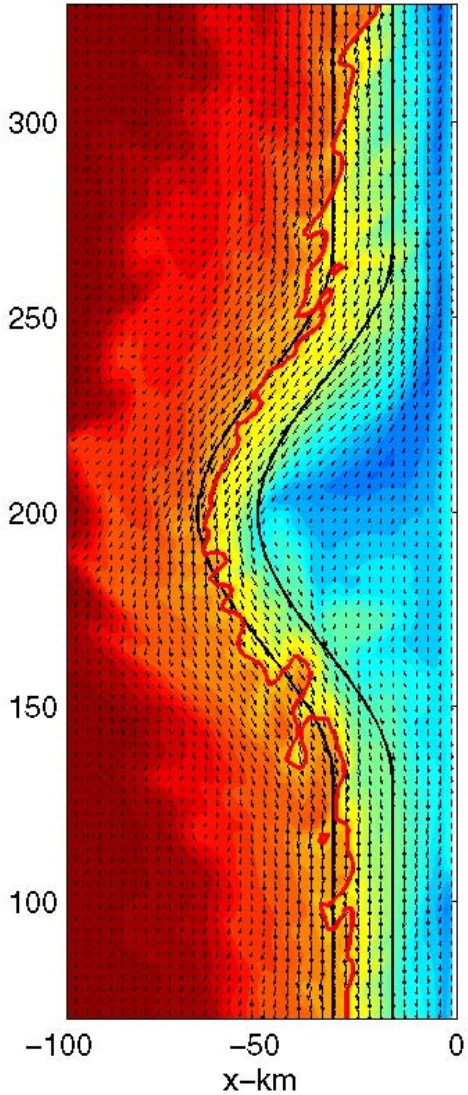
Surface velocities and temperature

τ = 0.12Pa

Bu = 1.10

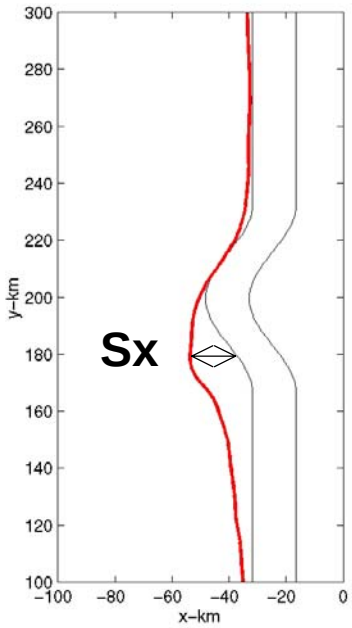


Bu = 0.38



larger bank

Castelao & Barth (in press, JPO)

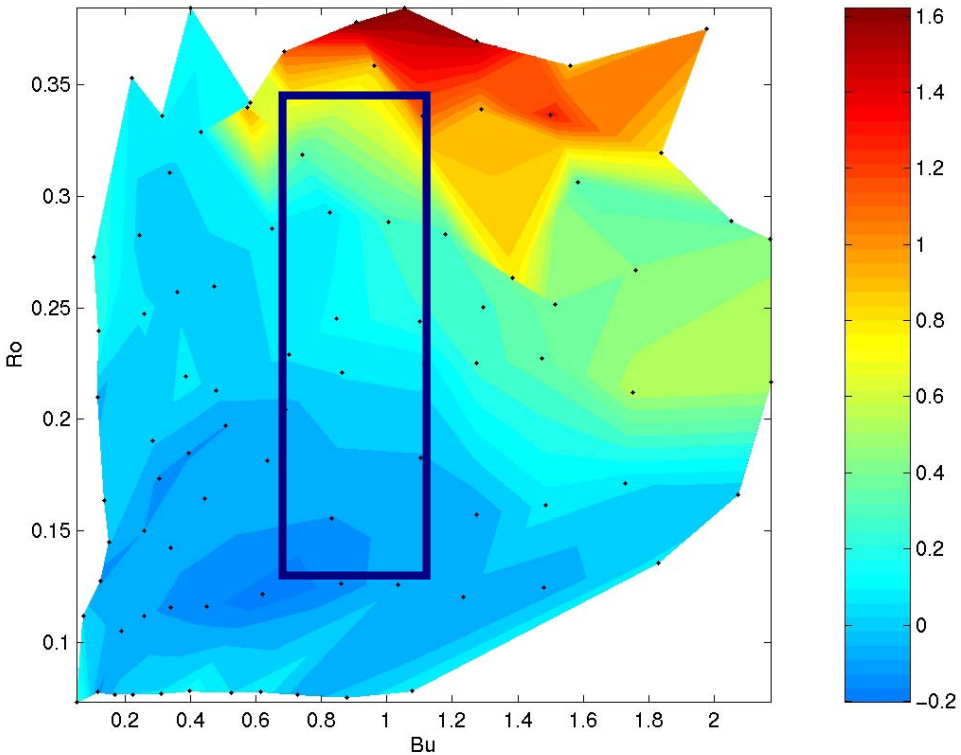


Stronger upwelling winds

Rossby number

Sx

Internal Rossby radius



Burger number

Increase bank radius

Oregon values

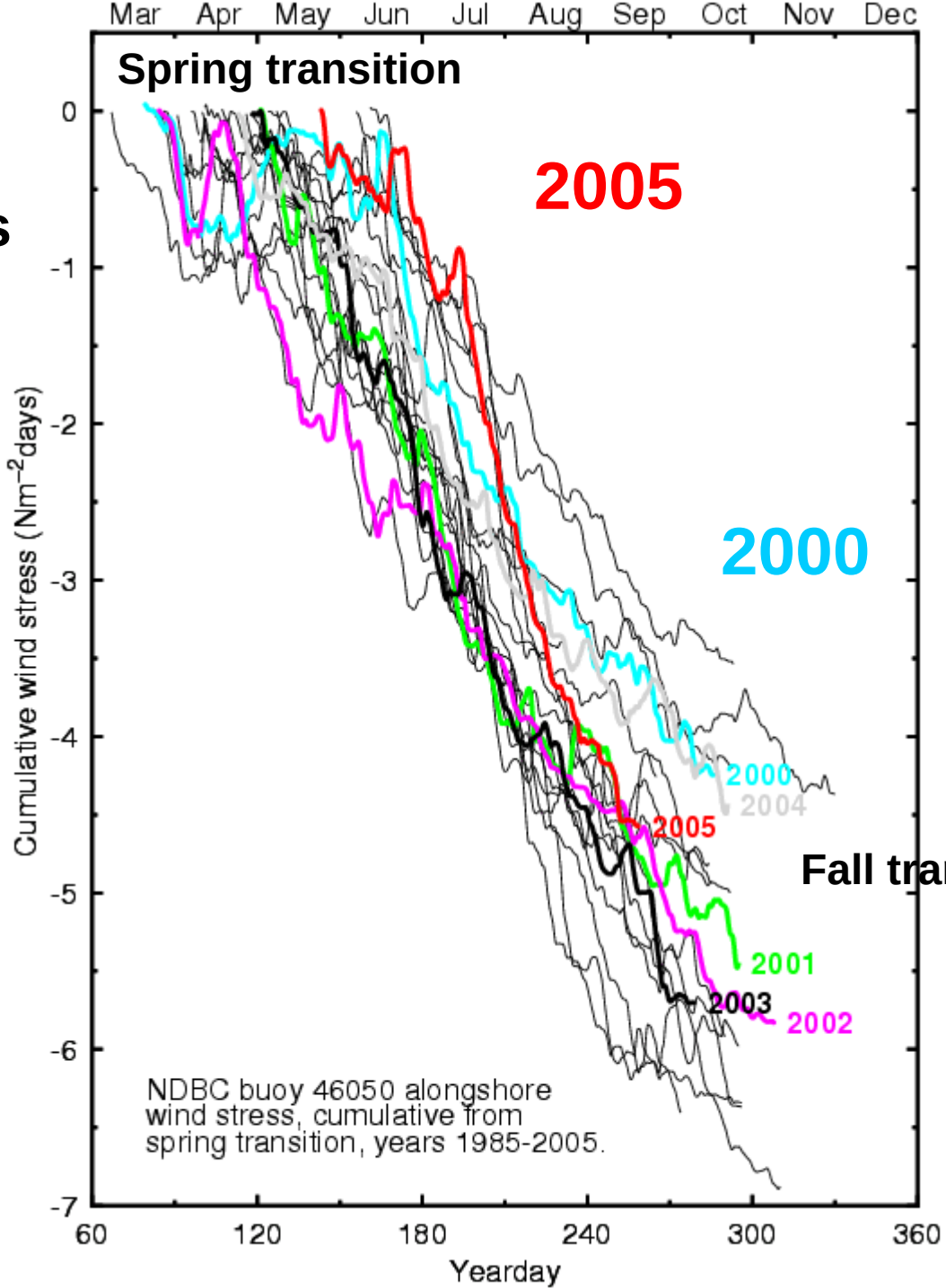
D ~ 15 km

Ro ~ 0.13 - 0.33

Bu ~ 0.7 – 1.1

Castelao & Barth (in press, JPO)

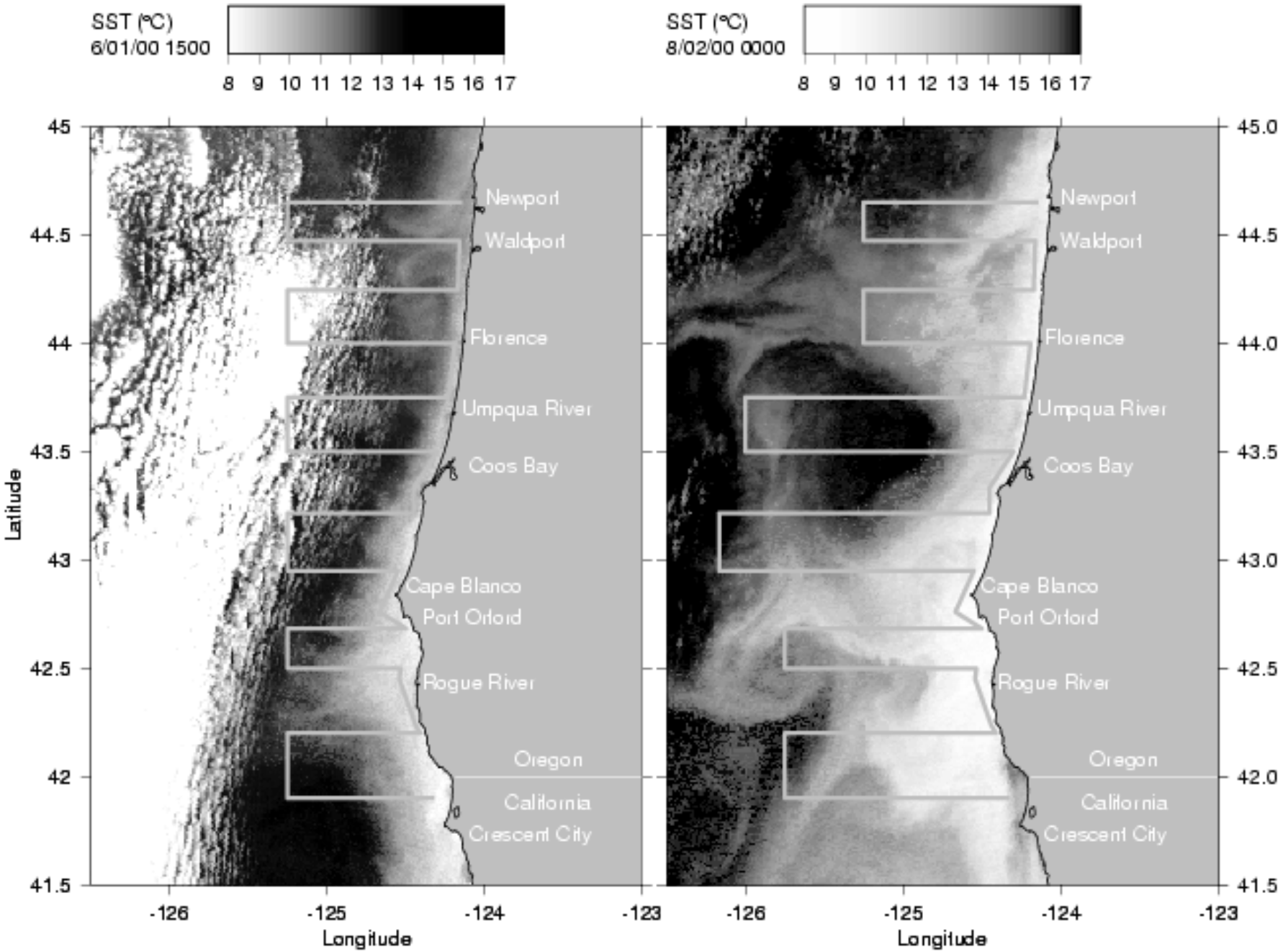
Interannual Variability in wind stress



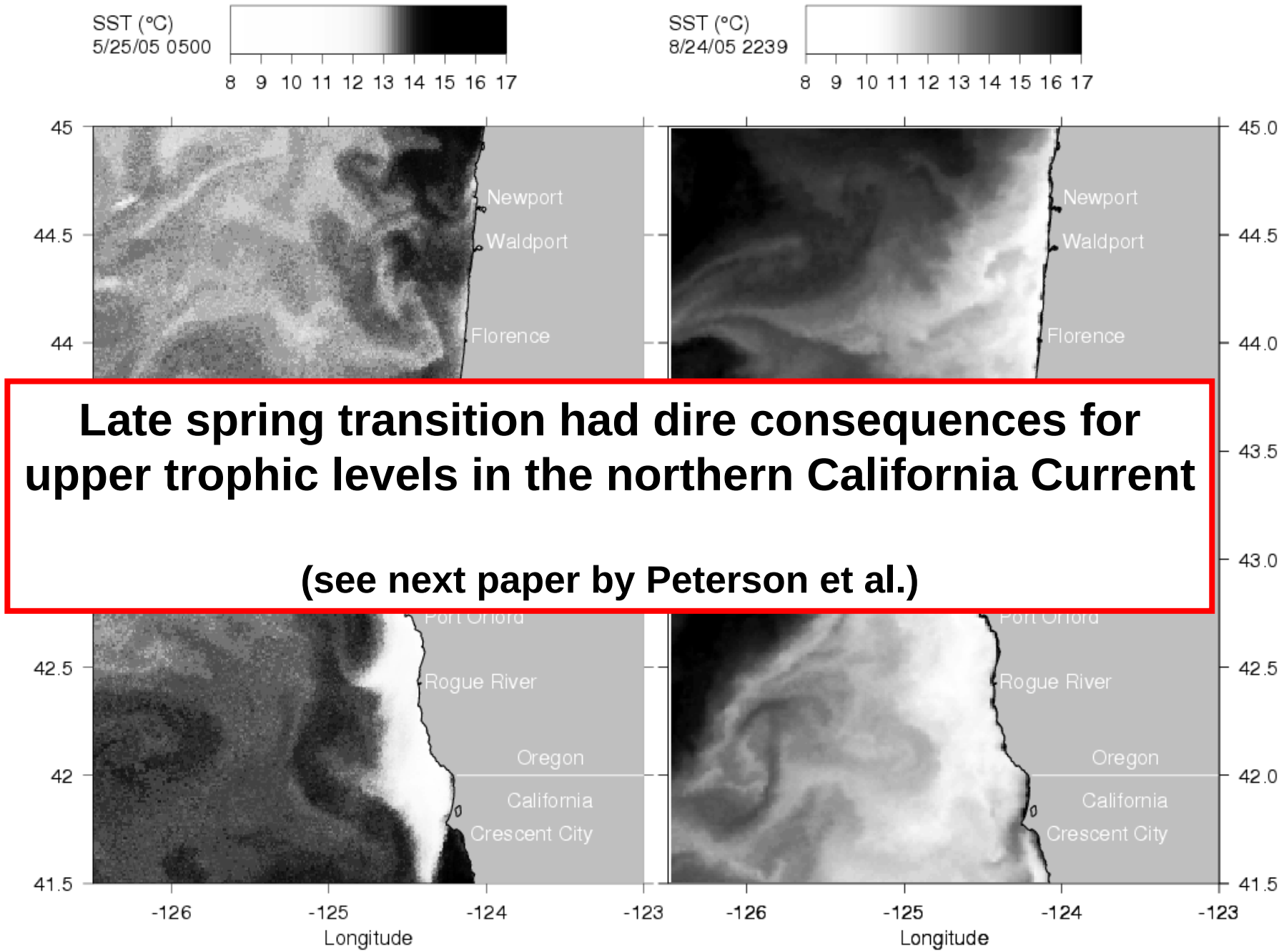
Equatorward, Upwelling favorable

Cumulative wind stress since Spring Transition

2000


SST (°C)
6/01/00 1500
8 9 10 11 12 13 14 15 16 17
SST (°C)
8/02/00 0000
8 9 10 11 12 13 14 15 16 17
Newport
Waldport
Florence
Umpqua River
Coos Bay
Cape Blanco
Port Orford
Rogue River
Oregon
California
Crescent City
Latitude
45
44.5
44
43.5
43
42.5
42
41.5
45.0
44.5
44.0
43.5
43.0
42.5
42.0
41.5
-126
-125
-124
-123
Longitude

2005



Late spring transition had dire consequences for upper trophic levels in the northern California Current

(see next paper by Peterson et al.)

Flow-Topography Interaction: Summary

- Redirects alongshore coastal jet offshore (~ 0.7 Sv off-shelf flux)
- Weaker flow in its “shadow”
- Time-variable winds lead to recirculation around bank (10-14 days)
- Ecological response:
  - enhanced biological productivity (plankton, fish, top predators)
  - bottom and nearshore waters may become hypoxic
- Strength of flow-topography interaction dictated by speed of flow (Rossby #) and size of topographic feature relative to fluid adjustment scale (Burger #)
- Interannual variability in wind forcing (timing, strength, steadiness) has profound influence on success at higher trophic levels

спасибо za внимание