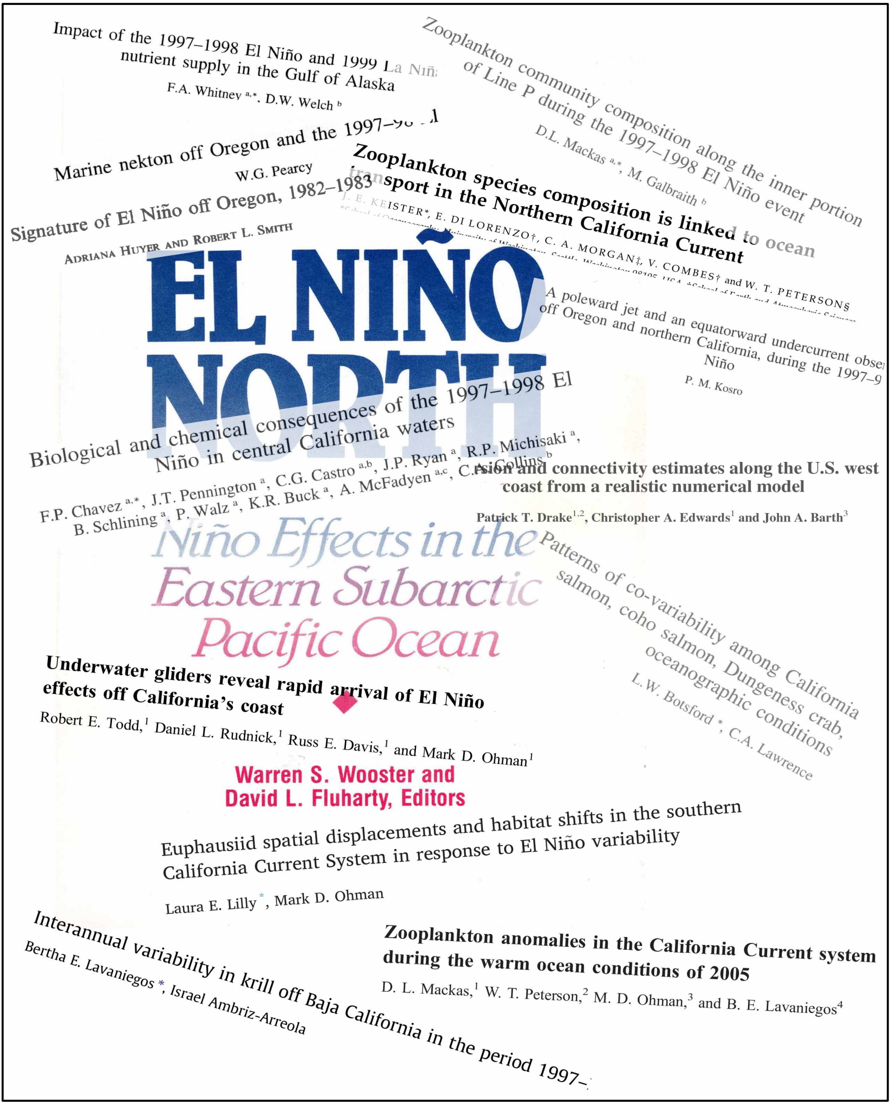
Anomalous Poleward Transports in the California Current System

Ted Strub, Corinne James, Melanie Fewings, Jessica Garwood, Andrew Scherer
Jennifer Fisher, Samantha Zeeman, Anna Bolm, Ricardo Matano, Vincent Combes

Oregon State University, NOAA NWFSC

Motivation

Observations of "tropical/subtropical" (warm-water) species of zooplankton and water properties off Oregon have been used to infer transports from far to the south during some years, especially El Niño warm events (1982-83, 1997-98).



Impact of the 1997–1998 El Niño and 1999 La Niñ
nutrient supply in the Gulf of Alaska
F.A. Whitney [a,*], D.W. Welch [b]

Zooplankton community composition along the inner portion of Line P during the 1997–1998 El Niño event
D.L. Mackas [a,*], M. Galbraith [b]

Marine nekton off Oregon and the 1997–9
W.G. Pearcy

Zooplankton species composition is linked to ocean transport in the Northern California Current
J. E. KEISTER*, E. DI LORENZO†, C. A. MORGAN‡, V. COMBES† and W. T. PETERSON§

Signature of El Niño off Oregon, 1982–1983
ADRIANA HUYER AND ROBERT L. SMITH

A poleward jet and an equatorward undercurrent obse
off Oregon and northern California, during the 1997–9
Niño
P. M. Kosro

EL NIÑO NORTH

Biological and chemical consequences of the 1997–1998 El Niño in central California waters
F.P. Chavez [a,*], J.T. Pennington [a], C.G. Castro [a,b], J.P. Ryan [a], R.P. Michisaki [a], B. Schlining [a], P. Walz [a], K.R. Buck [a], A. McFadyen [a,c], C.A. Collins [b]

sion and connectivity estimates along the U.S. west coast from a realistic numerical model
Patrick T. Drake[1,2], Christopher A. Edwards[1] and John A. Barth[3]

Niño Effects in the Eastern Subarctic Pacific Ocean

Patterns of co-variability among California salmon, coho salmon, Dungeness crab, oceanographic conditions
L.W. Botsford *, C.A. Lawrence

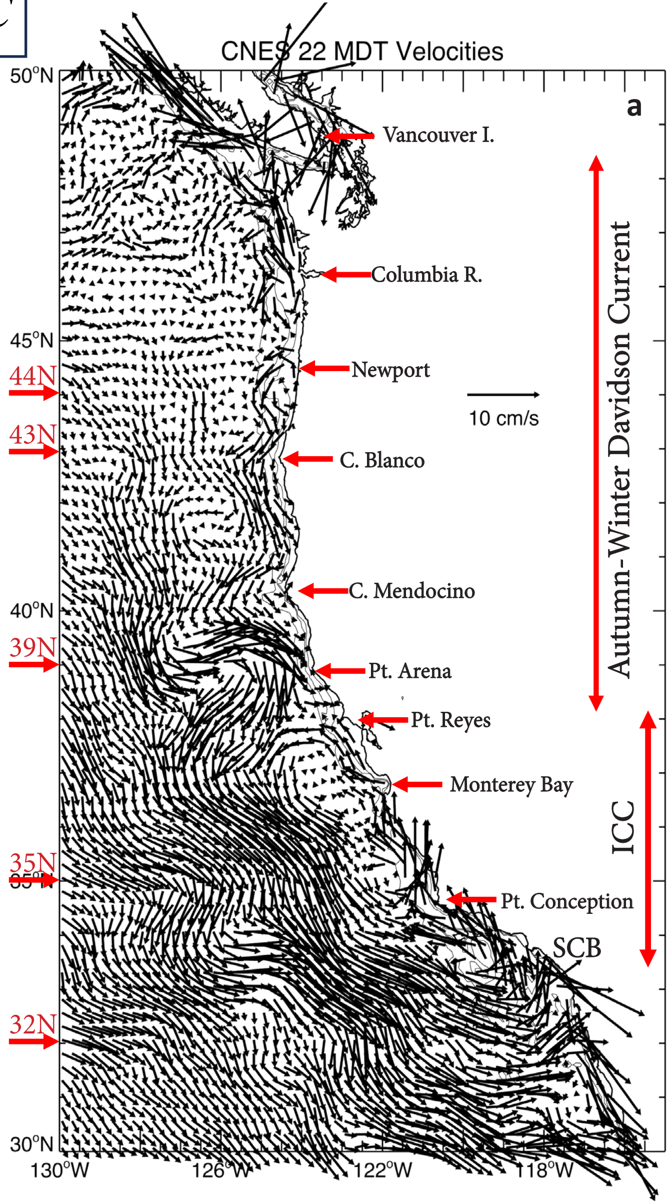
Underwater gliders reveal rapid arrival of El Niño effects off California's coast
Robert E. Todd,[1] Daniel L. Rudnick,[1] Russ E. Davis,[1] and Mark D. Ohman[1]

Warren S. Wooster and
David L. Fluharty, Editors

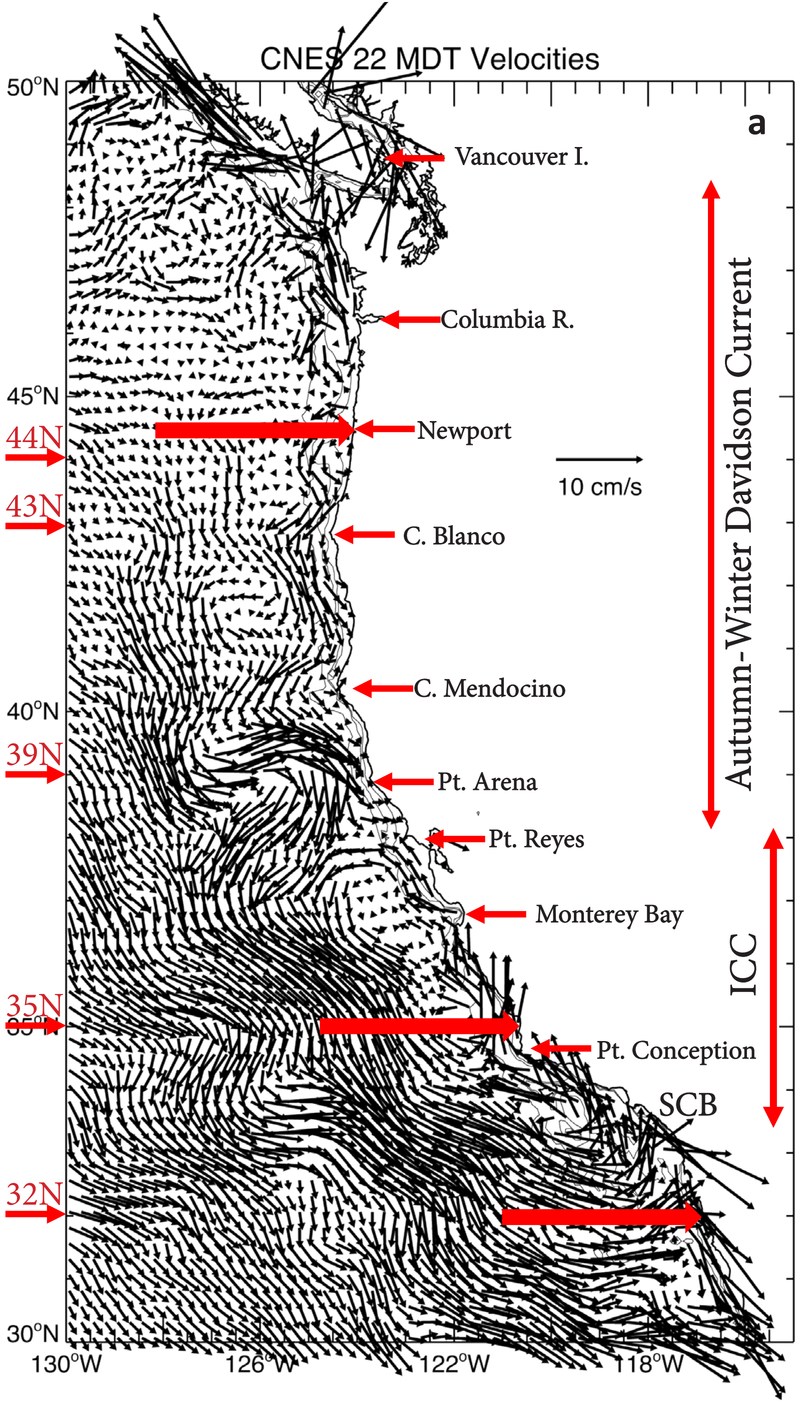
Euphausiid spatial displacements and habitat shifts in the southern California Current System in response to El Niño variability
Laura E. Lilly *, Mark D. Ohman

Zooplankton anomalies in the California Current system during the warm ocean conditions of 2005
D. L. Mackas,[1] W. T. Peterson,[2] M. D. Ohman,[3] and B. E. Lavaniegos[4]

Interannual variability in krill off Baja California in the period 1997–
Bertha E. Lavaniegos *, Israel Ambriz-Arreola



Oregon State University
College of Earth, Ocean, and Atmospheric Sciences



Questions:

- From how far to the south can passive water parcels arrive off Oregon (Newport) in one year? Southern California? Baja California? Central America? Equator?
- Is there systematic interannual variability in Lagrangian transports related to zooplankton distributions?
- What is the "nature" of the Lagrangian pathways taken by these passive parcels?
- What roles are played by the: ICC, Davidson Current, Offshore Eddy Field, Eastward Inflow from the west, Meso- & Sub-Mesoscale "diffusion", Wind-driven Ekman Transports?

Methods

- Calculate daily Lagrangian trajectories using the "Parcels" software
  - Absolute geostrophic velocities from SLA + CLS CNES MDT22
  - "OSCAR": Ekman transports in the top 30m + Absolute geostrophic velocities
- Release 20 parcels daily along 4° E-W transects at 32°N (SCB), 35°N (just north of the SCB) & 44.65°N (Newport)
- Track forward and backward for 1 year.

From How Far Can They Come in One Year?

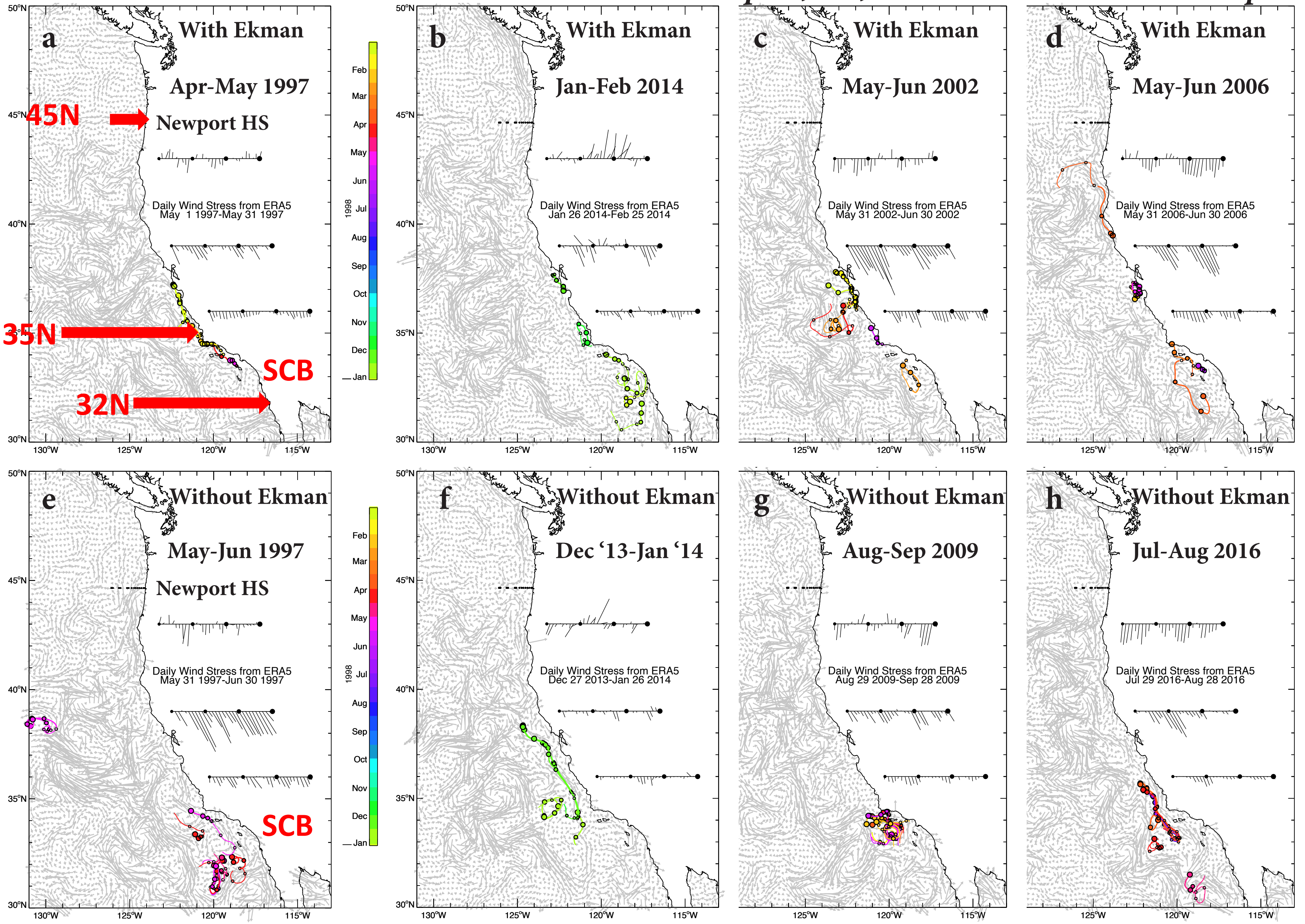
Top: →
With Ekman Velocities

2-month trajectories for the 10 parcels tracked backwards from the Newport Hydrographic Line which come from the most southern source during a given year.

Bottom: →
Without Ekman Velocities

The Southern California Bight

Farthest Southern Source - Backward Tracked From Newport, OR; With/Without Ekman Transport

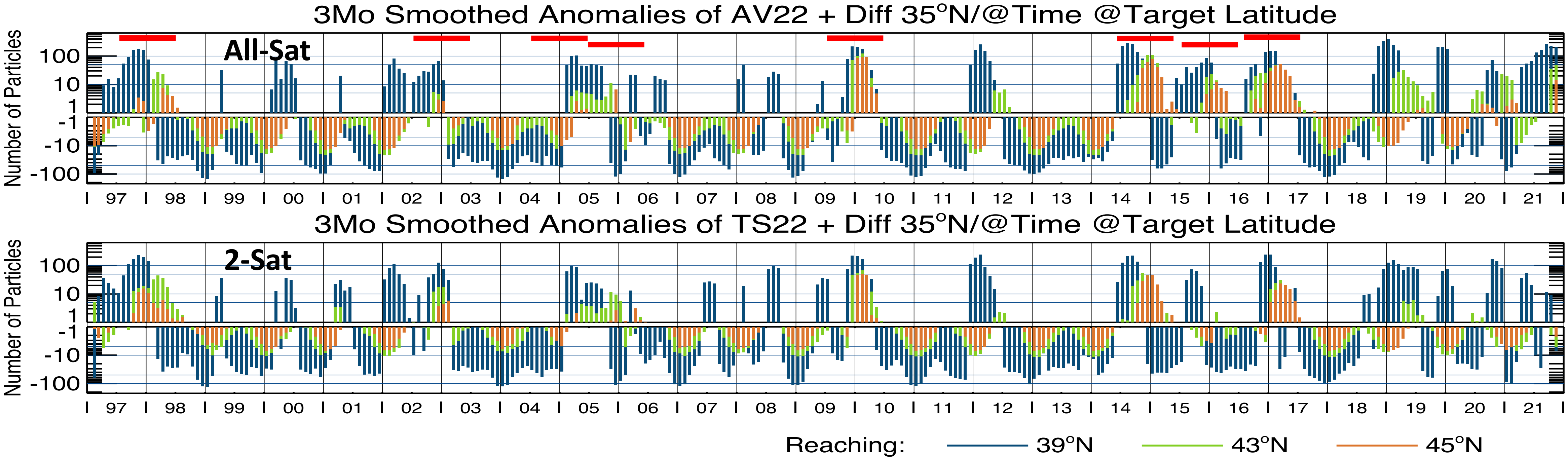


Interannual Variability

Parcel Transport Anomalies (Seasonal Cycle Removed)

Number of Parcels Released from 35°N that Reach 3 Target Latitudes

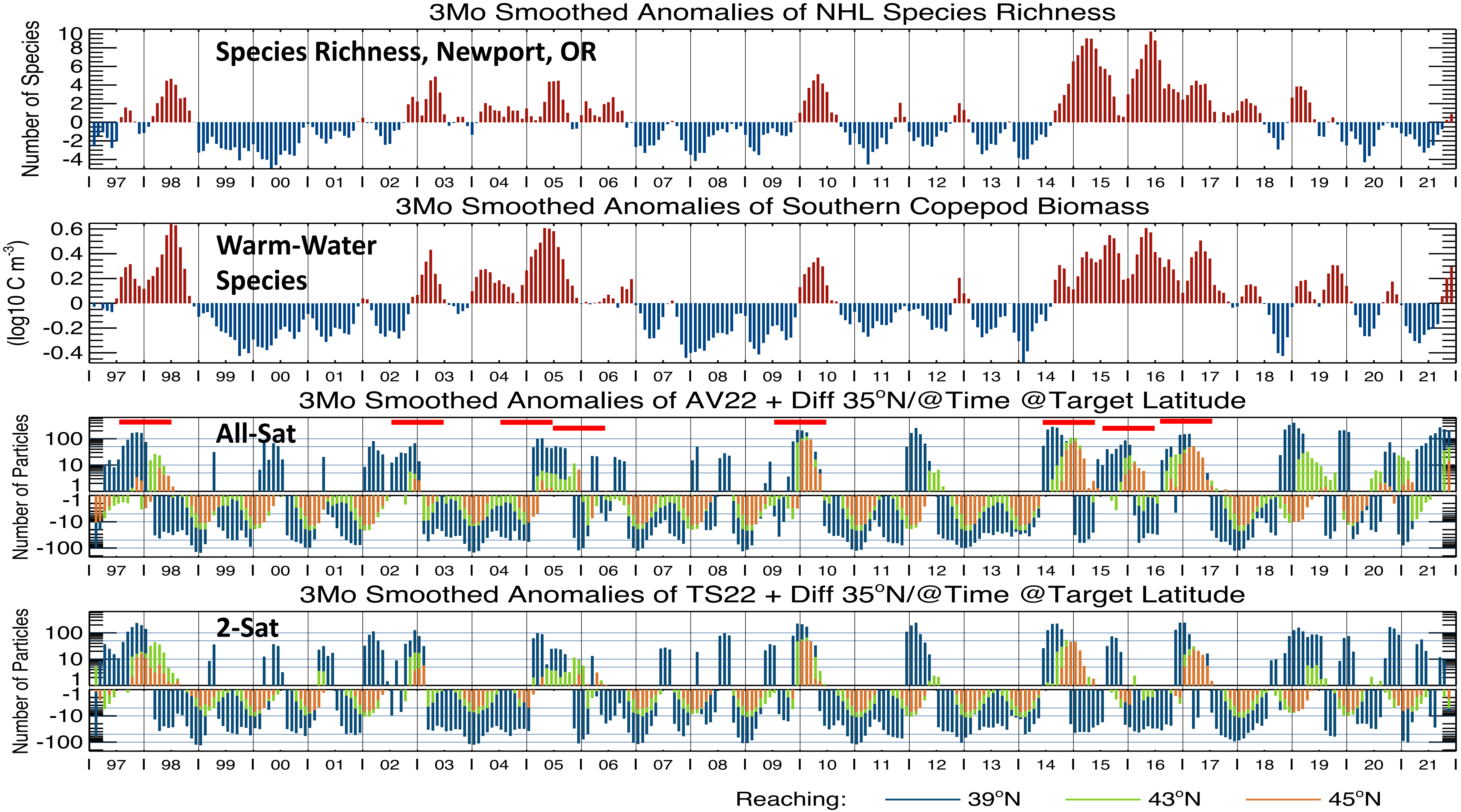
All-Sat and 2-Sat



3Mo Smoothed Anomalies of AV22 + Diff 35°N/@Time @Target Latitude

3Mo Smoothed Anomalies of TS22 + Diff 35°N/@Time @Target Latitude

Parcel Transport Anomalies vs Zooplankton Anomalies (Newport, OR)



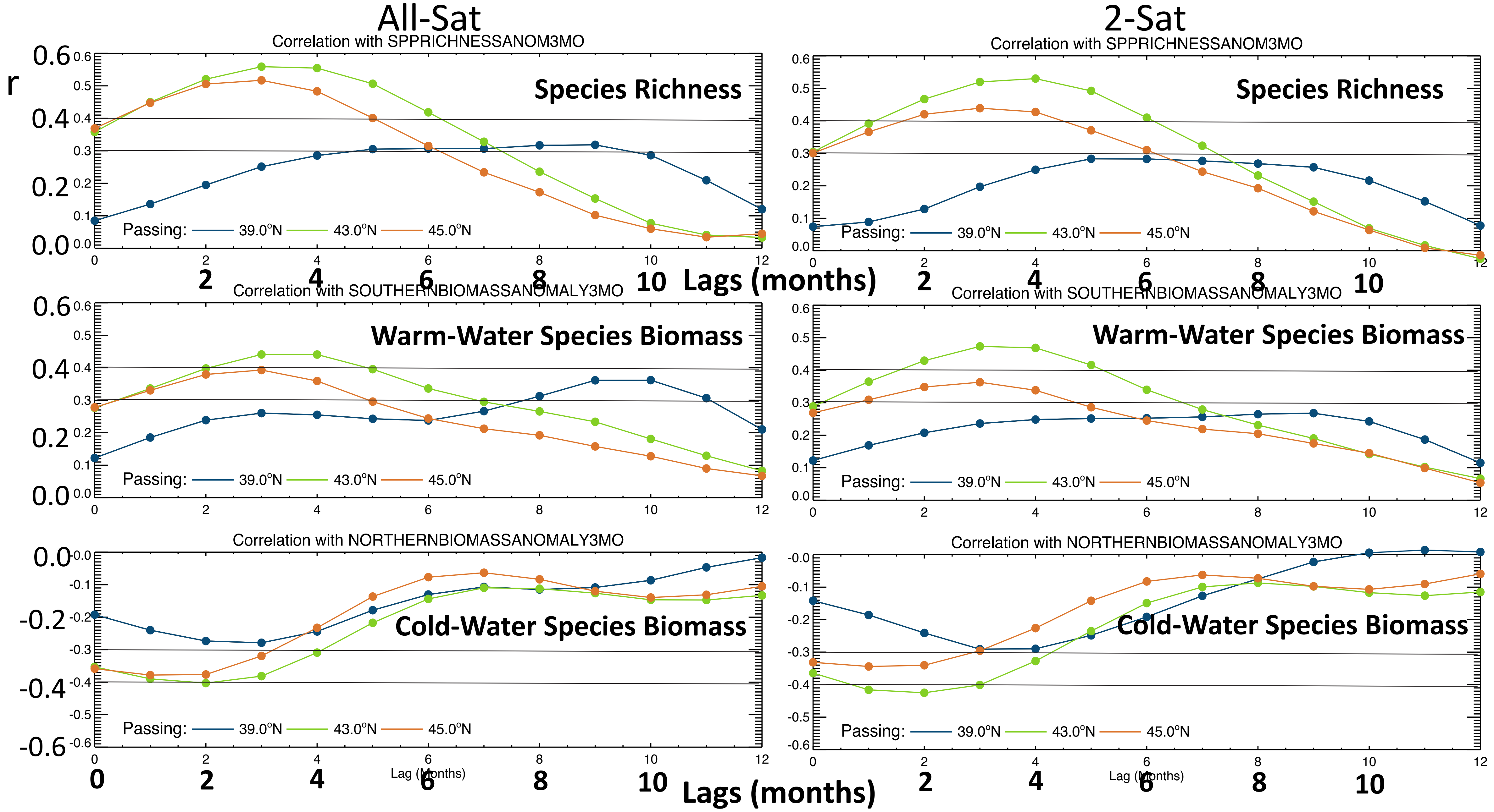
3Mo Smoothed Anomalies of NHL Species Richness

3Mo Smoothed Anomalies of Southern Copepod Biomass

3Mo Smoothed Anomalies of AV22 + Diff 35°N/@Time @Target Latitude

3Mo Smoothed Anomalies of TS22 + Diff 35°N/@Time @Target Latitude

Correlations: Transport Anomalies with Zooplankton Anomalies



Density of Parcels in 0.5° Cells, Released at 35°N, 30-365 Days Earlier

Warm vs Other Years (Geostrophic + Diffusion)

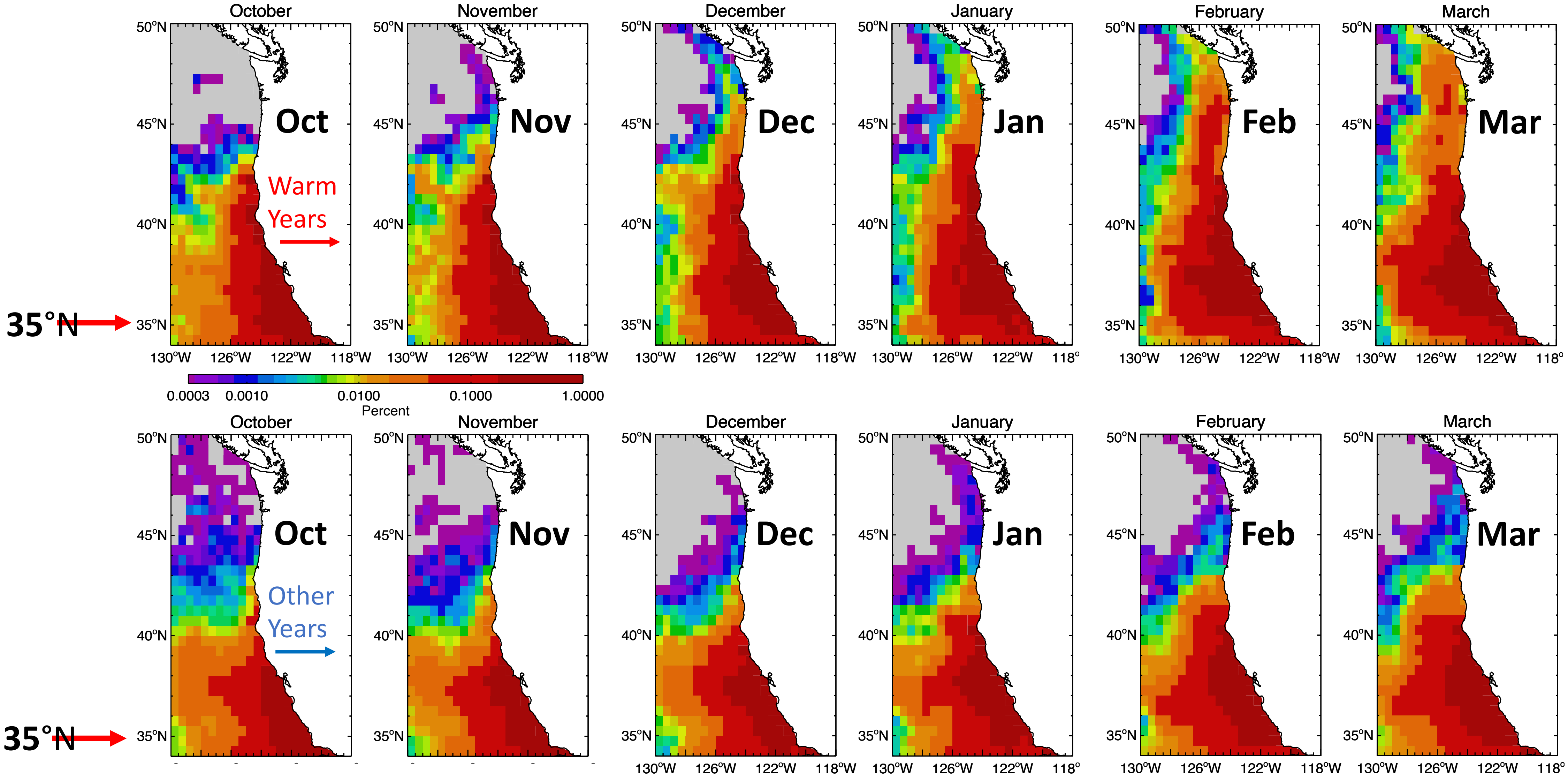


Figure 21. Seasonal monthly mean density of parcels in 0.5 degree squares. Colors represent the percent of the possible number of parcels that could be in a square, if all of the parcels released during the previous 365 days were gathered into that one square. The 8 "warm years" include 1997-98, 2002-03, 2004-05, 2005-06, 2009-10, 2014-15, 2015-16, 2016-17. The "other years" include the remaining 15 years during 1997-2020.

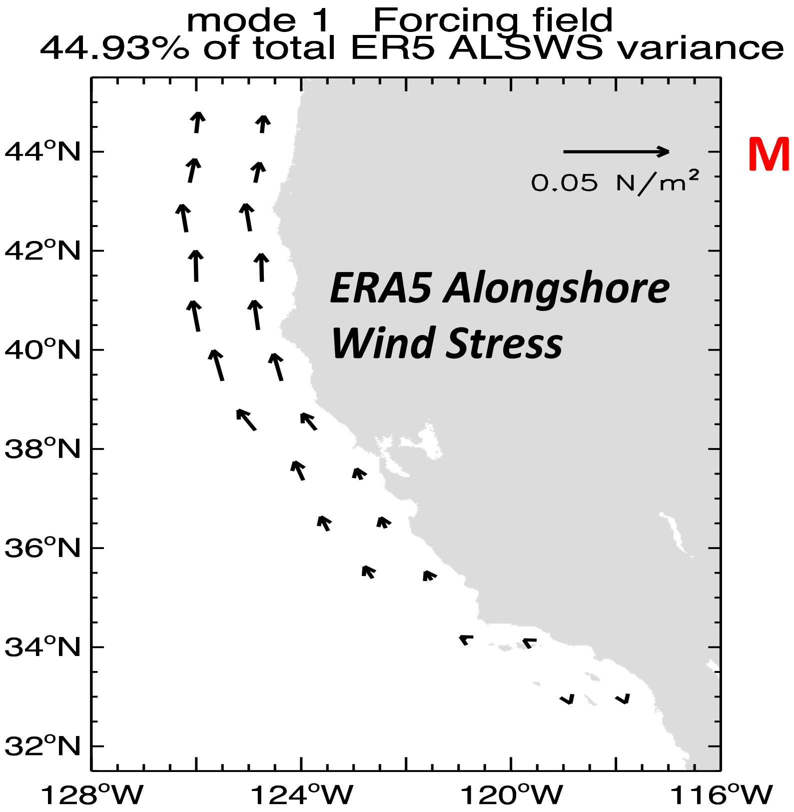
PEPs

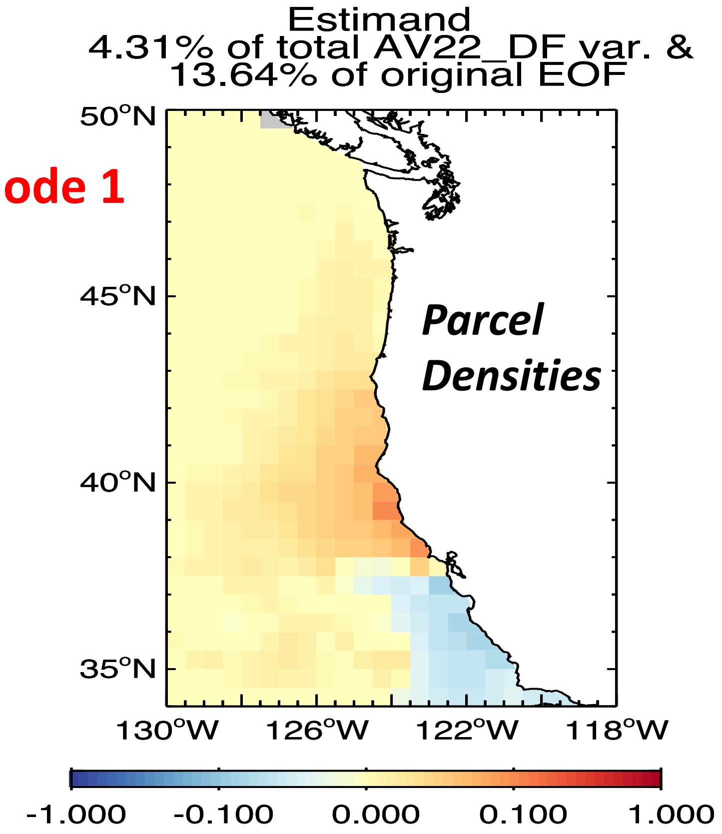
Principle Estimator Patterns

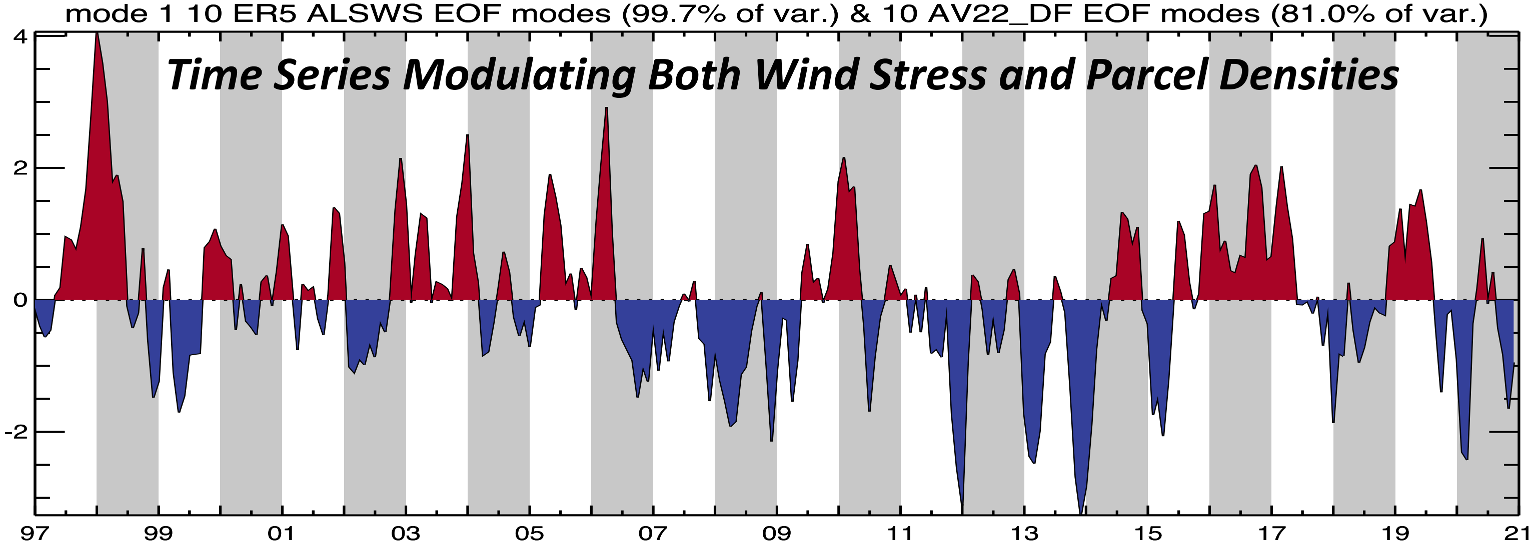
10 EOFs of the forcing fields (alongshore wind stress) and the response (the parcel density fields) are combined to produce single patterns of the forcing field and response perfectly correlated with one time series (like a joint EOF).

The densities of the parcels released at 35°N are increased in the region north of ~38°N by the poleward wind stress in the northern part of the CCS. The time series is strongest during the same "warm years" that saw greater species richness & biomass of warm zooplankton species in the north.

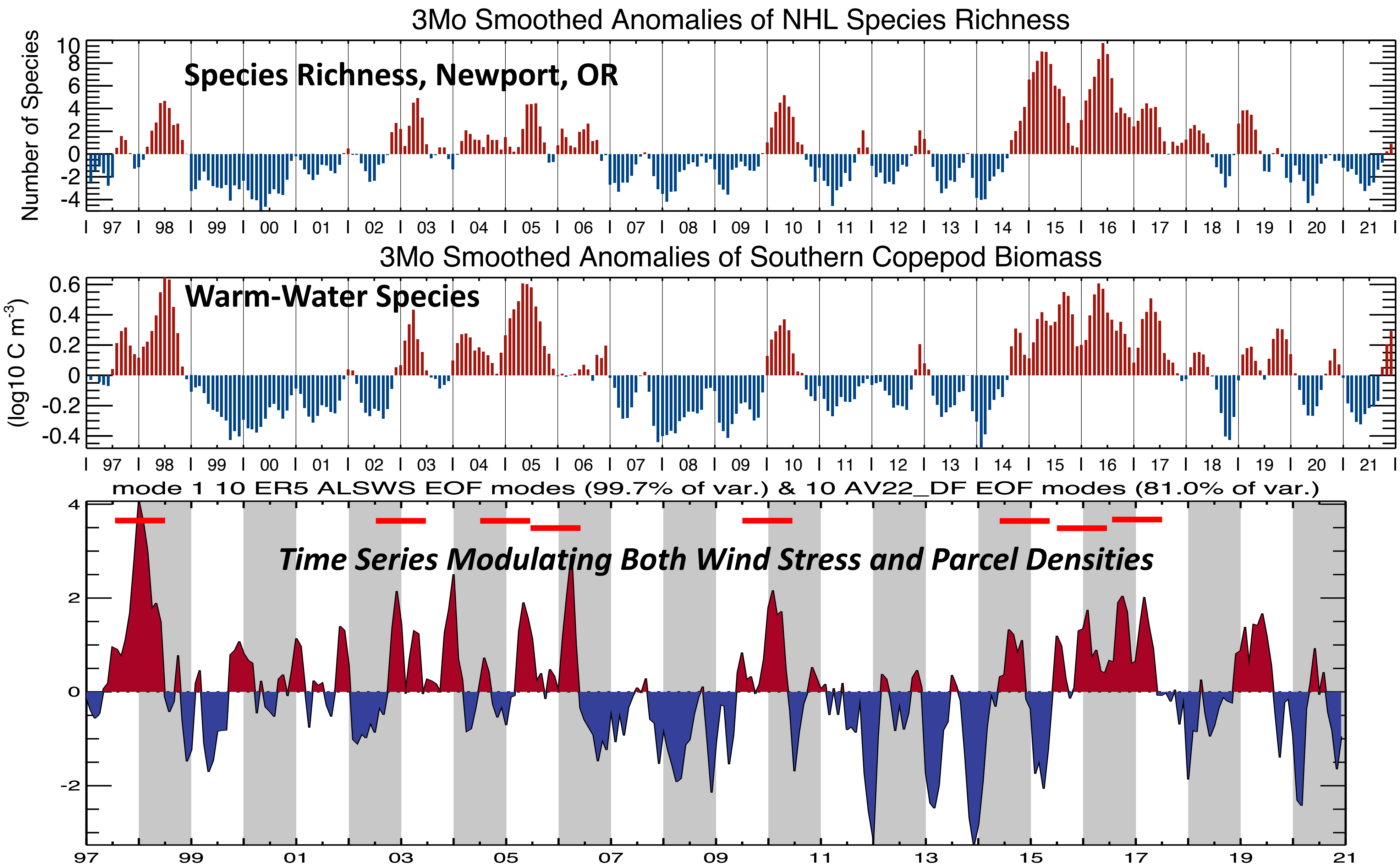
Mode 1







Zooplankton Anomalies (Oregon) vs Strength of Poleward Wind Stress and Northern Parcel Density Anomalies



Questions and Answers:

- **From how far to the south can passive water parcels arrive off Oregon (Newport)? Southern California? Baja California? Central America? Equator?**
  - **In one year, from the Southern California Bight (30°N)**
  - **In multiple years, from ~26°-27°N and from the west.**

- **Is there systematic interannual variability in Lagrangian transports related to zooplankton distributions?**
  - **Yes: Years with greater numbers of parcels that reach 43°N and 45°N are correlated with the appearance of southern "warm water" species and greater "species richness" off Oregon.**
  - **These are often El Niño warm events or Marine Heat Wave years**
  - **The increased densities of southern water parcels in the north is associated with increased poleward wind stress in the northern half of the CCS, i.e., signals arriving through the "atmospheric pathway".**
  - **What about the "oceanic pathway"? Stay tuned.**

- **What is the "nature" of the Lagrangian pathways taken by these passive parcels?**
  - **They travel in the semi-permanent poleward ICC in the south during summer and autumn and in the poleward Davidson Current in the autumn and winter (November-February).**
  - **They are more successful in reaching higher latitudes when horizontal "eddy-diffusion" is included to approximate the action of mesoscale and sub-mesoscale motions.**