

Wind and Nutrient Controls on Phytoplankton Biomass in the Coastal and Transitional Areas of the California Current System

Mike Jacox

NOAA Southwest Fisheries Science Center

International Symposium on
Understanding Changes in the Transitional Areas of the Pacific
April 25, 2018

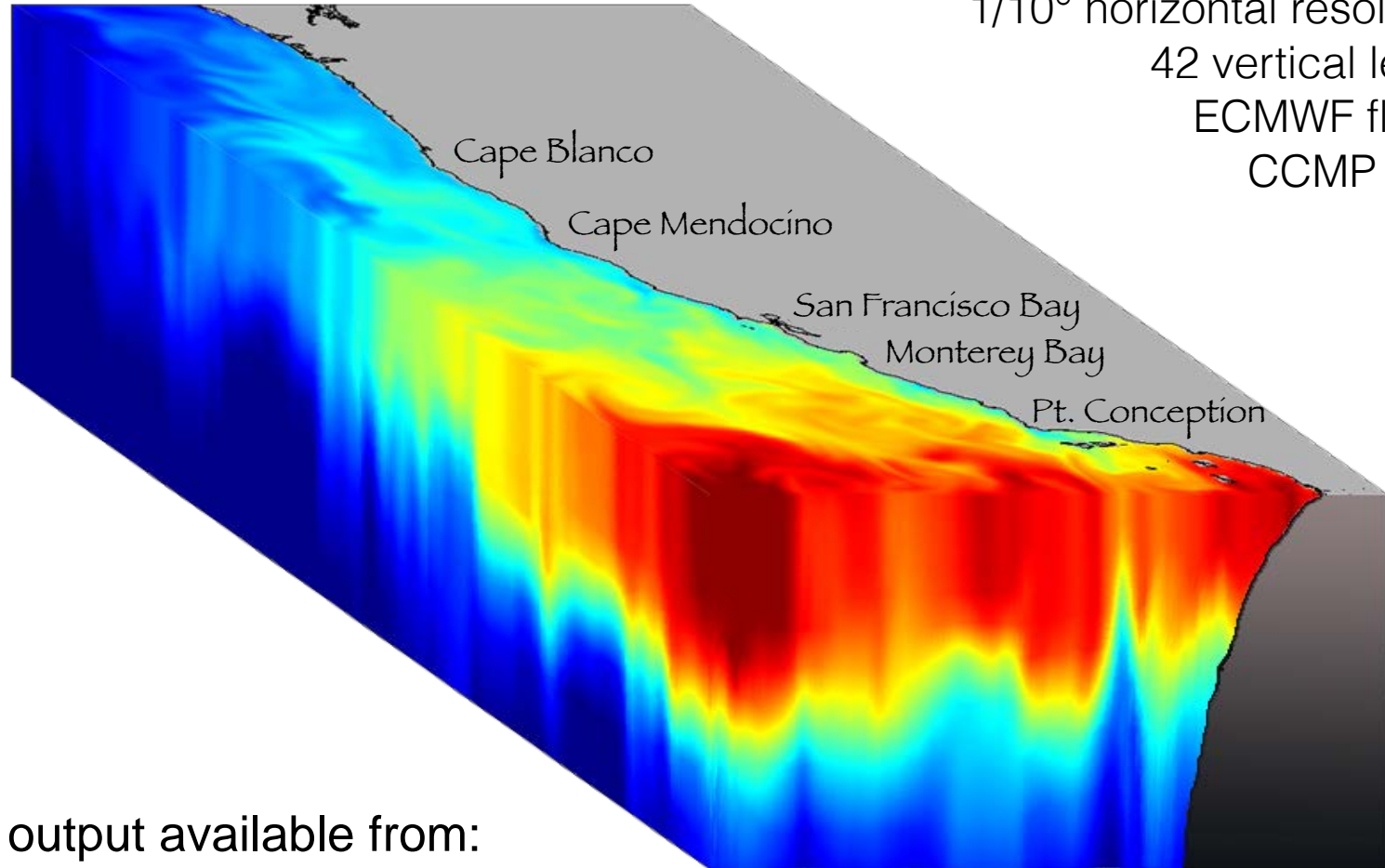


Steven Bograd
Elliott Hazen

Chris Edwards
Andy Moore

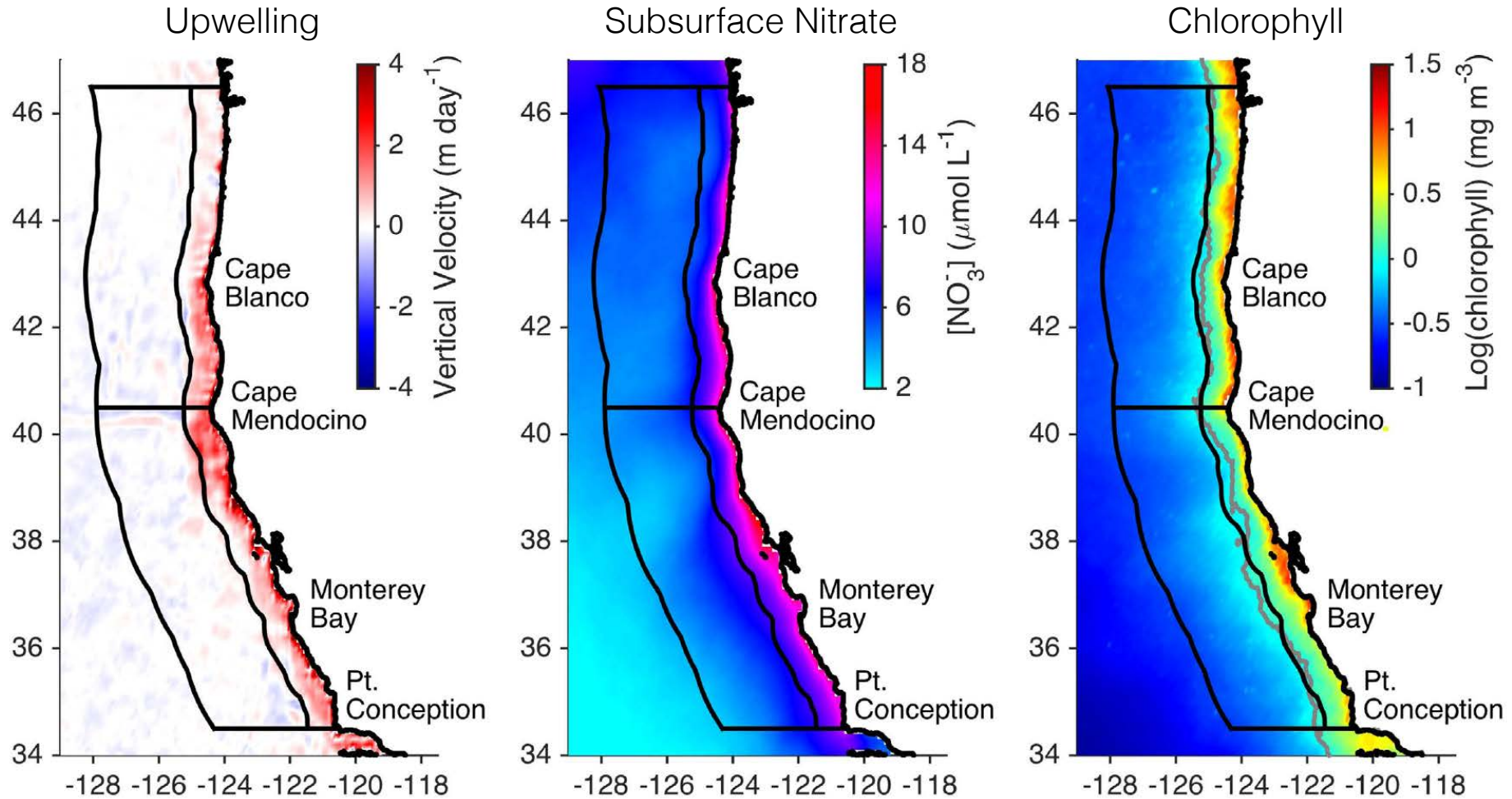


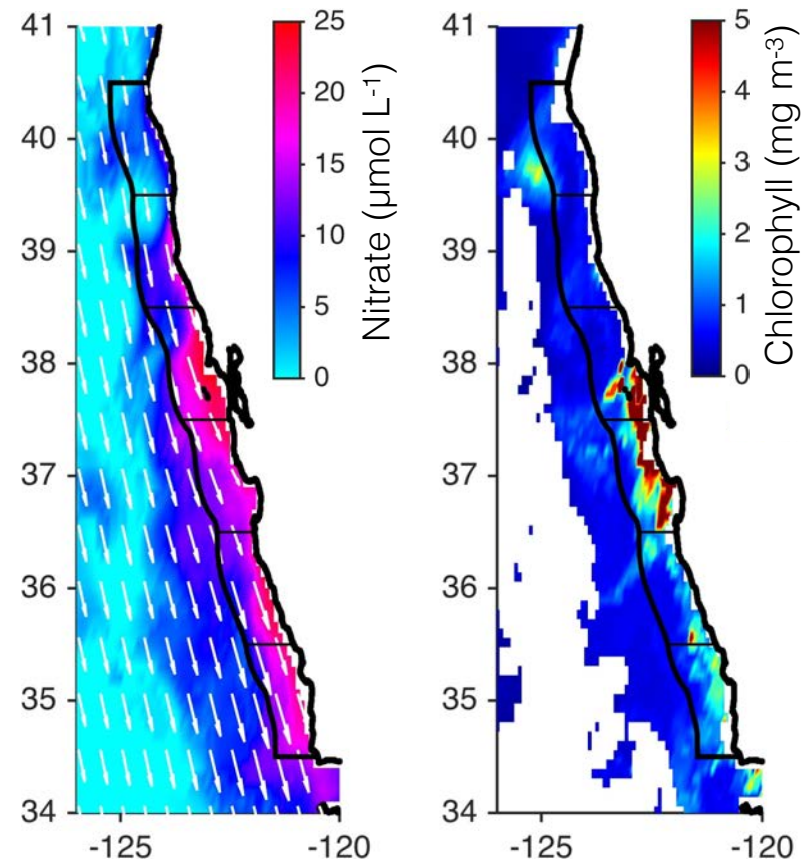
Regional Ocean Modeling System (ROMS)
Data Assimilation (SST, SSH, T, S)
1/10° horizontal resolution
42 vertical levels
ECMWF fluxes
CCMP wind

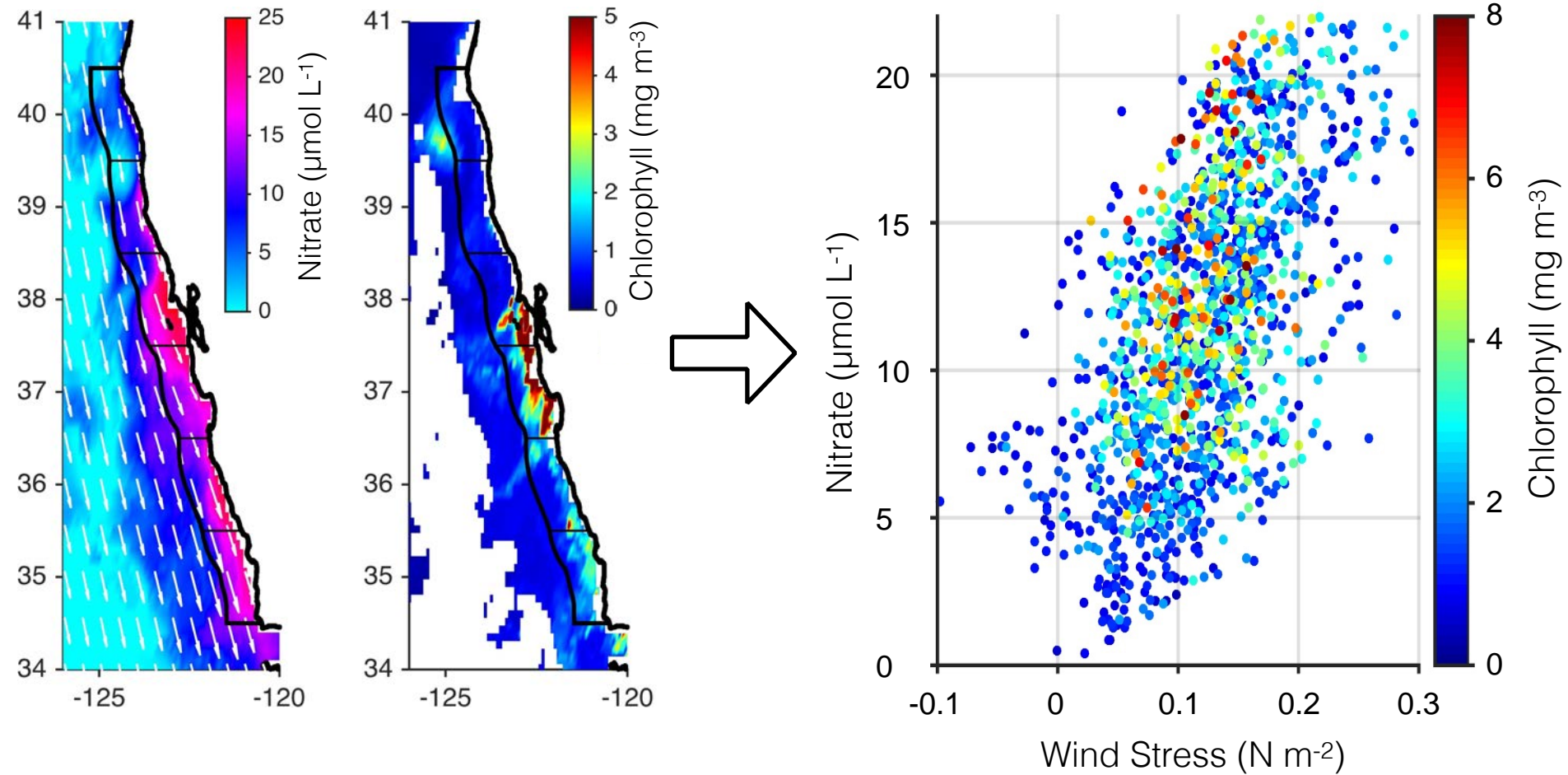


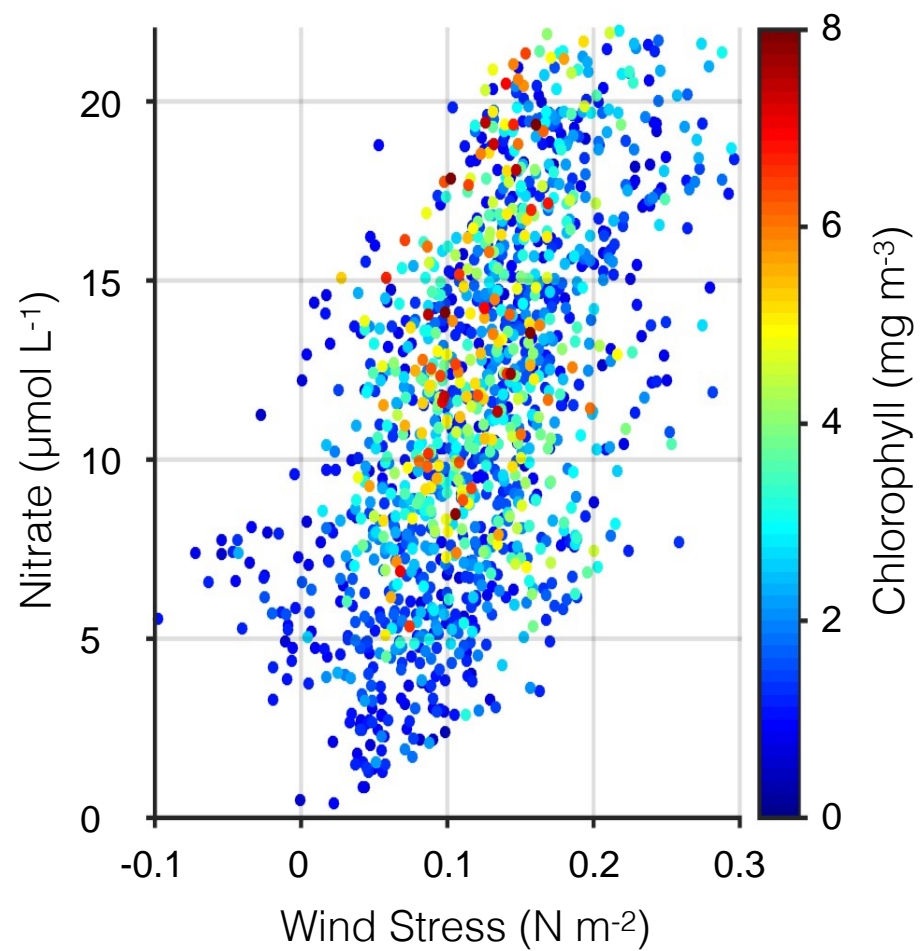
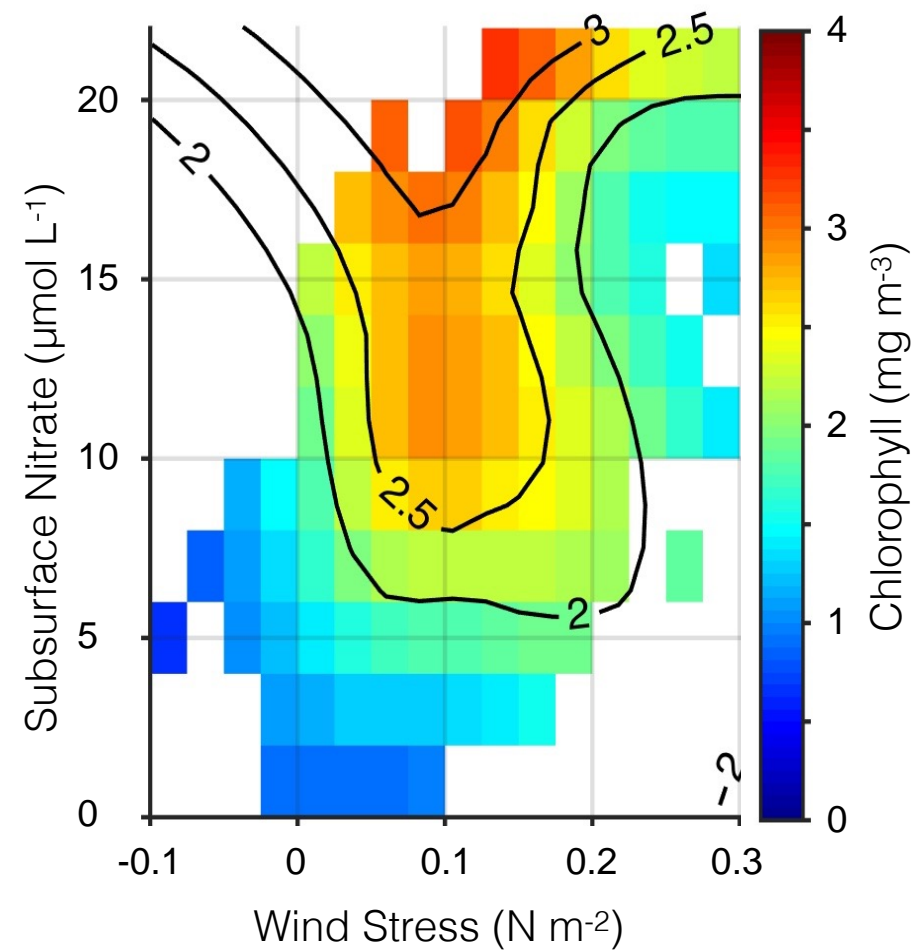
Model output available from:
oceanmodeling.ucsc.edu

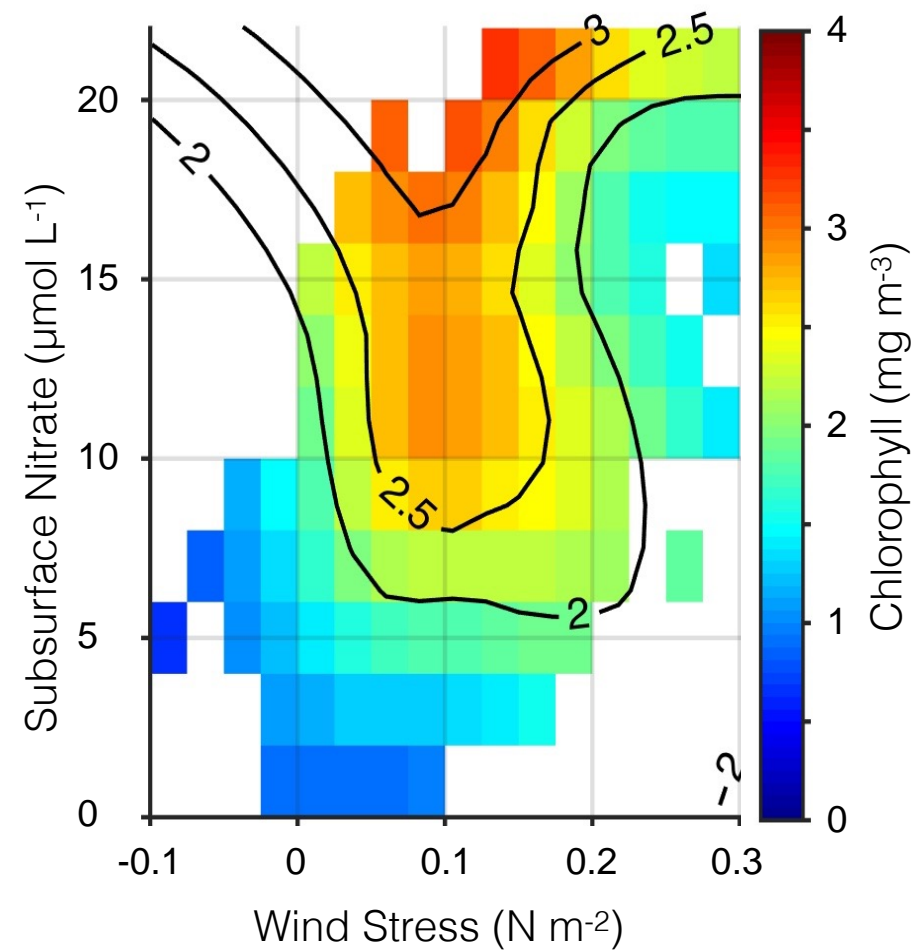
Upwelling Season (March - July) Mean Conditions







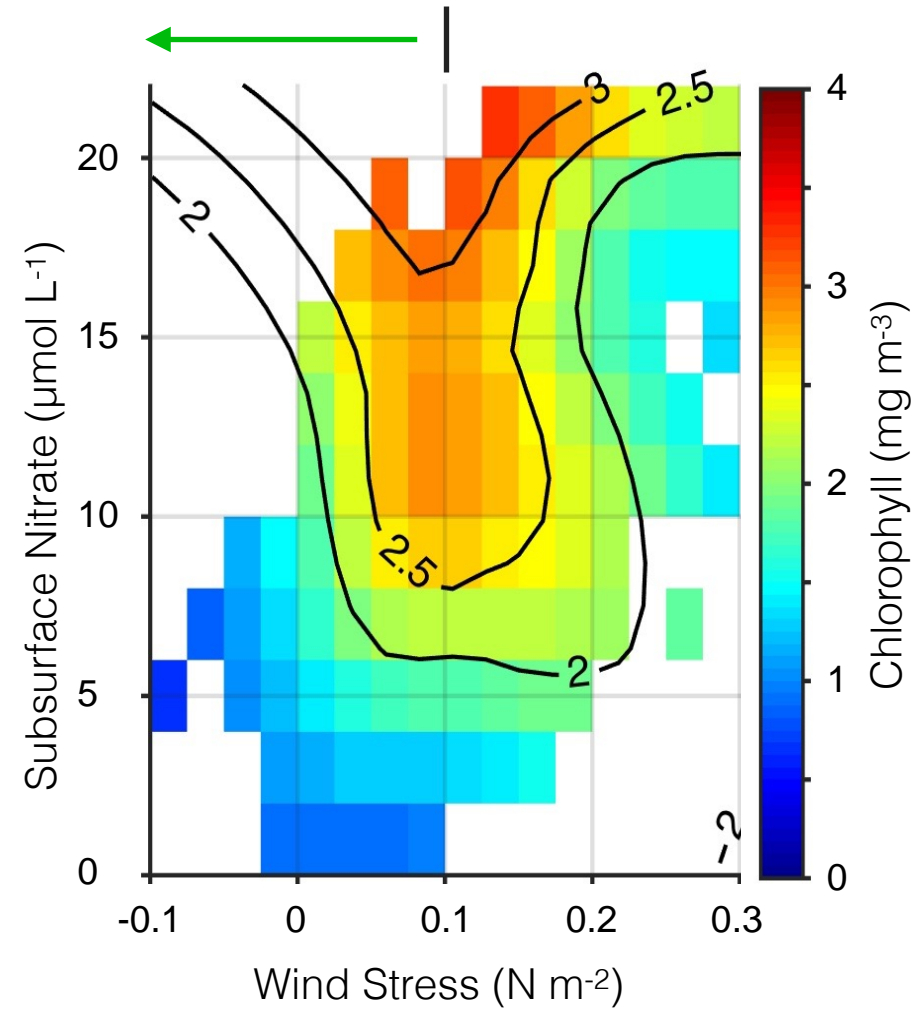




Nutrient Limitation

Nutrient Limitation

Weak upwelling



Nutrient Limitation Physical Limitation

Nutrient Limitation

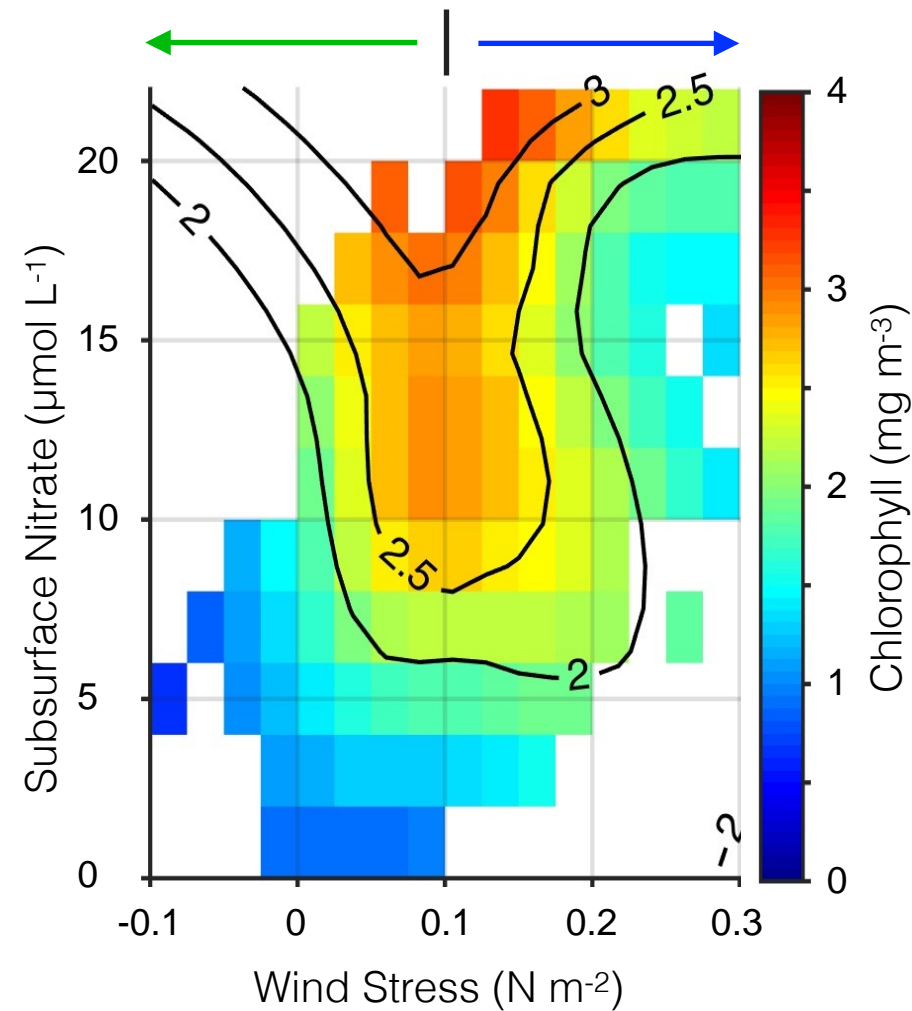
Weak upwelling

Physical Limitation

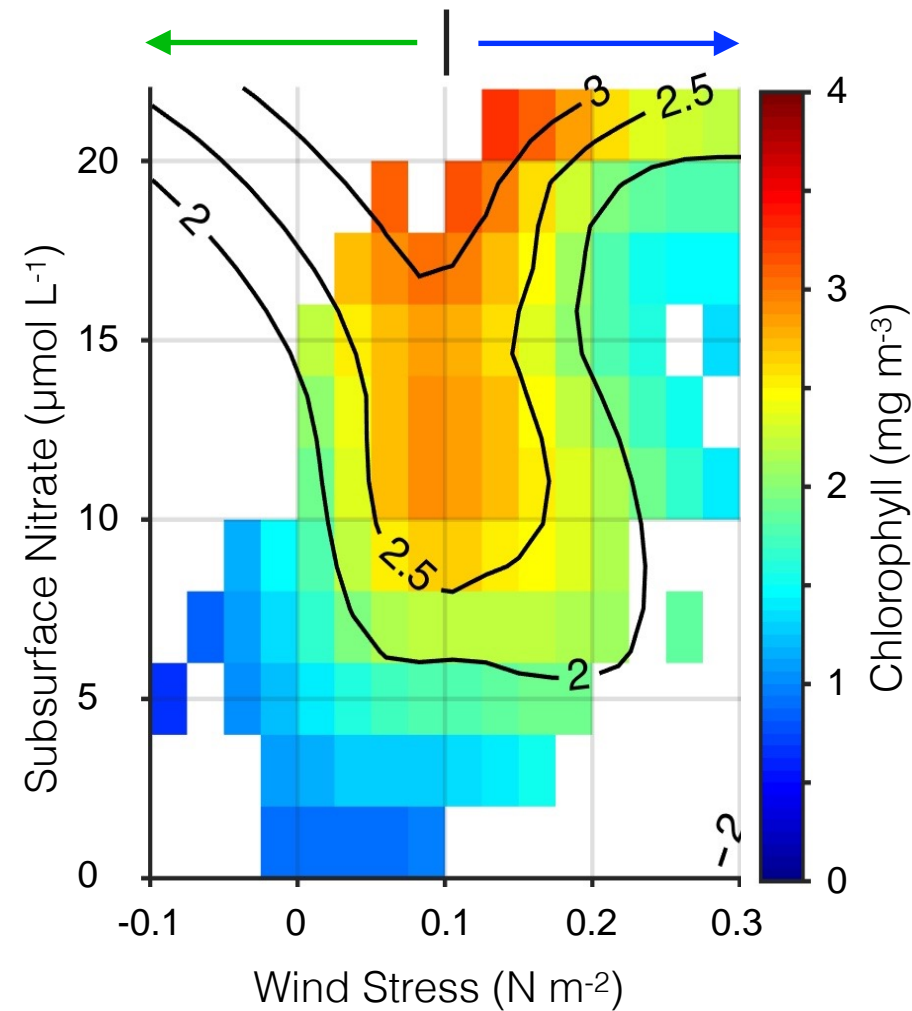
Offshore advection

Subduction

Deep mixed layer (light limitation)



Nutrient Limitation Physical Limitation

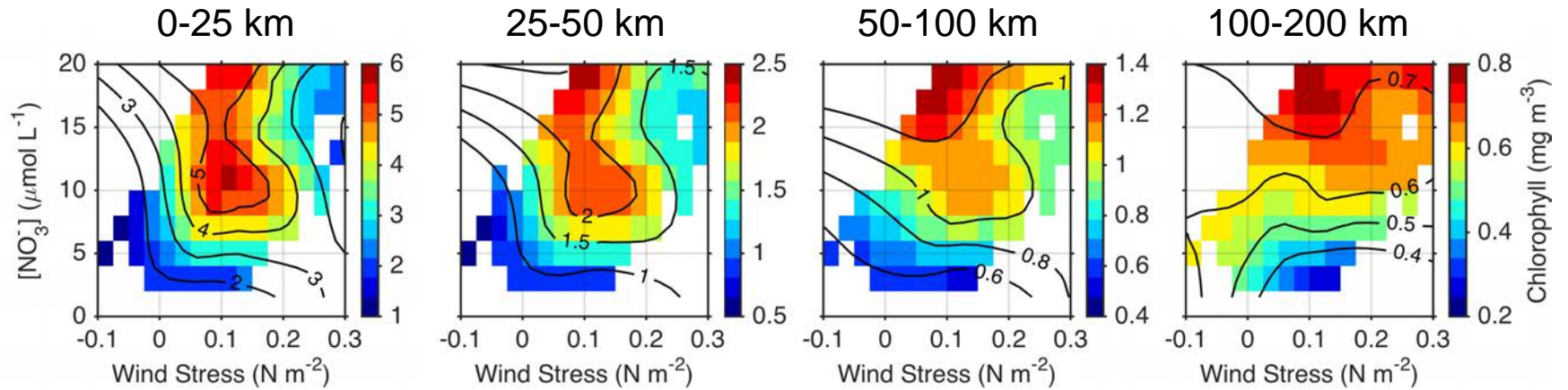


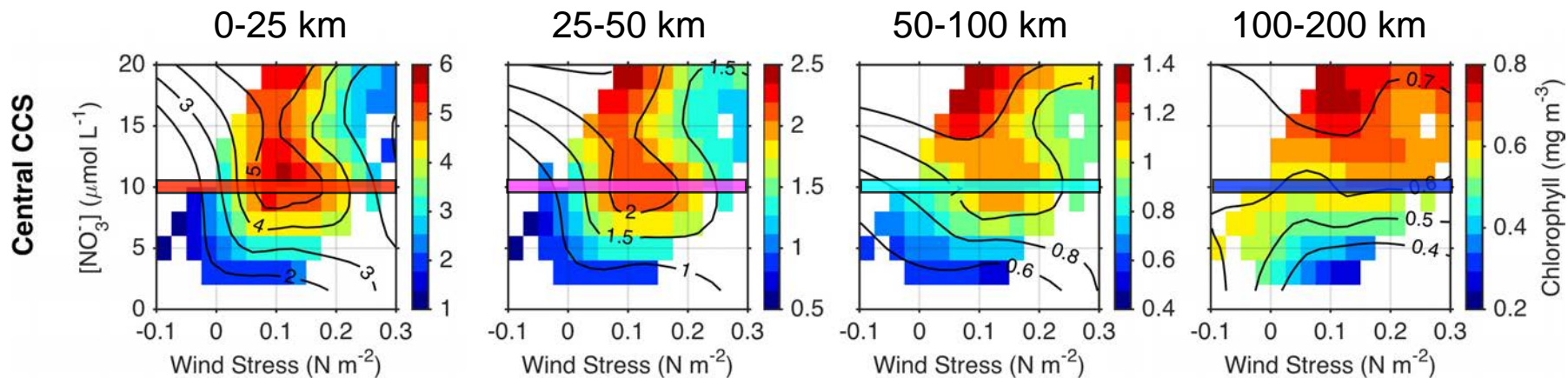
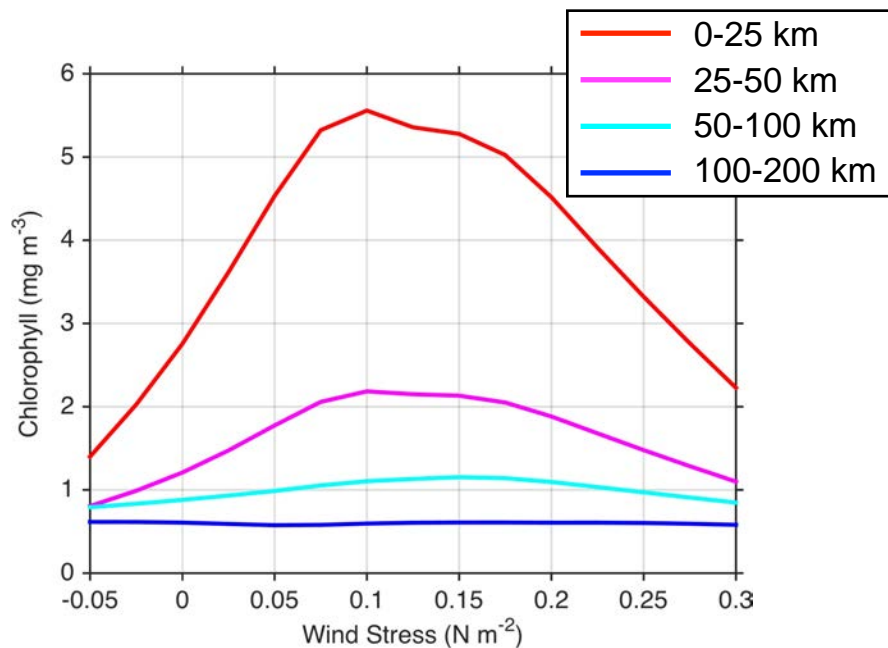
Nutrient Limitation

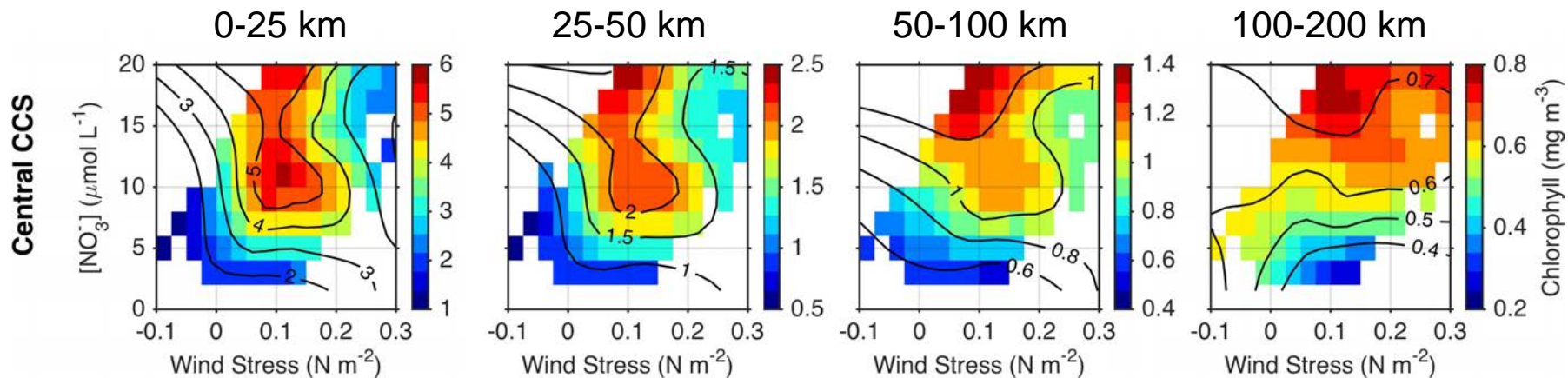
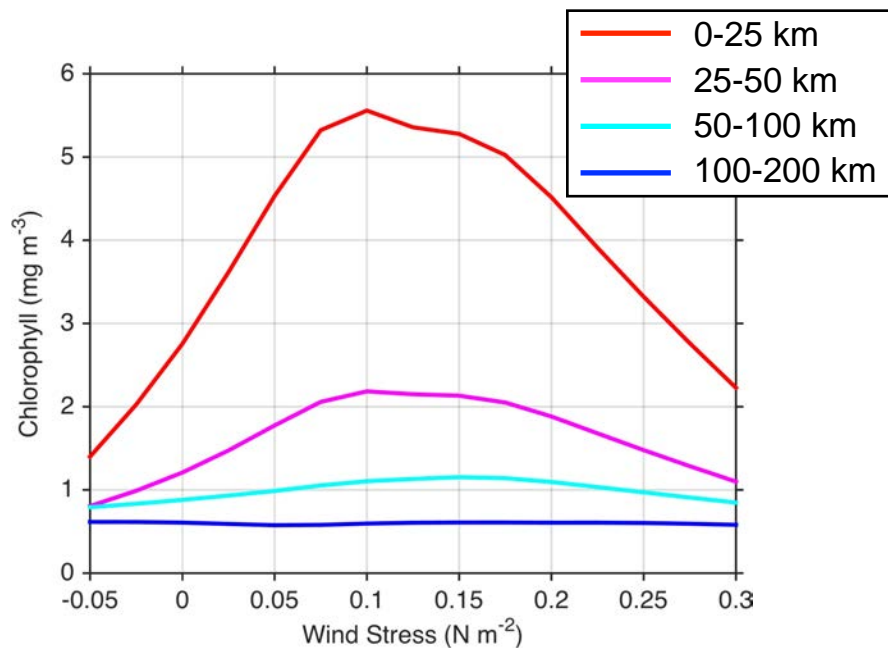
Weak upwelling
Nitrate-poor source waters

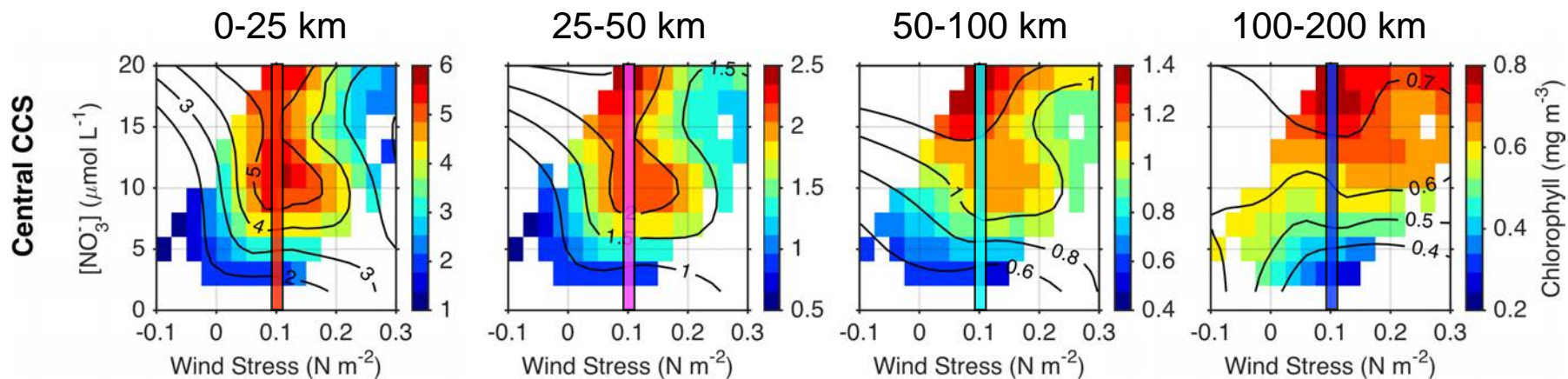
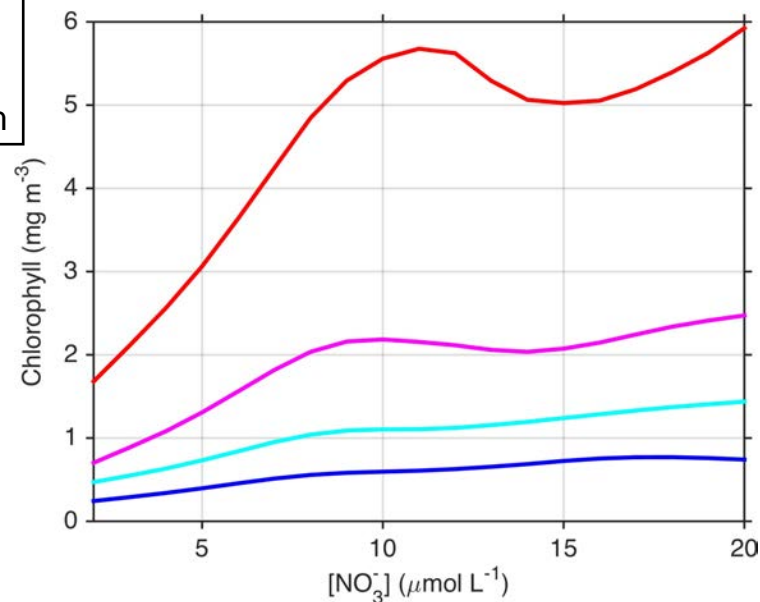
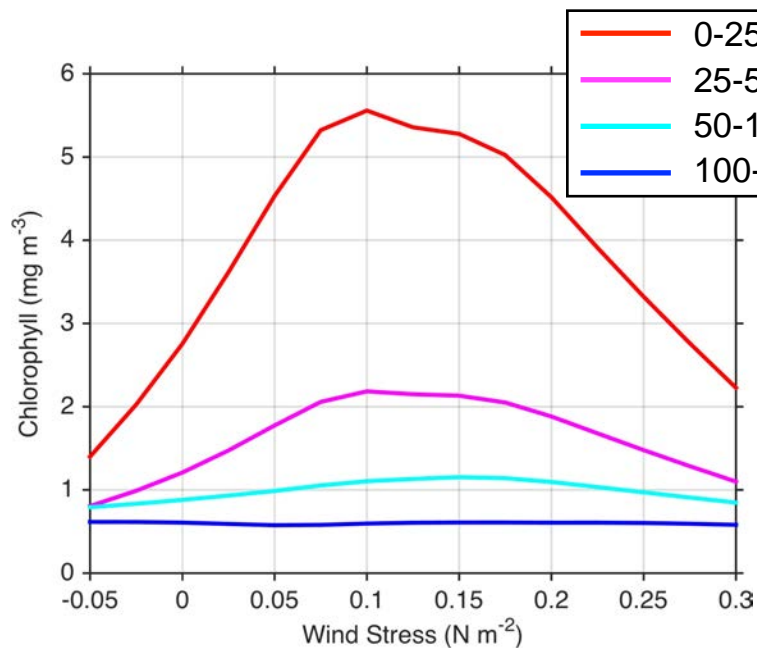
Physical Limitation

Offshore advection
Subduction
Deep mixed layer (light limitation)

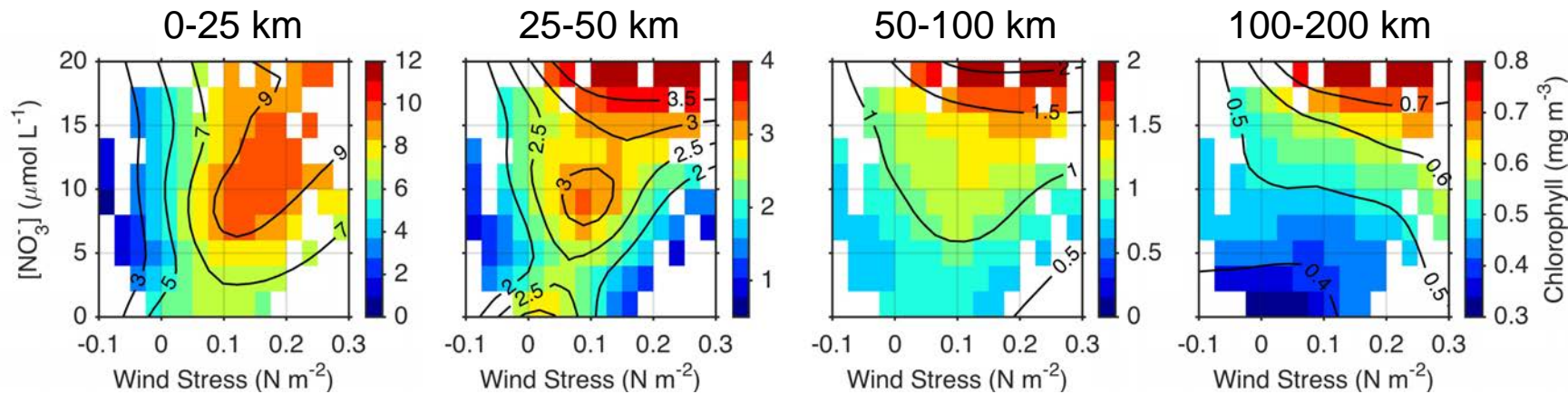




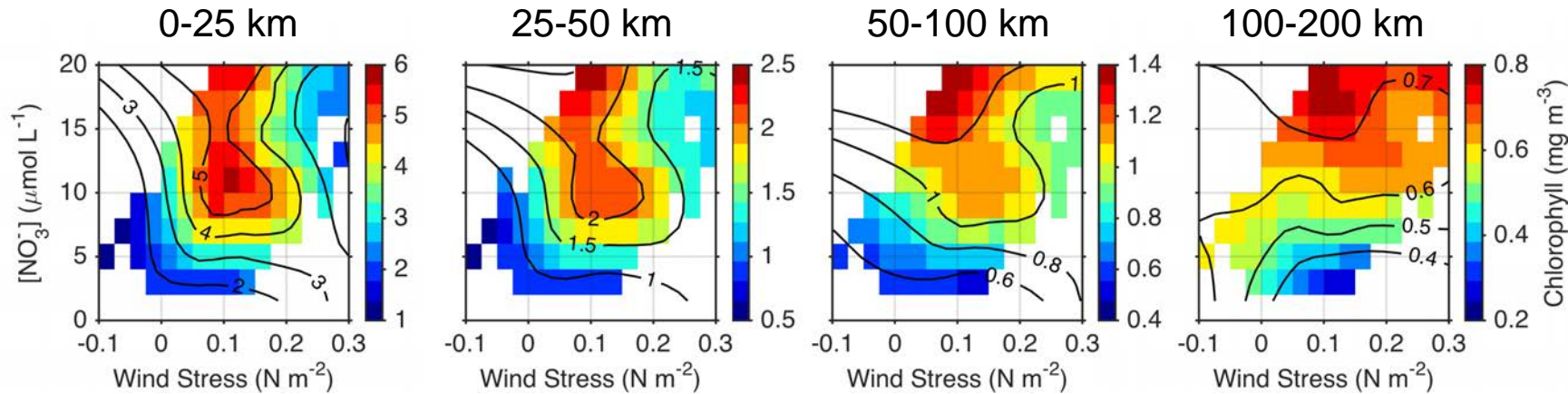


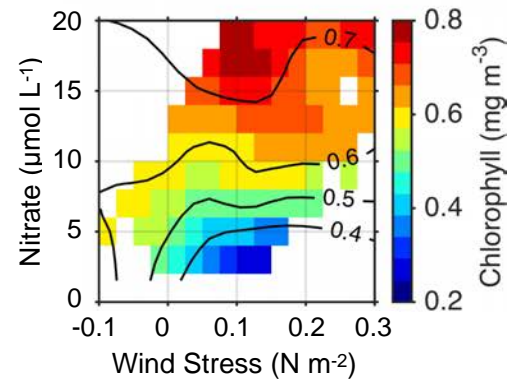
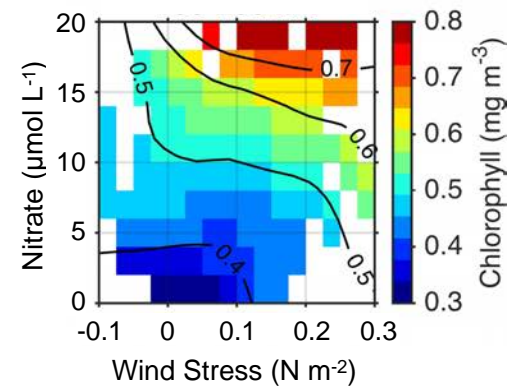
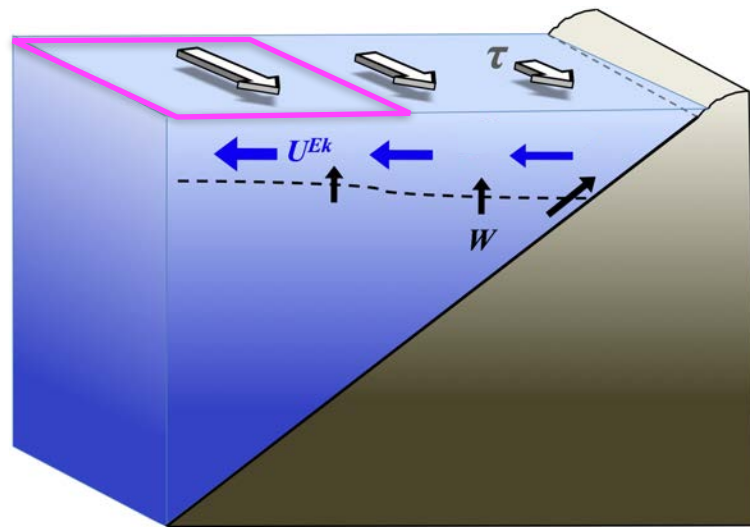


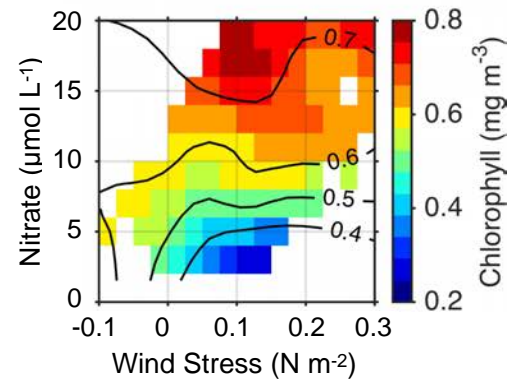
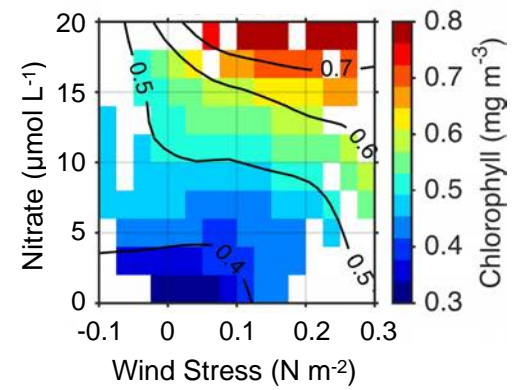
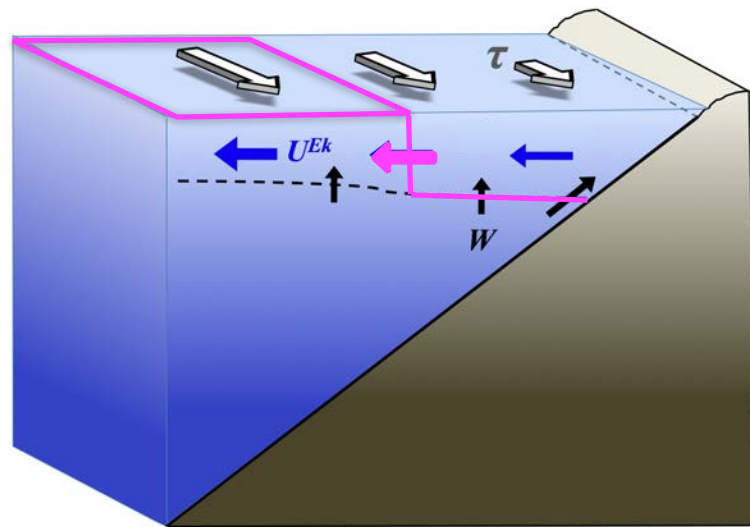
Northern CCS

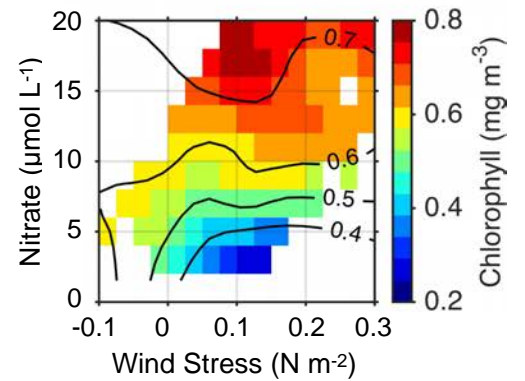
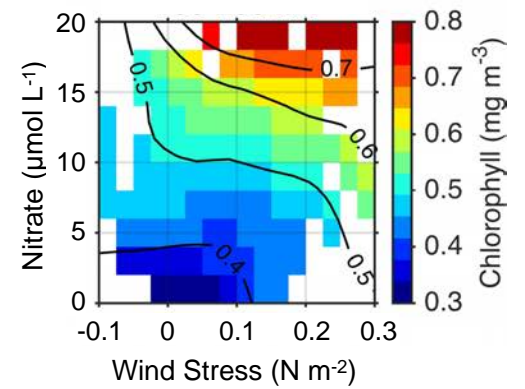
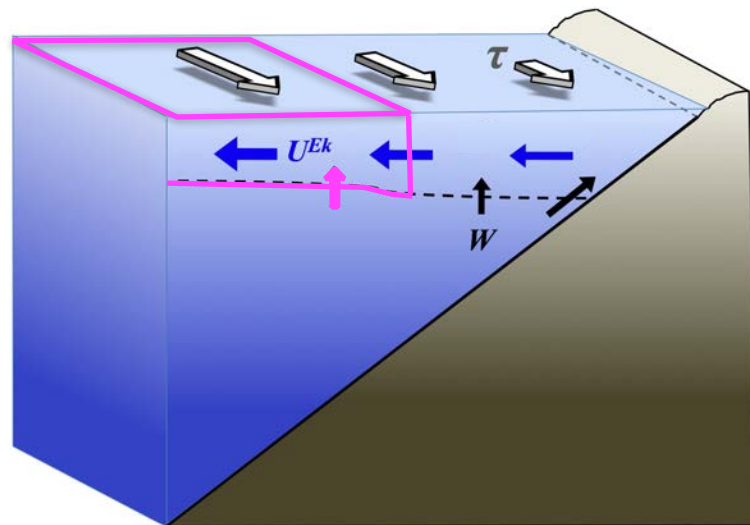


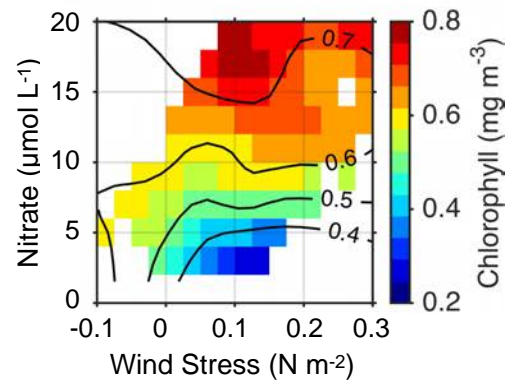
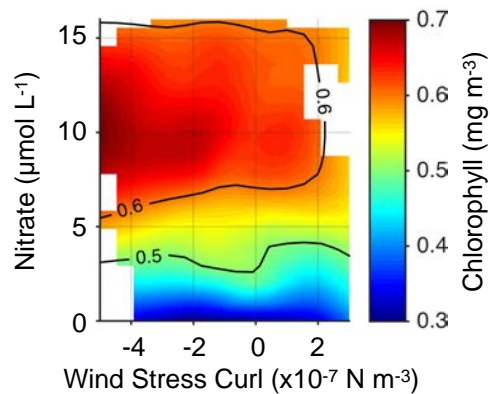
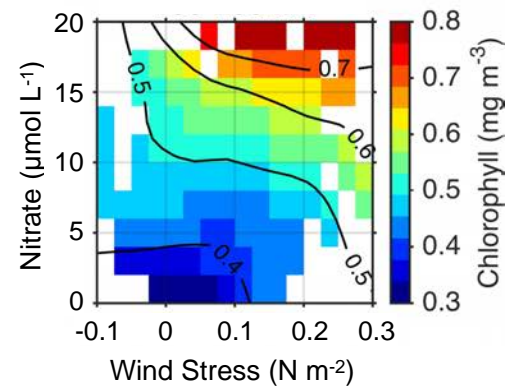
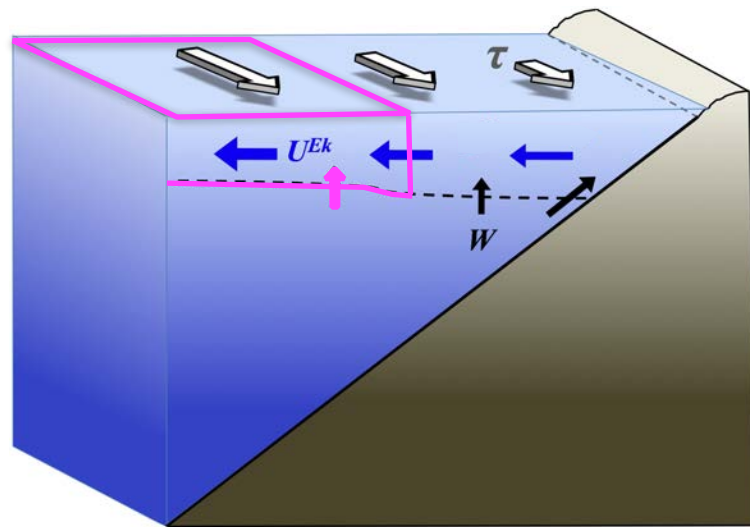
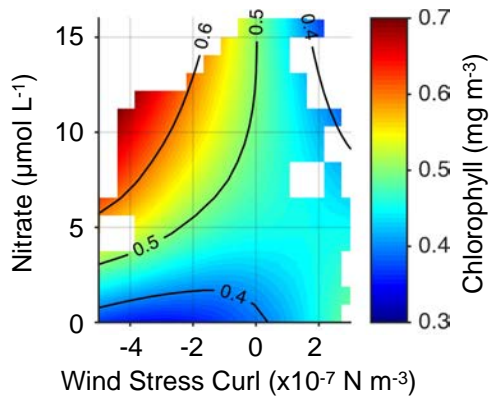
Central CCS

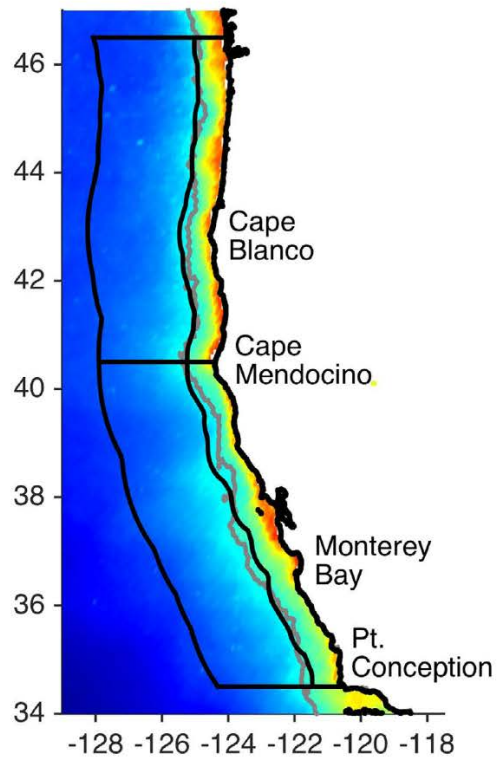


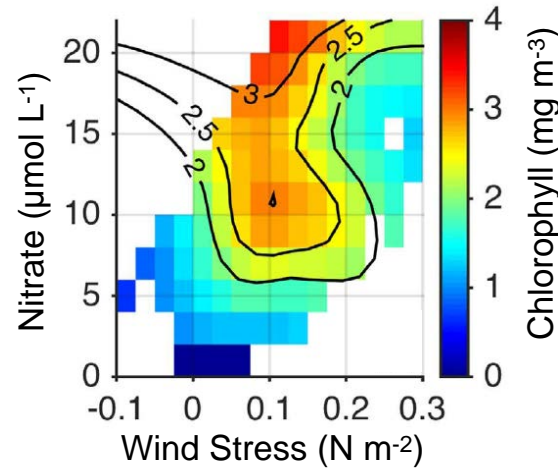
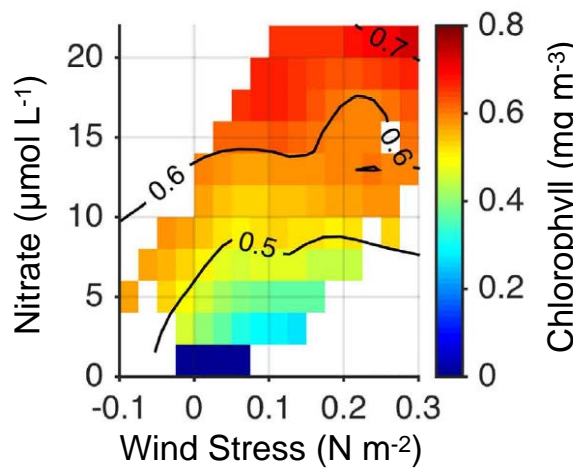
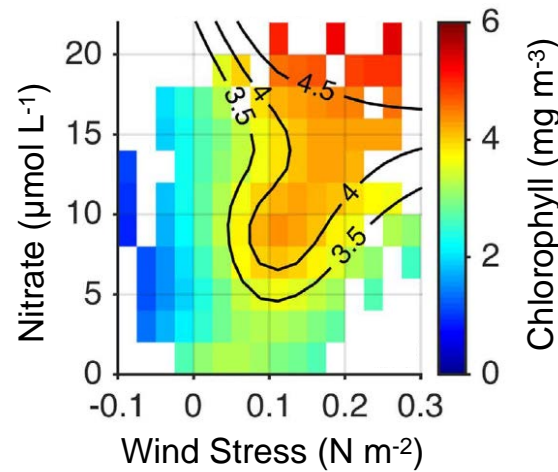
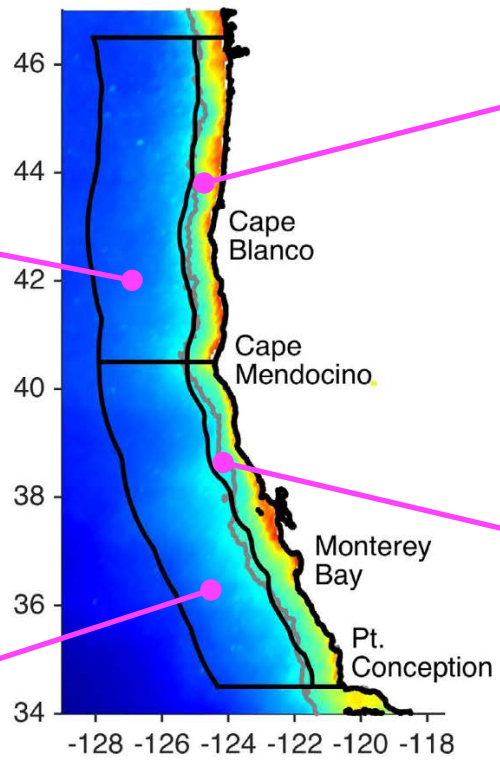
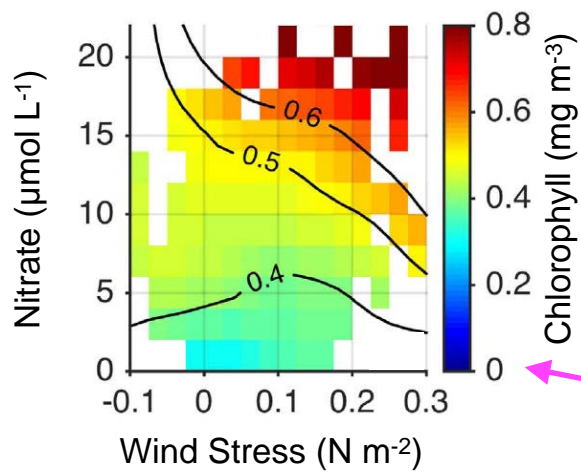










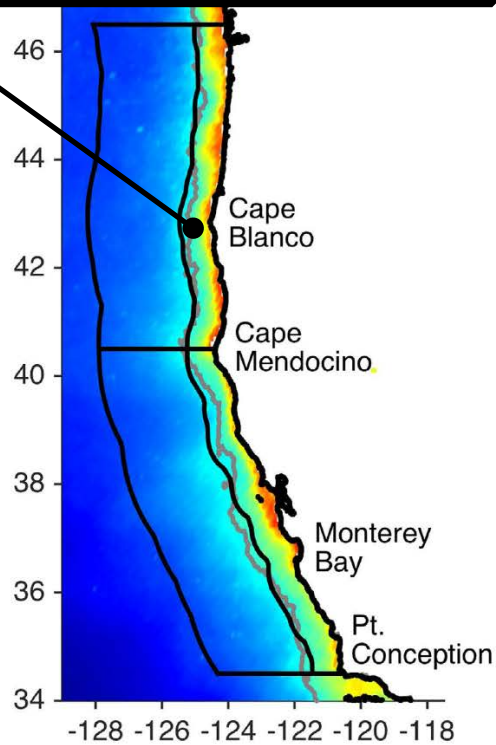


Delayed upwelling alters nearshore coastal ocean ecosystems in the northern California current

John A. Barth^{*†}, Bruce A. Menge[‡], Jane Lubchenco^{†‡}, Francis Chan[‡], John M. Bane[§], Anthony R. Kirincich^{*}, Margaret A. McManus[¶], Karina J. Nielsen[¶], Stephen D. Pierce^{*}, and Libe Washburn^{**}

^{*}College of Oceanic and Atmospheric Sciences and [†]Department of Zoology, Oregon State University, Corvallis, OR 97331; [‡]Department of Marine Sciences, University of North Carolina, Chapel Hill, NC 27599; [§]Department of Oceanography, University of Hawaii, Manoa, HI 96822; [¶]Department of Biology, Sonoma State University, Rohnert Park, CA 94928; and ^{**}Department of Geography, University of California, Santa Barbara, CA 93106

Contributed by Jane Lubchenco, January 22, 2007 (sent for review December 9, 2006)

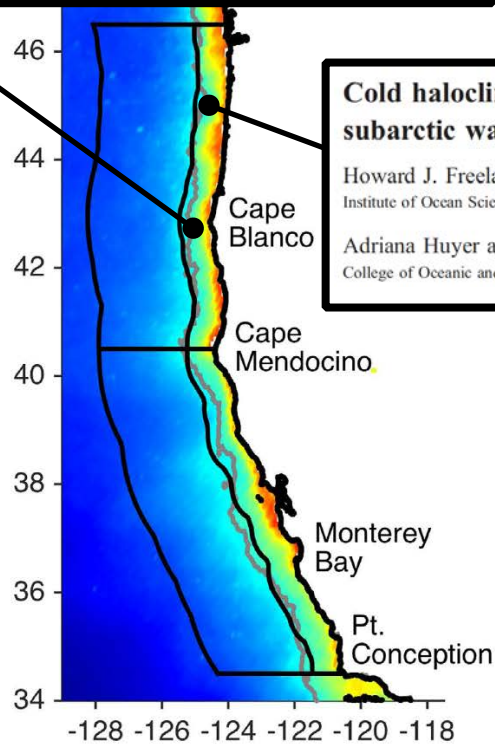


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Cold halocline in the northern California Current: An invasion of subarctic water

Howard J. Freeland and Germaine Gatién

Institute of Ocean Sciences, Fisheries, and Oceans Canada—Pacific Region, Sidney, British Columbia, Canada

Adriana Huyer and Robert L. Smith

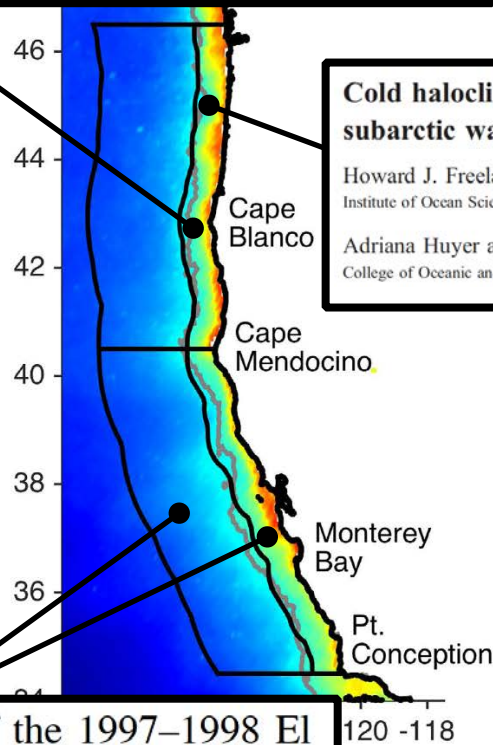
College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon, USA

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Biological and chemical consequences of the 1997–1998 El Niño in central California waters

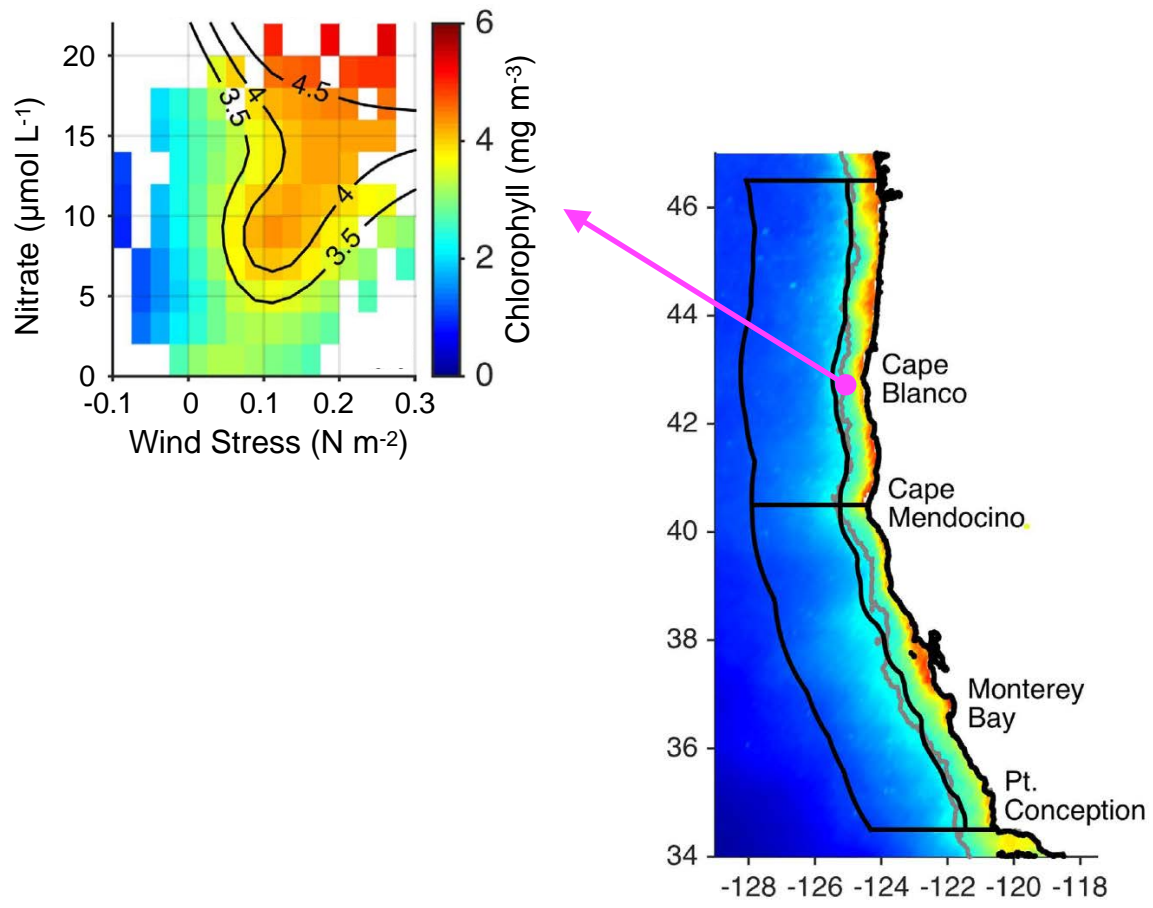
F.P. Chavez^{a,*}, J.T. Pennington^a, C.G. Castro^{a,b}, J.P. Ryan^a, R.P. Michisaki^a, B. Schlining^a, P. Walz^a, K.R. Buck^a, A. McFadyen^{a,c}, C.A. Collins^b

^a Monterey Bay Aquarium Research Institute, 9644-7700, Sandholdt Road, Moss Landing, CA 95039-0628, USA

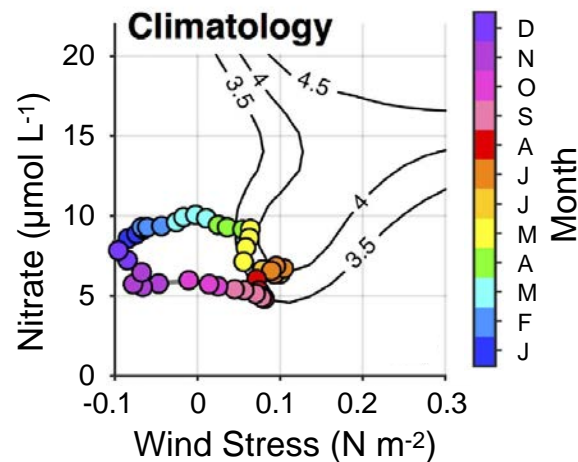
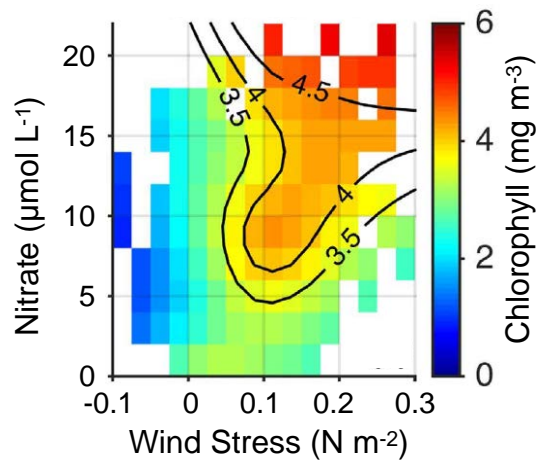
^b Department of Oceanography, Naval Postgraduate School, Monterey, CA 93943, USA

^c Department of Oceanography, University of Washington, Seattle, WA, USA

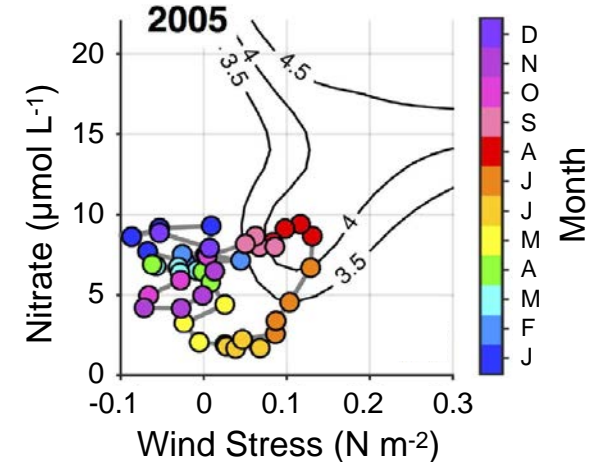
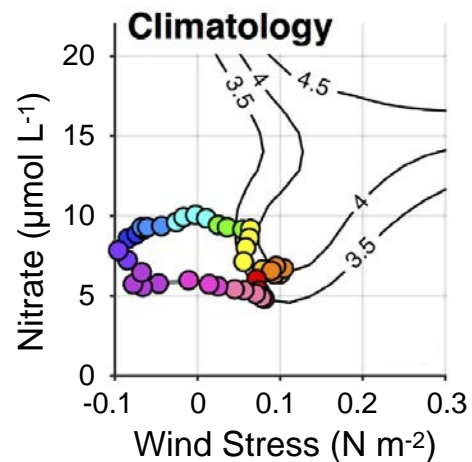
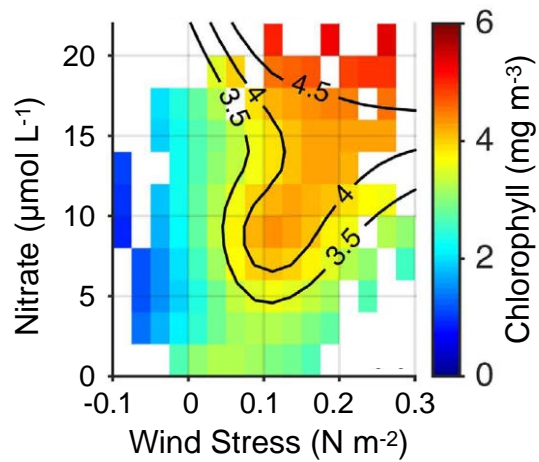
Delayed Upwelling in the Northern CCS (2005)



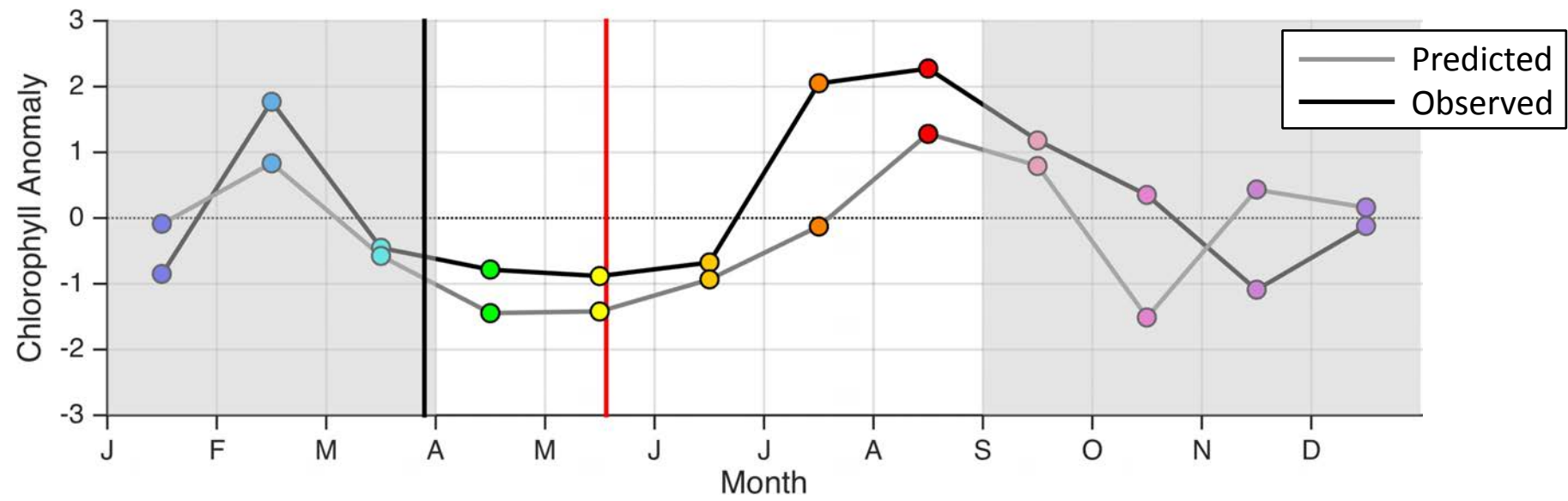
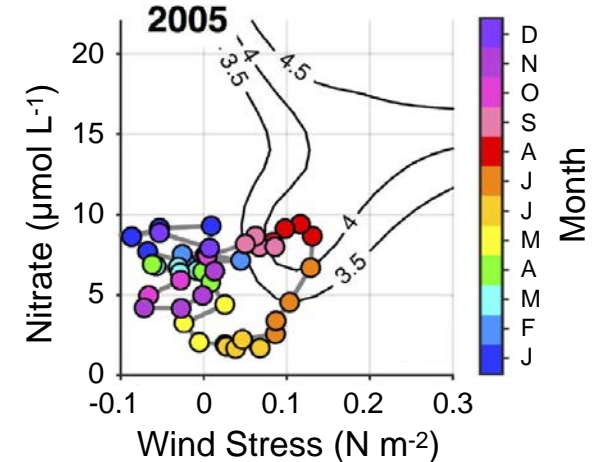
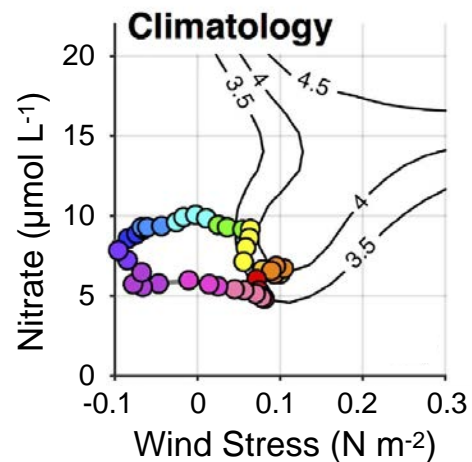
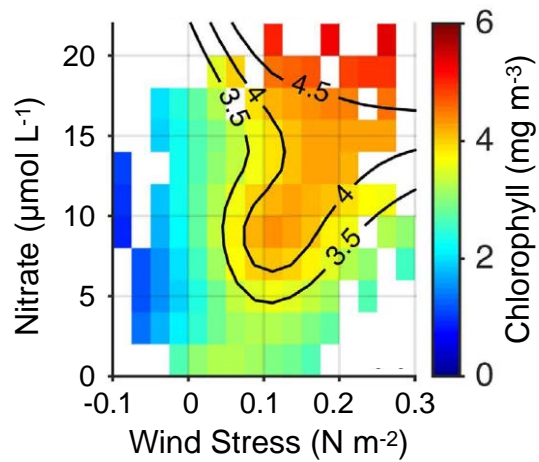
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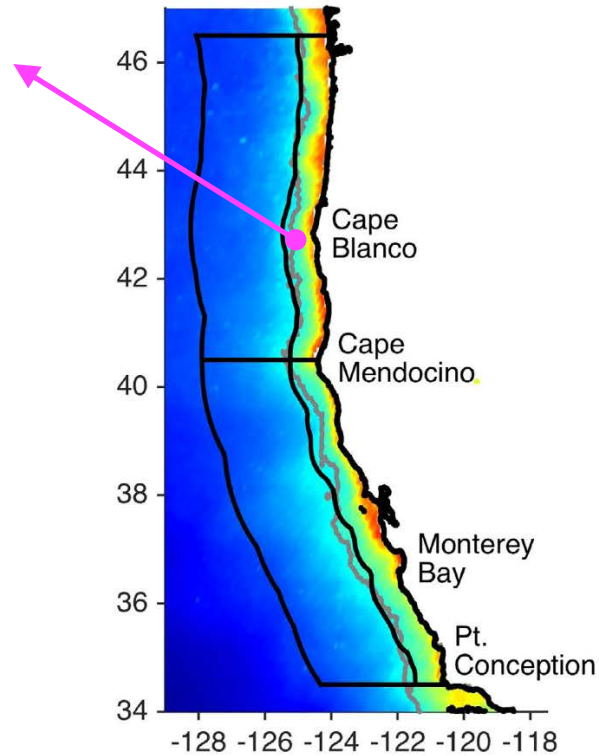
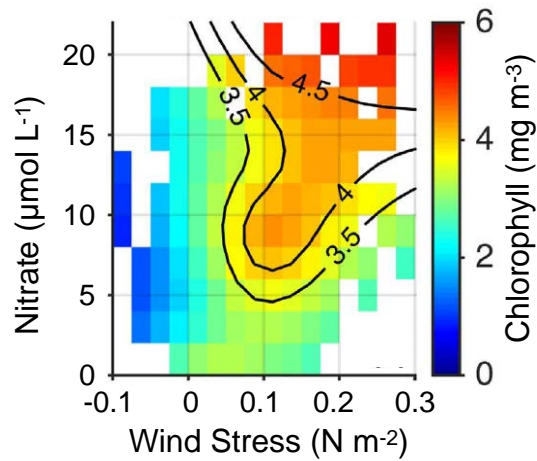
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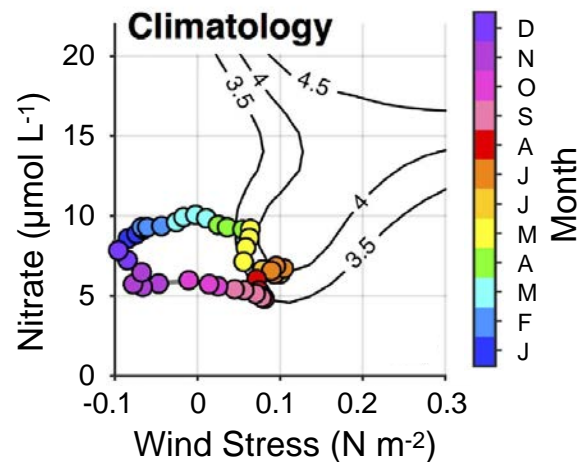
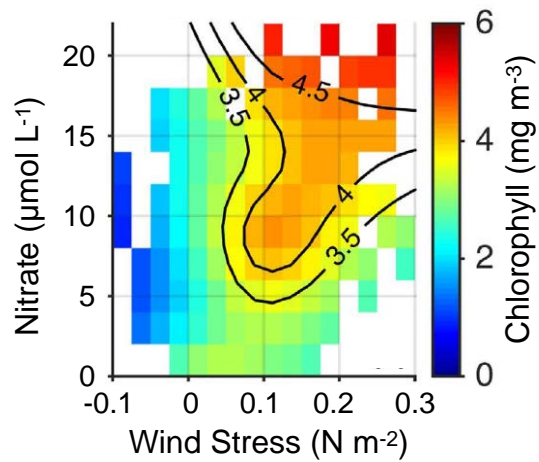
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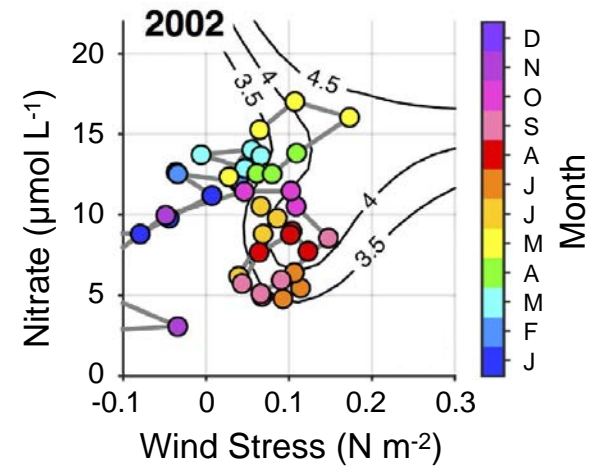
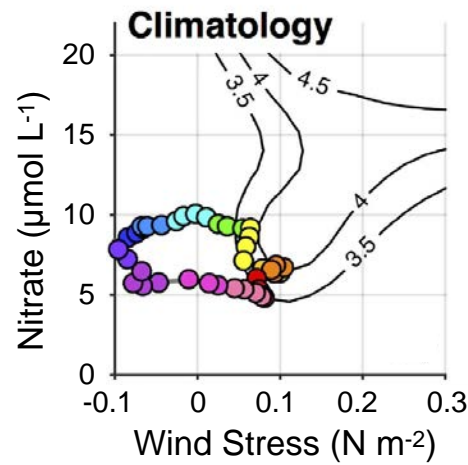
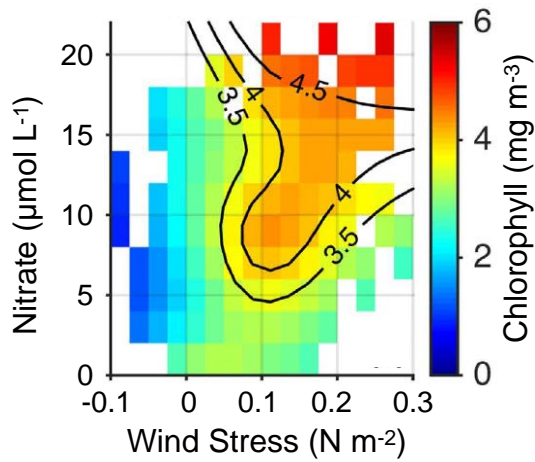
Strong Subarctic Influence in the Northern CCS (2002)



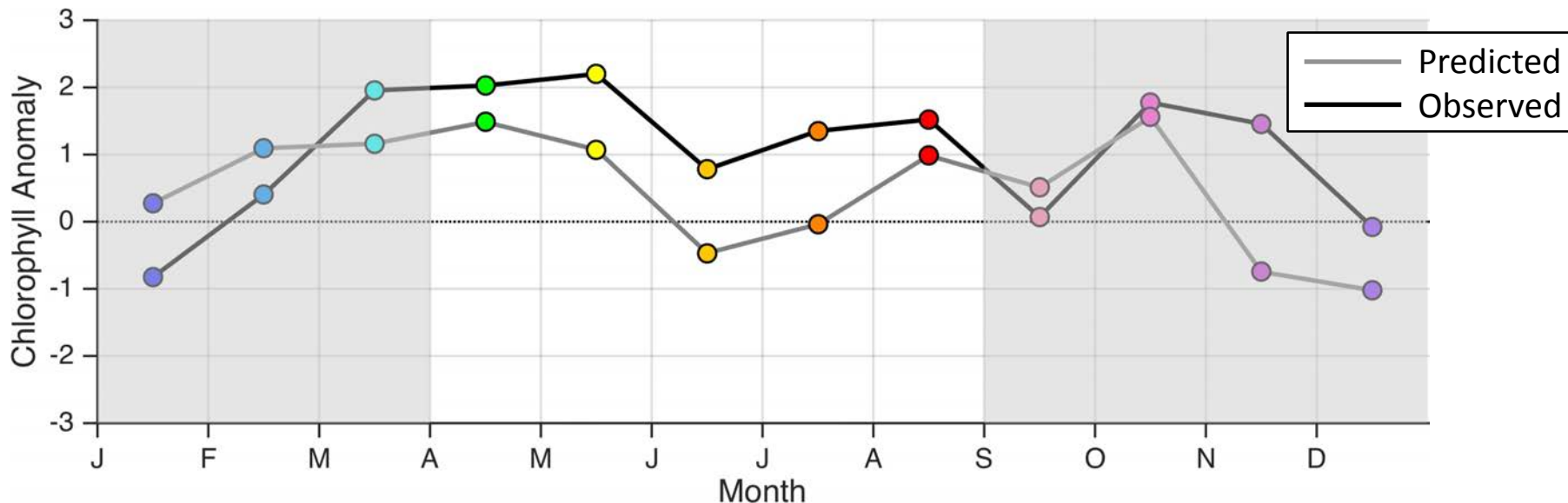
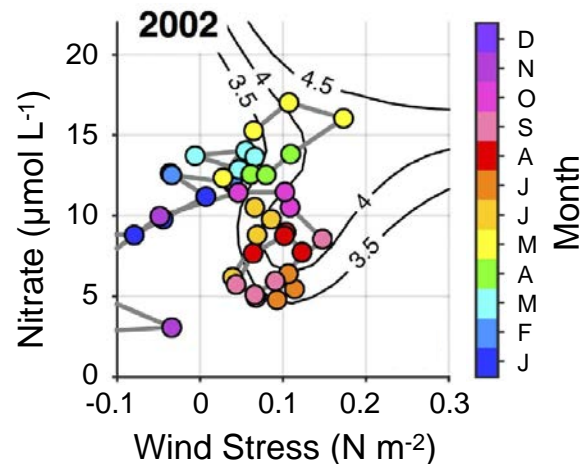
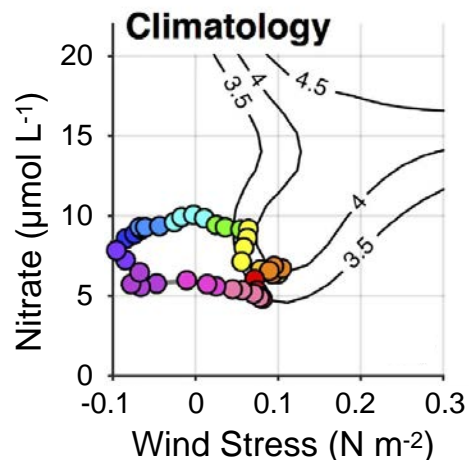
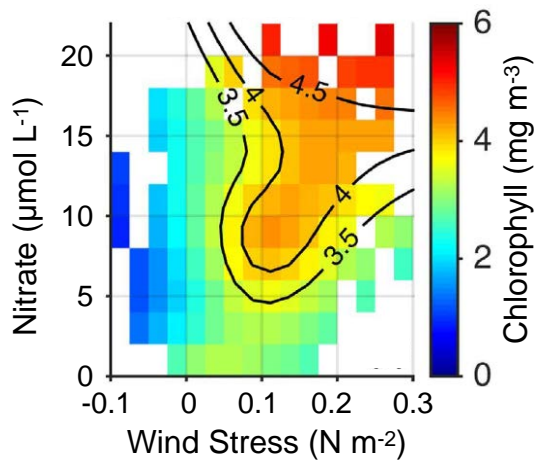
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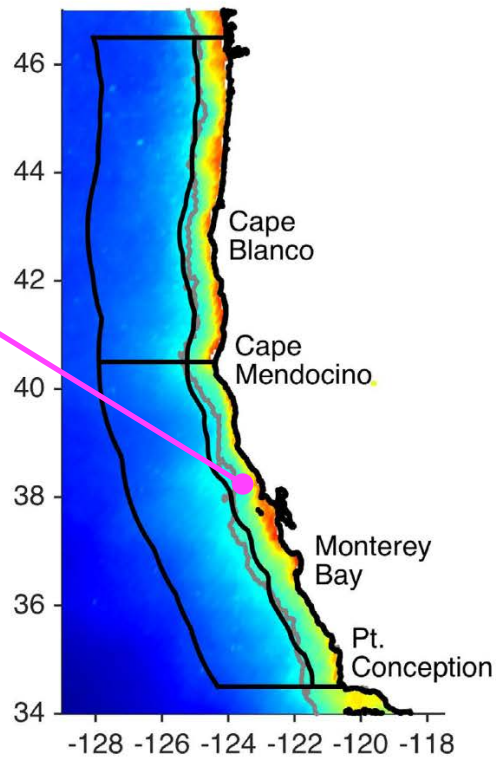
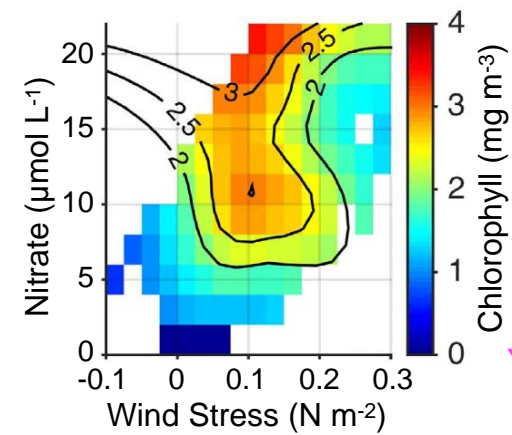
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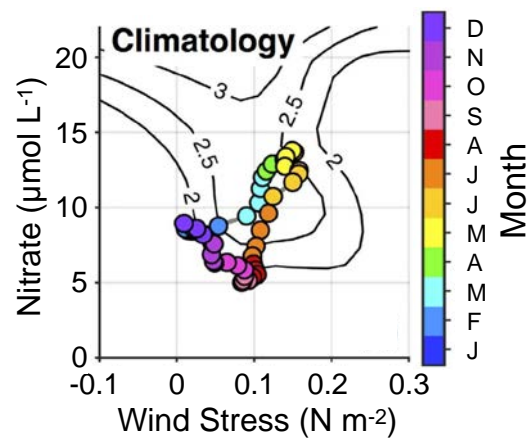
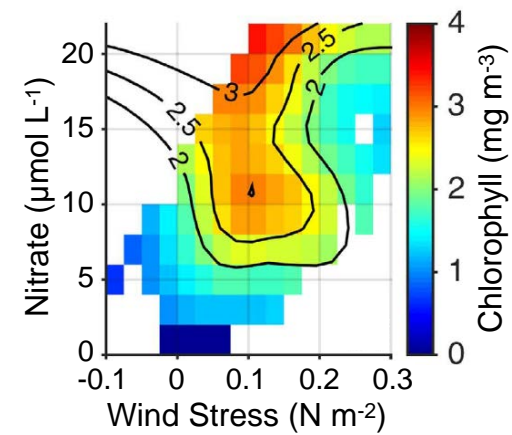
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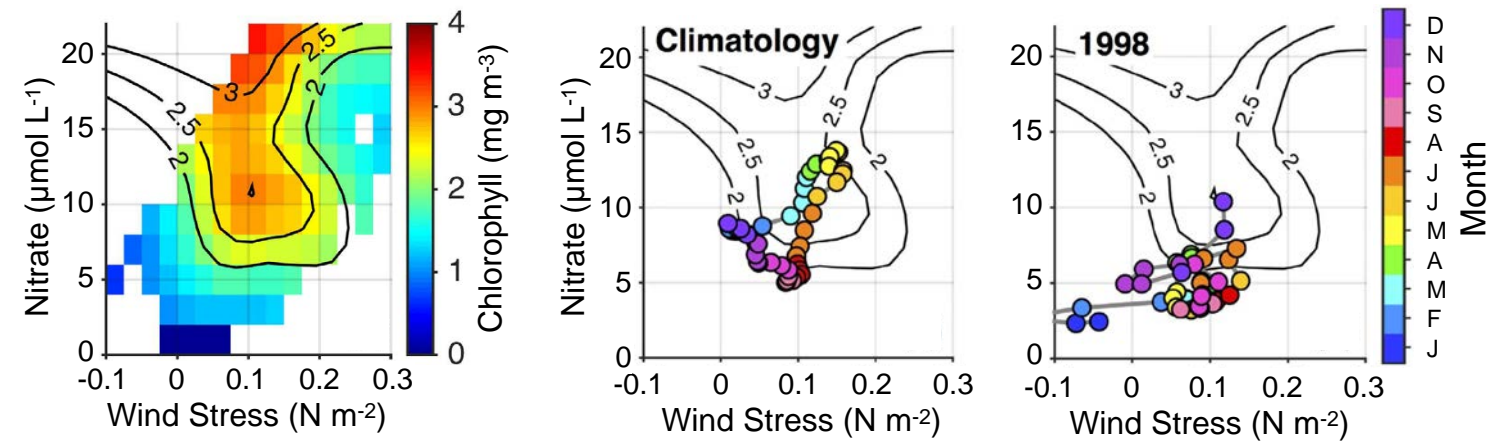
El Niño / La Niña in the Central CCS (1998-1999)



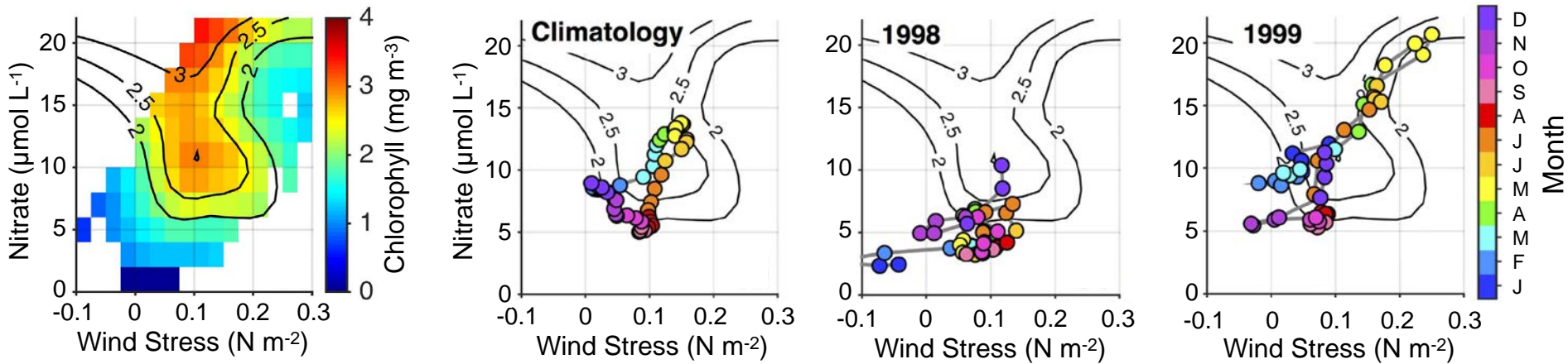
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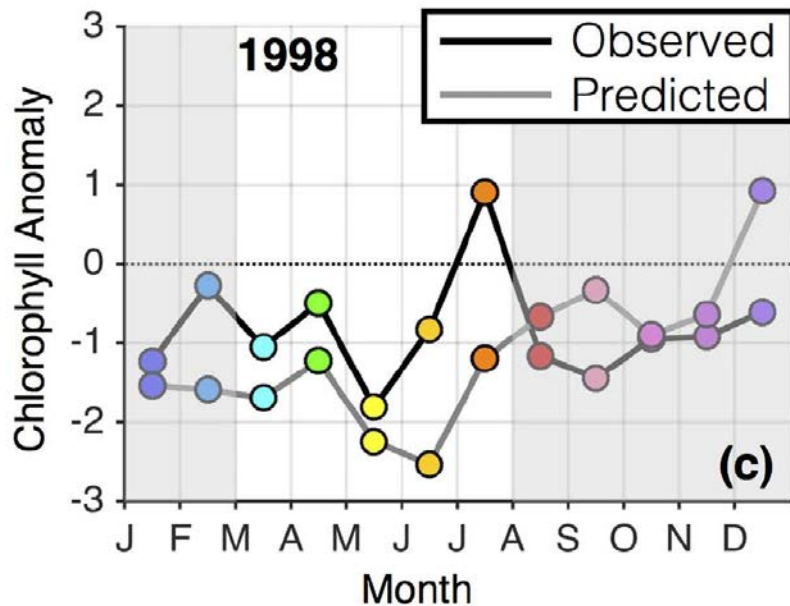
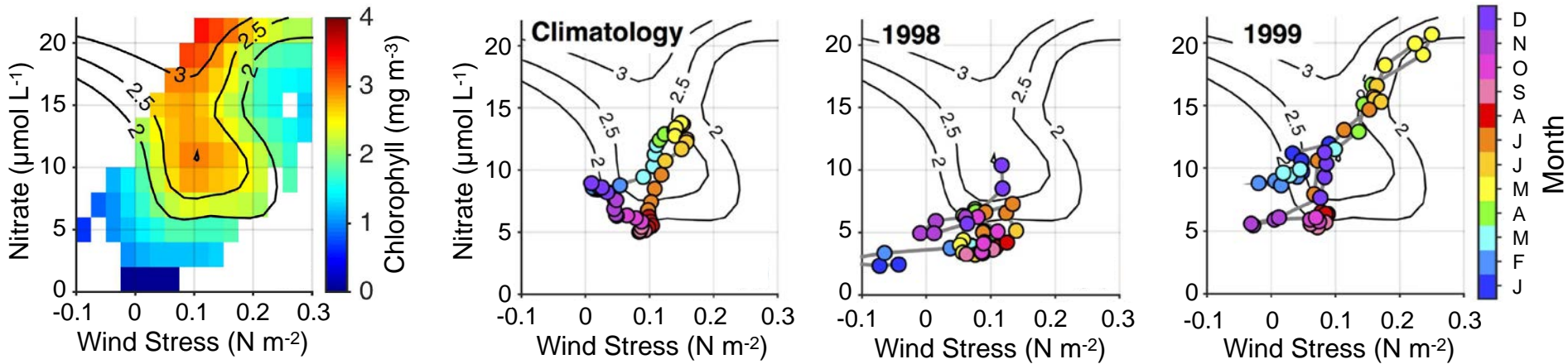
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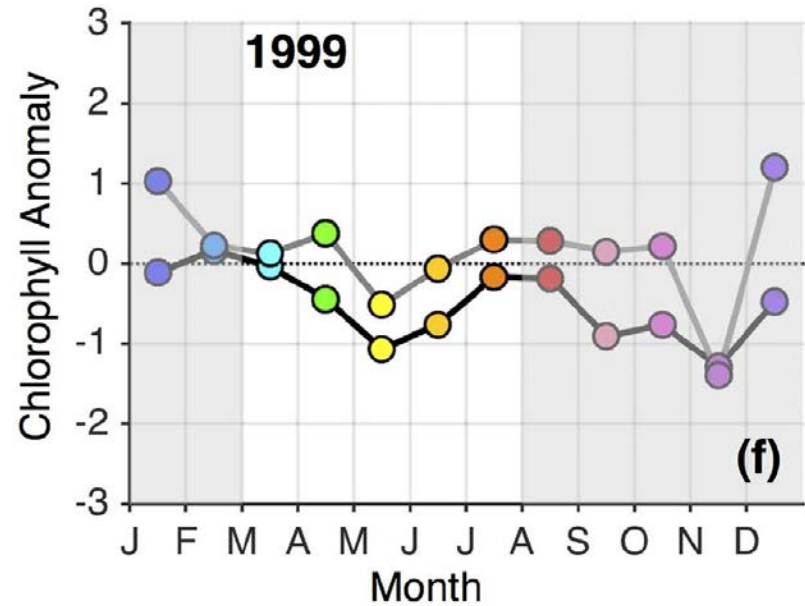
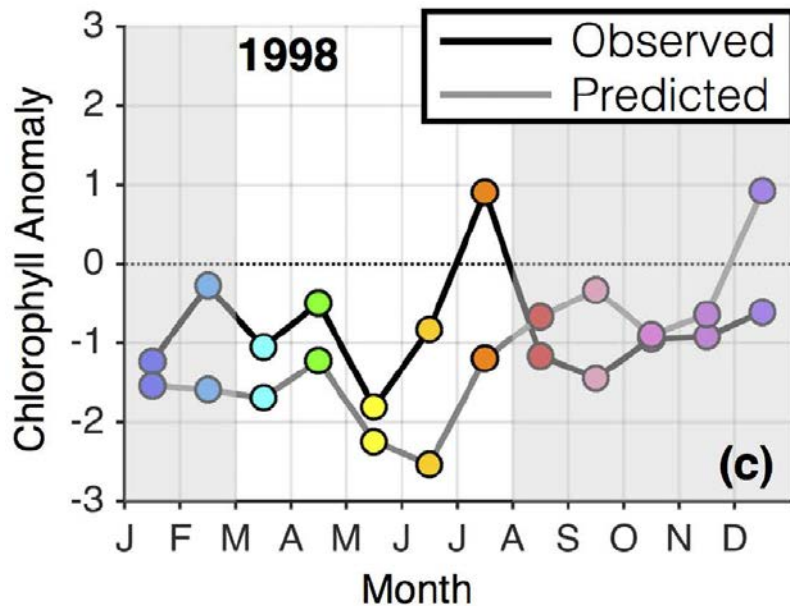
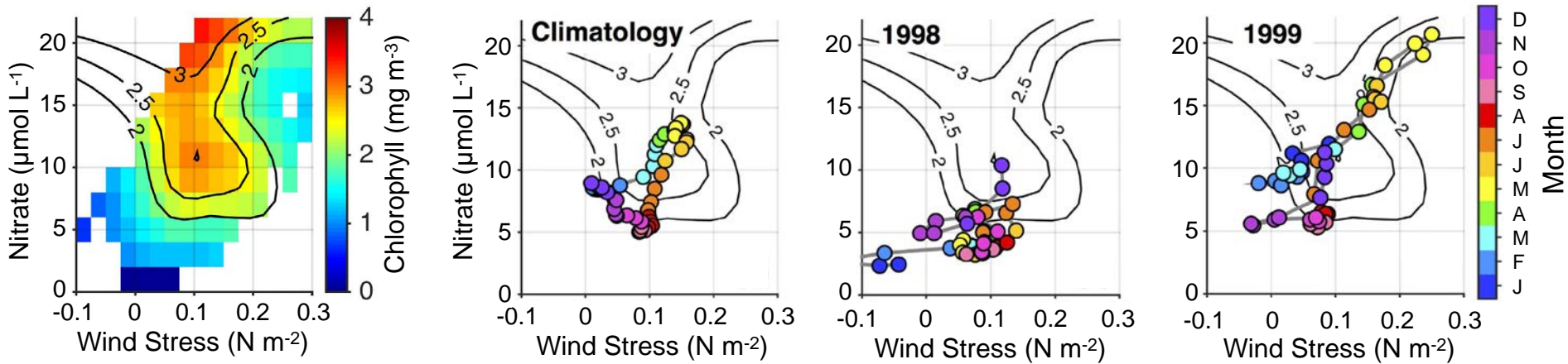
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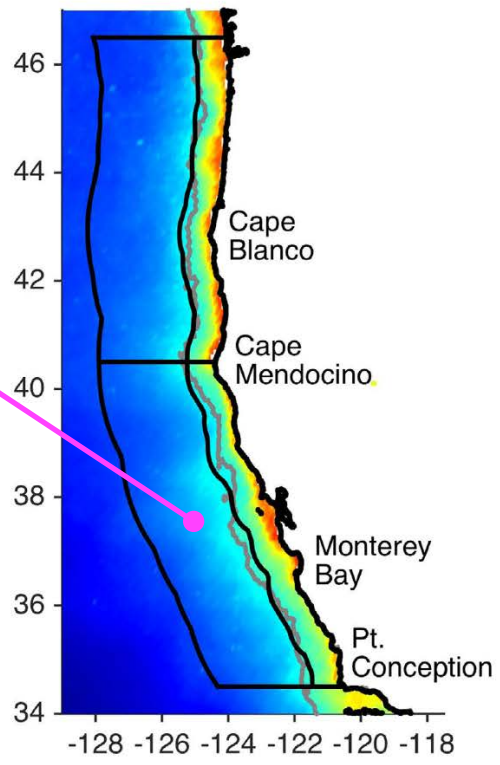
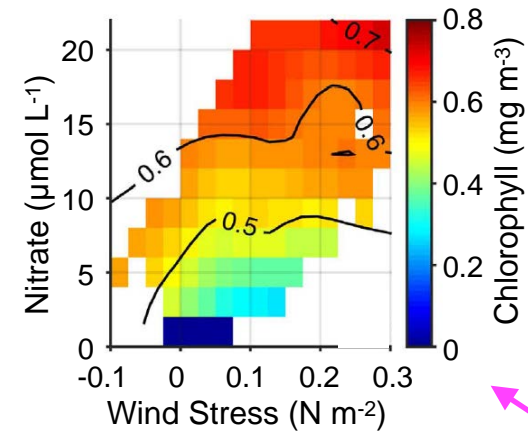
El Niño / La Niña in the Central CCS (1998-1999)



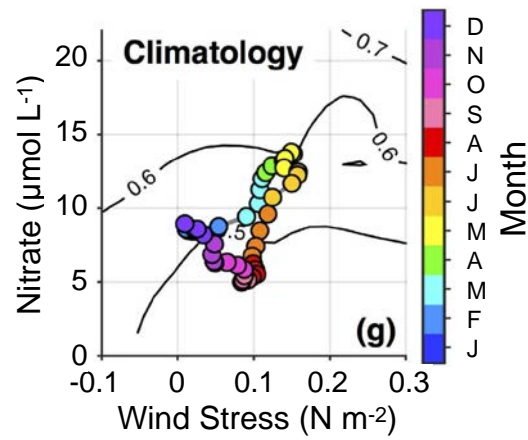
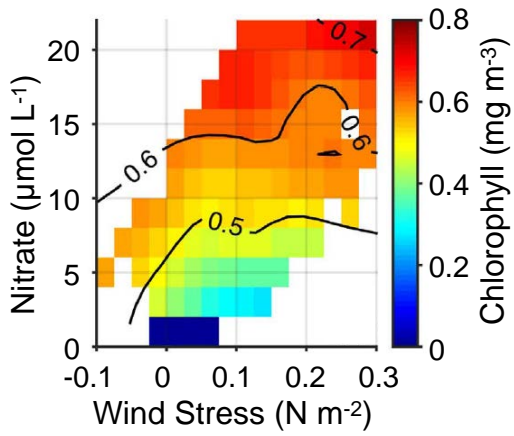
El Niño / La Niña in the Central CCS (1998-1999)



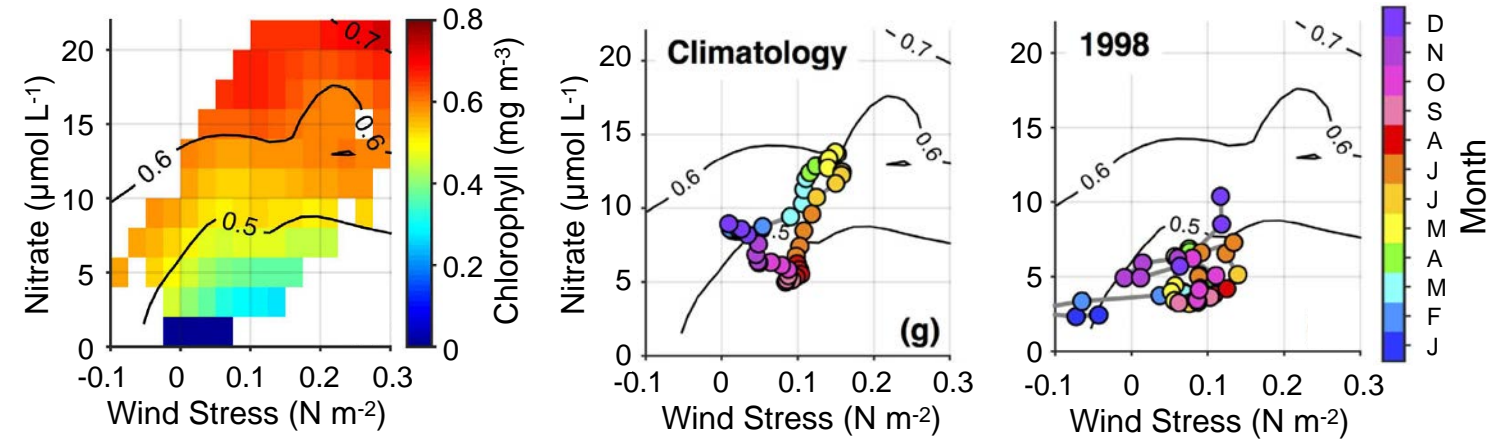
El Niño / La Niña in the Central CCS (1998-1999)



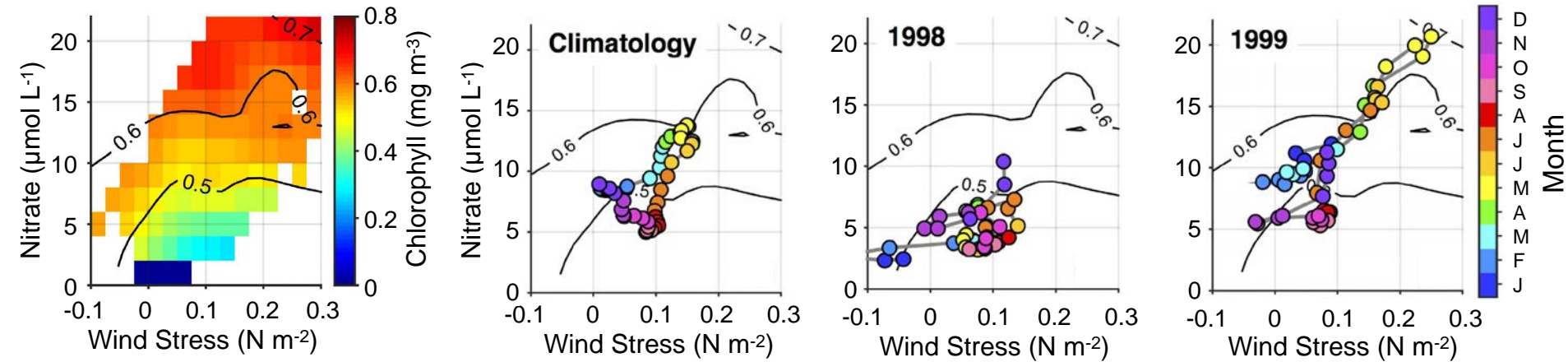
El Niño / La Niña in the Central CCS (1998-1999)



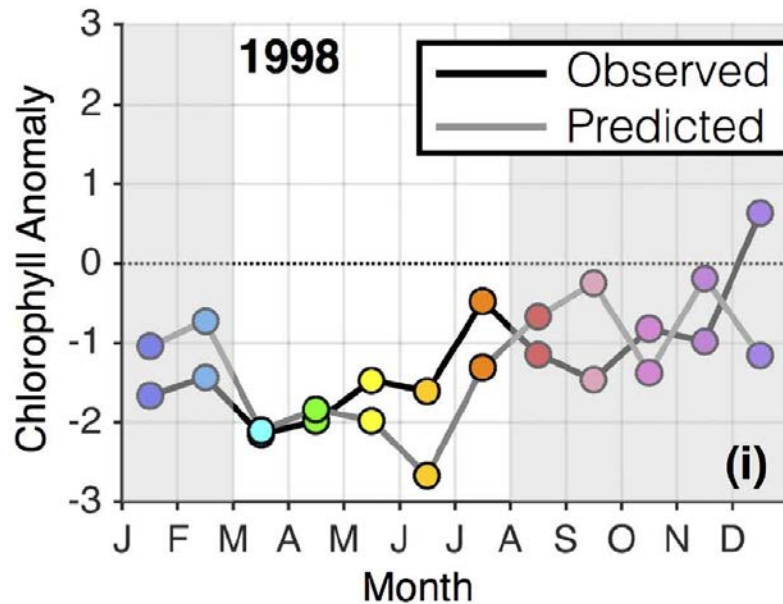
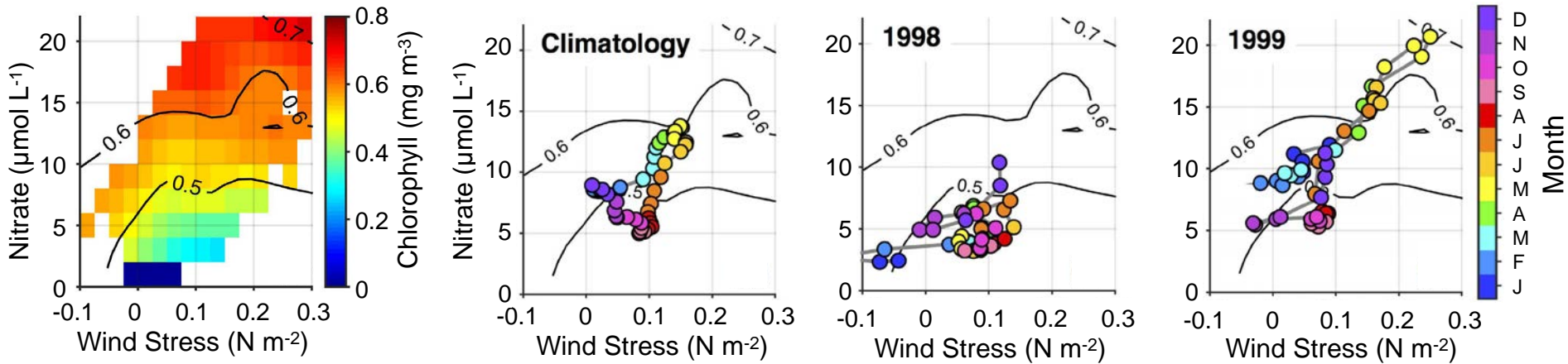
El Niño / La Niña in the Central CCS (1998-1999)



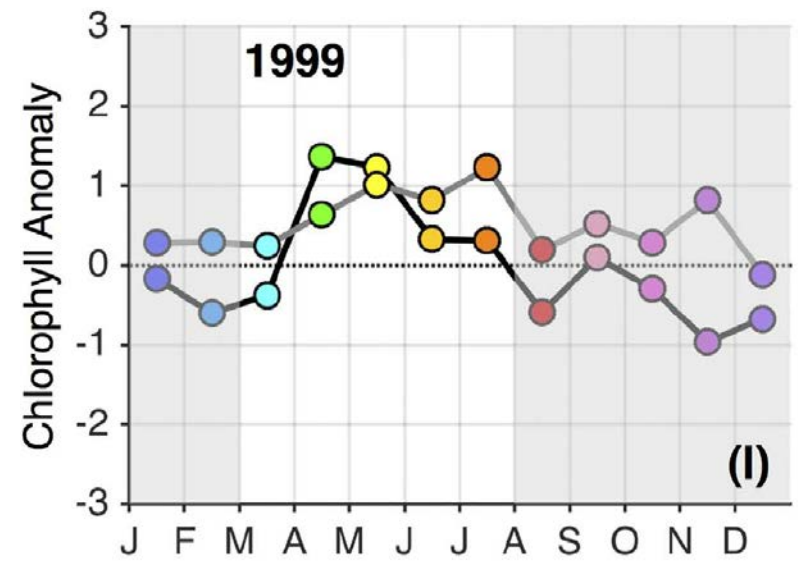
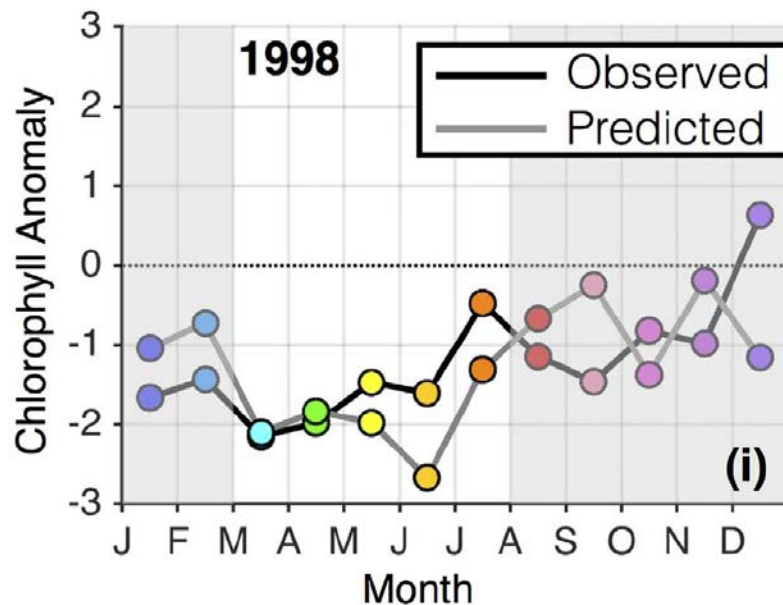
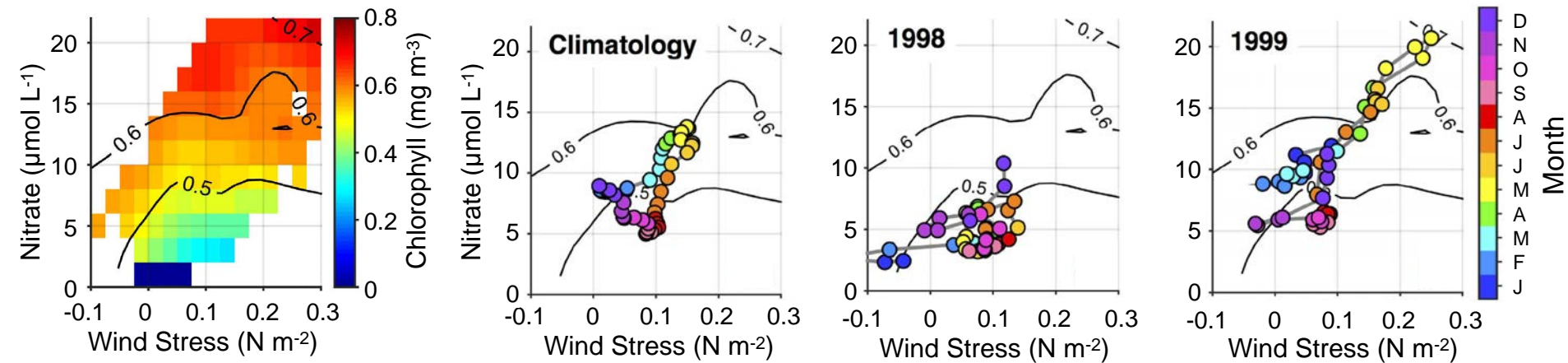
El Niño / La Niña in the Central CCS (1998-1999)



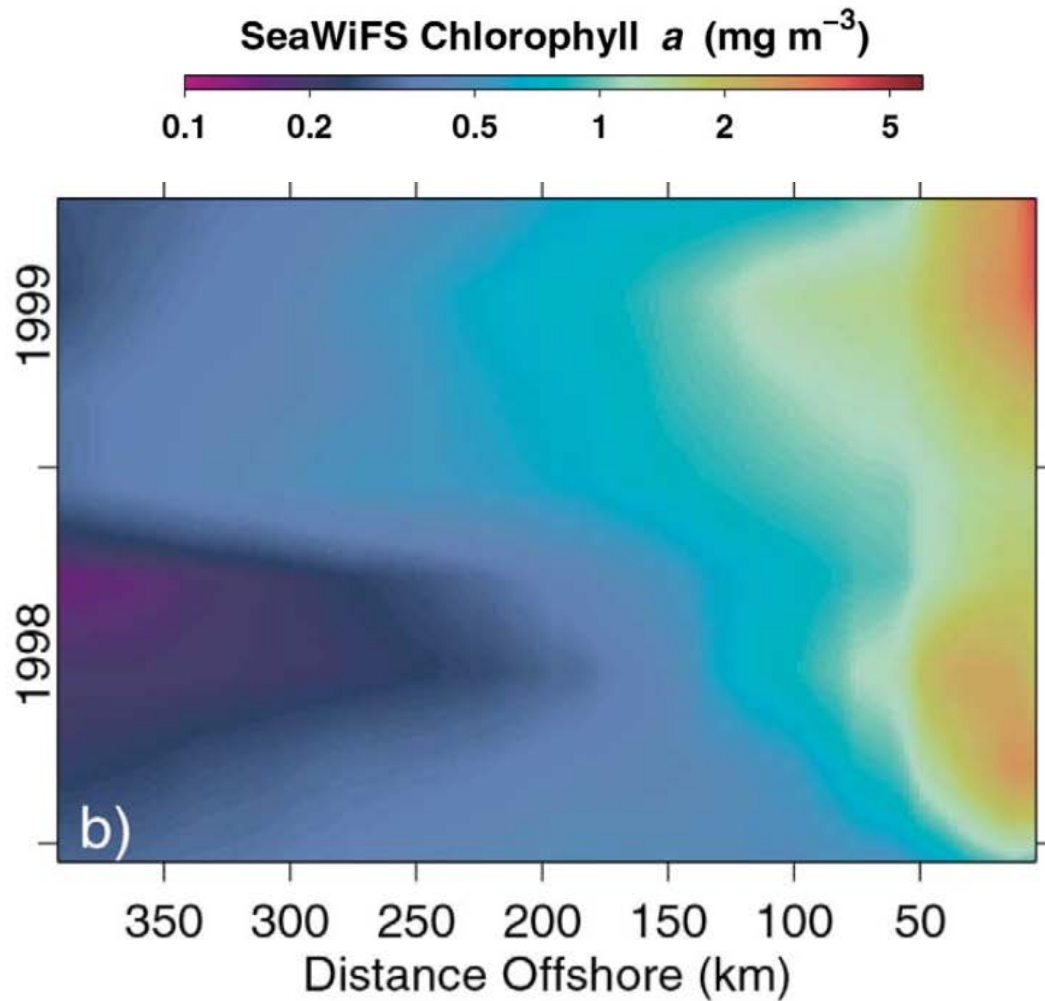
El Niño / La Niña in the Central CCS (1998-1999)



El Niño / La Niña in the Central CCS (1998-1999)

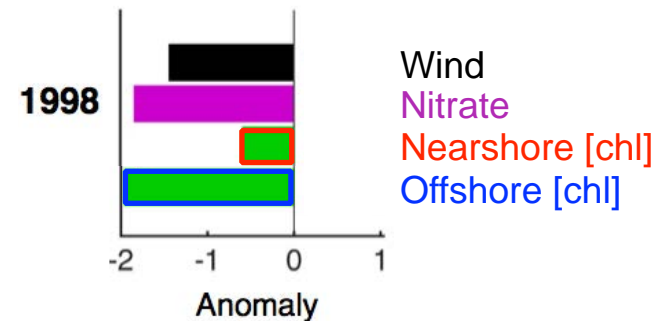
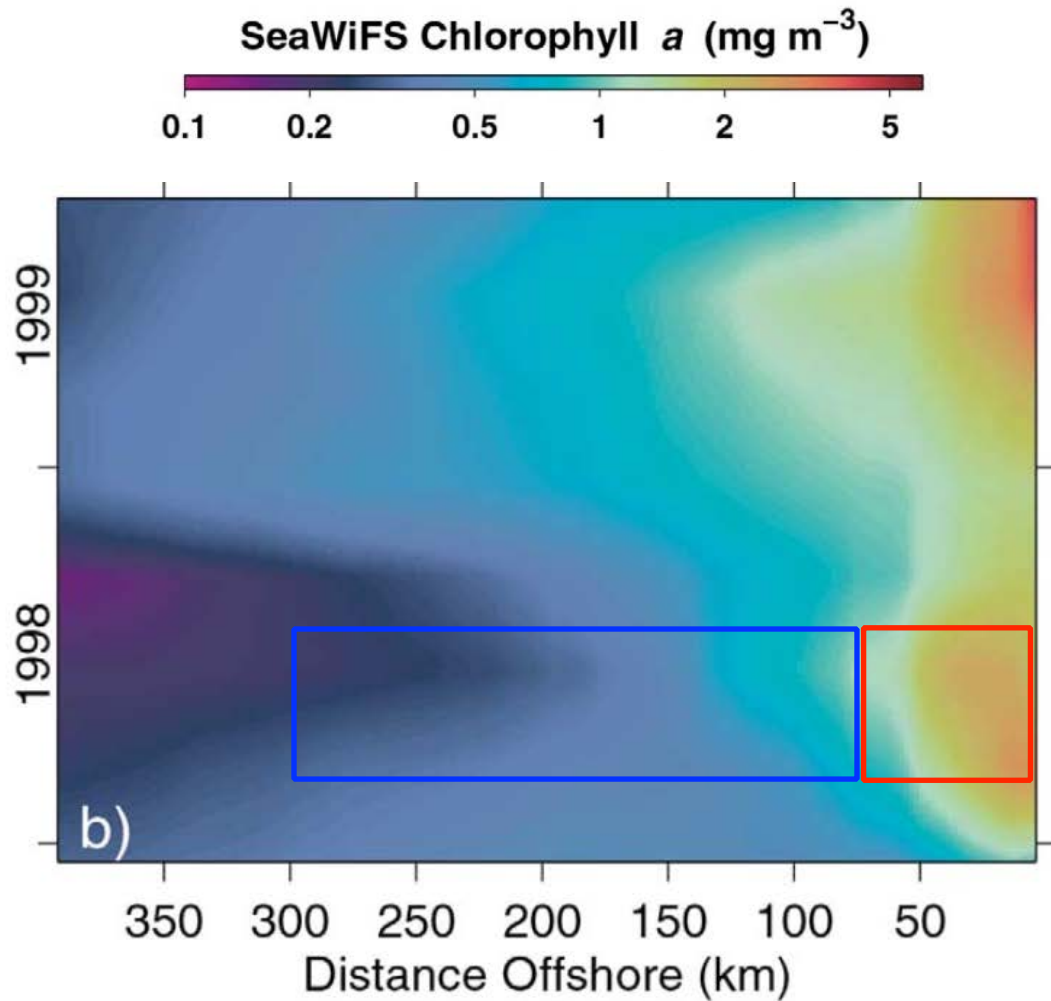


El Niño / La Niña in the Central CCS (1998-1999)



Chavez et al., Prog. Oceanogr. (2002)

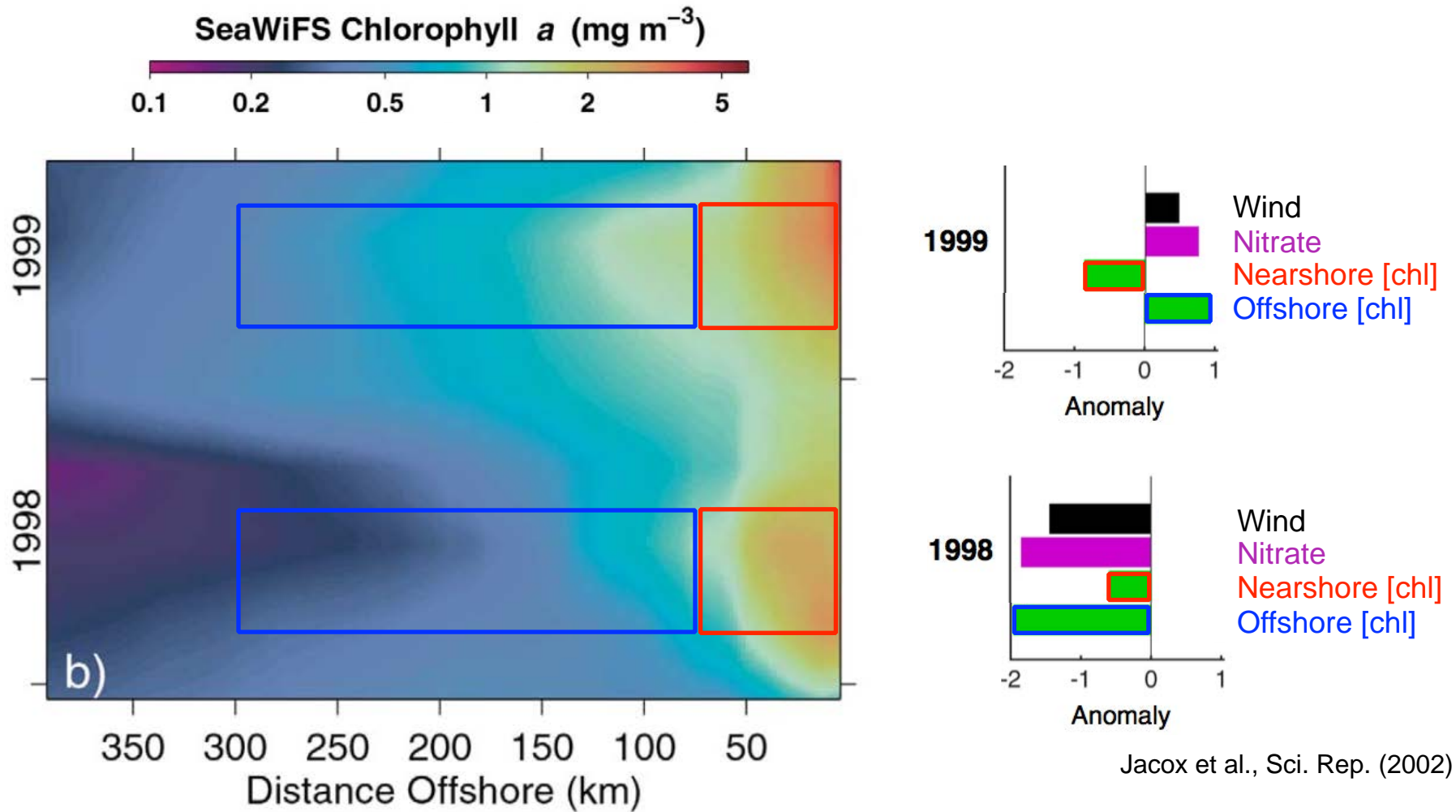
El Niño / La Niña in the Central CCS (1998-1999)



Jacox et al., Sci. Rep. (2002)

Chavez et al., Prog. Oceangr. (2002)

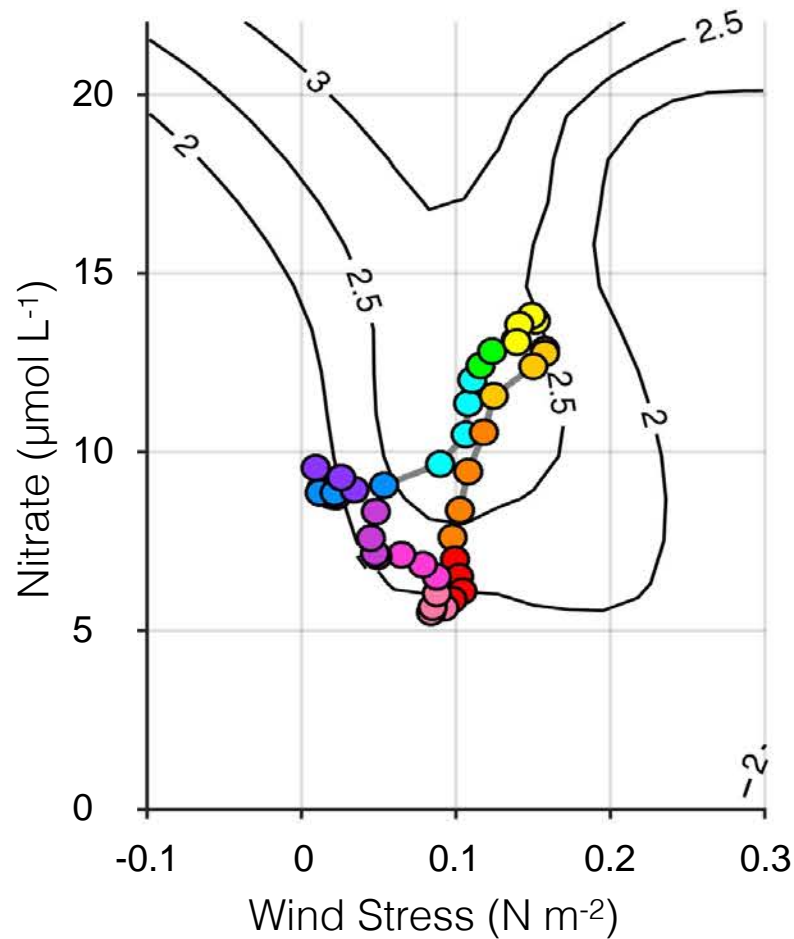
El Niño / La Niña in the Central CCS (1998-1999)



Chavez et al., Prog. Oceanogr. (2002)

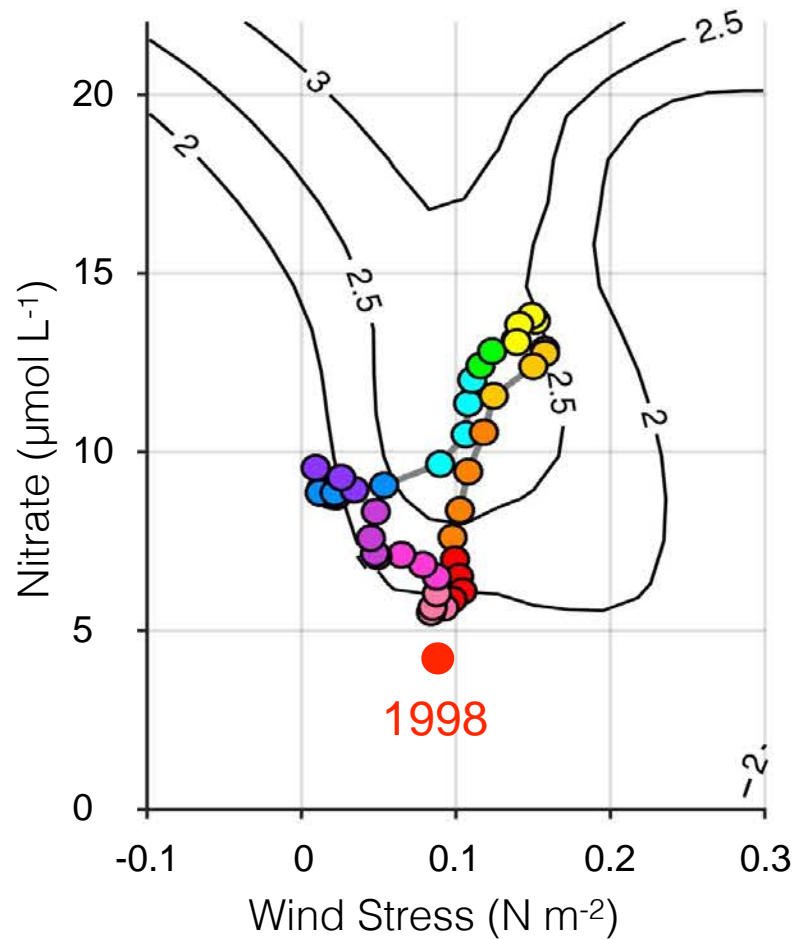
Jacox et al., Sci. Rep. (2002)

A Framework for Assessing Impacts of Climate **Variability**



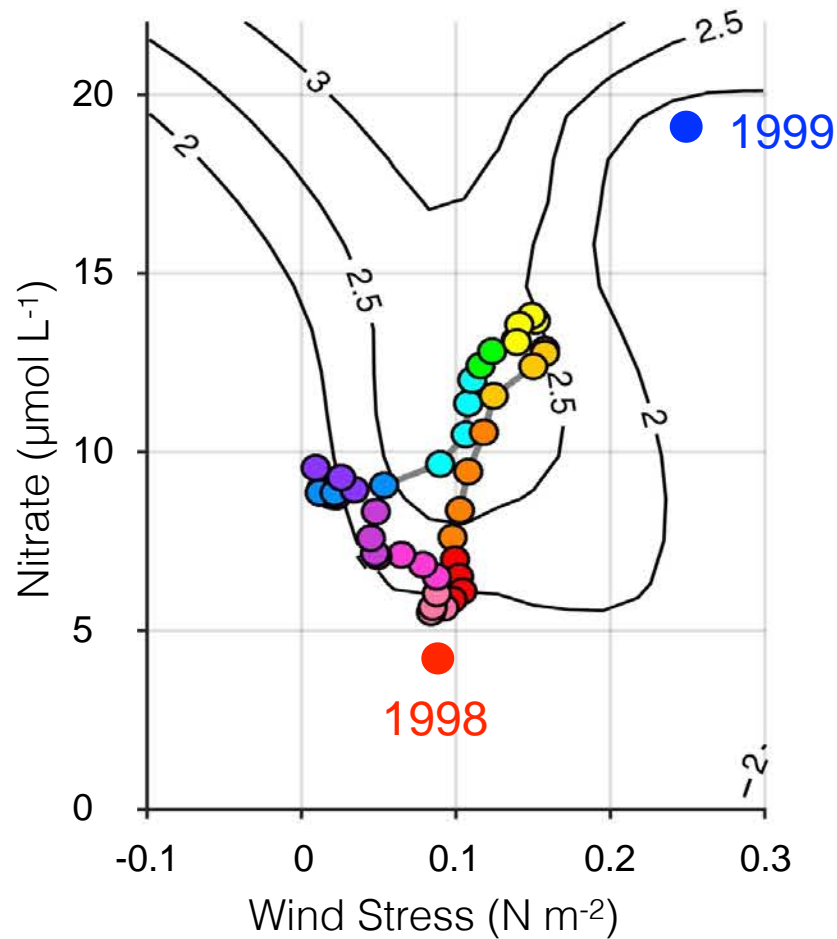
Jacox et al., Scientific Reports (2016)

A Framework for Assessing Impacts of Climate **Variability**



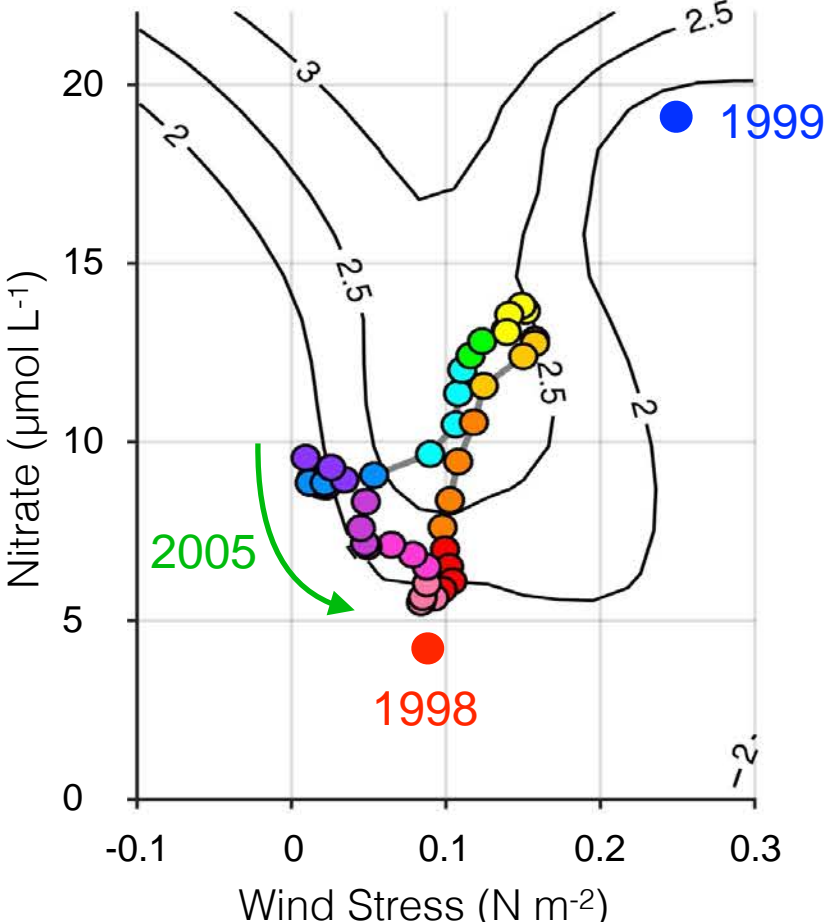
Jacox et al., Scientific Reports (2016)

A Framework for Assessing Impacts of Climate **Variability**



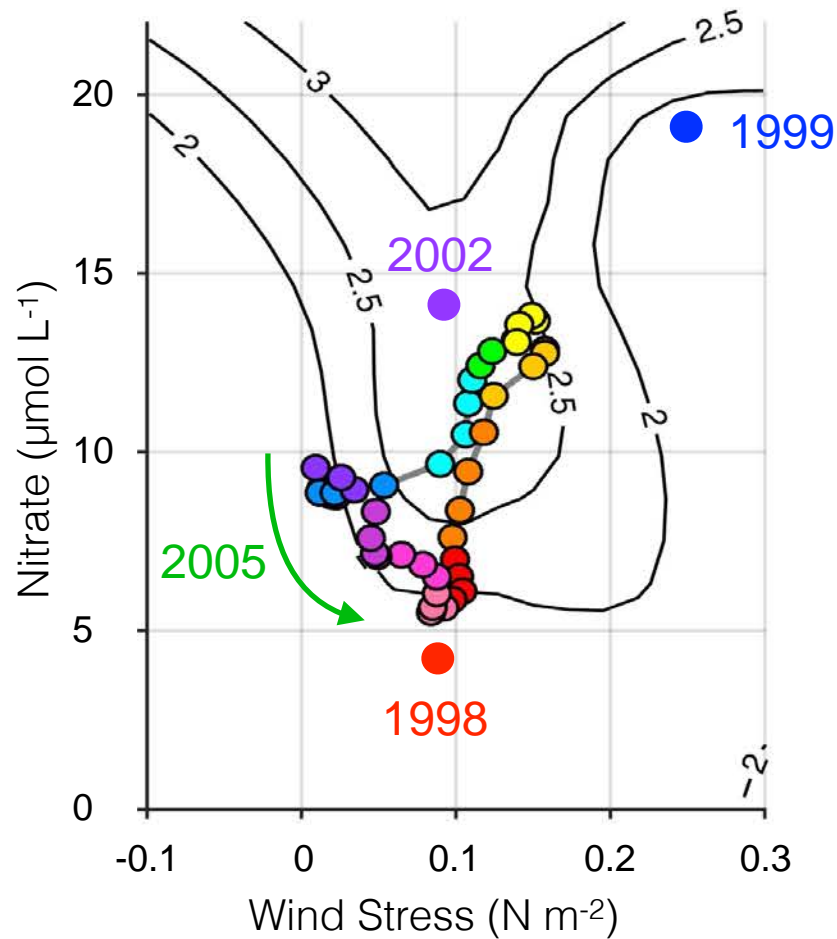
Jacox et al., Scientific Reports (2016)

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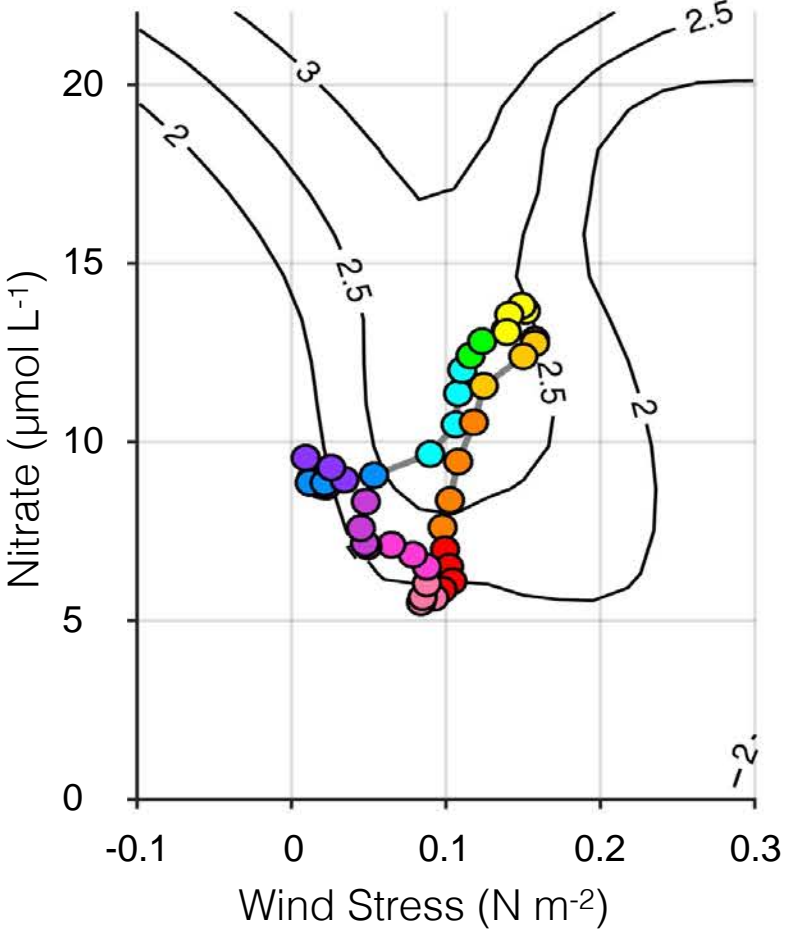
Jacox et al., Scientific Reports (2016)

A Framework for Assessing Impacts of Climate **Variability**



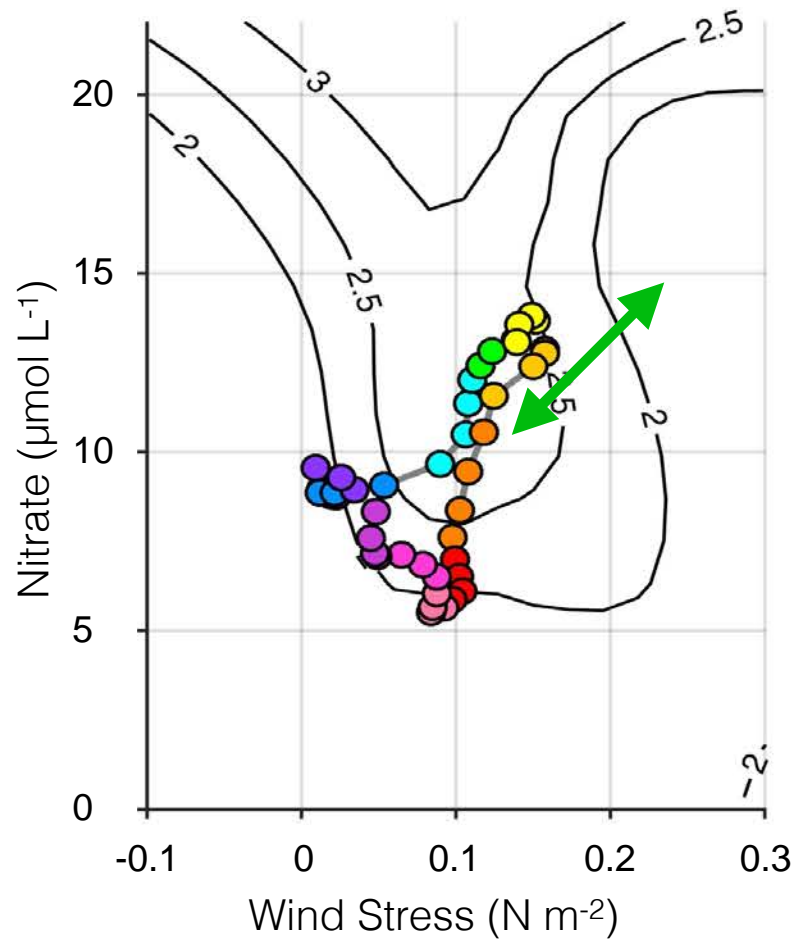
Jacox et al., Scientific Reports (2016)

A Framework for Assessing Impacts of Climate Change?



Jacox et al., Scientific Reports (2016)

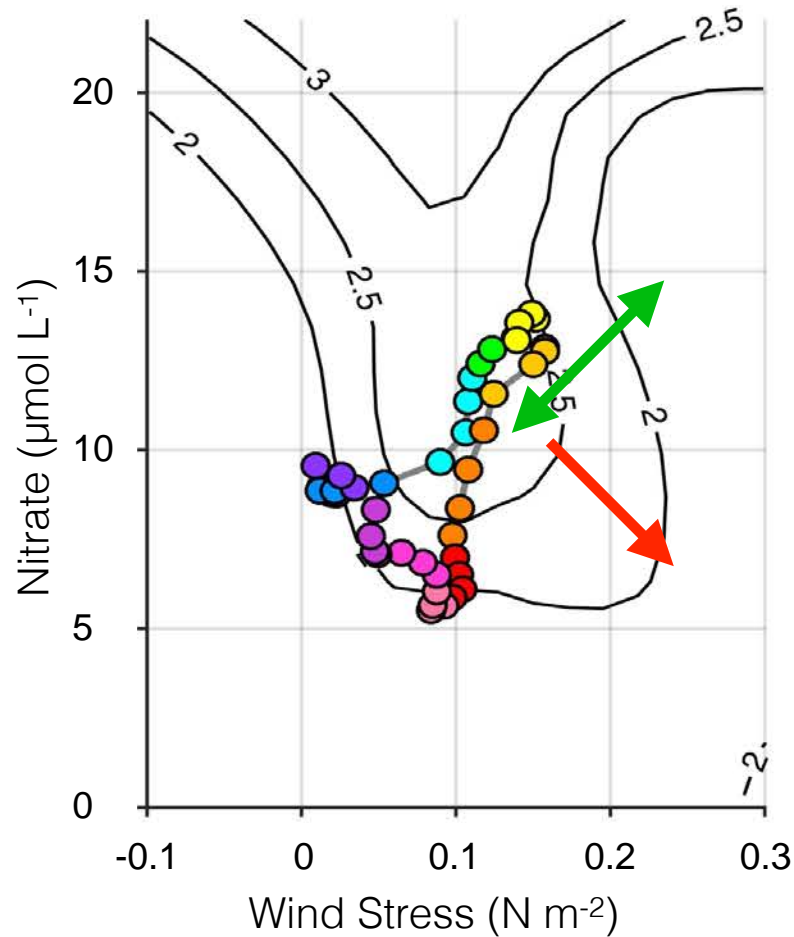
A Framework for Assessing Impacts of Climate **Change?**



Wind dominates
Bakun et al. (1990)
Aquad et al. (2006)

Jacox et al., Scientific Reports (2016)

A Framework for Assessing Impacts of Climate Change?



Wind dominates

Bakun et al. (1990)

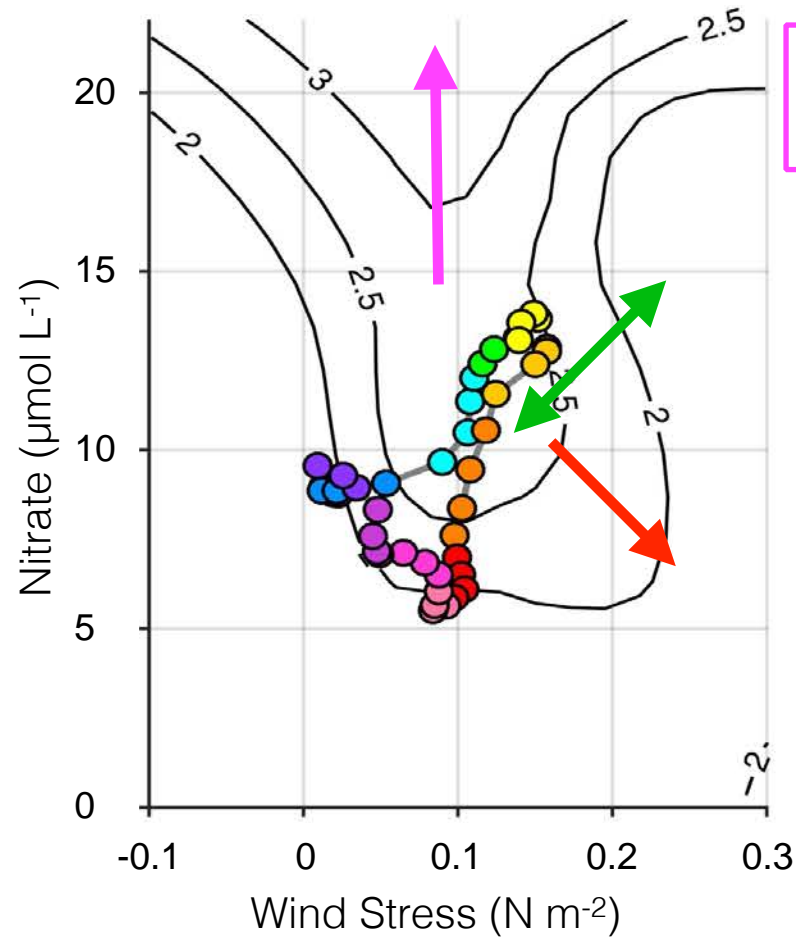
Auad et al. (2006)

Heat Flux dominates

Di Lorenzo et al. (2005)

Jacox et al., Scientific Reports (2016)

A Framework for Assessing Impacts of Climate Change?



Source Nitrate dominates

Rykaczewski and Dunne (2010)

Wind dominates

Bakun et al. (1990)

Auad et al. (2006)

Heat Flux dominates

Di Lorenzo et al. (2005)

Jacox et al., Scientific Reports (2016)