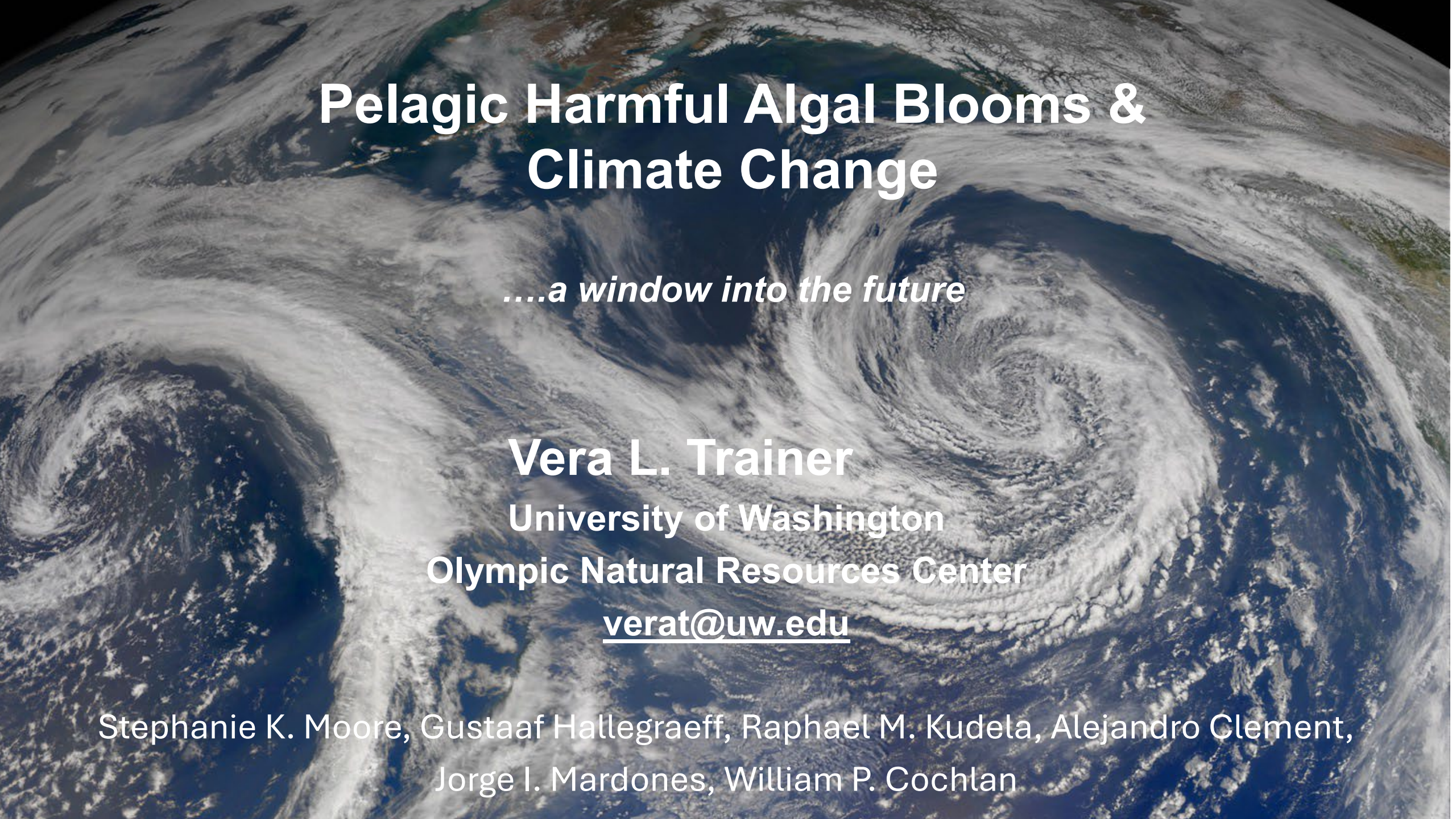


Pelagic Harmful Algal Blooms & Climate Change

….a window into the future

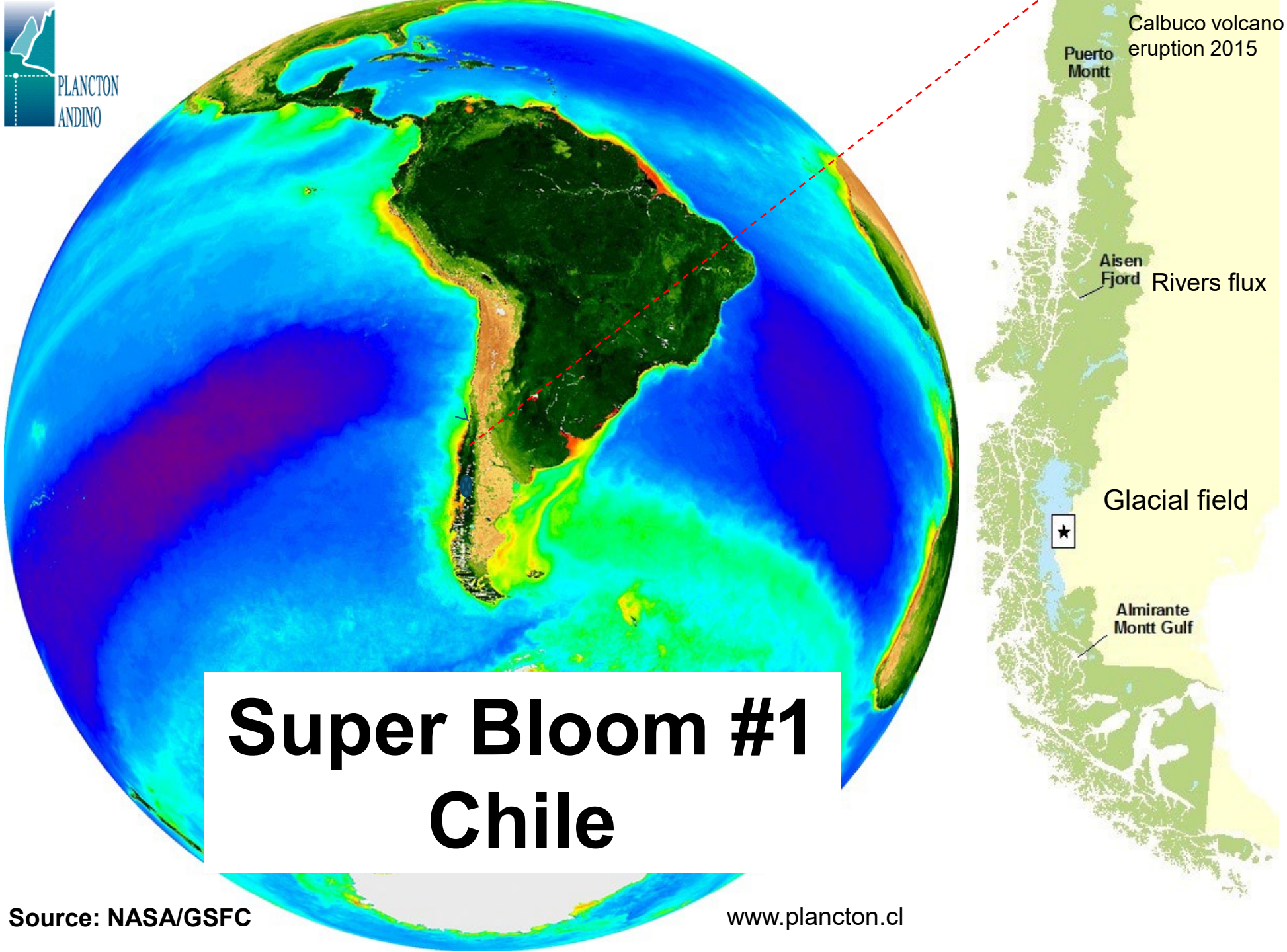
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Stephanie K. Moore, Gustaaf Hallegraeff, Raphael M. Kudela, Alejandro Clement, Jorge I. Mardones, William P. Cochlan



Super Bloom #1 Chile

Source: NASA/GSFC

www.plancton.cl

INTRODUCTION

1. Exceptional summer-fall climatic anomalies and/or “El Niño” signals during 2016.
2. Several HABs in fjords & oceanic coastal waters with enormous social & economic impacts.
3. These blooms have been the most damaging in South America with losses >US$ 600 M.
4. Main species were ***Pseudochattonella* cf. *verruculosa***, and ***A. catenella***, among other flagellates.



Thousands of clams beached in southern Chile where fish and shellfish has been poisoned by the red tide, heaping economic pressure on fishermen. Photograph: Alvaro Vidal/AFP/Getty Images

Thousands of fishermen are protesting the government's failure to mitigate effects of a poisonous 'red tide' algal bloom scientists call largest in history

Reuters in Santiago /3 May 2016



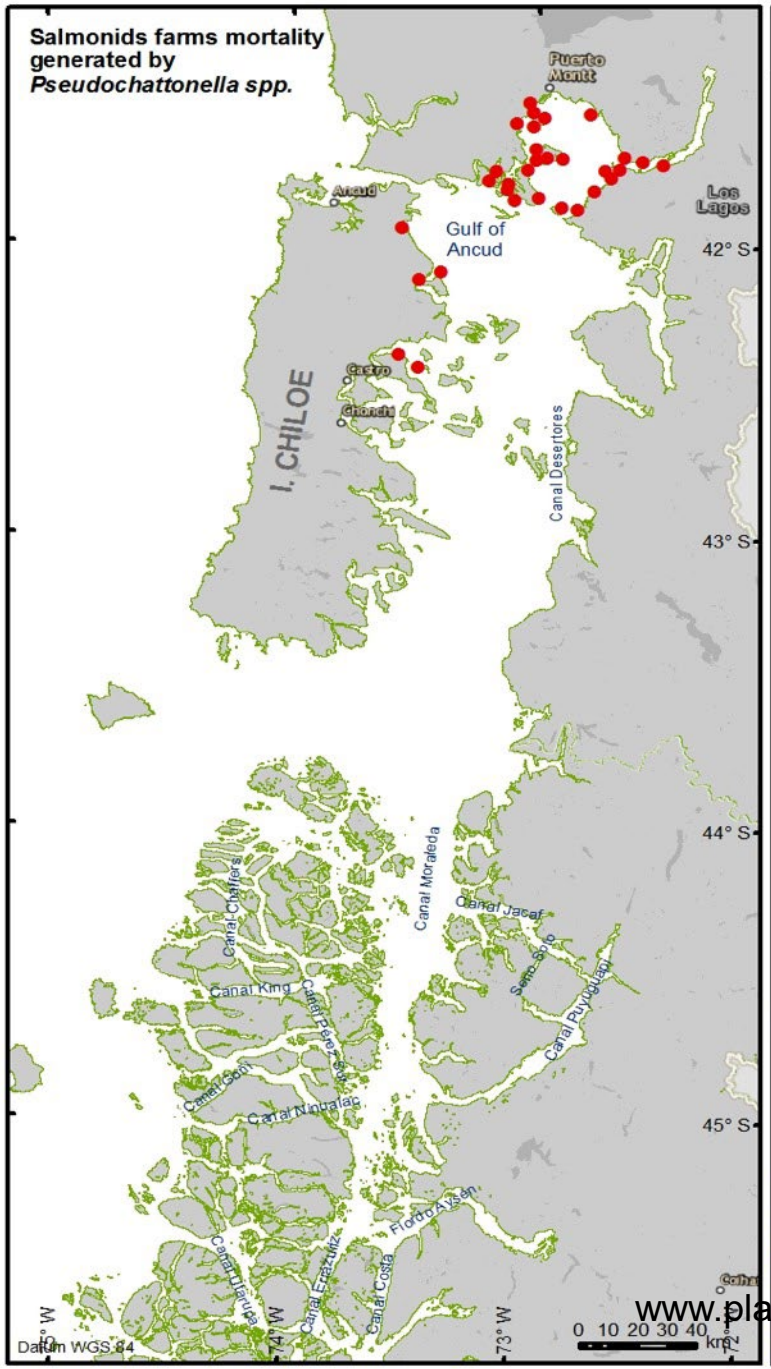
Chilean fishermen protest after blocking some of the main routes of Isla Grande in Chiloé. Alvaro Vidal/EPA

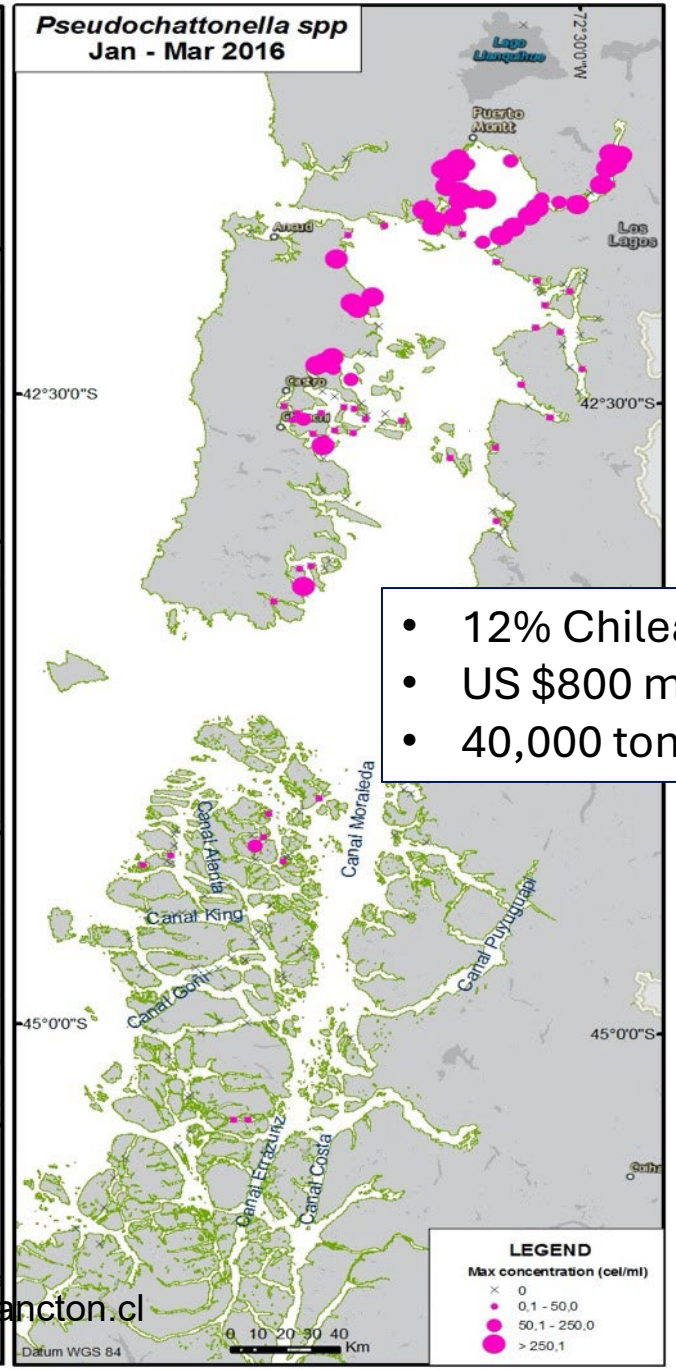


Credit: Pilar Pezoa/IPS

PLANCTON ANDINO

Salmon farms mortality due to *Pseudochattonella* blooms January and first half of March 2016.



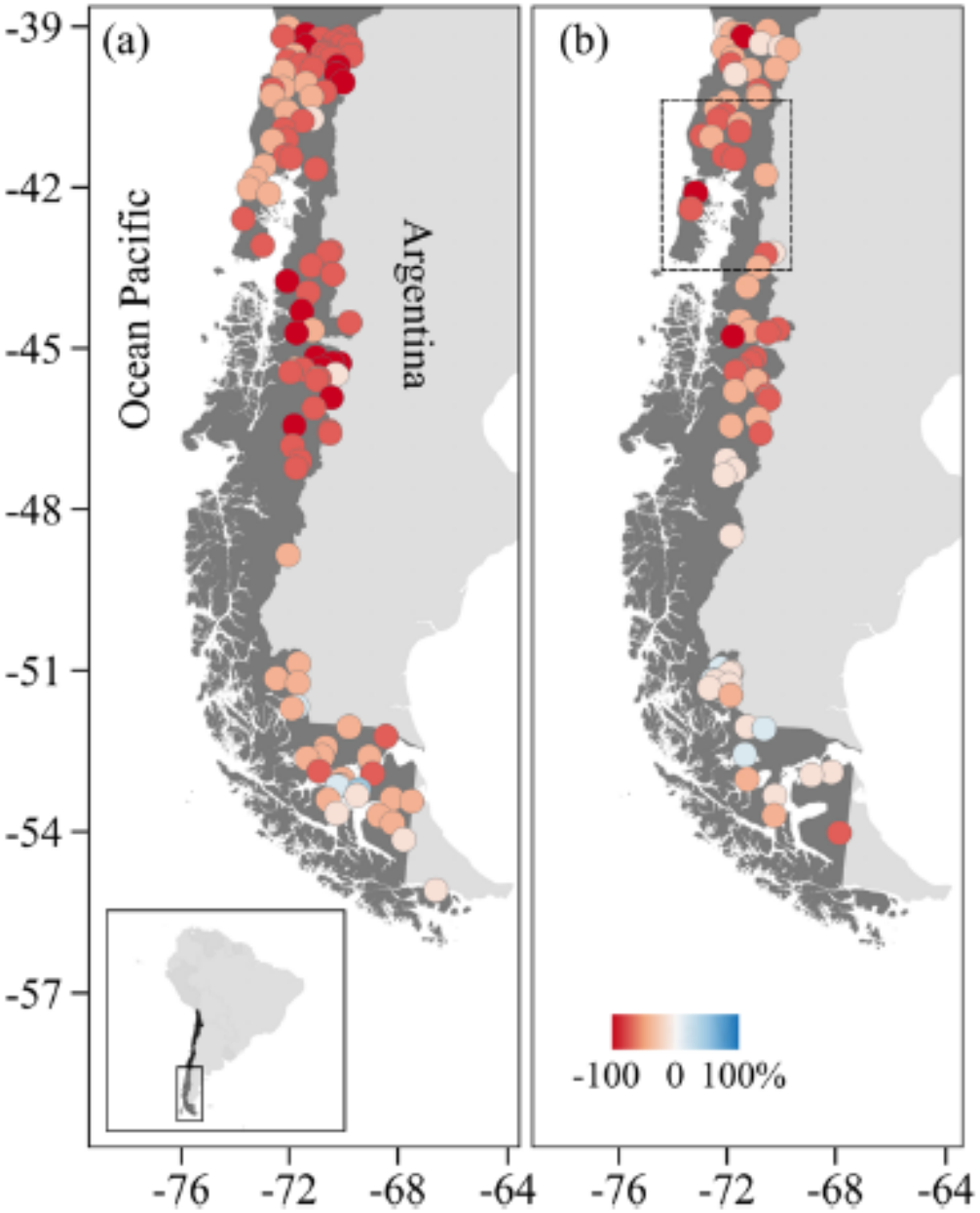


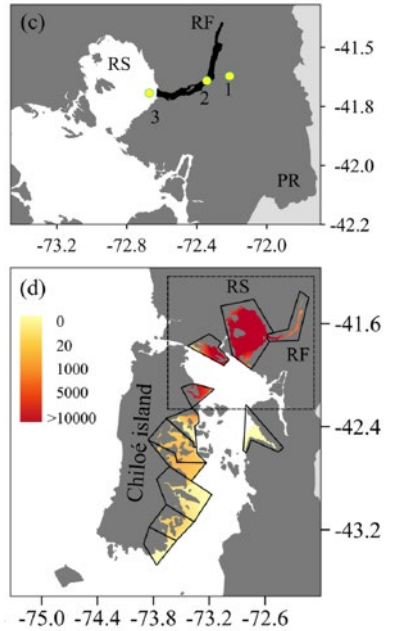
- 12% Chilean salmon lost
- US $800 million
- 40,000 tons biomass

www.plancton.cl

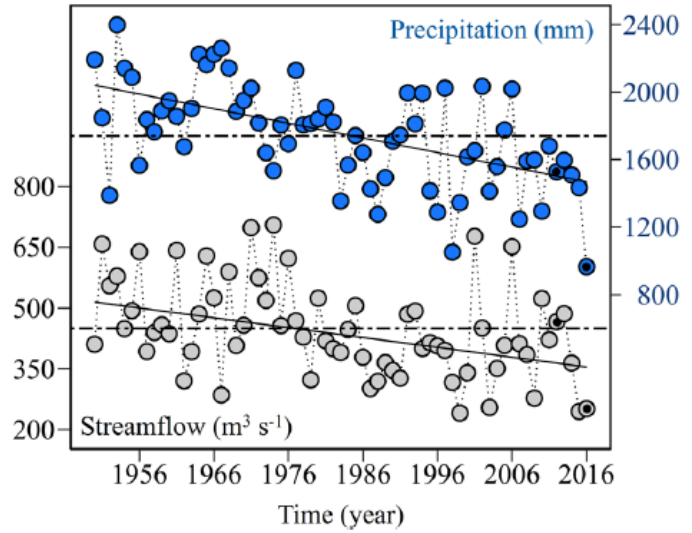
Rainfall anomaly

Streamflow anomaly



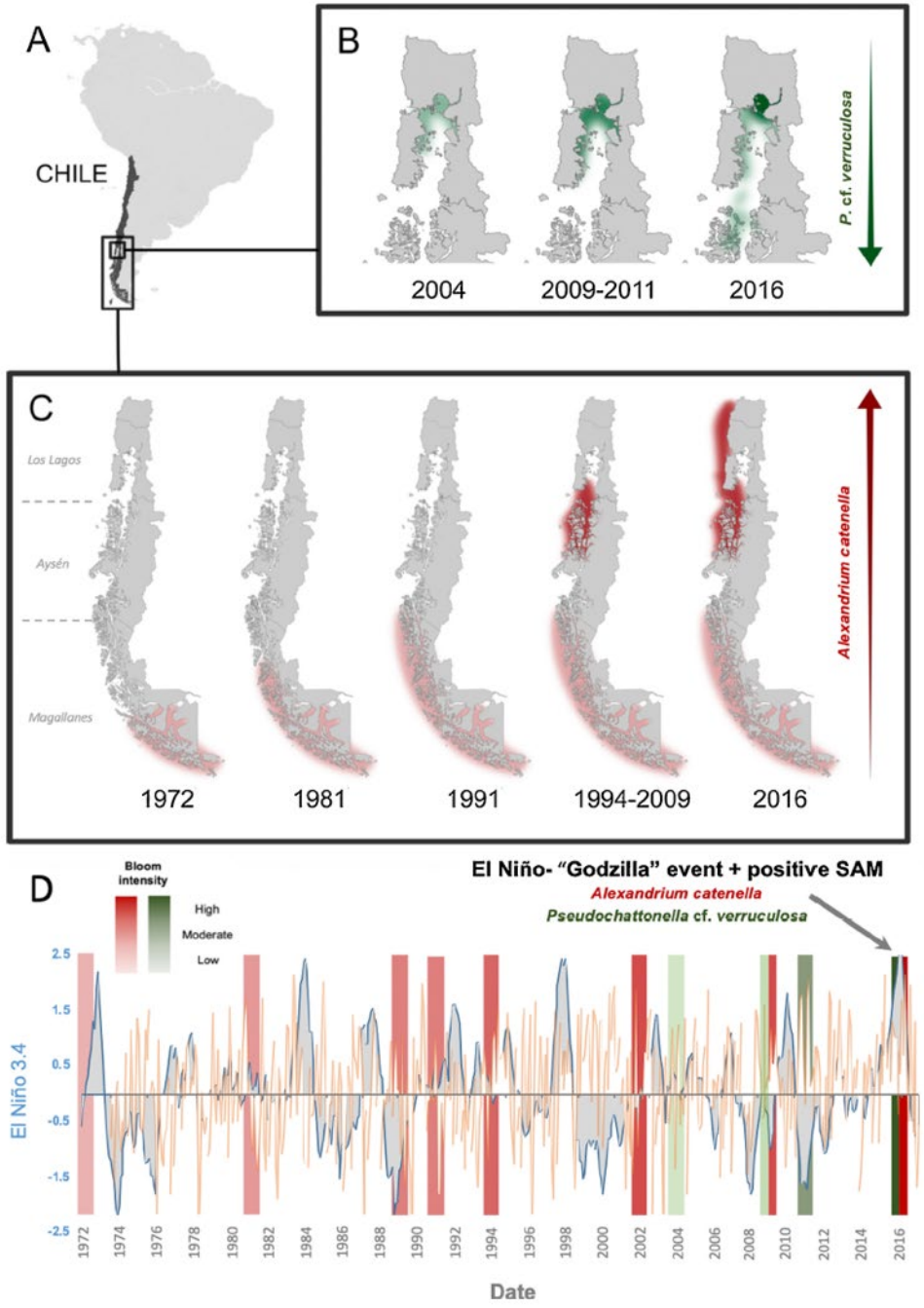


Gauging stations, *Pseudochattonella* bloom



Puedo River (Jan, Feb, Mar)
Puerto Montt annual precip

Leon-Munoz et al. 2018



Southward expansion of *Pseudochattonella*

Northward expansion of *Alexandrium*

Orange: Southern Annual Mode
Blue: El Niño 3.4 index

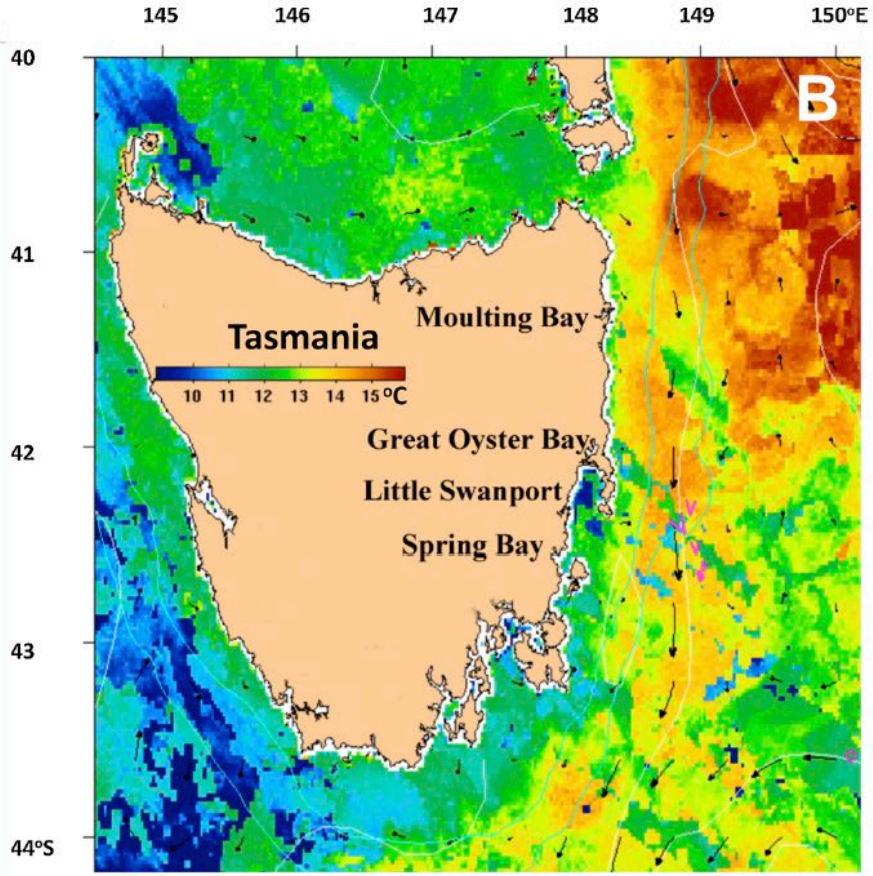
- SAM = anthropogenic forcing
- El Niño usually favors negative phase of SAM
- Climate change overcomes negative El Niño forcing to SAM

Leon-Munoz et al. 2018

Super Bloom #2
Tasmania
2012-2018

A

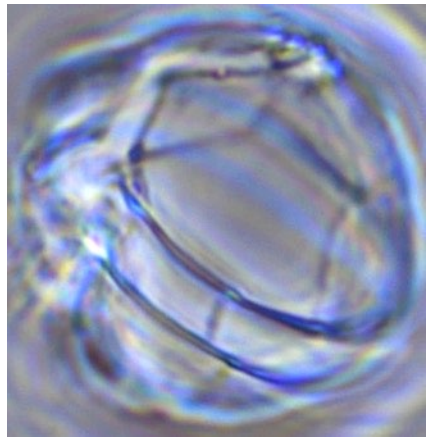




Hidden Flora

"present in sediment, but not expressed"

- Sediments indicate *A. catenella* group 1 present since at least 1987
- No historic records of paralytic shellfish poisoning (PSP) from Aboriginal tribes
- Not a ballast water intrusion or range expansion

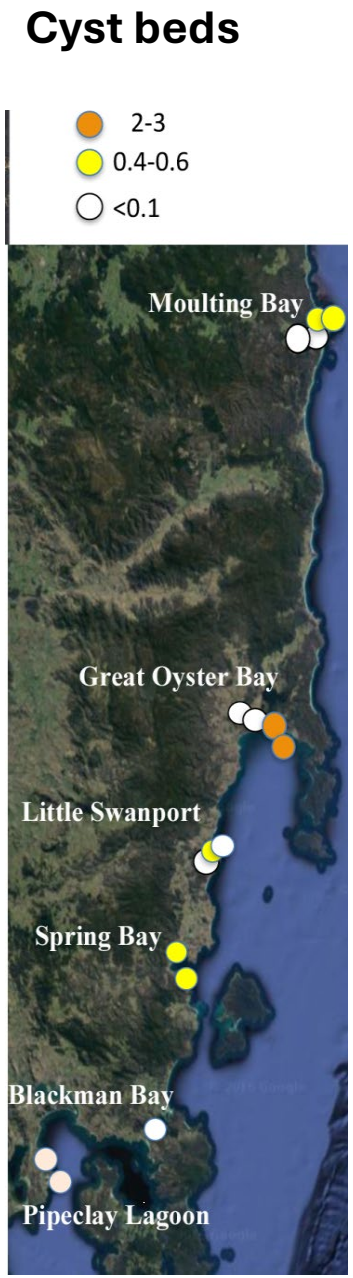


Previously cryptic genotype newly stimulated stimulated by climate-driven increases in stratification during winter and early spring

Hidden flora

- Narrow T window (10-15ºC) but not a simple response to increasing T
- High rainfall and land runoff
- Lower Si
- Stronger EAC and rapidly increasing ocean T (2.3ºC warmer than 1940s) – earlier development of stratified conditions





The Impact

Fisheries; Aquaculture; Human Health; Tourism

2012: 12 mg PST /kg in mussels; $23M loss
2013 and 2014: low toxicity , no closures
2015; 19 mg PST /kg; 300,000 cells/L;
4 hospitalizations; 20 wk closures
2016: 30 mg/kg; 24 wk closures
2017: 186 mg/kg; 300,000 cells/L; 25 wk
2018: 17 mg/kg in mussels

0.8 mg/kg regulatory closure level

+ Risk for Salmon Farms





186



27



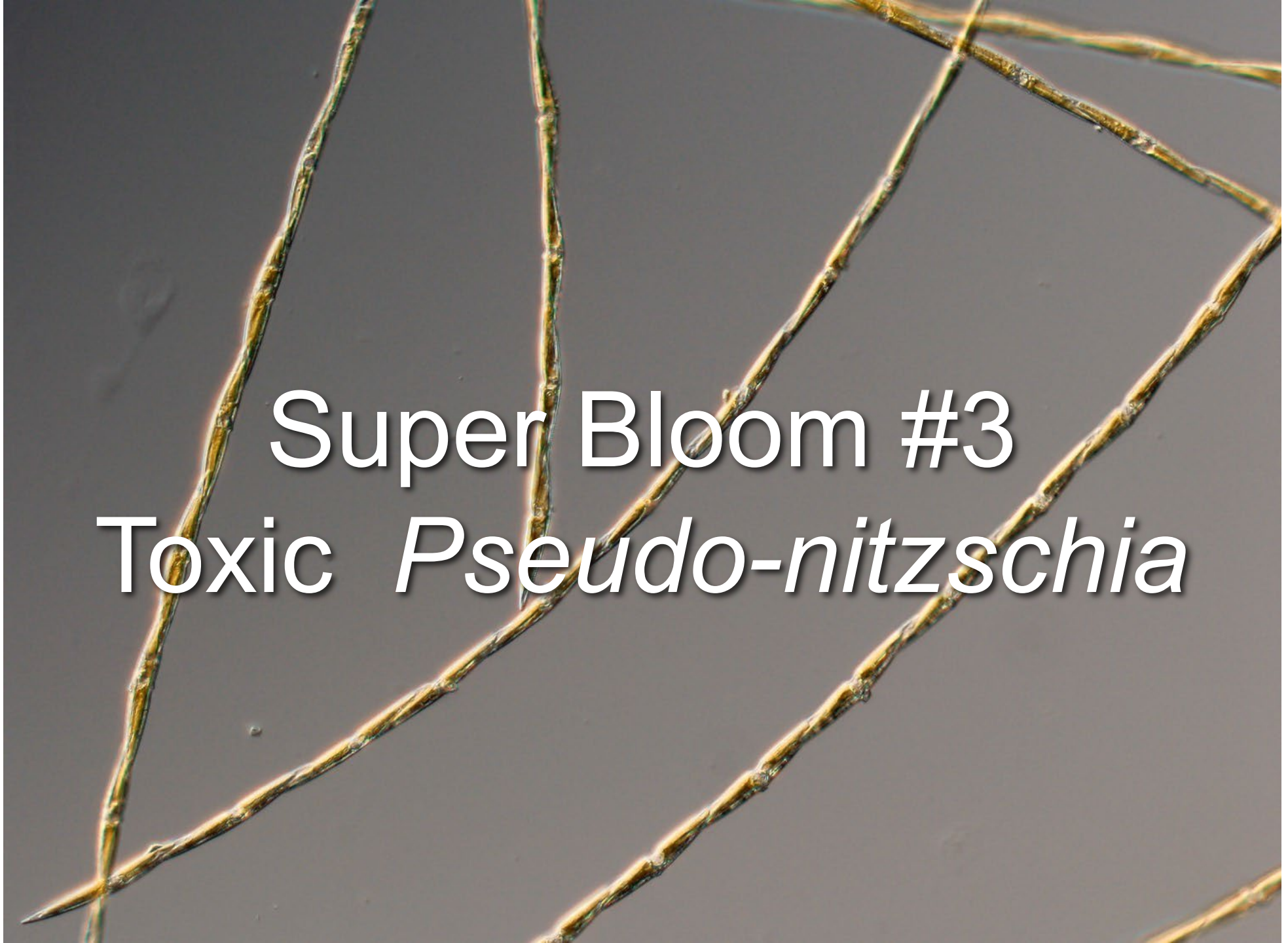
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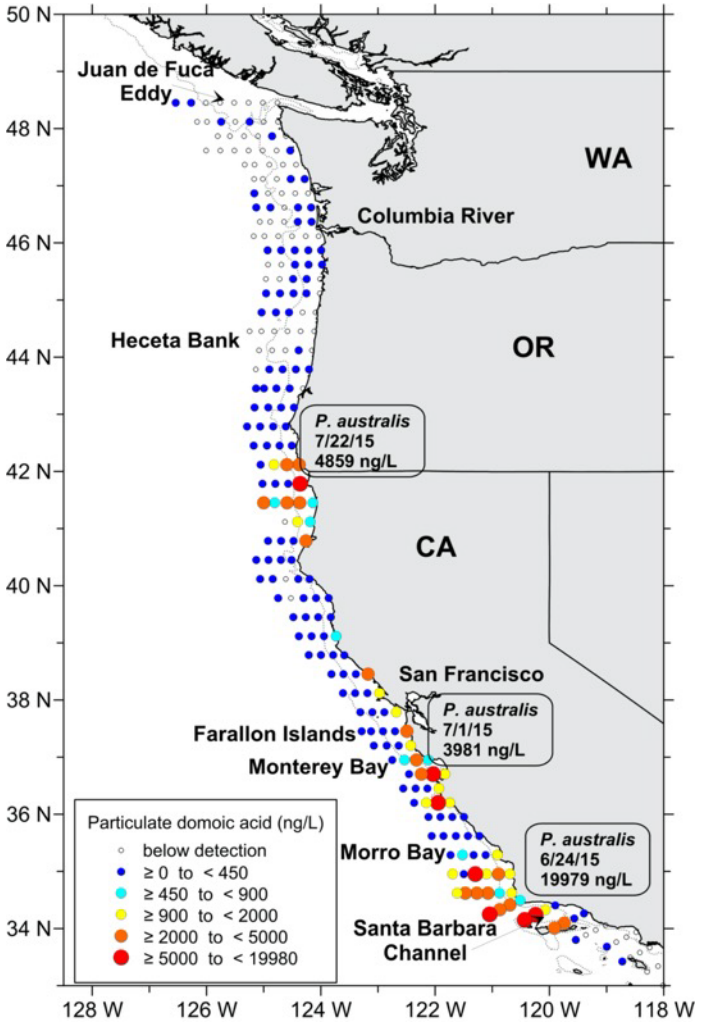
1.6 (foot)



14 HP mg STXdiHCl.eq/kg


Super Bloom #3
Toxic *Pseudo-nitzschia*

2015 Massive *Pseudo-nitzschia* bloom



Particulate Domoic Acid (ng/L)
(NOAA R/V *Shimada* cruise)

McCabe et al. 2016 Geophys. Res. Lett.

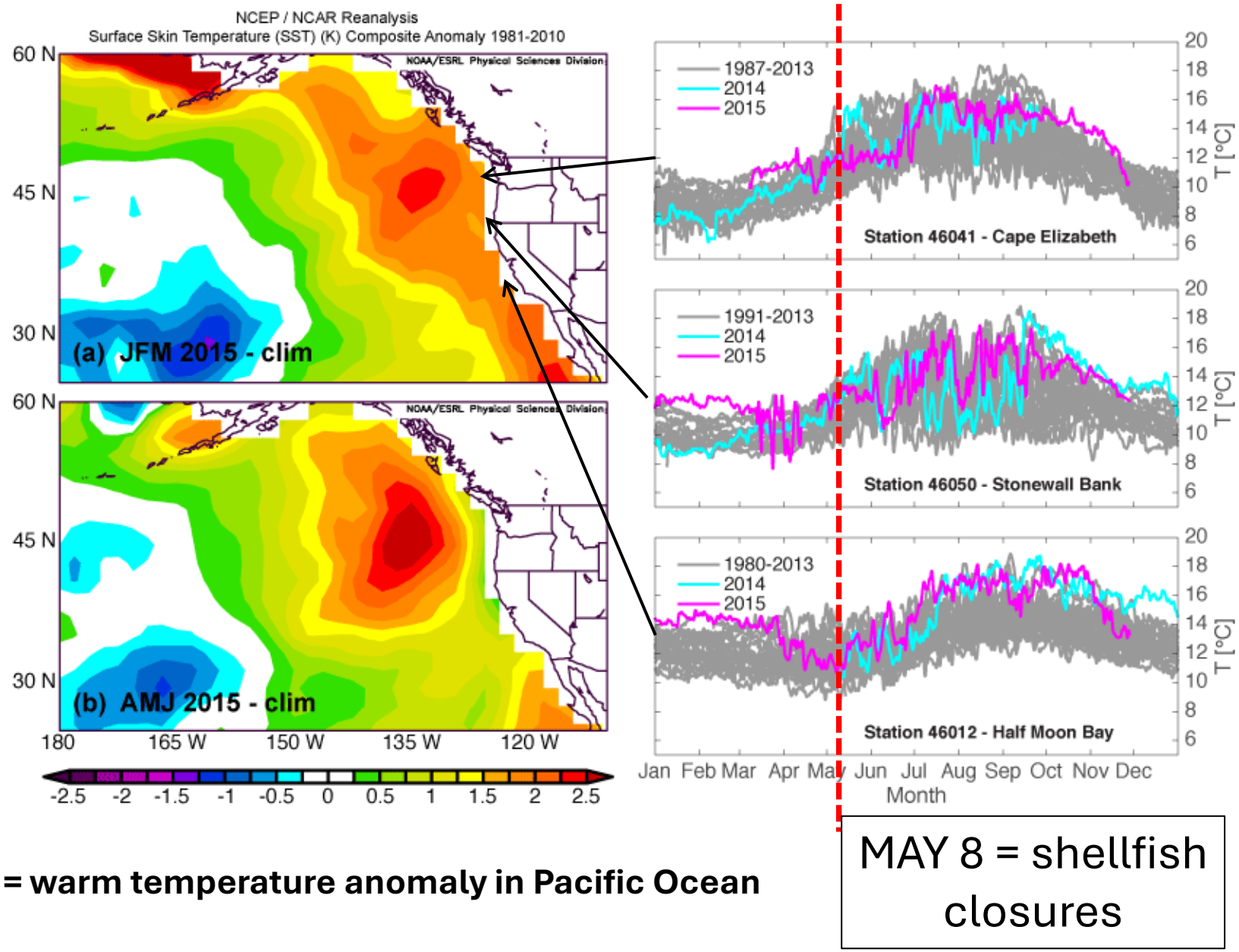
Peak toxin levels of >100,000 ng/L (new record)

Trophic Transfer:

Regulatory limit 20 ppm

- Mussels up to 200 ppm
- Anchovy 100-600 ppm, viscera >3,000 ppm
- Razor Clam 340 ppm
- Rock Crab = 1,000 ppm
- Dungeness = 270 ppm
- West Coast survey: 100% of planktivorous fish contaminated

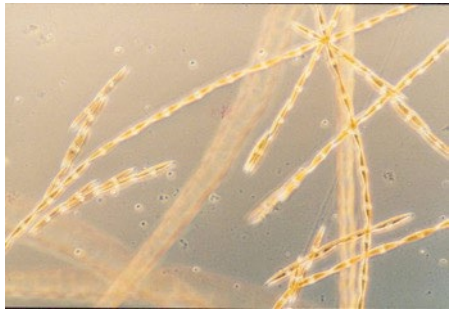
Blob water came to the coast in Sept 2014 – March 2015

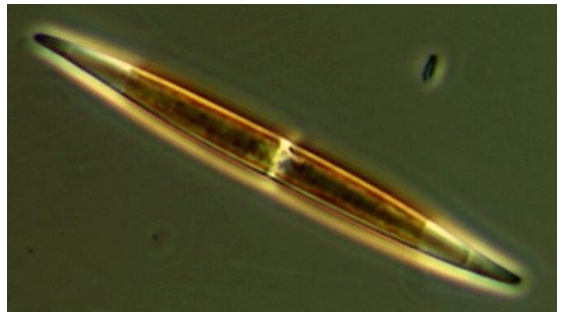


The "Blob" = warm temperature anomaly in Pacific Ocean

MAY 8 = shellfish closures

What made 2015 an unusual year

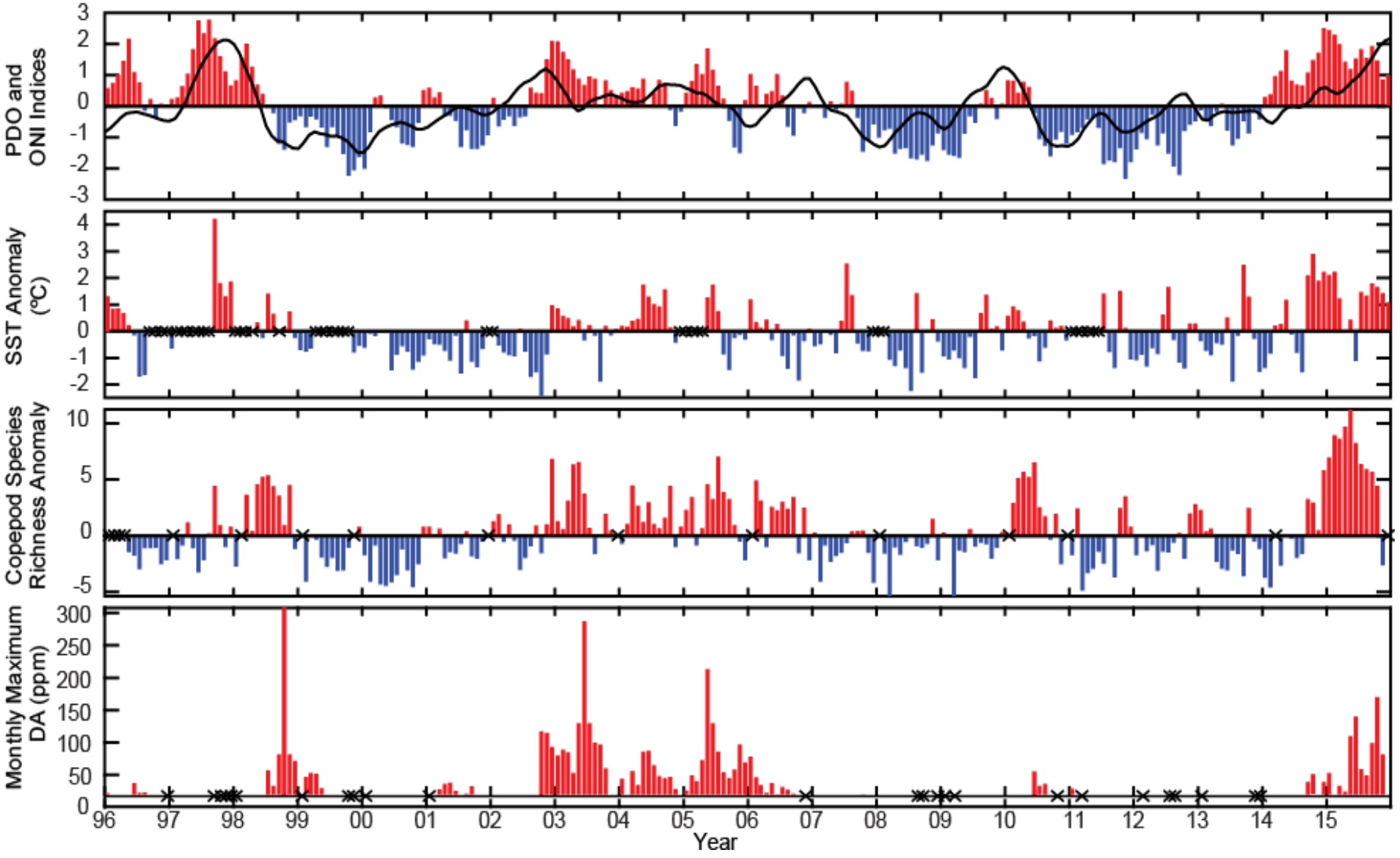


- Spring timing of large toxic *Pseudo-nitzschia* bloom
- Simultaneous coastwide closures of shellfish harvest (California to Canada)
- Unusual delivery of toxic cells due to large-scale weather patterns that cause more northward transport over NE Pacific Ocean
- The Blob as an offshore delivery mechanism & incubator for toxic cells

What does the future hold?

Toxic *Pseudo-nitzschia* & climate



McCabe et al., 2016
McKibben et al. 2017

Acknowledgements

USA Story

- Stephanie Moore (NOAA Fisheries)
- Raphael Kudela (U. Calif. Santa Cruz)
- William Cochlan (San Francisco State Univ)

Chile Story

- Alejandro Clemént (Plancton Andino spA)
- Jorge Mardones (Centro de Estudios de Algas Nocivas)

Tasmania Story

- Gustaaf Hallegraeff (U. Tasmania)

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Trainer et al. 2019 Harmful Algae