Impact of Pacific Ocean Heatwaves on Phytoplankton Community Composition

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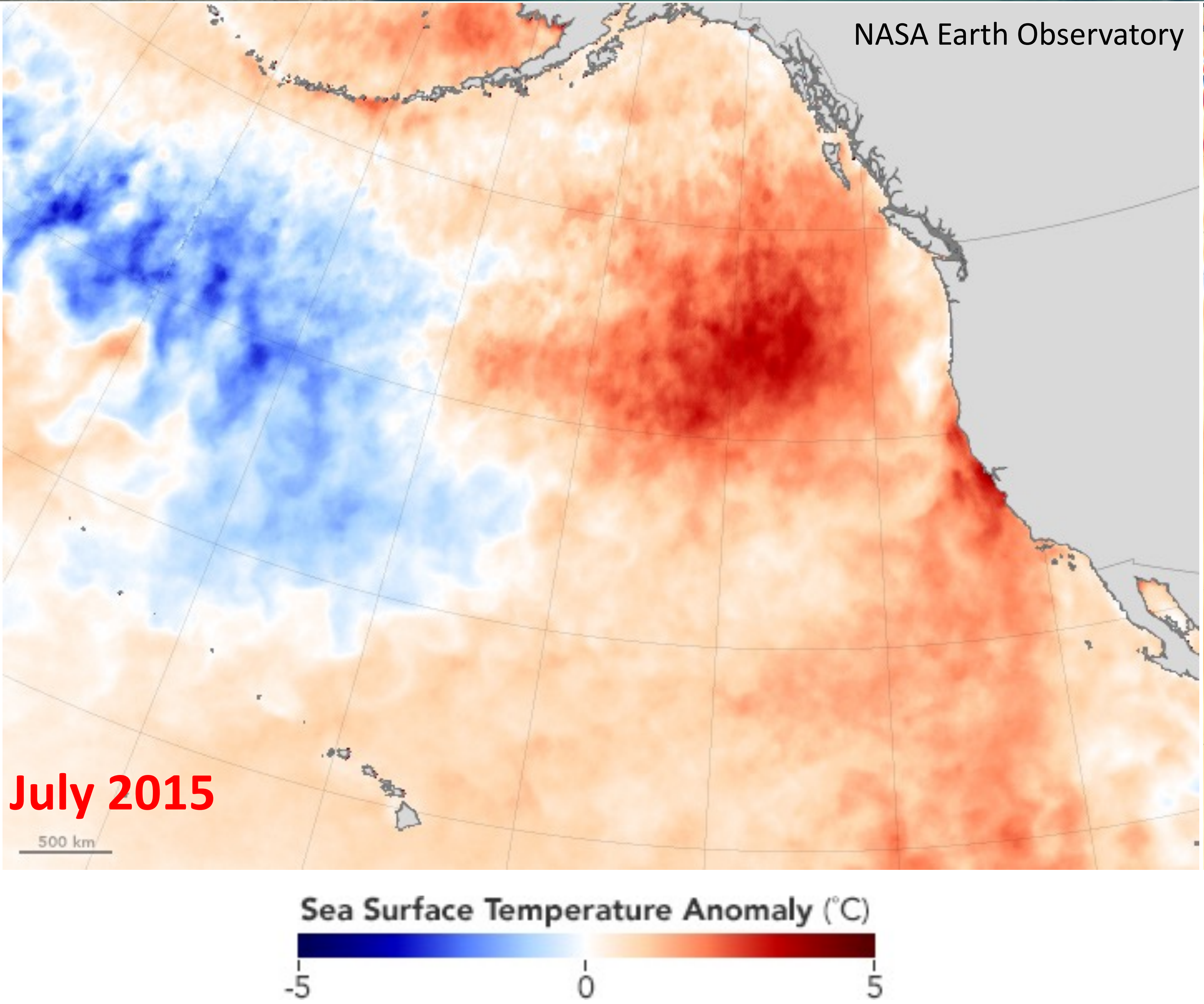
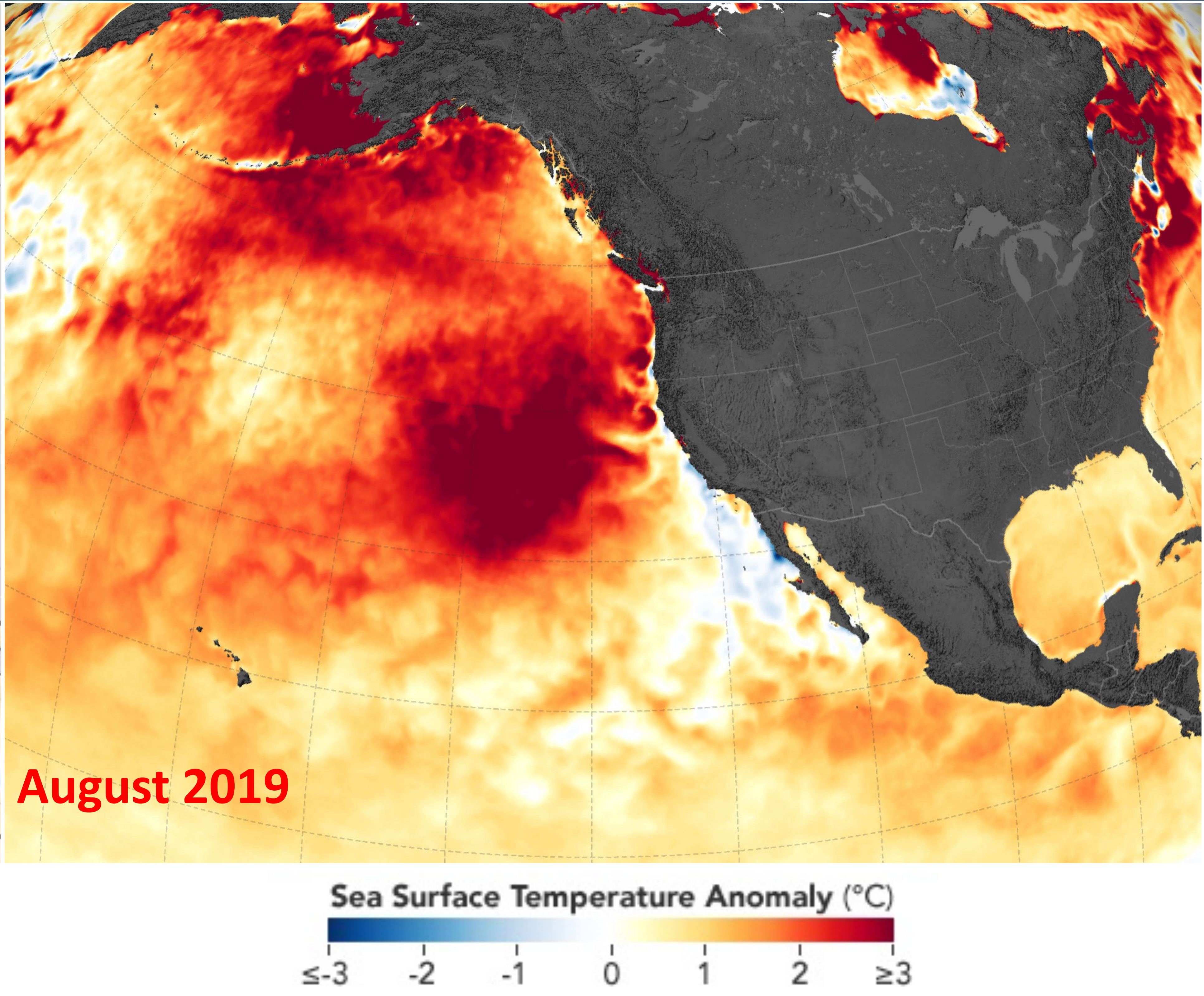
Marine heat wave return to the Northeast Pacific





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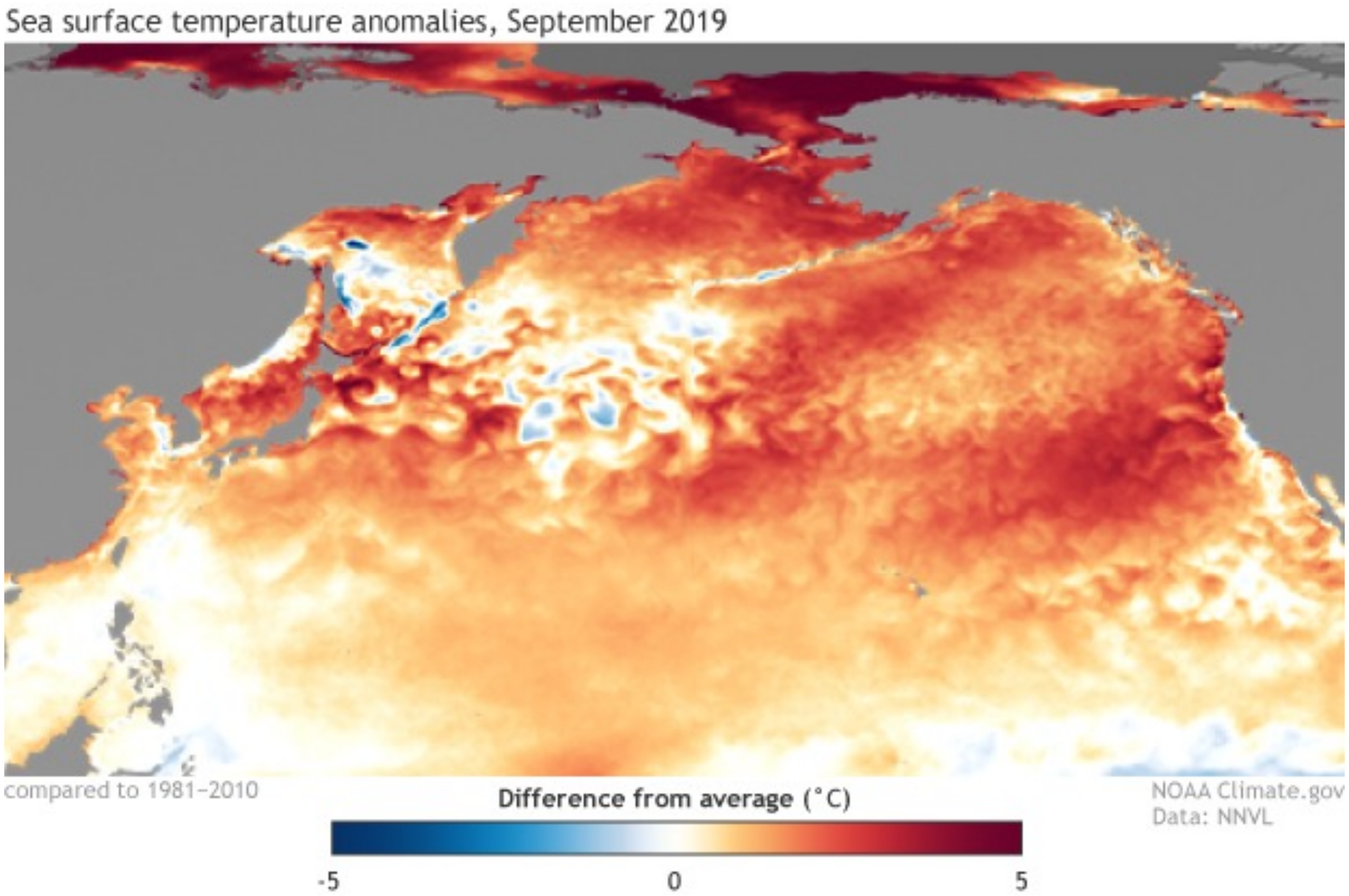
Marine heat waves in the Pacific



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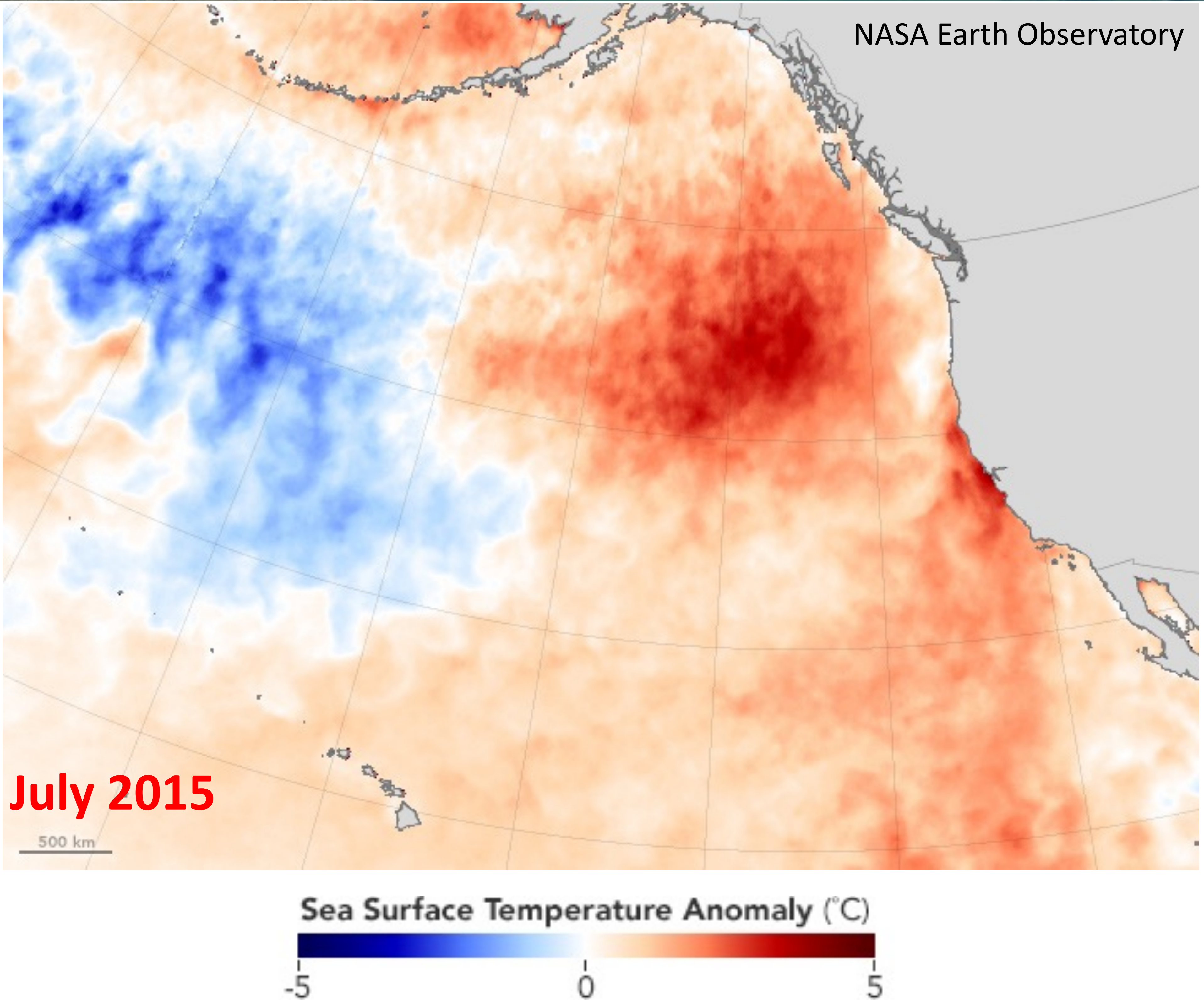
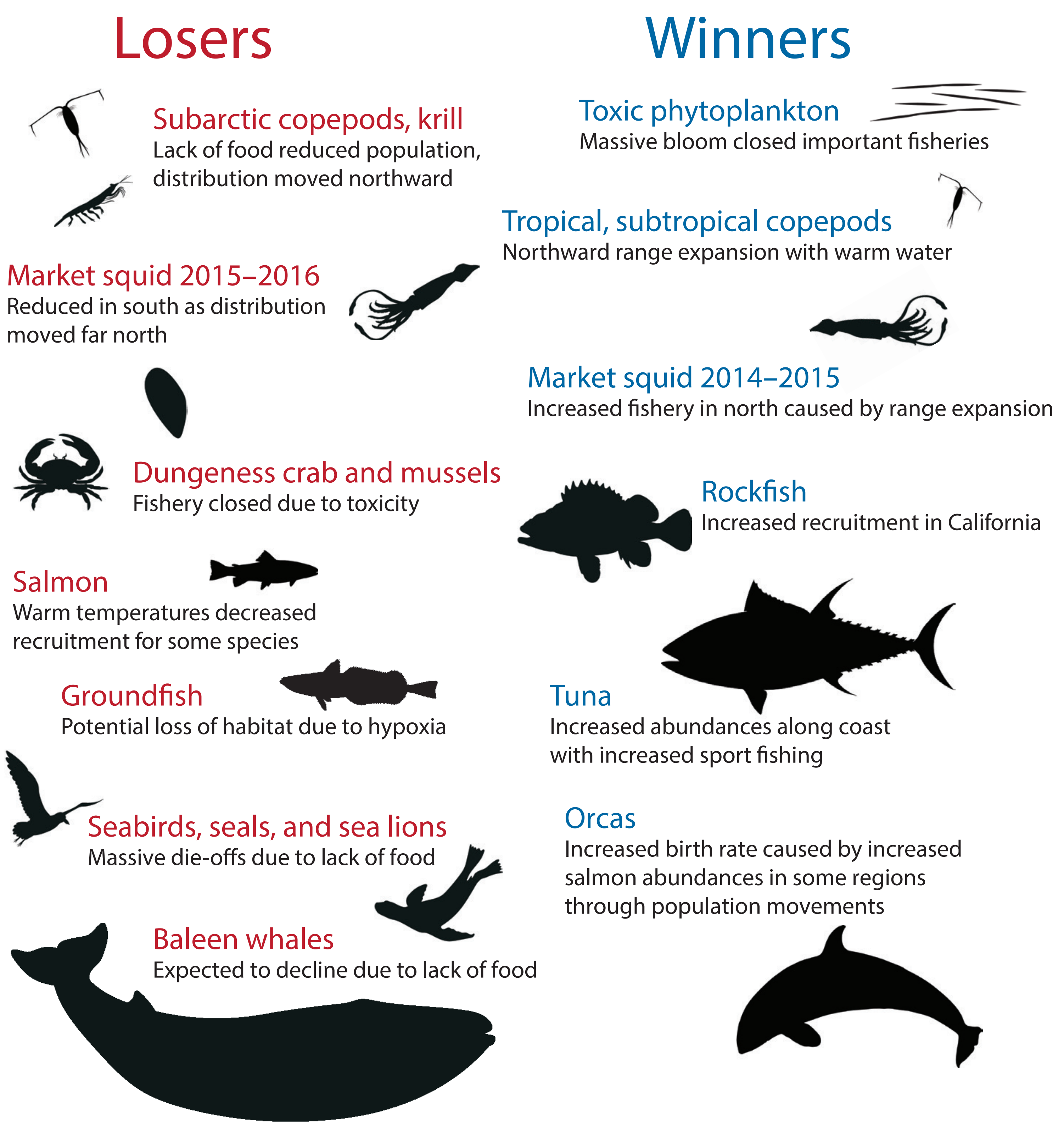
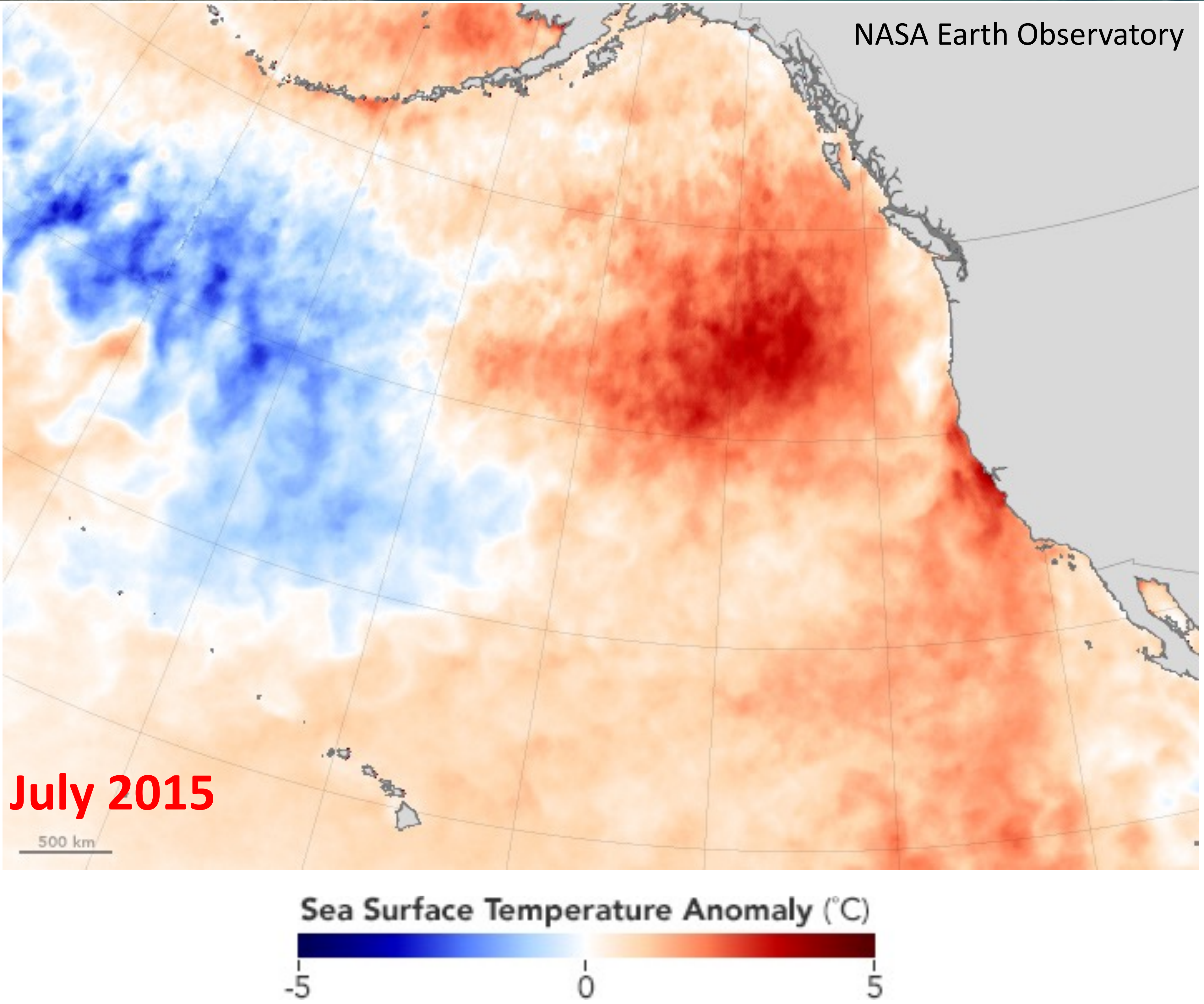
Ecosystem consequences





Cavole et al. (2016)

Ecosystem consequences



Losers

Subarctic copepods, krill
Lack of food reduced population, distribution moved northward

Market squid 2015–2016
Reduced in south as distribution moved far north

Dungeness crab and mussels
Fishery closed due to toxicity

Salmon
Warm temperatures decreased recruitment for some species

Groundfish
Potential loss of habitat due to hypoxia

Seabirds, seals, and sea lions
Massive die-offs due to lack of food

Baleen whales
Expected to decline due to lack of food

Winners

Toxic phytoplankton
Massive bloom closed important fisheries

Tropical, subtropical copepods
Northward range expansion with warm water

Market squid 2014–2015
Increased fishery in north caused by range expansion

Rockfish
Increased recruitment in California

Tuna
Increased abundances along coast with increased sport fishing

Orcas
Increased birth rate caused by increased salmon abundances in some regions through population movements

Cavole et al. (2016)

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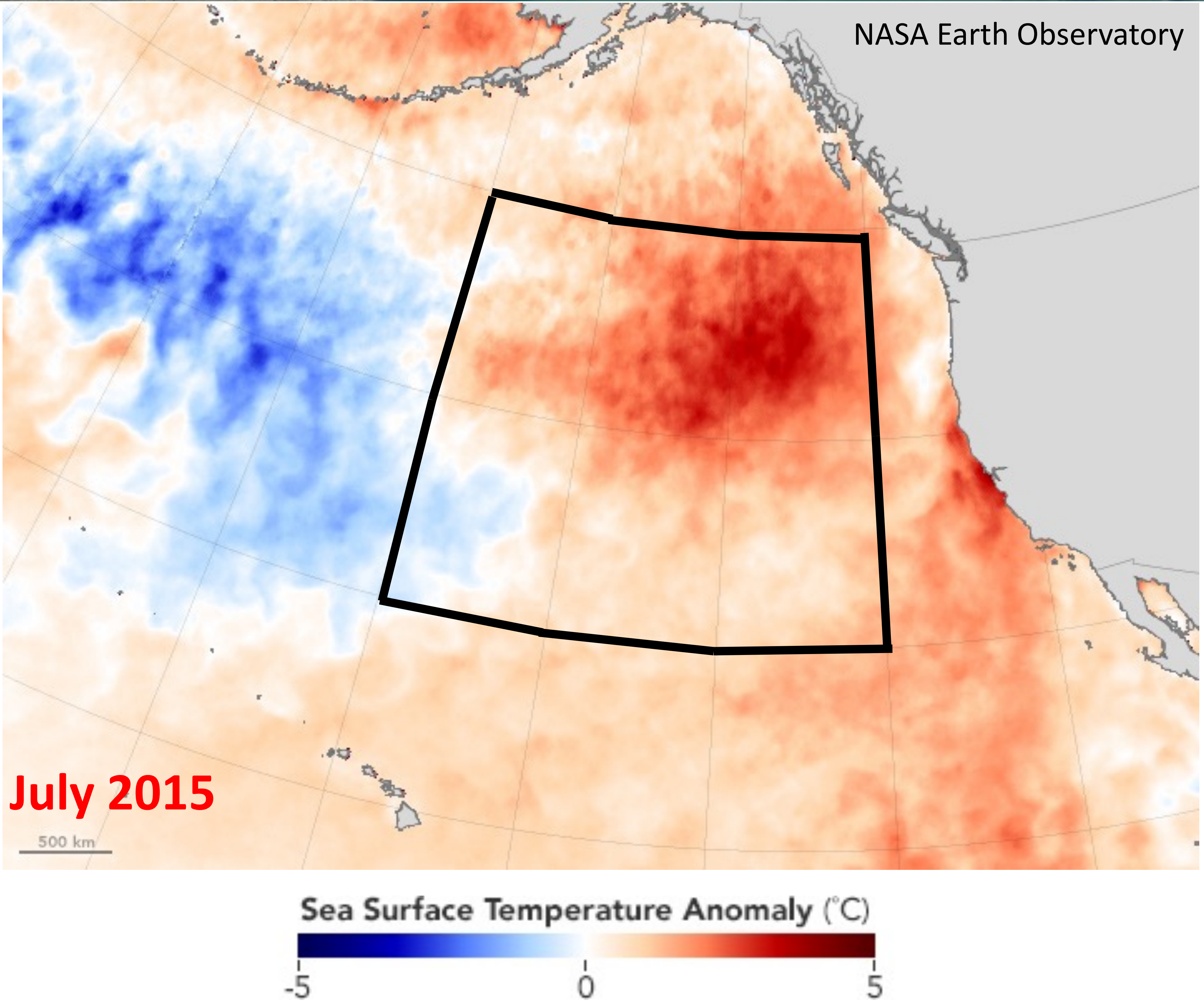
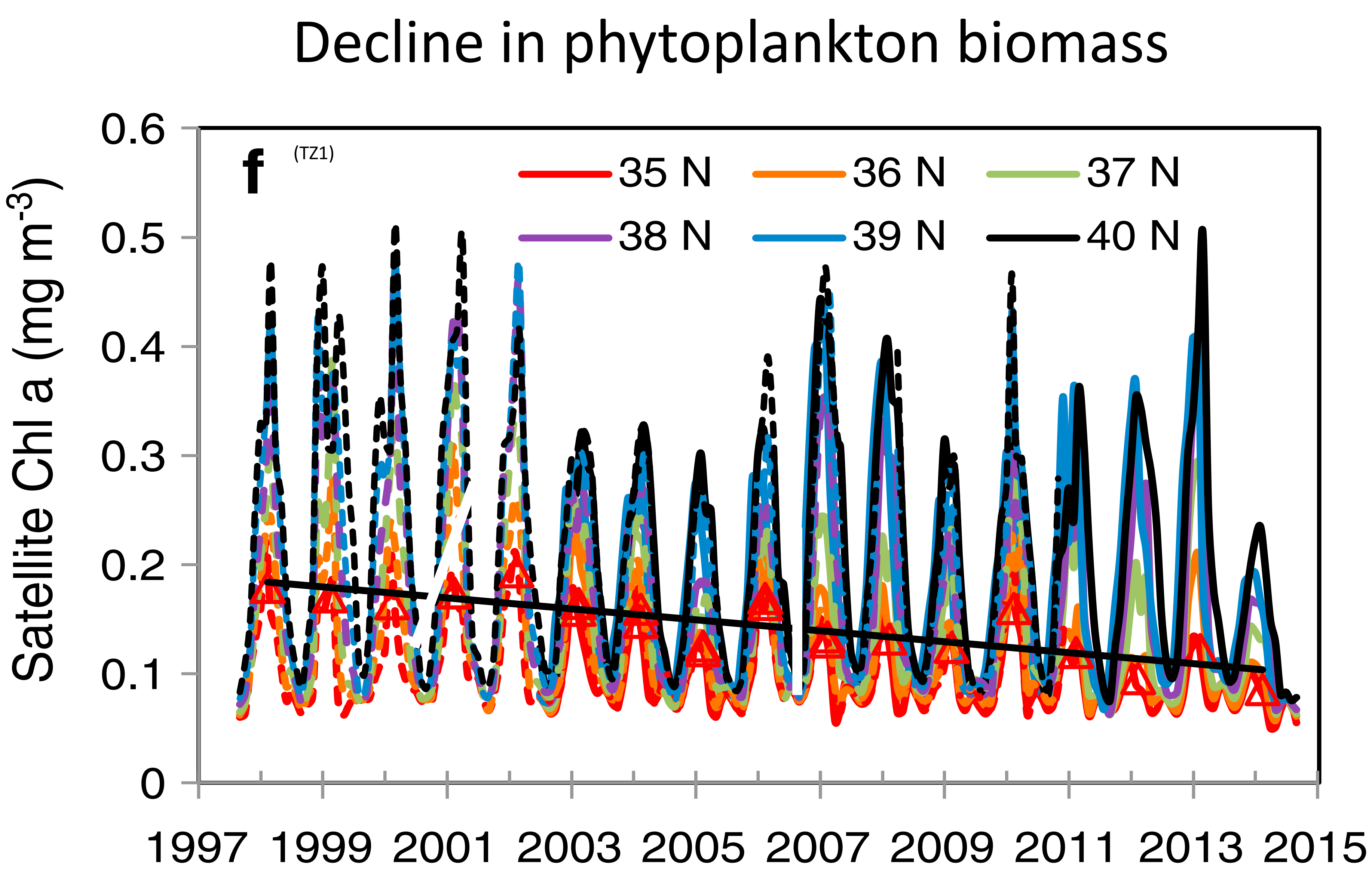
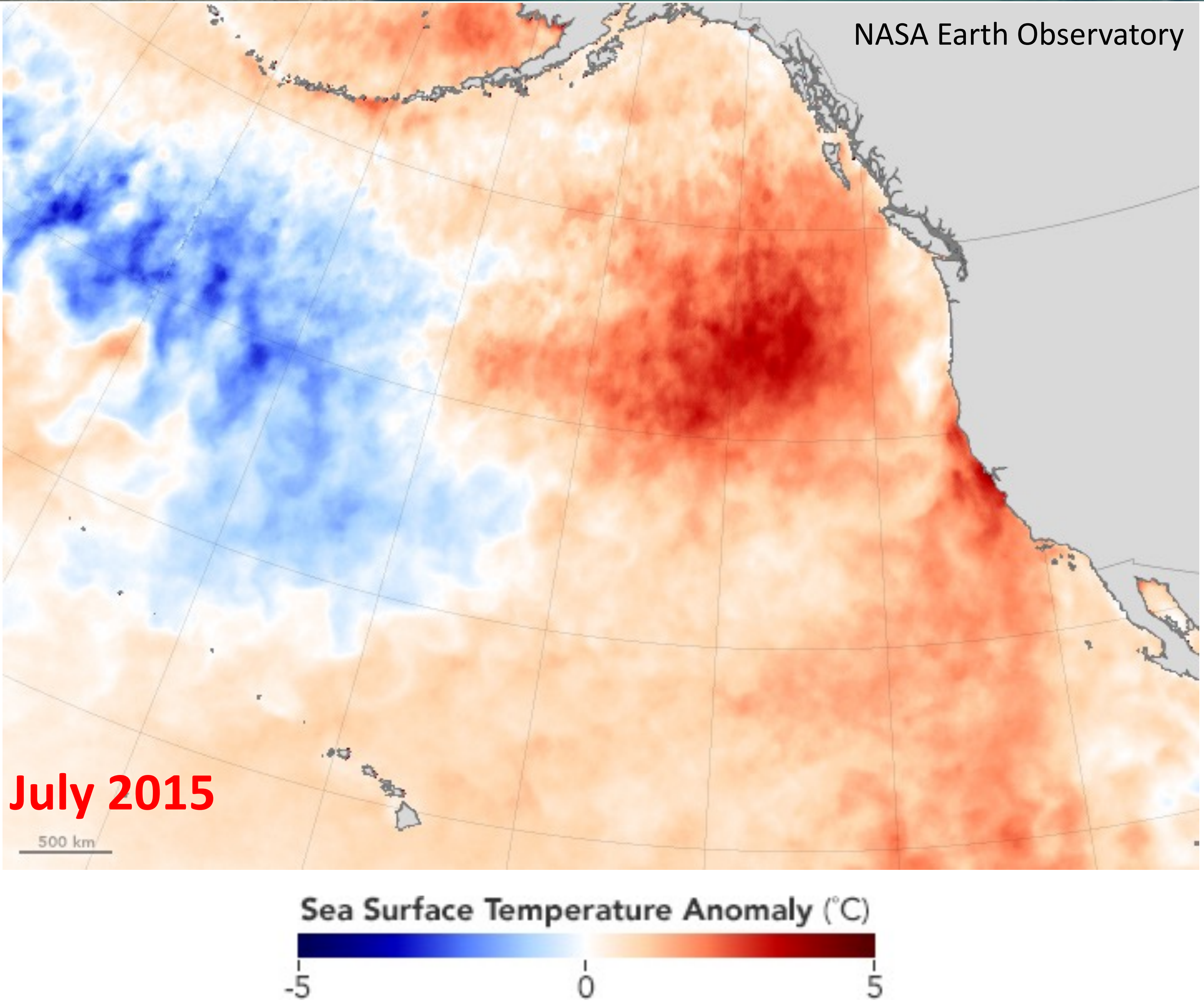
Decline in chlorophyll stocks

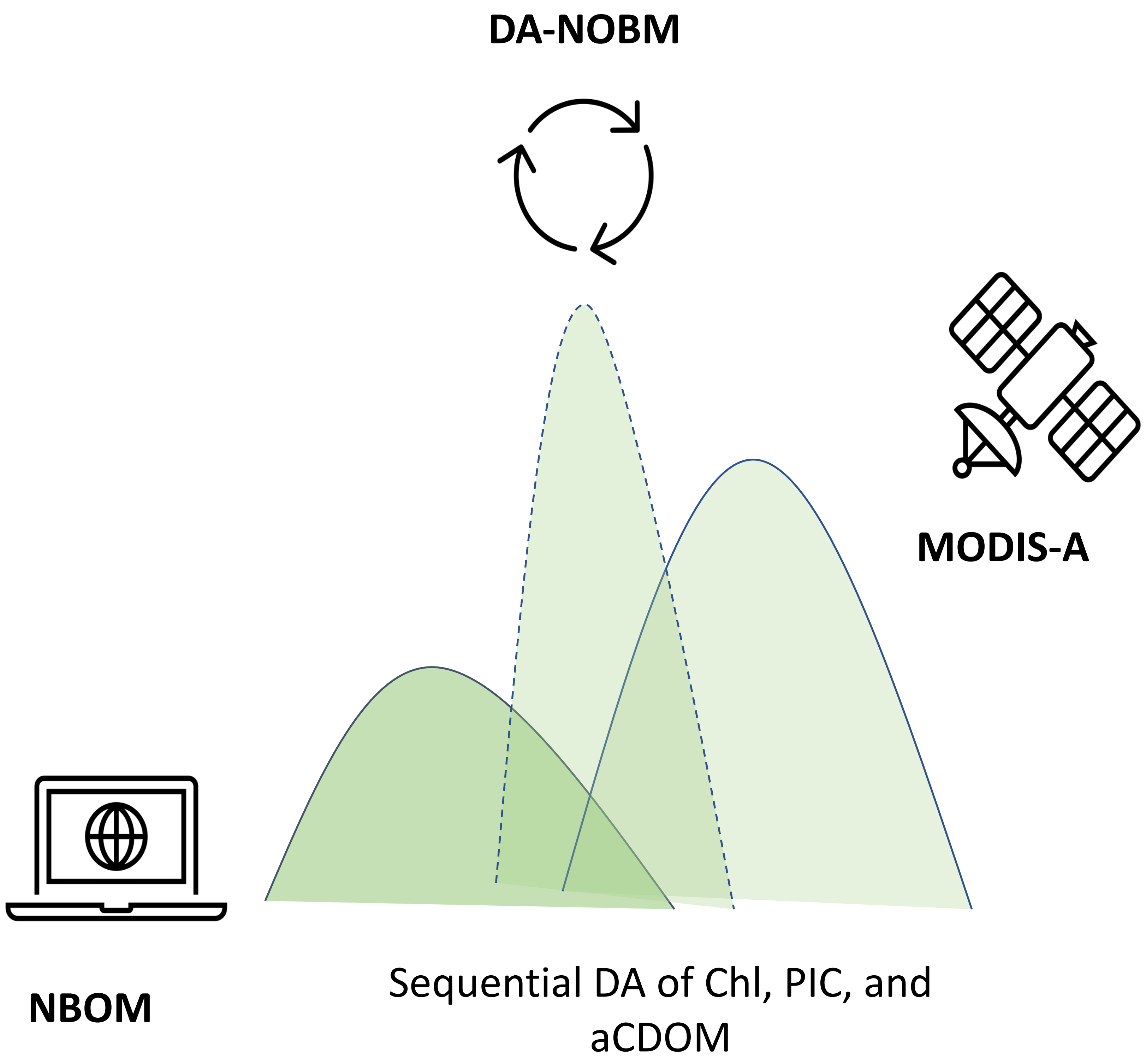




Whitney (2015)

NASA Ocean Biogeochemical Model (NOBM)





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Main findings

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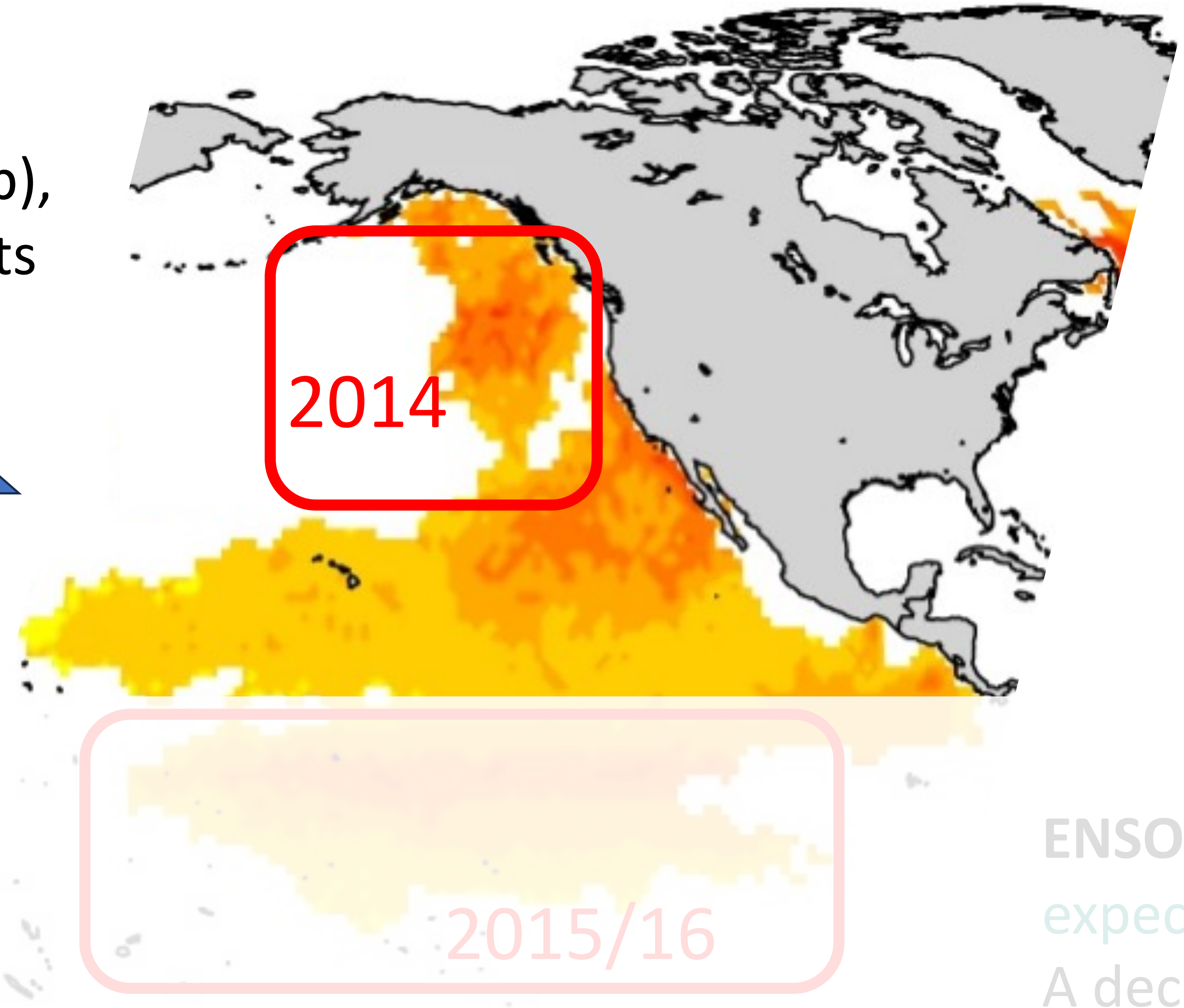
GOA: Mechanistically more interesting; Chlorophyll levels initially increase with the onset of the warm anomaly (The Blob), due to changes in the delivery of nutrients (silicate) and its impact on the dominant diatoms.



ENSO 3.4: More in line with expectations, but more dramatic; A decline of 40 % in mean surface chlorophyll was associated to a near full decline in diatoms.

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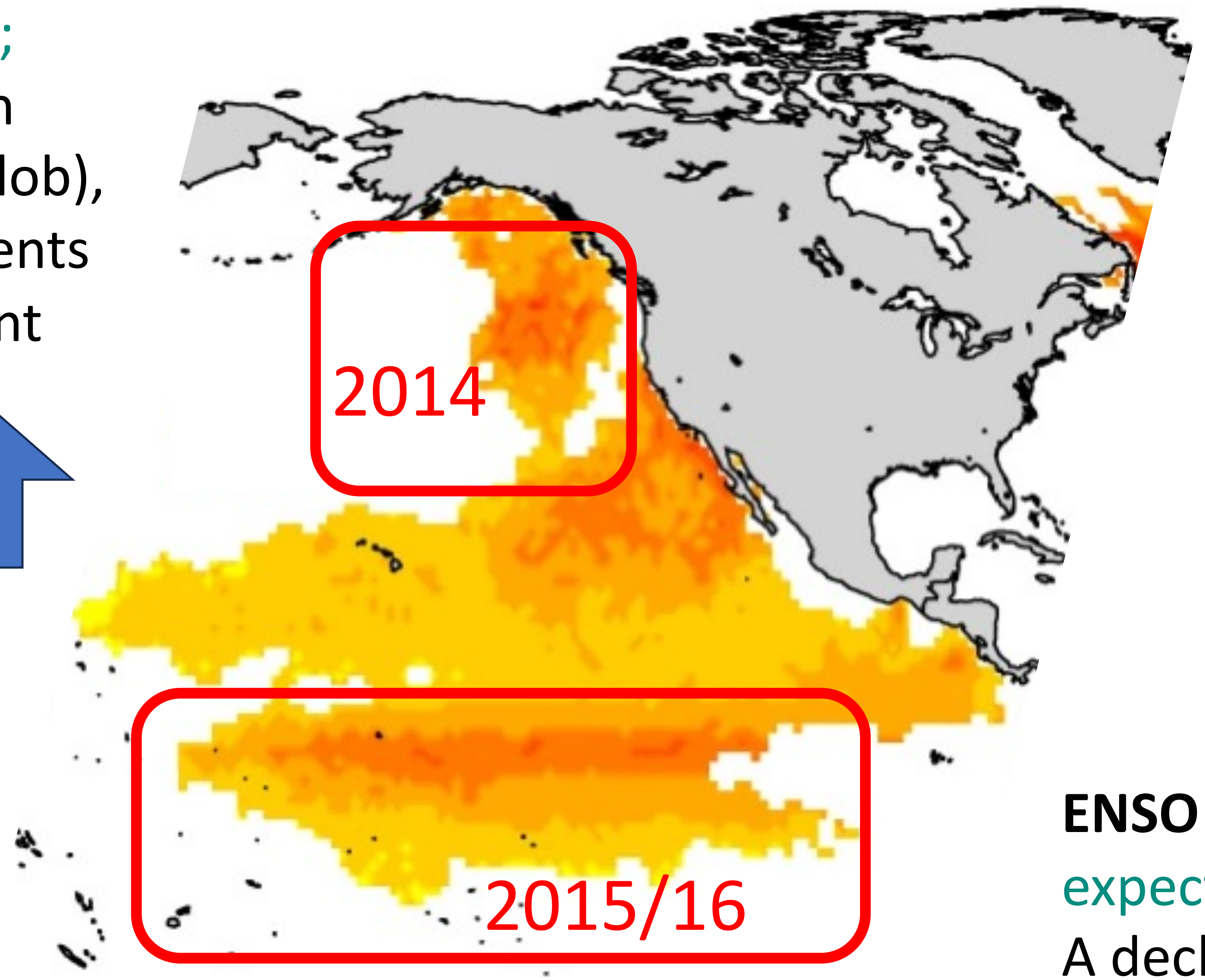

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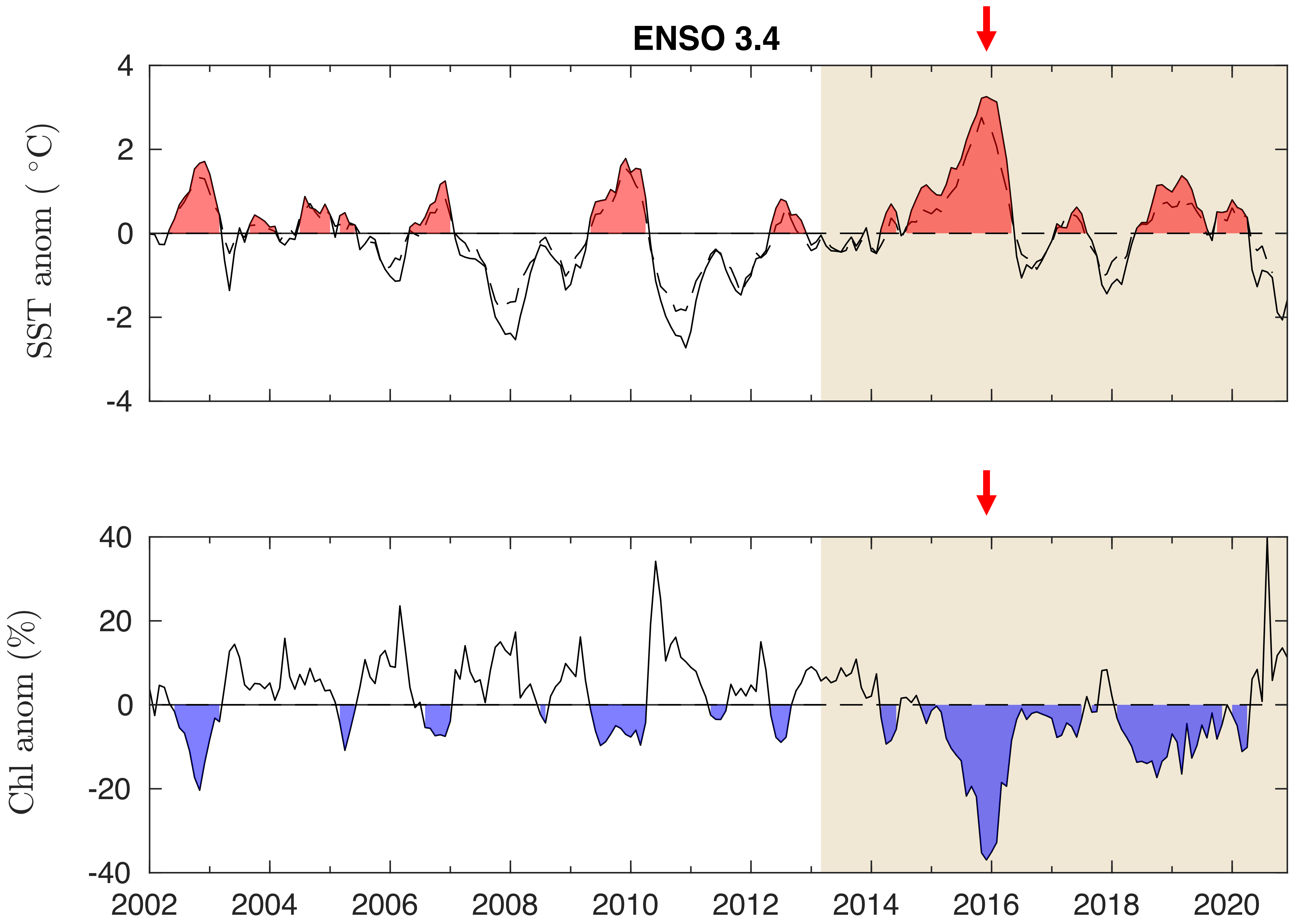
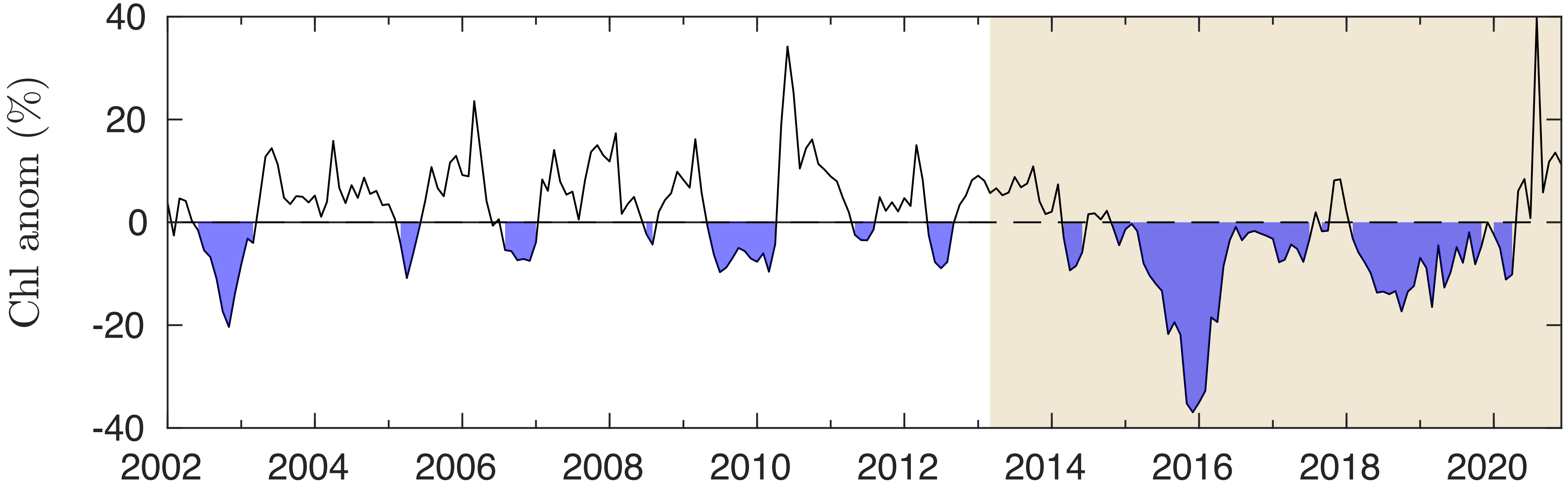
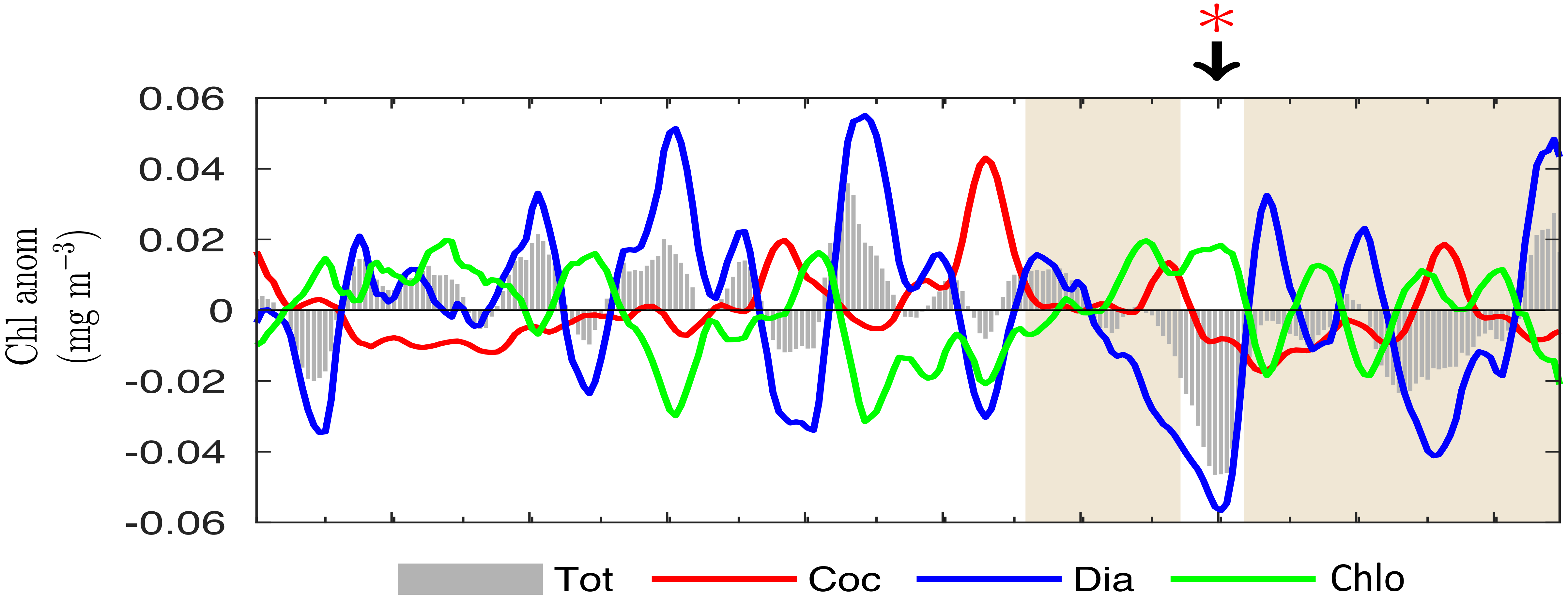
Results: Equatorial Pacific (ENSO 3.4)

ENSO 3.4: SST and biomass

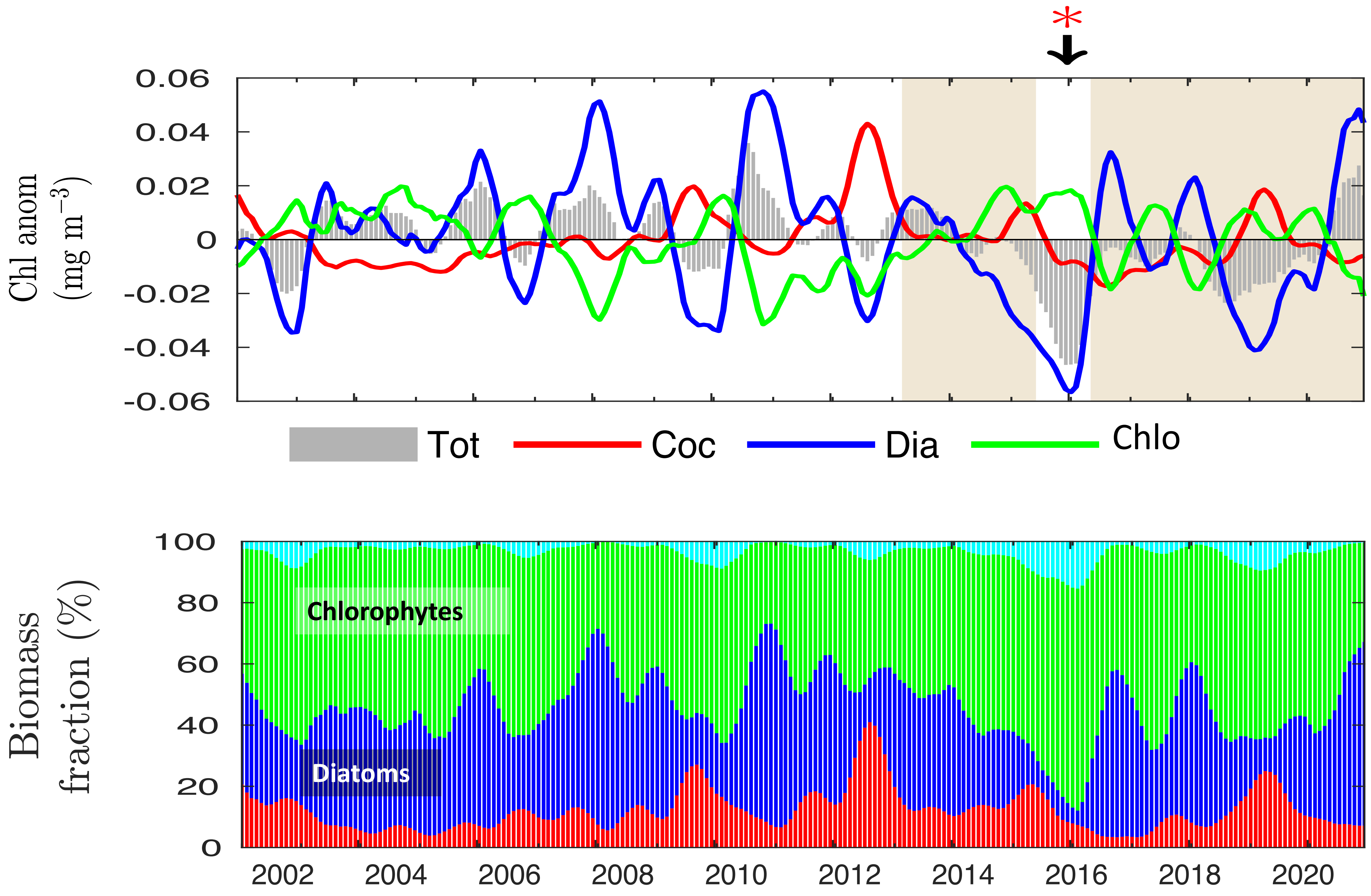


ENSO 3.4: Biomass changes

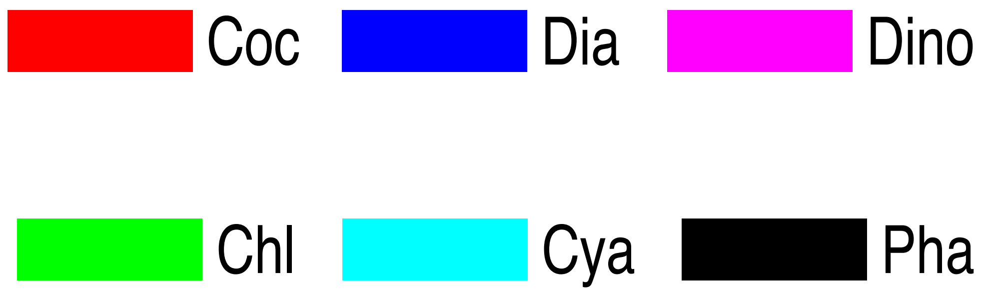


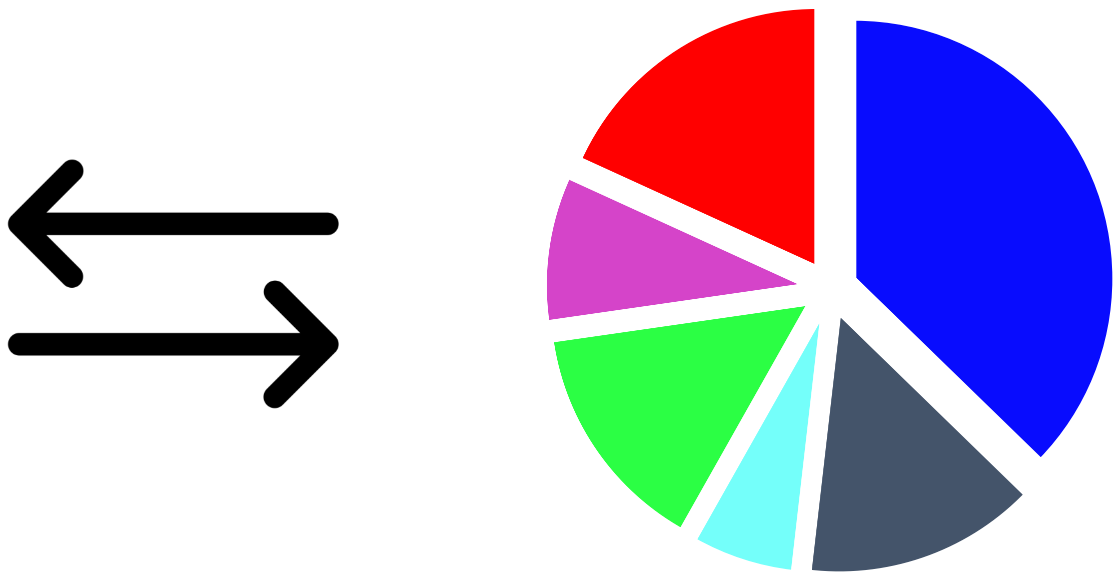


ENSO 3.4: Phytoplankton community changes

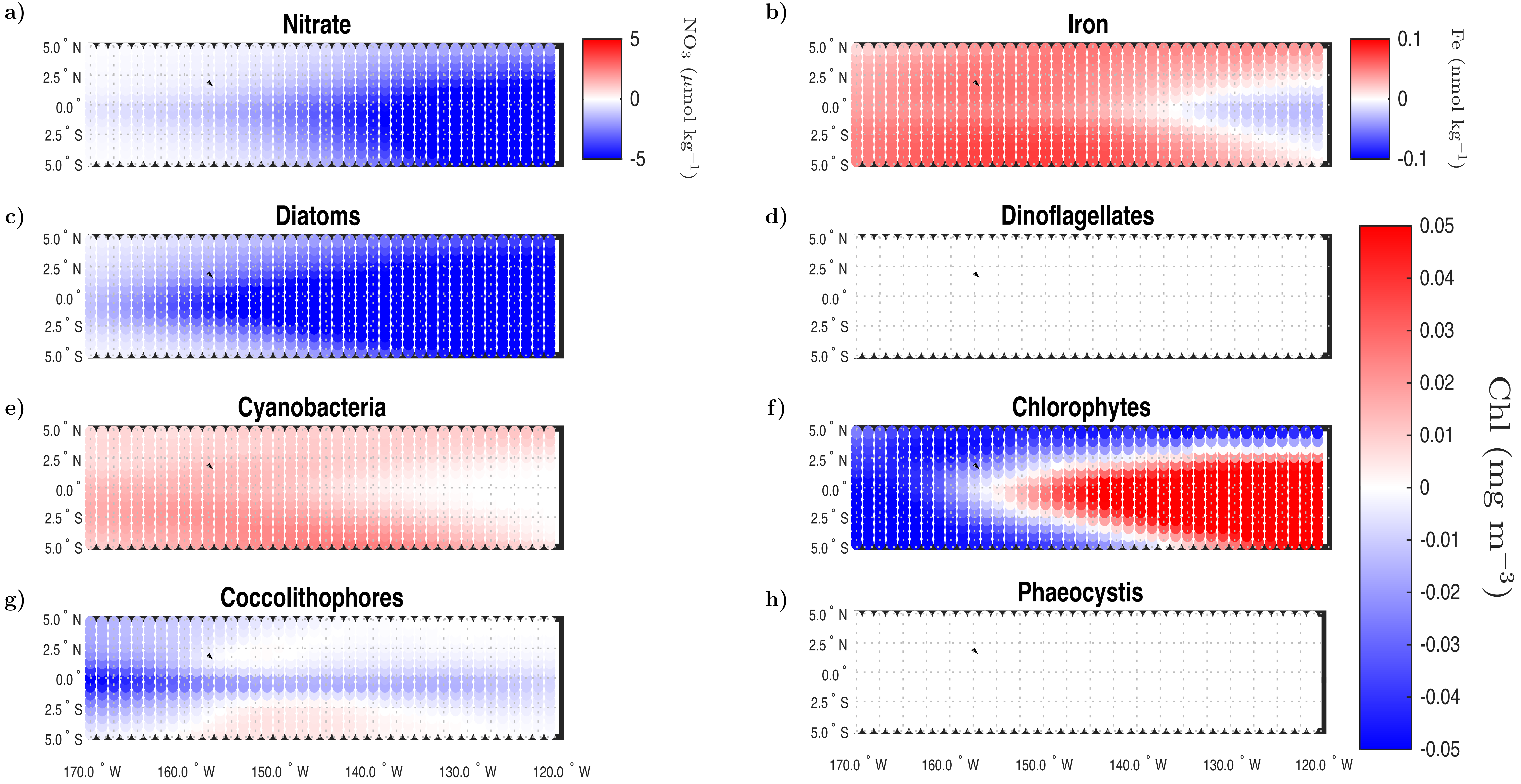


Phytoplankton Functional Types (PFTs)





ENSO 3.4: Ecological re-arrangement (early 2016)



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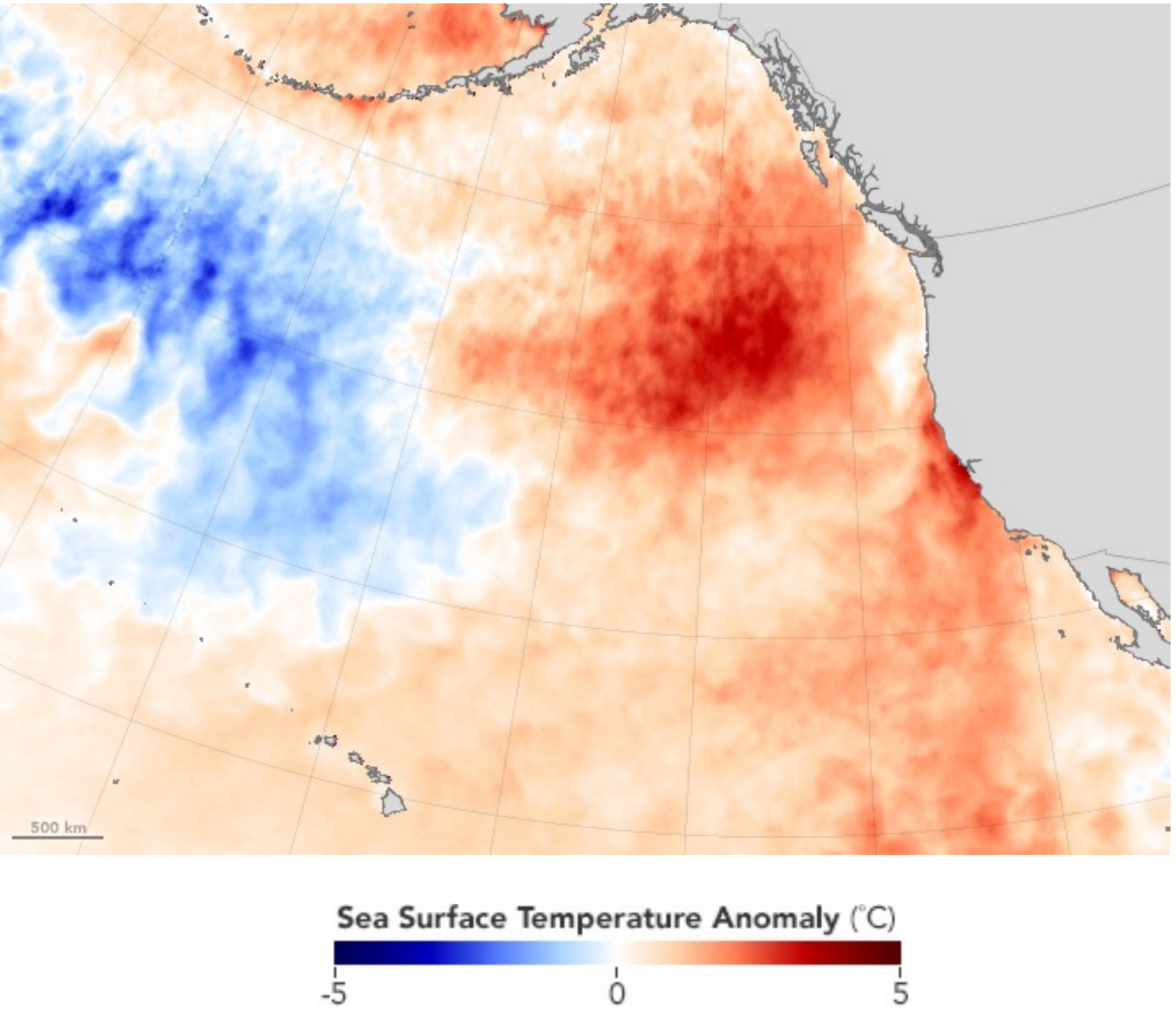
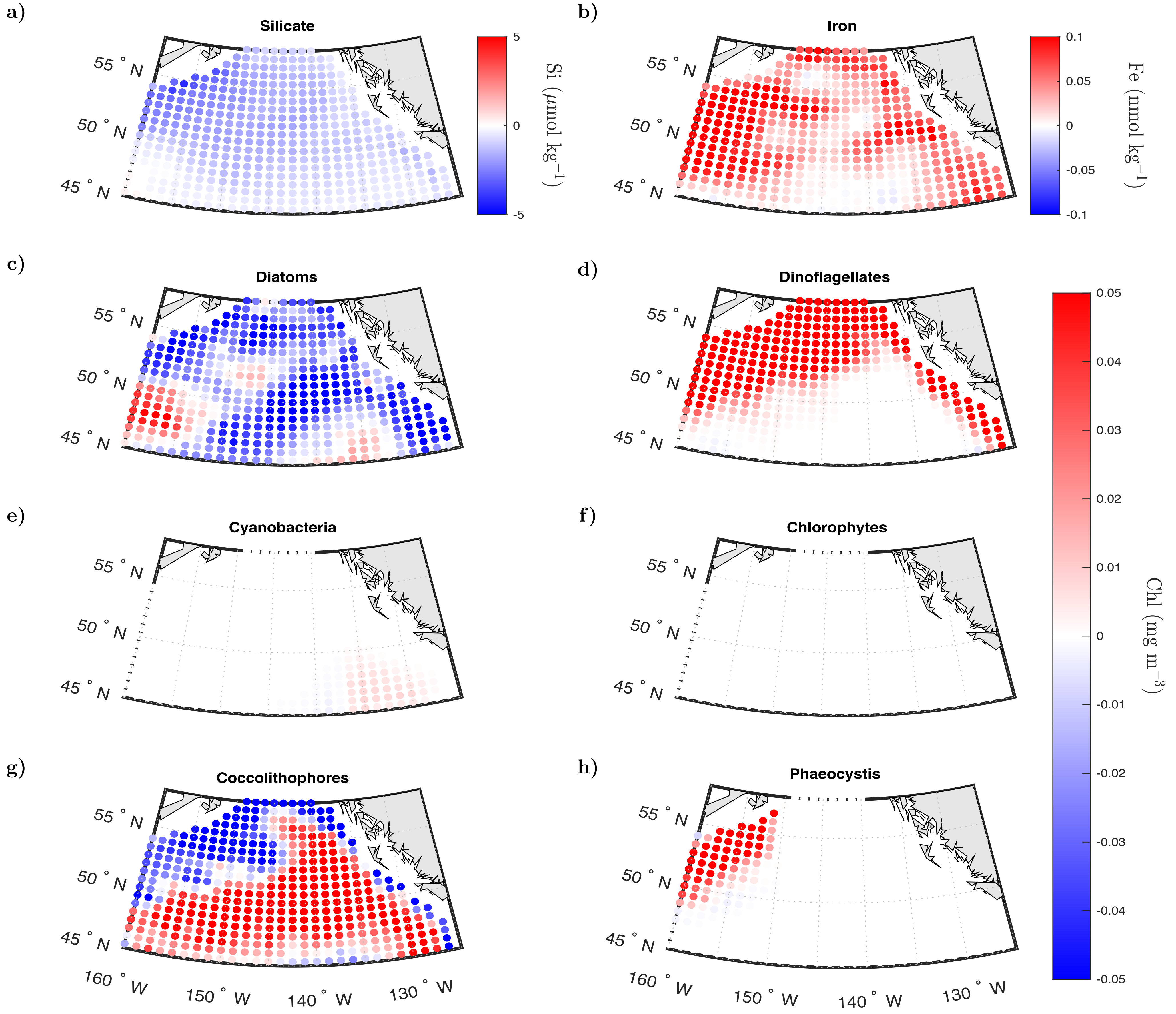
Results: Gulf of Alaska (GOA)

GOA: Ecological re-arrangement (Fall 2014)





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Results: Hints for a warmer future?

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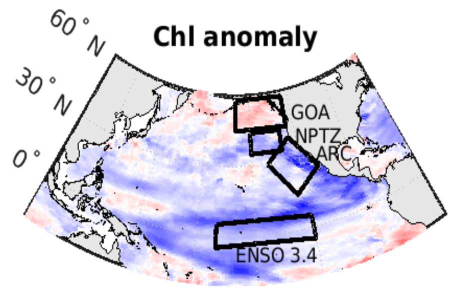
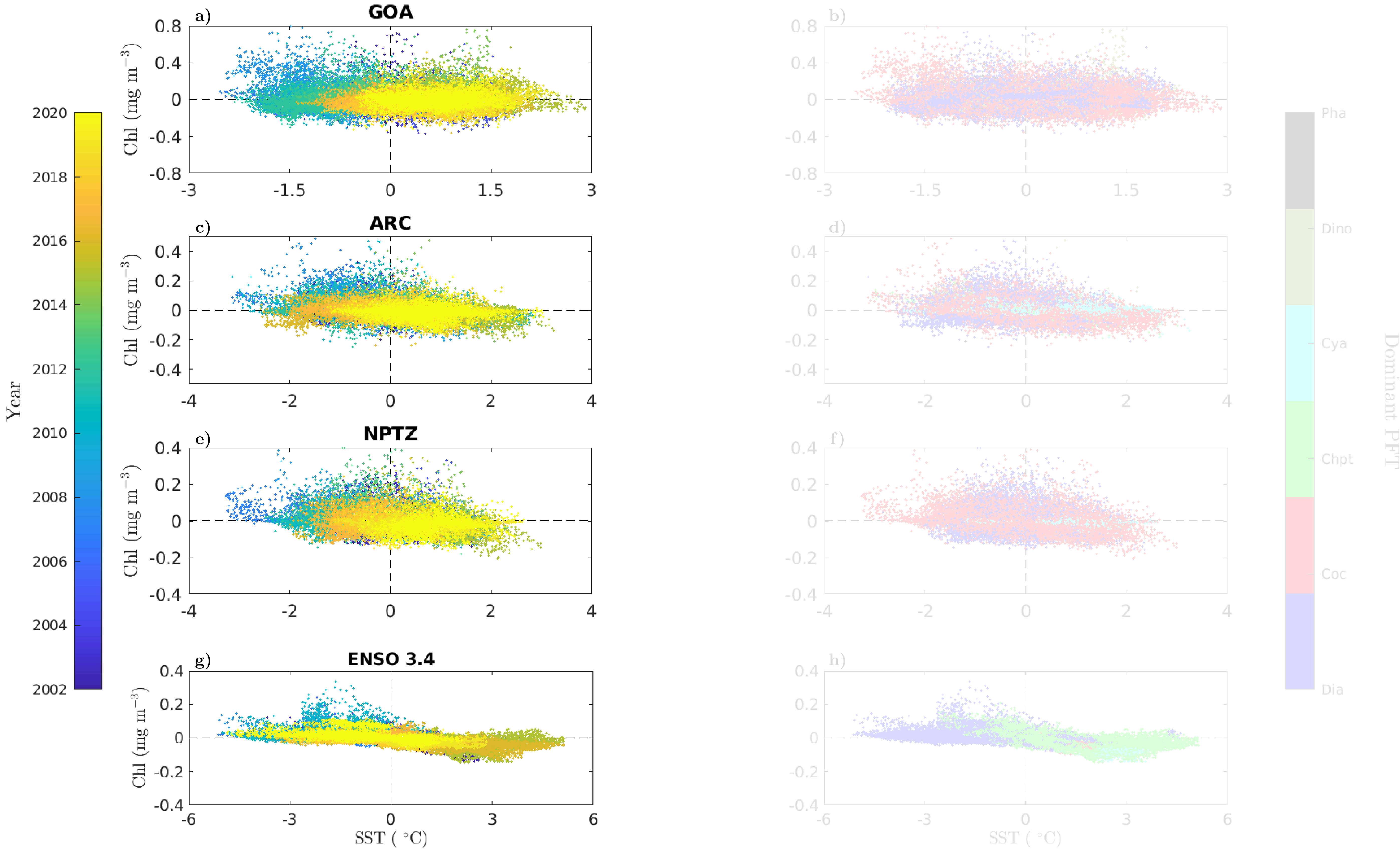
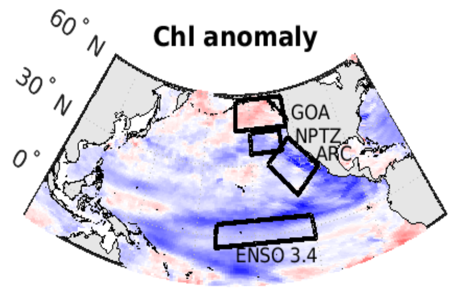
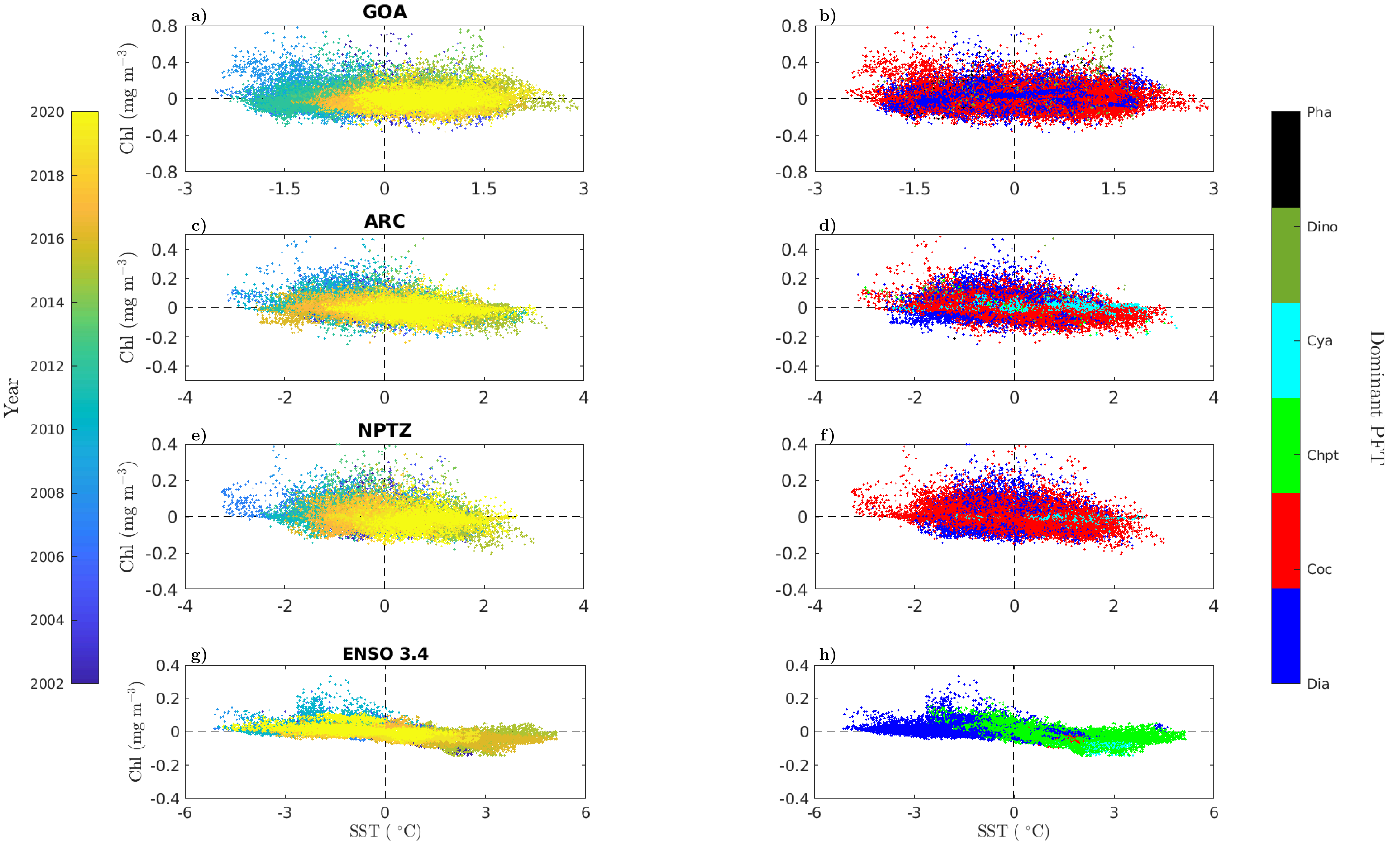




Hints for a warmer future?





Conclusions

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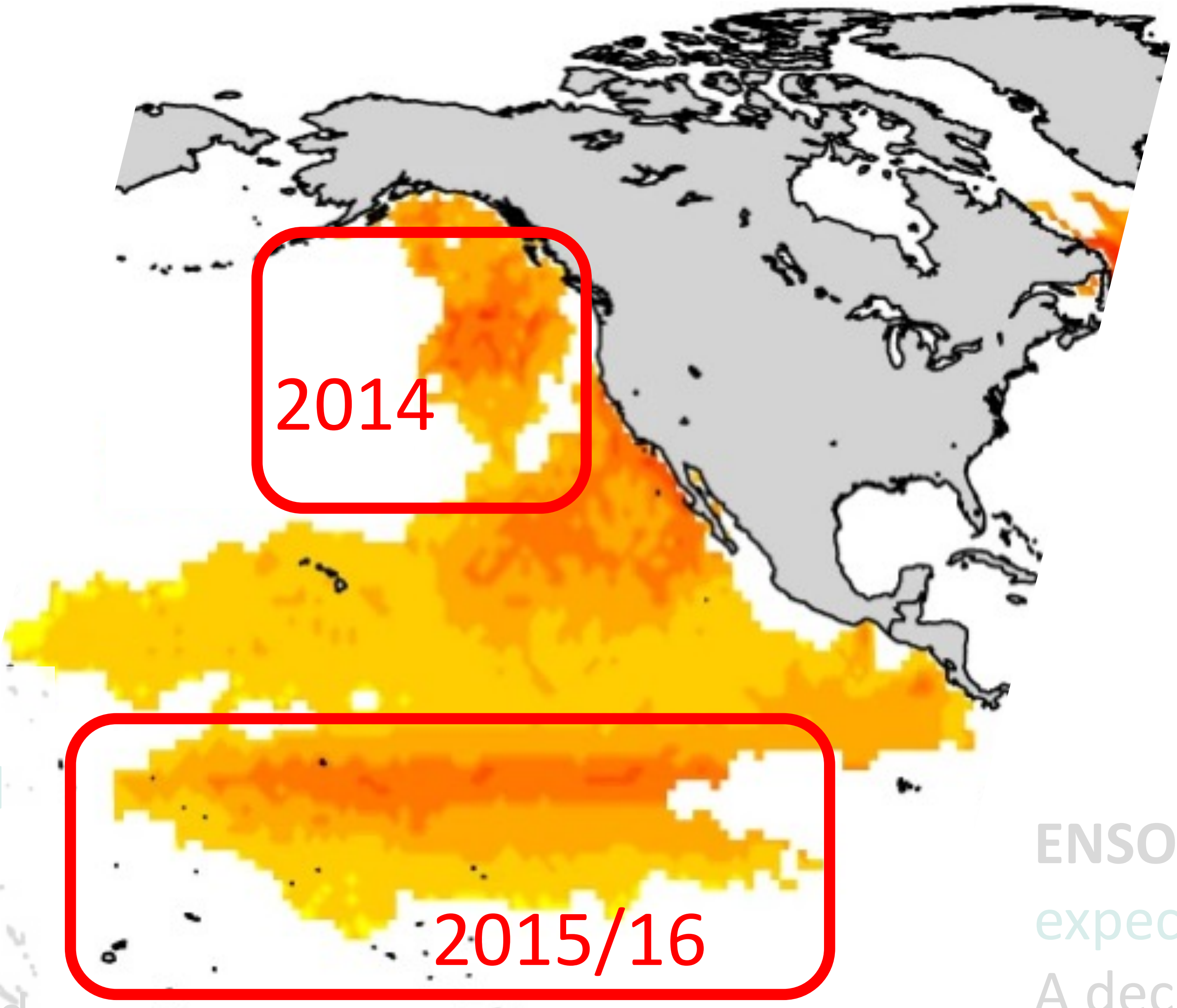
GOA: Mechanistically more interesting; Reduced silica supply led to a switch in community composition from diatoms to dinoflagellates, resulting in an increase in surface ocean chlorophyll during the Summer–Fall of 2014.

Pacific Ocean: A clear trend towards warmer SST and lower surface chlorophyll levels is evident in the three examined regions of the North Pacific (GOA, ARC, and NPTZ) over the 2002–2020 assimilated satellite record.



Perturbations: Need to be of a greater magnitude than those imposed by the natural climate variability of the seasonal cycle or create a unique imbalance in elicit a clear change in the phytoplankton community composition.

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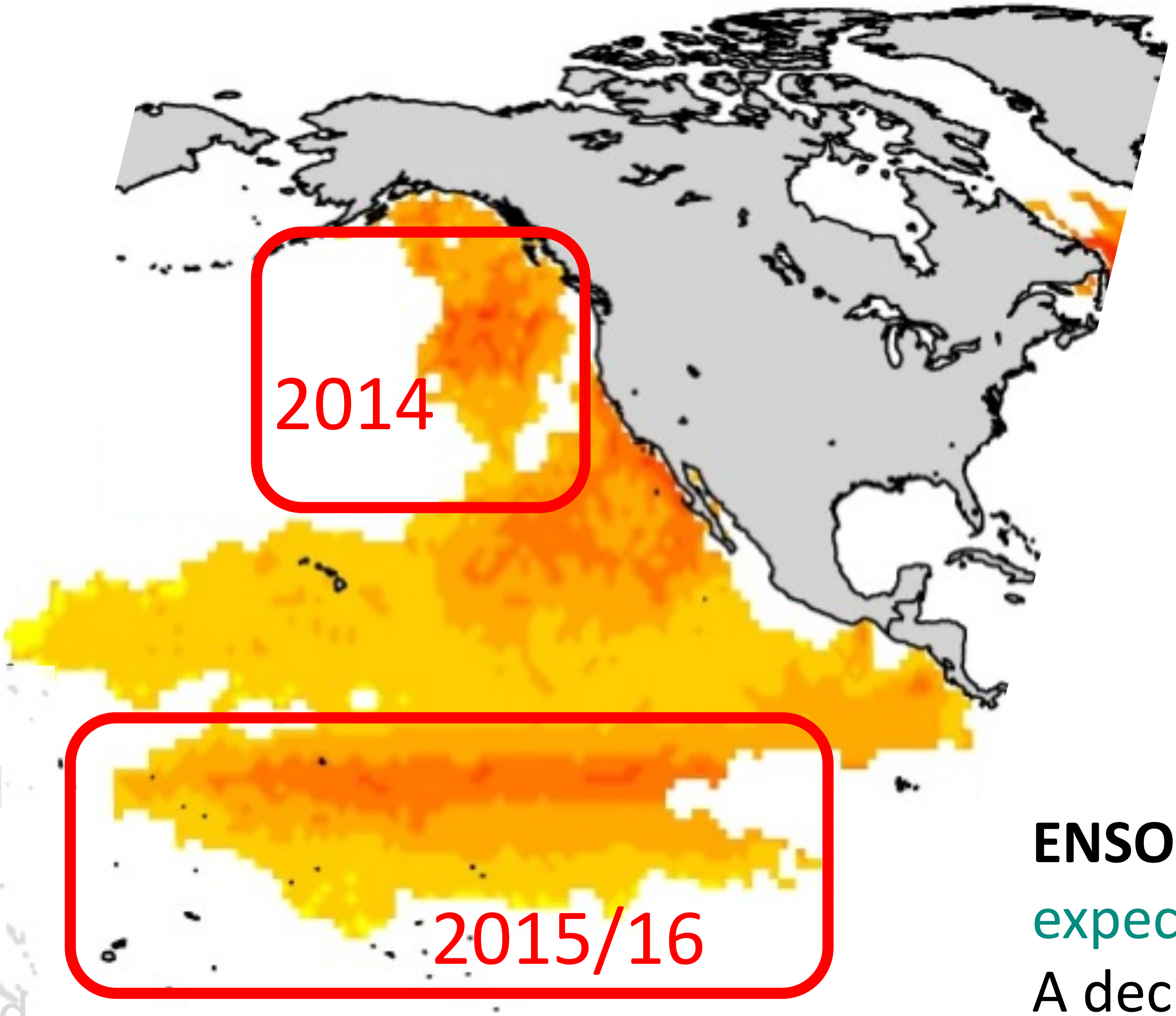

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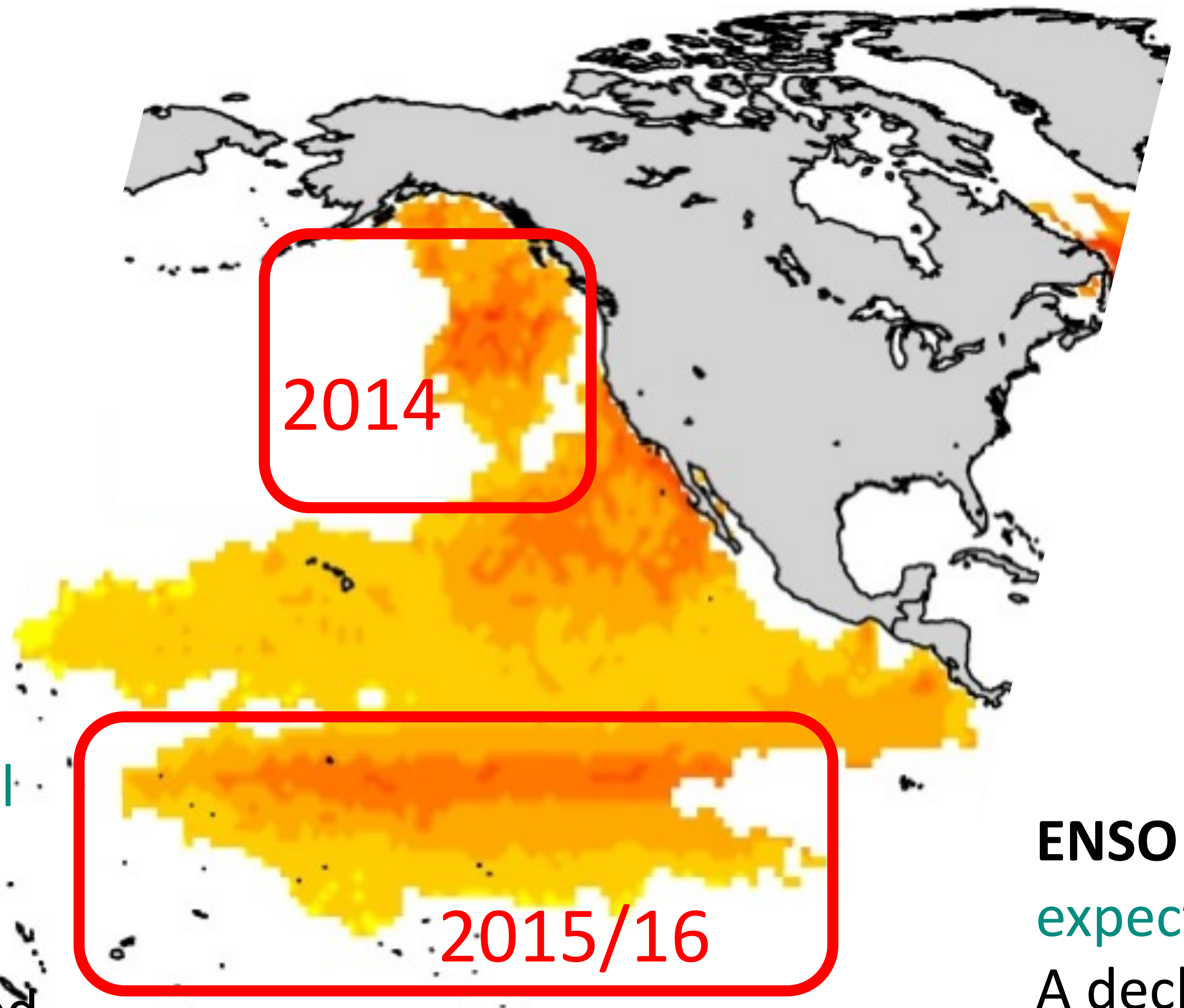

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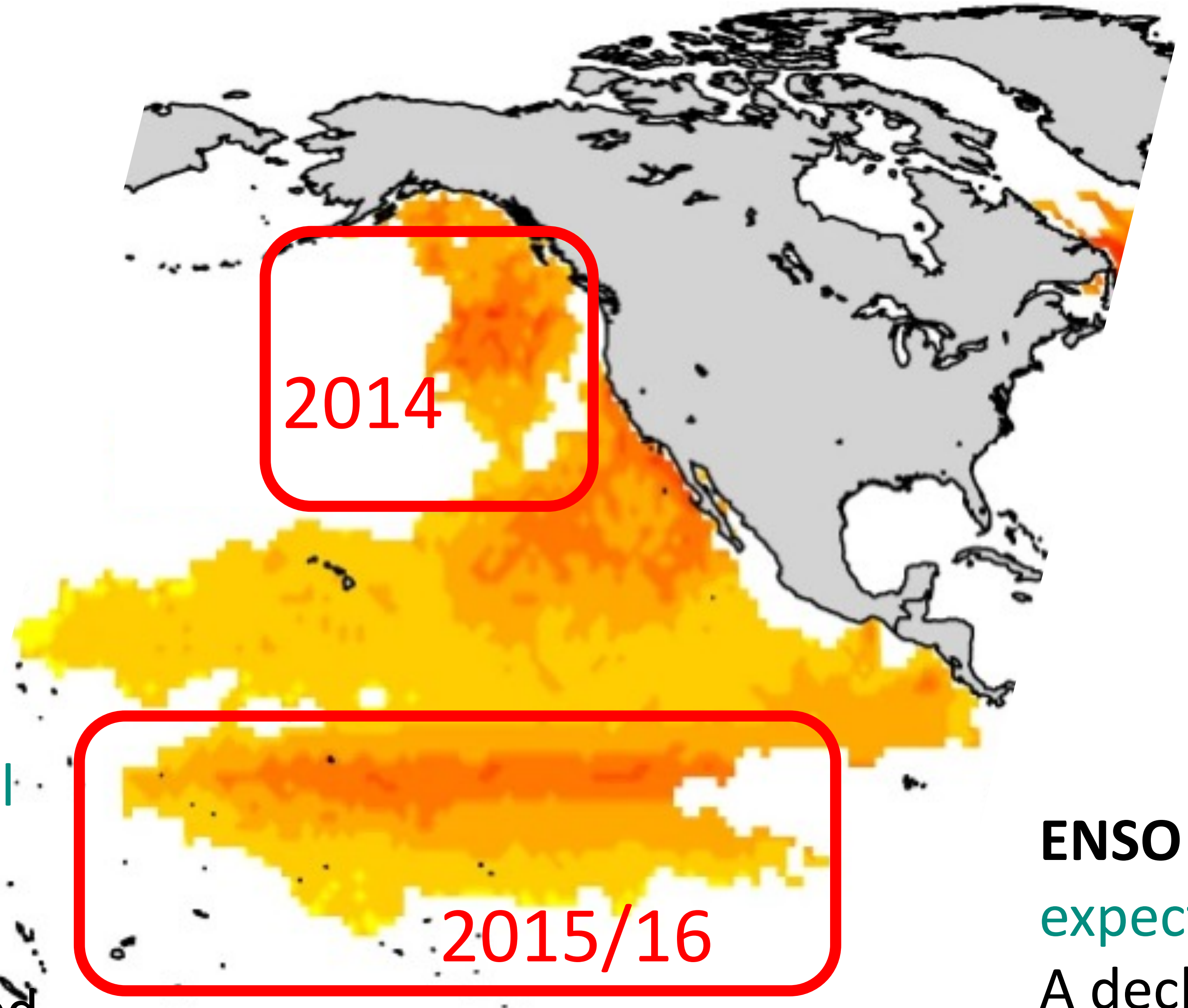

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EXPORTS: EXport Processes in the Ocean from RemoTe Sensing

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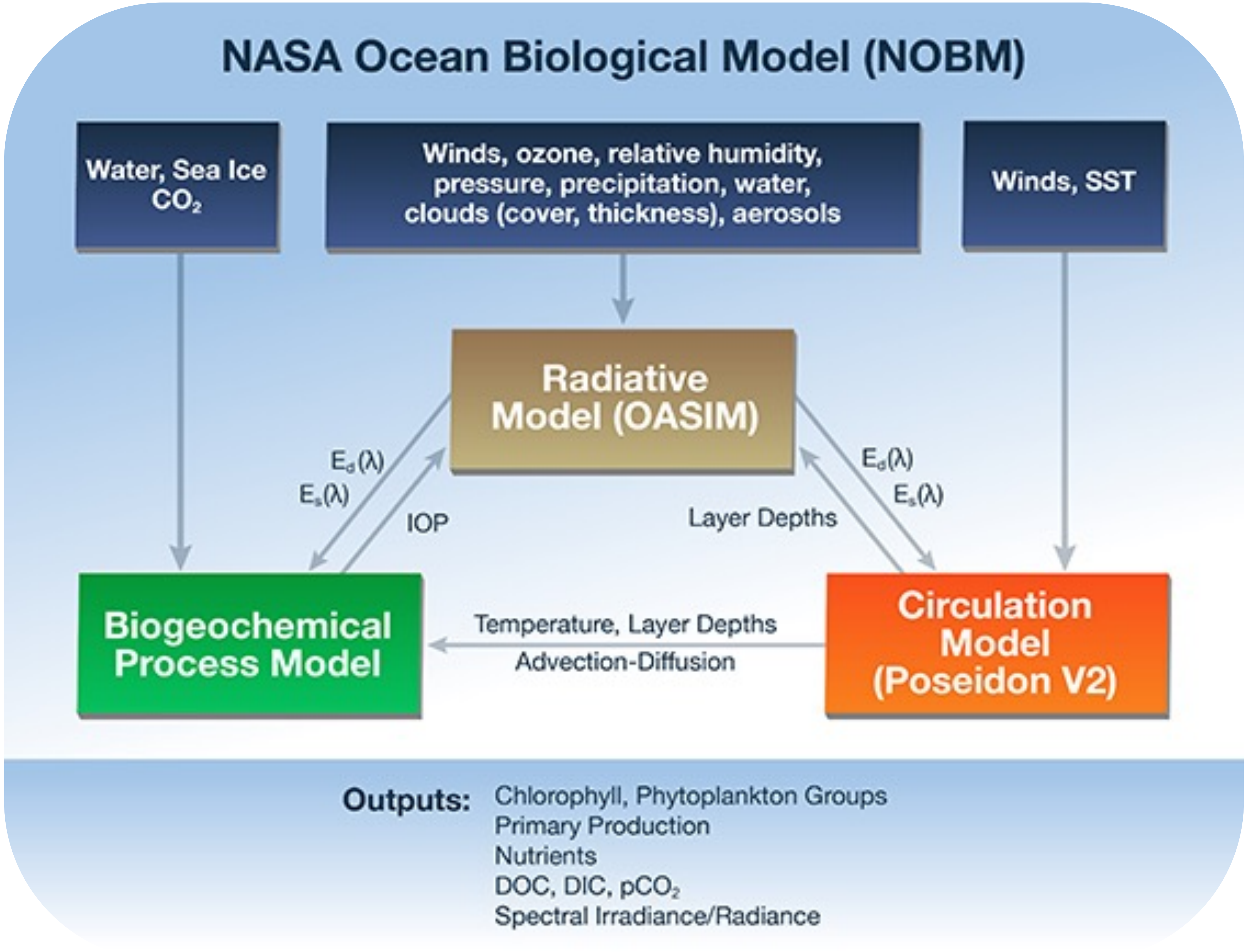
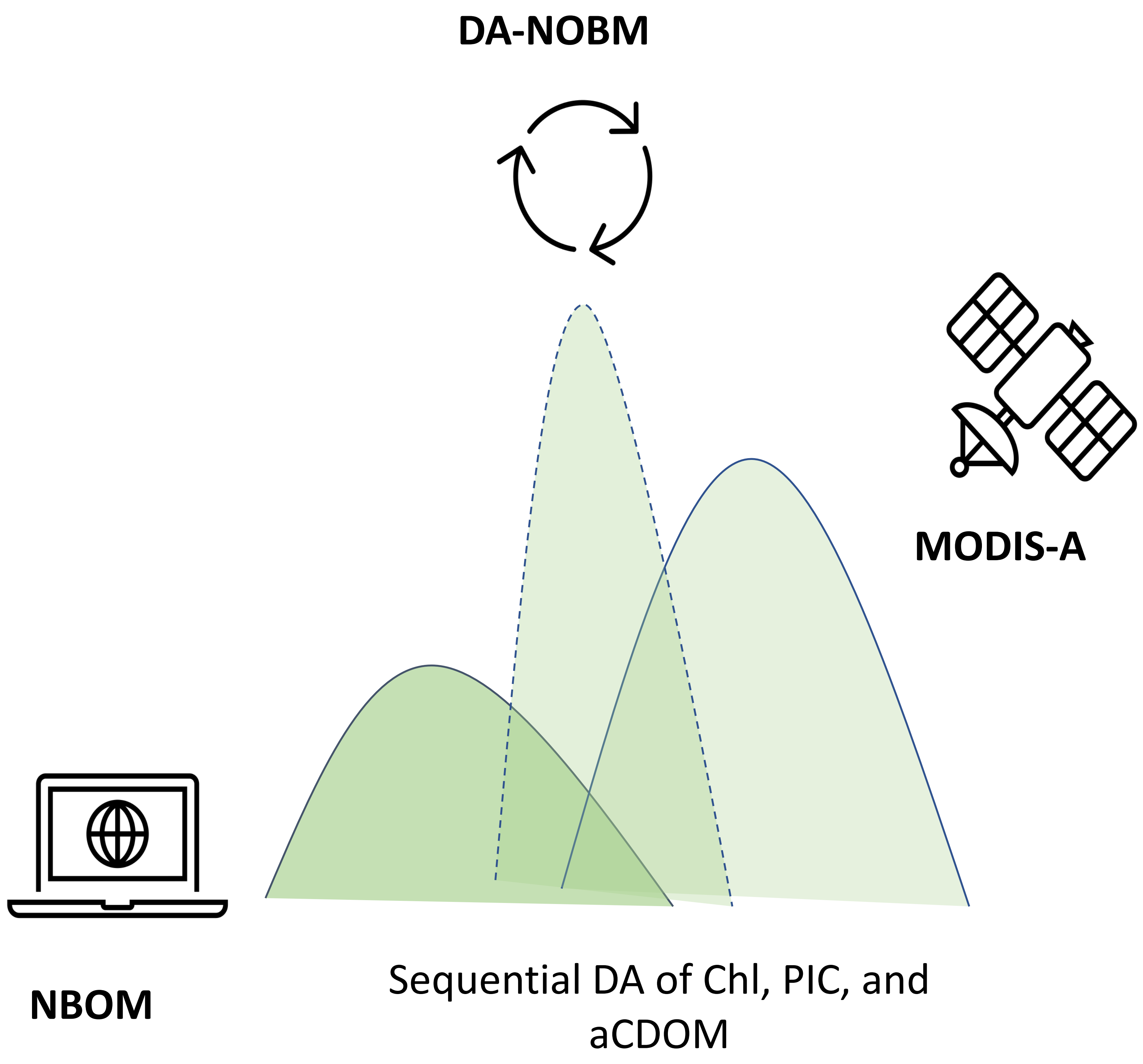
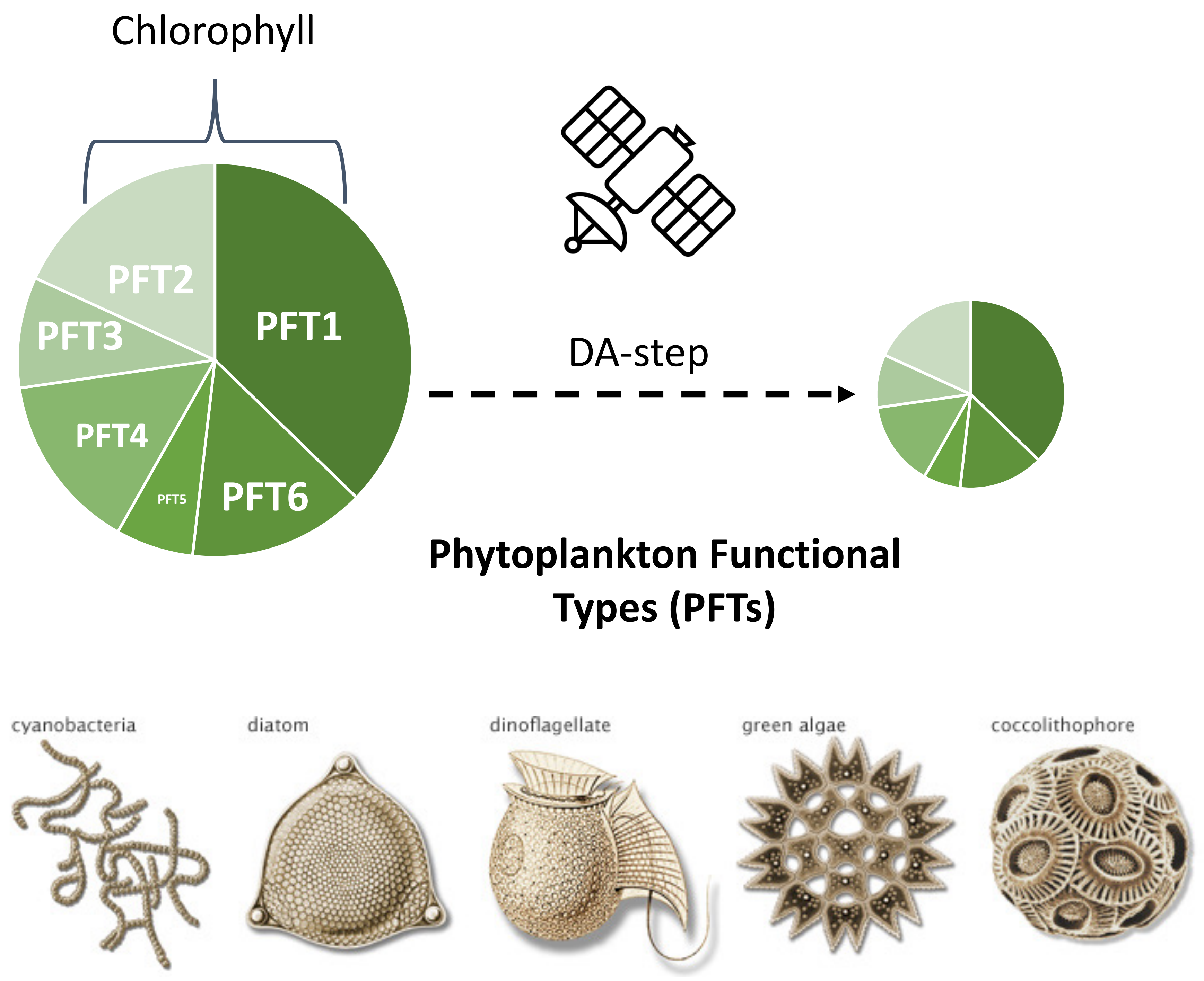
Backup: NOBM



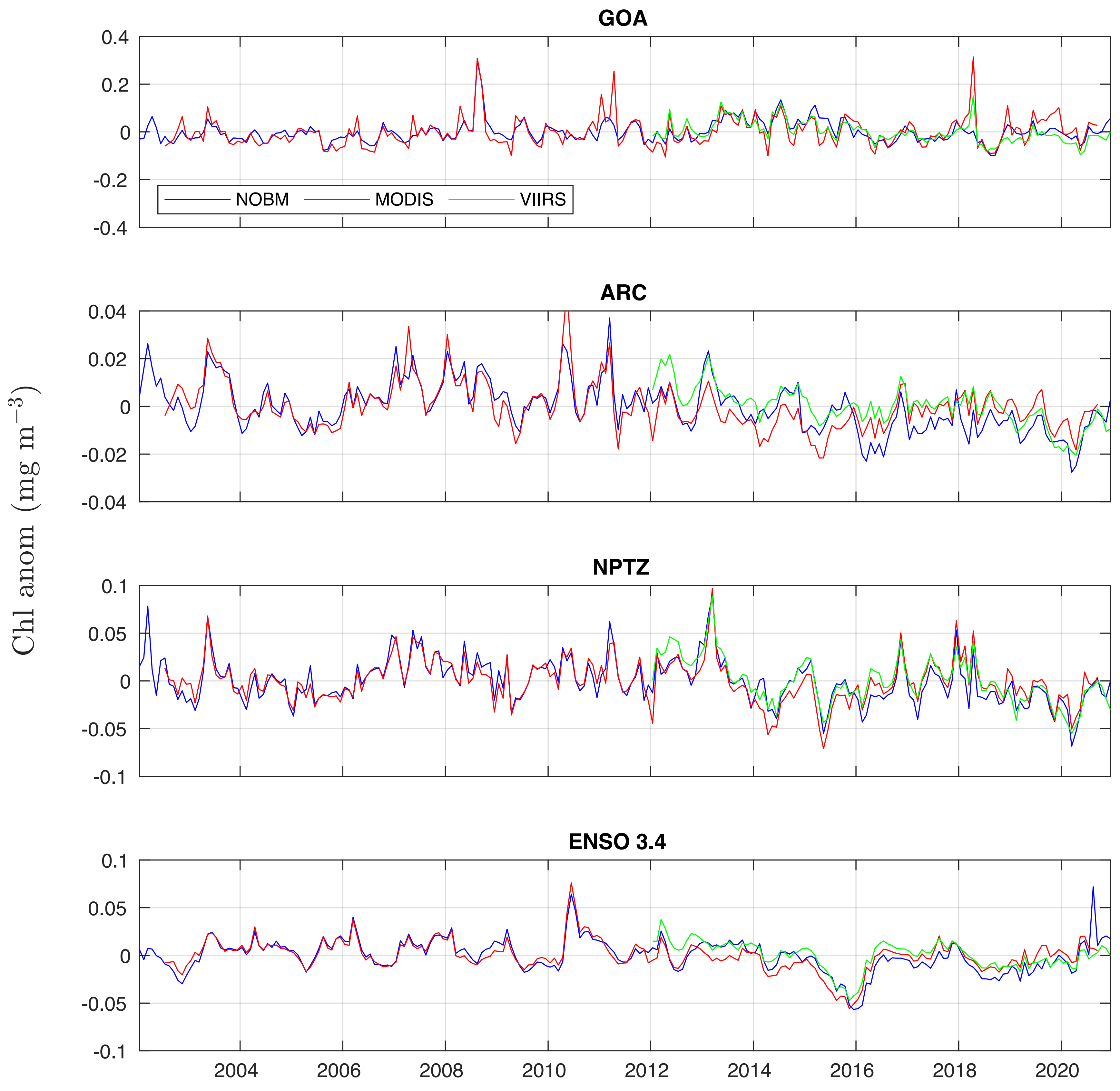
NASA Ocean Biological Model (NOBM)
Water, Sea Ice
CO2
Winds, ozone, relative humidity,
pressure, precipitation, water,
clouds (cover, thickness), aerosols
Winds, SST
Radiative
Model (OASIM)
Ed(λ)
Es(λ)
IOP
Layer Depths
Ed(λ)
Es(λ)
Biogeochemical
Process Model
Temperature, Layer Depths
Advection-Diffusion
Circulation
Model
(Poseidon V2)
Outputs:
Chlorophyll, Phytoplankton Groups
Primary Production
Nutrients
DOC, DIC, pCO2
Spectral Irradiance/Radiance

Backup: NASA Ocean Biogeochemical Model (NOBM)

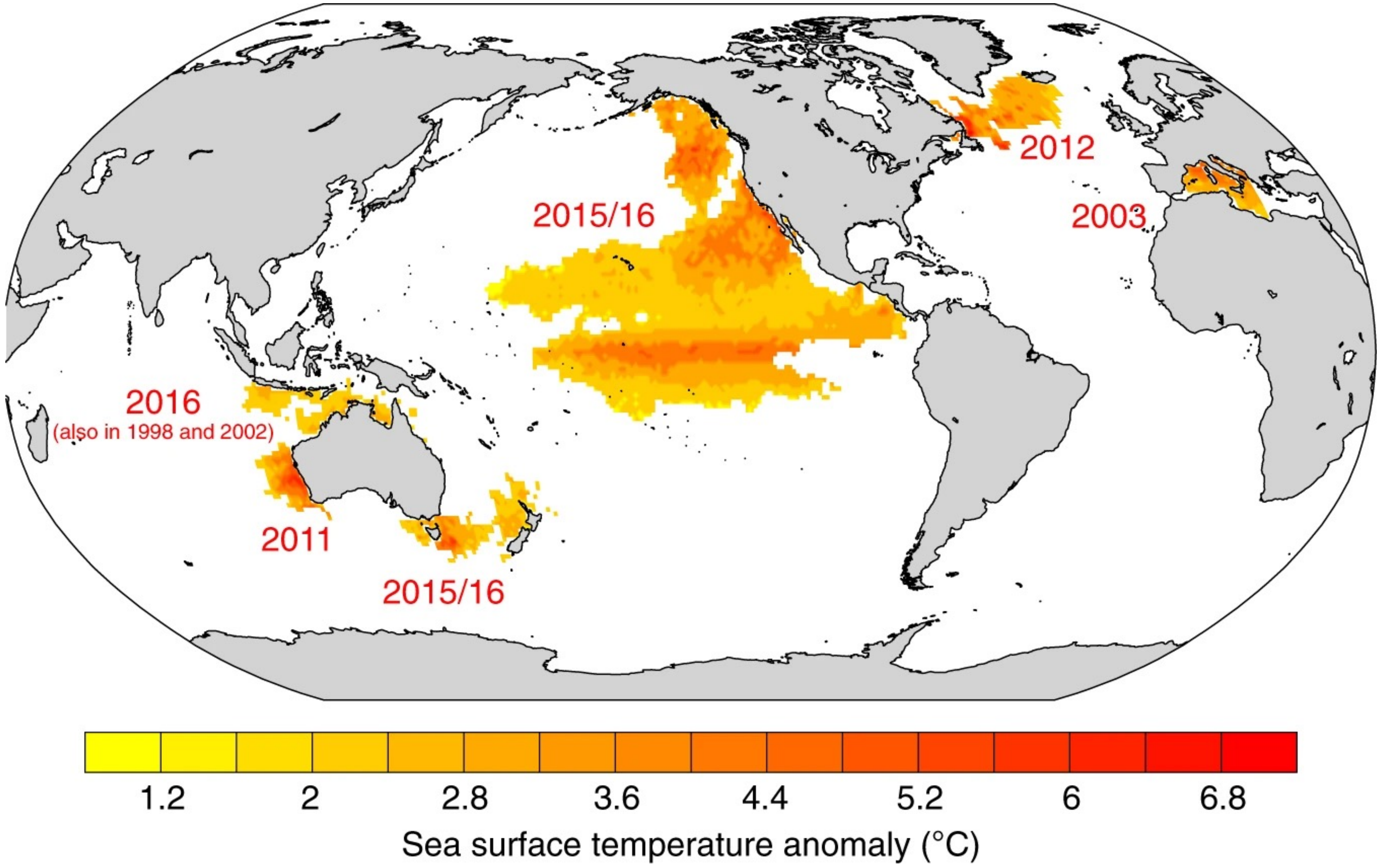




Backup: Validation

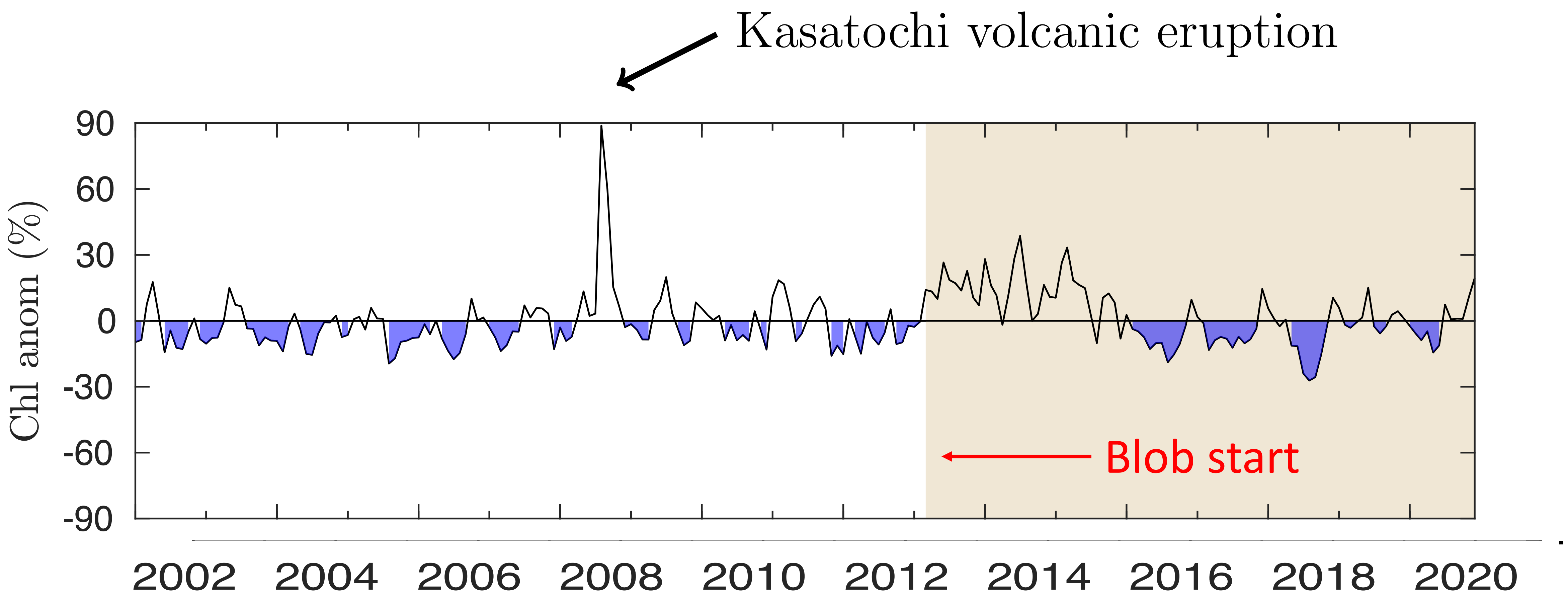


Backup: Marine heat waves globally



Frölicher and Laufkötter (2018)

GOA: Biomass changes



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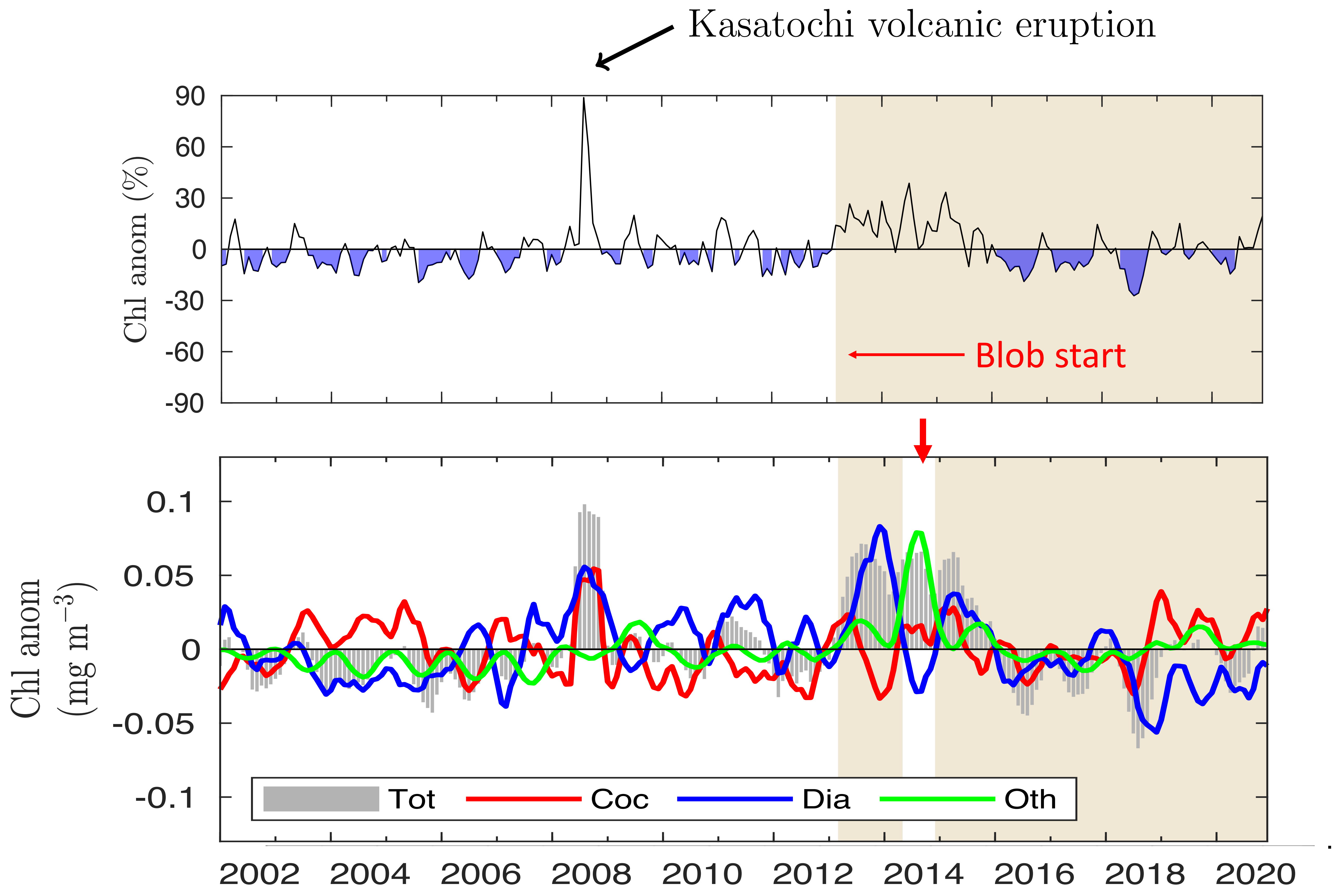
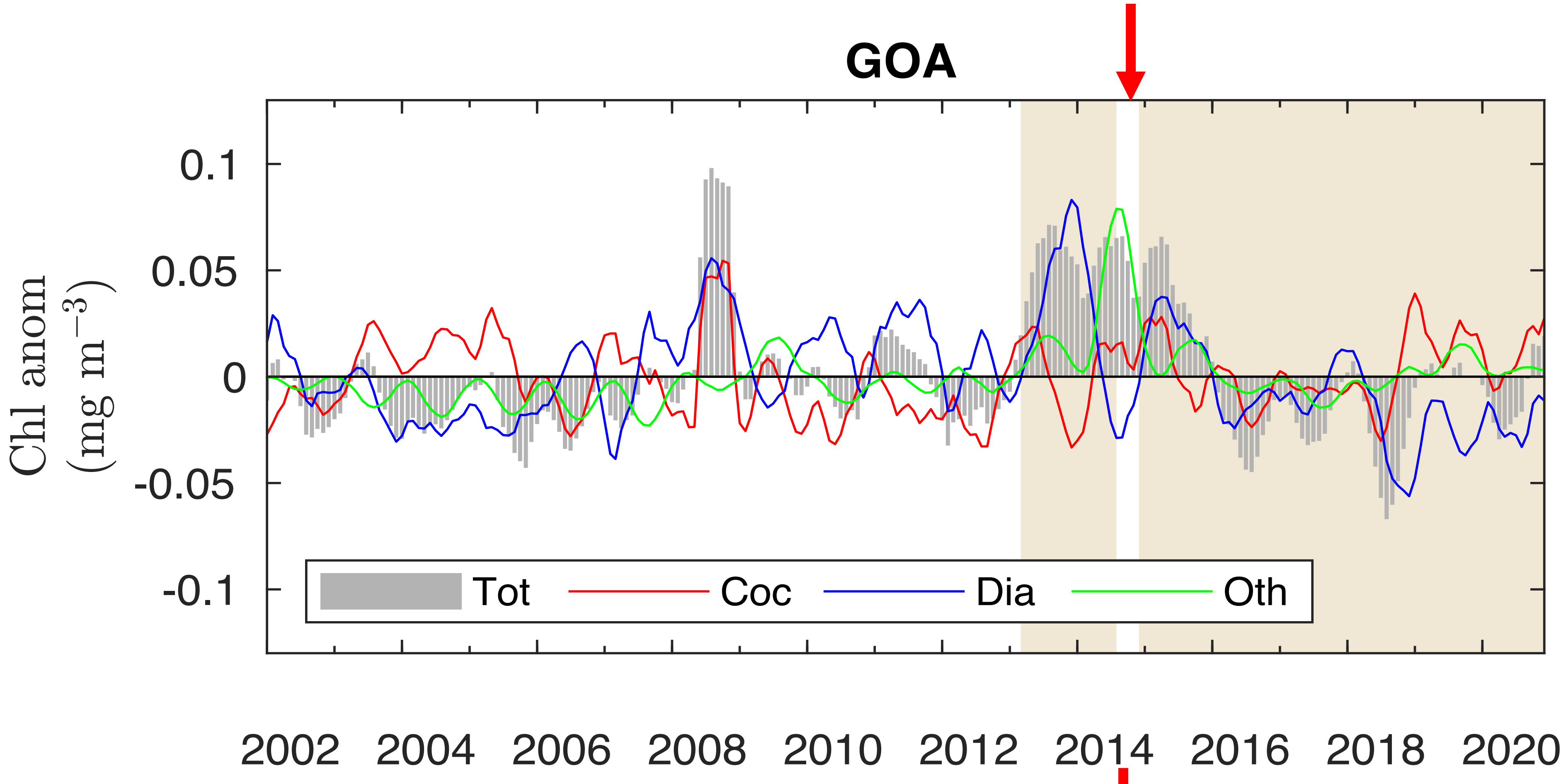
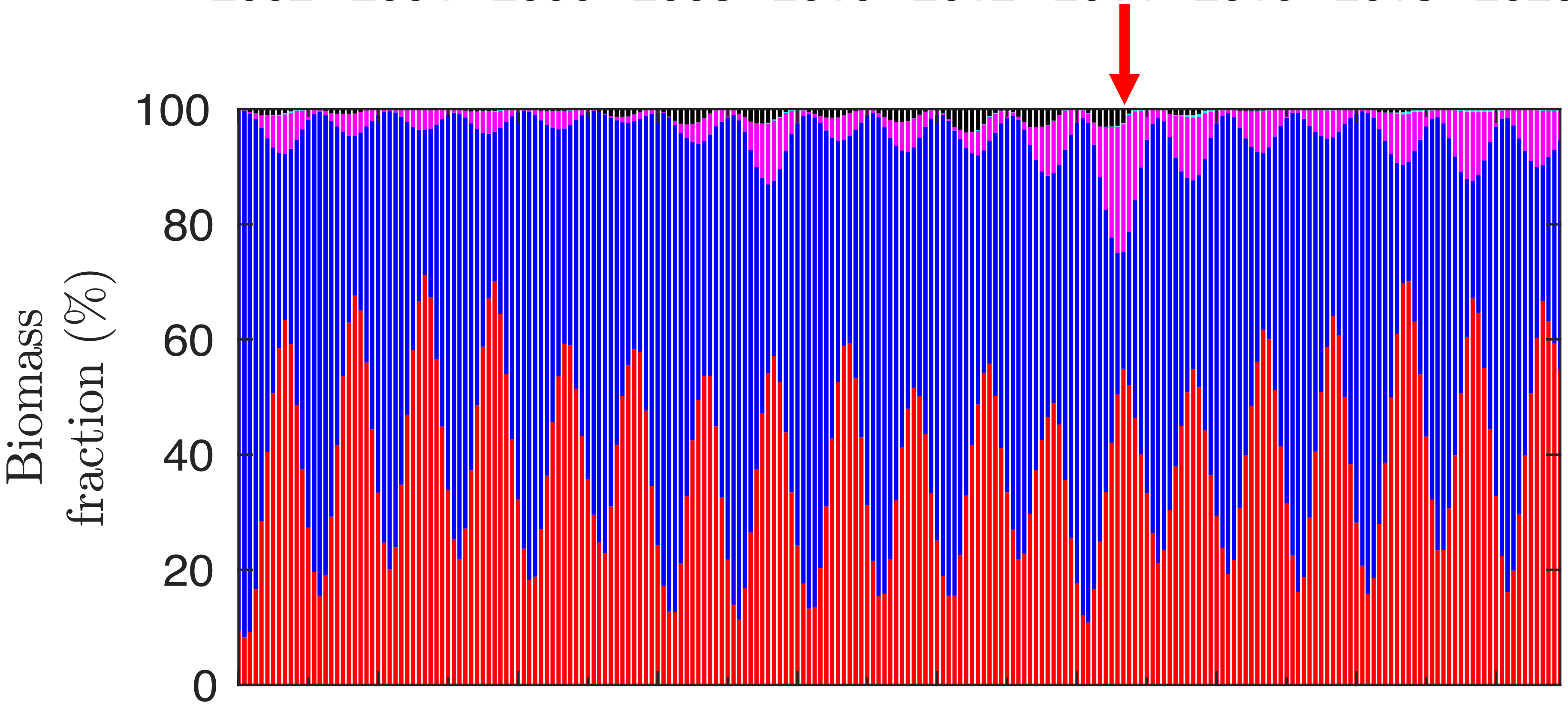
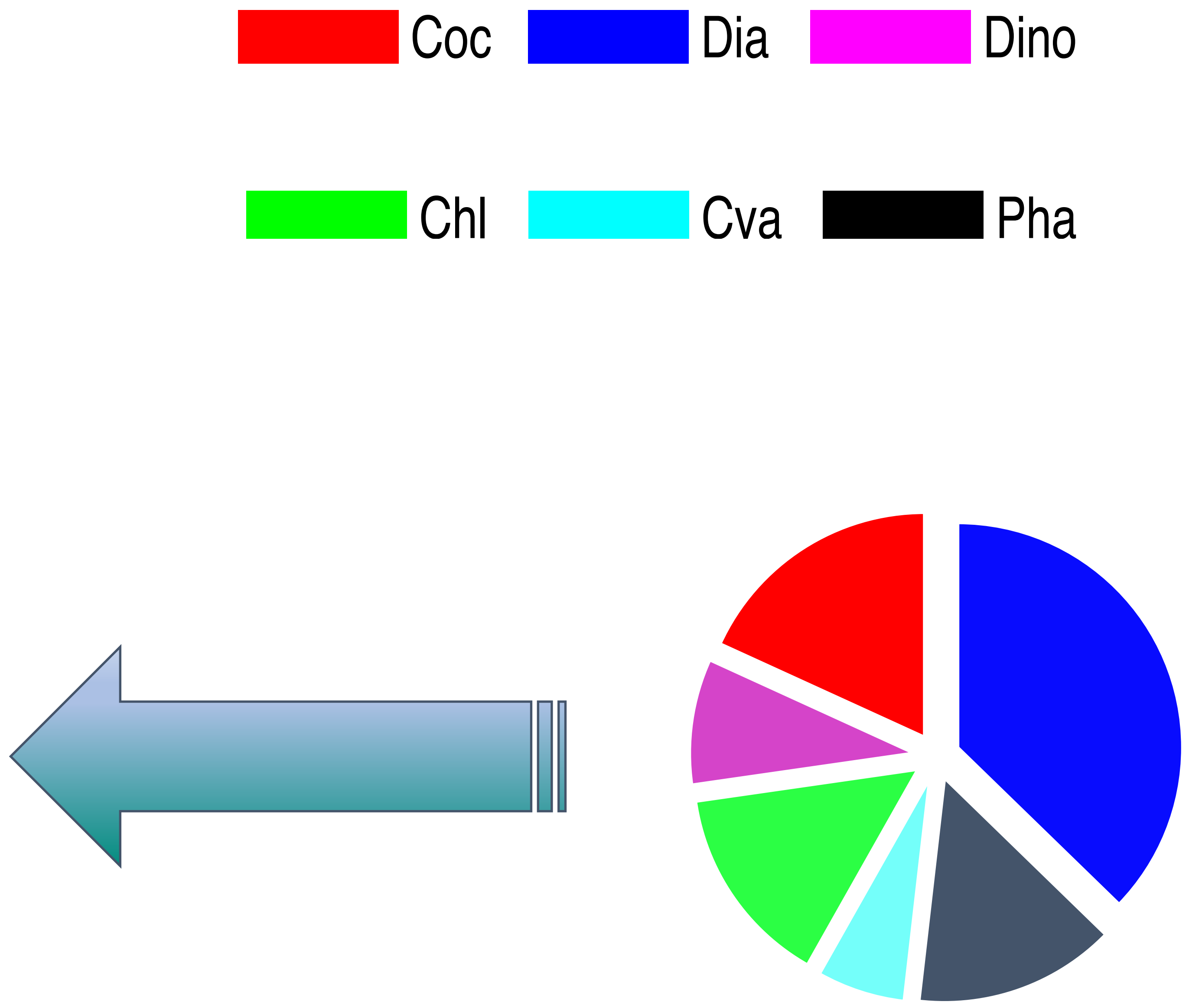


GOA: Phytoplankton community changes





Phytoplankton Functional Types (PFTs)



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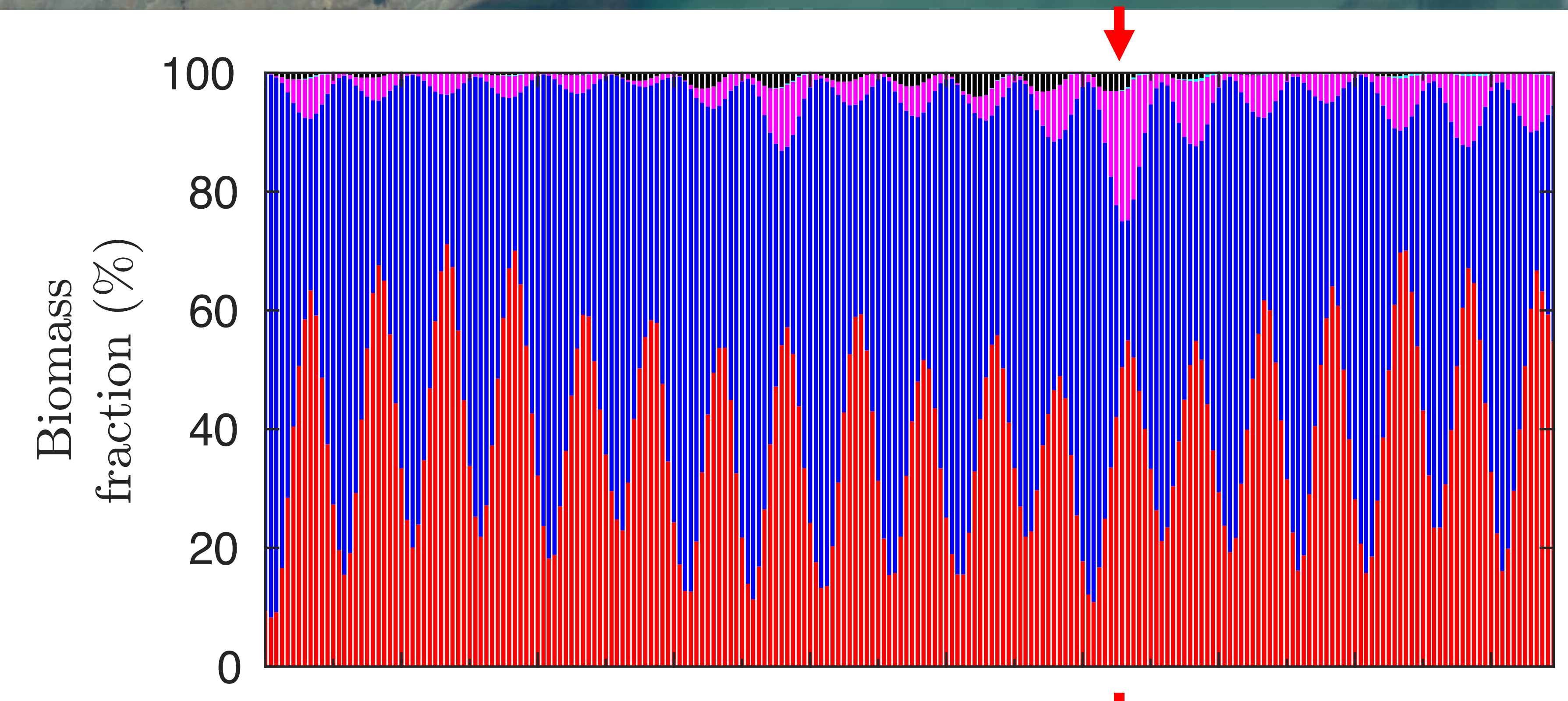
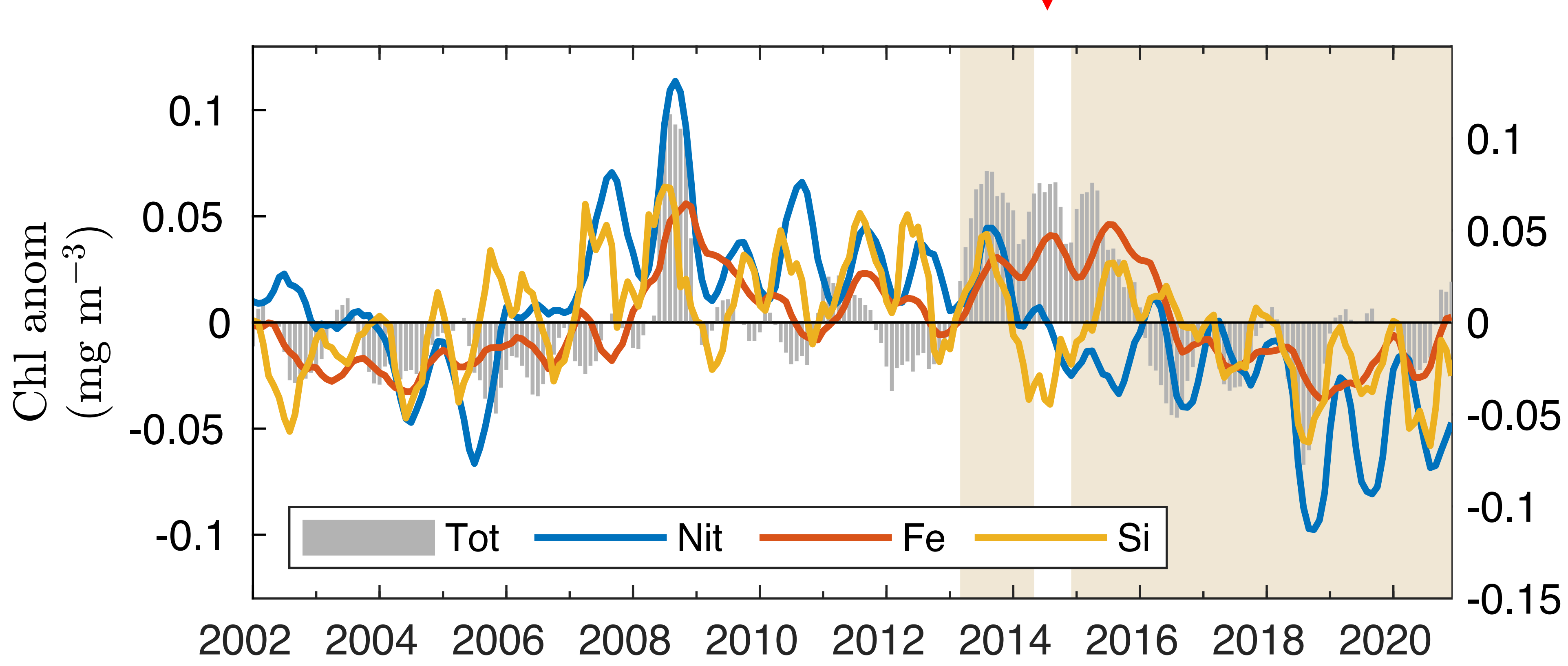


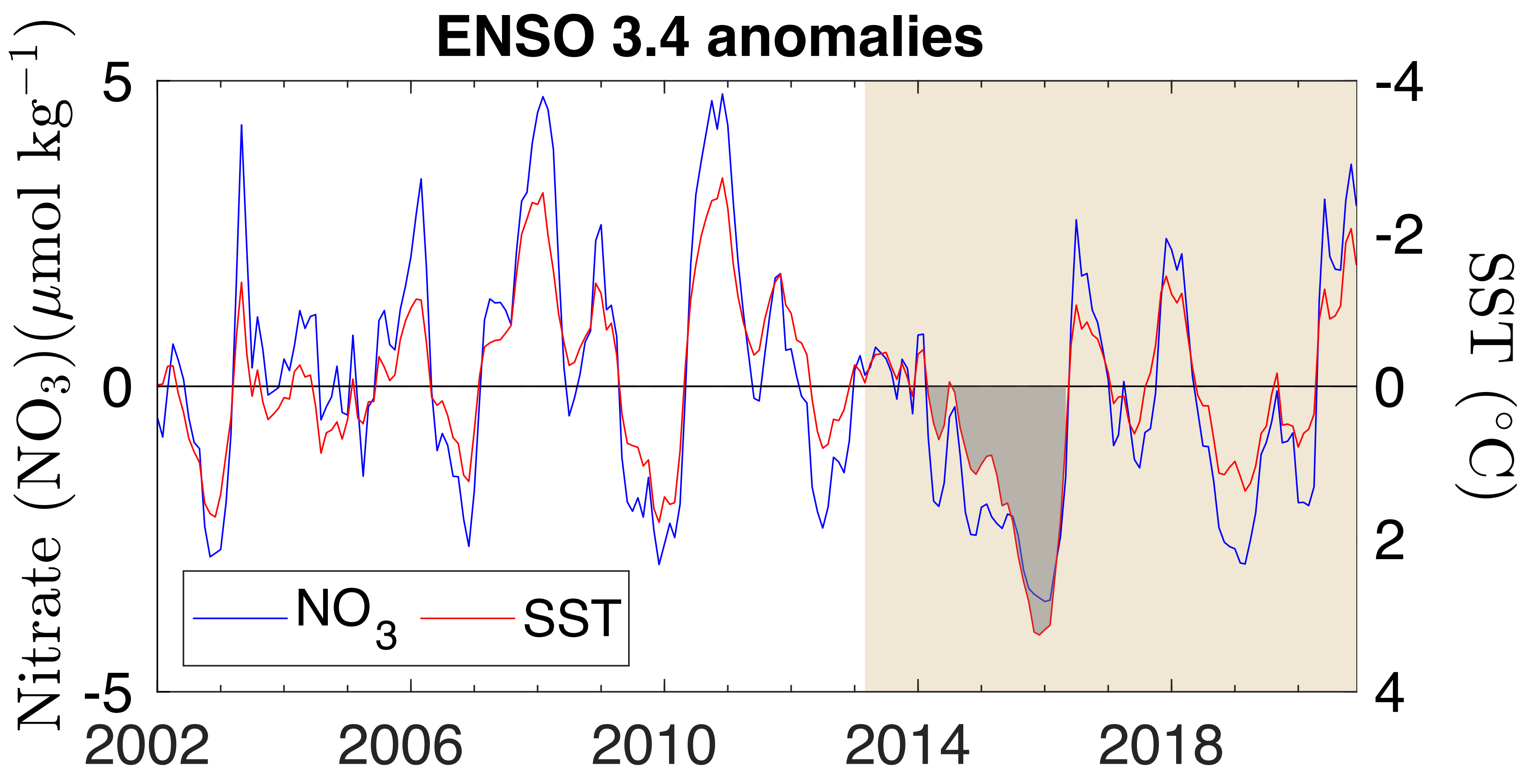


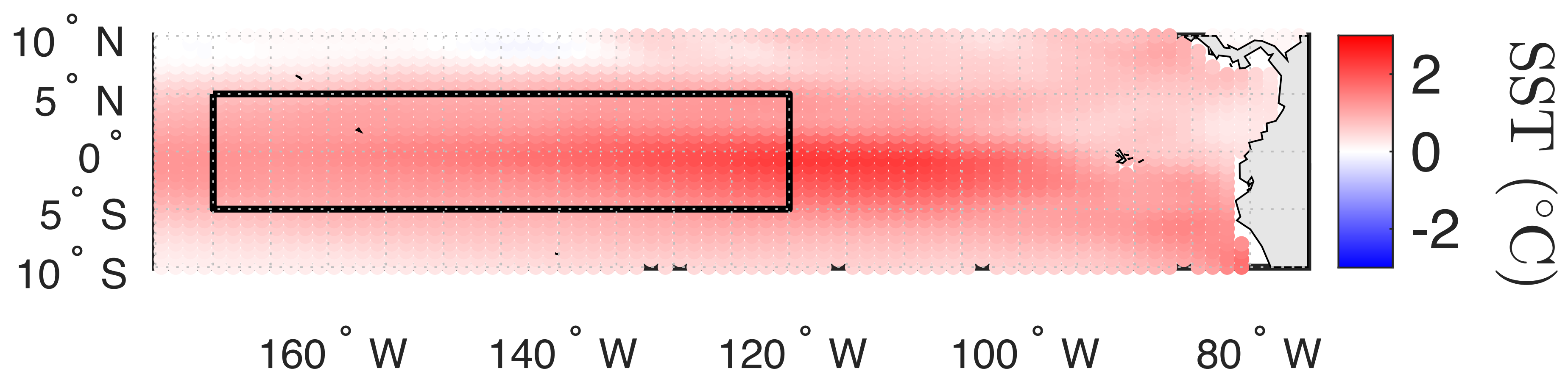
Phytoplankton Functional Types (PFTs)

Coc Dia Dino

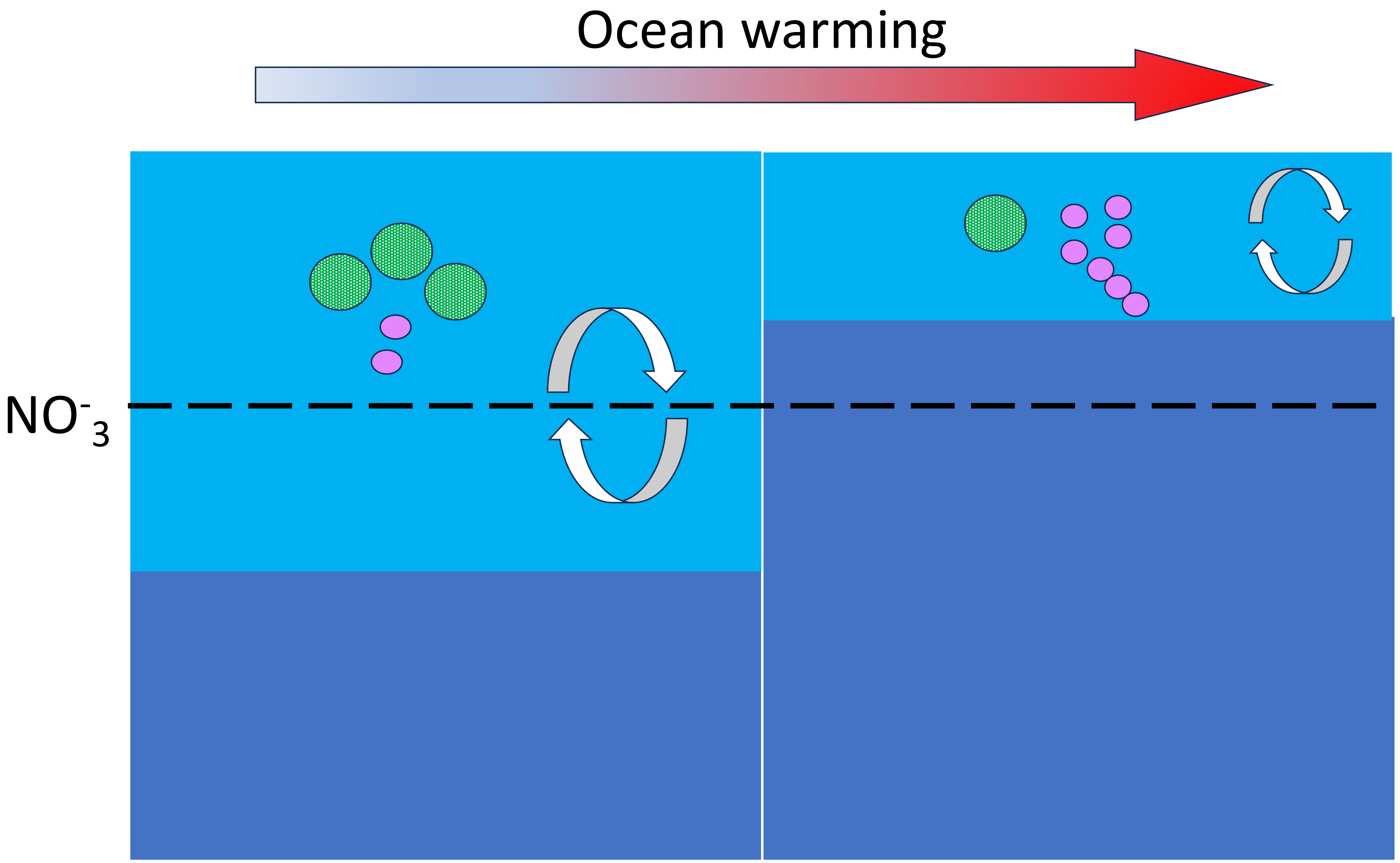
Chl Cva Pha

ENSO 3.4: Mechanisms





Backup: Hypothesis



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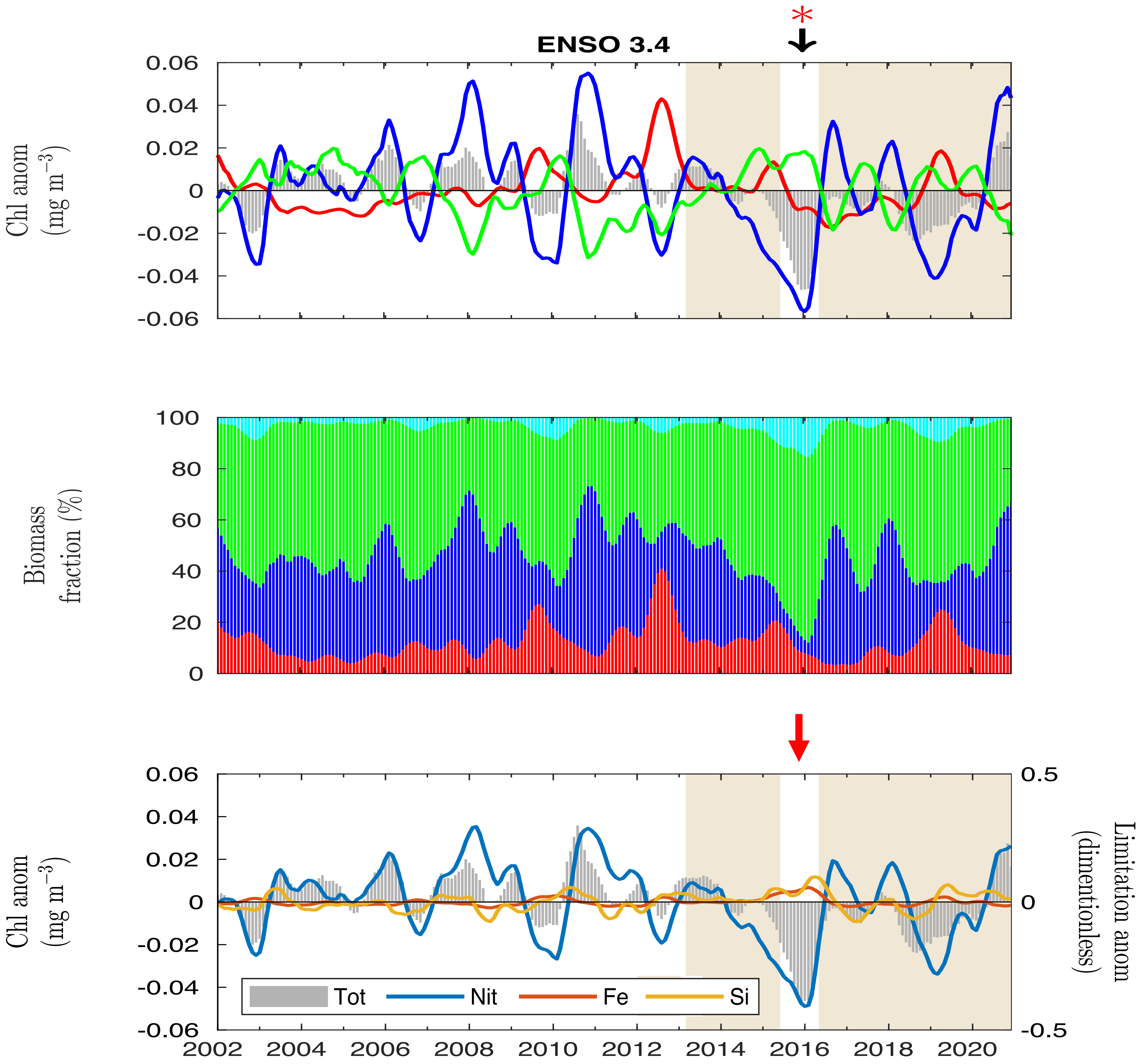
ENSO 3.4: Biomass and community changes



Phytoplankton Functional Types (PFTs)

Coc Dia Dino

Chl Cva Pha

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Backup: Top-Down controls

- **… it's all top-down driven**

Grazing is applied to the individual phytoplankton functional groups proportionately to their relative abundances. This enables herbivore grazing to self-adapt the prevailing phytoplankton community.

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