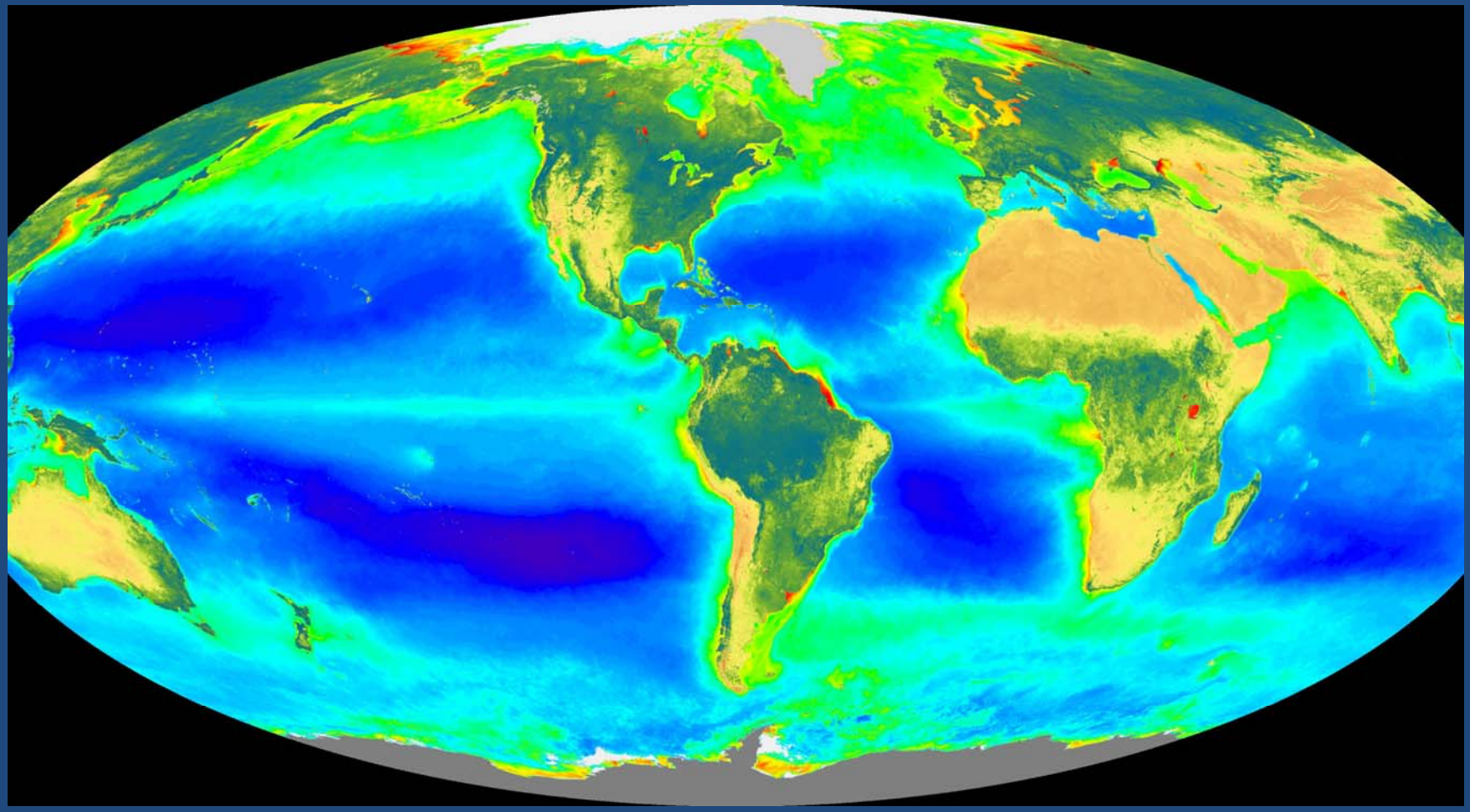
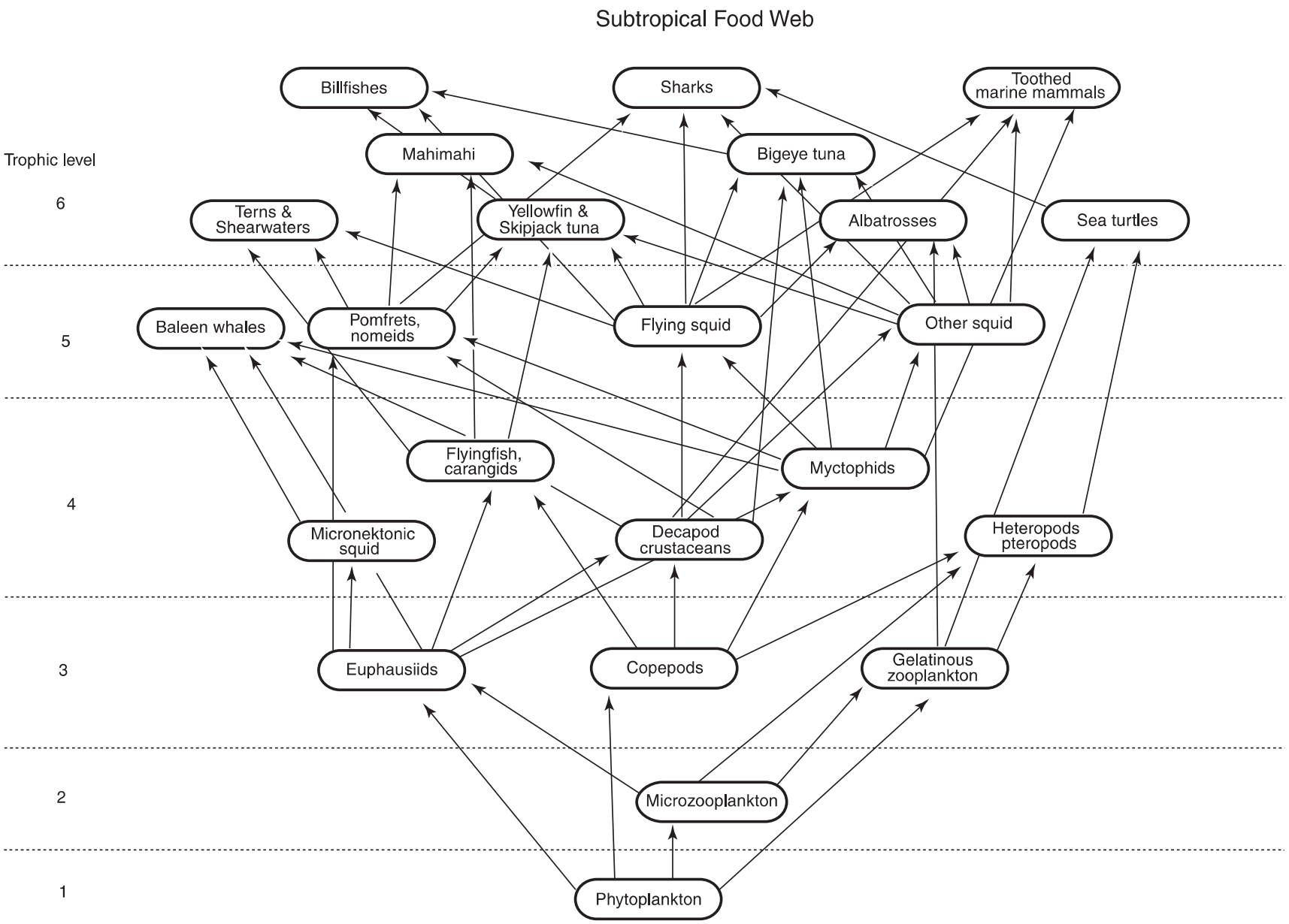
Overview of N Pacific Subtropical Gyre

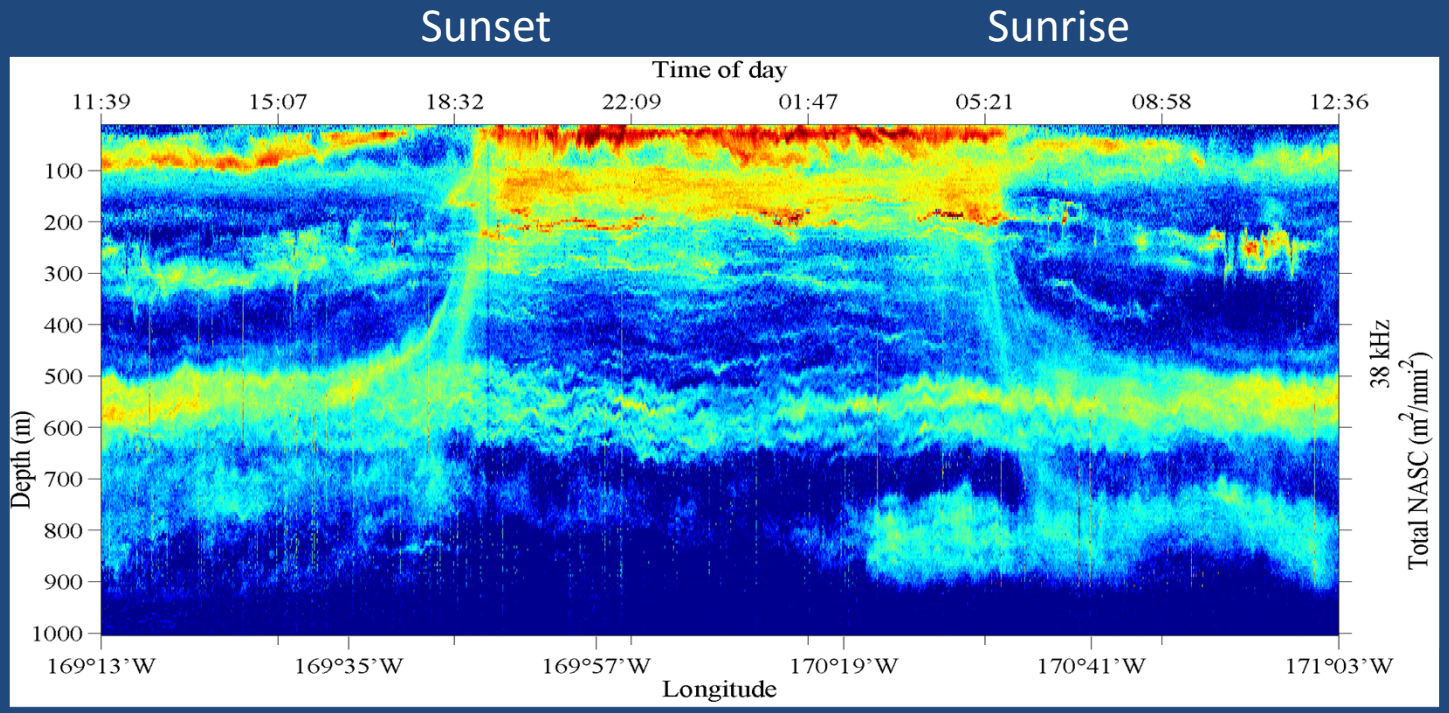


Jeffrey Polovina


Subtropical Food Web
Trophic level
6
5
4
3
2
1
Billfishes
Sharks
Toothed marine mammals
Mahimahi
Bigeye tuna
Terns & Shearwaters
Yellowfin & Skipjack tuna
Albatrosses
Sea turtles
Baleen whales
Pomfrets, nomeids
Flying squid
Other squid
Flyingfish, carangids
Myctophids
Micronektonic squid
Decapod crustaceans
Heteropods pteropods
Euphausiids
Copepods
Gelatinous zooplankton
Microzooplankton
Phytoplankton

Foraging hotspots

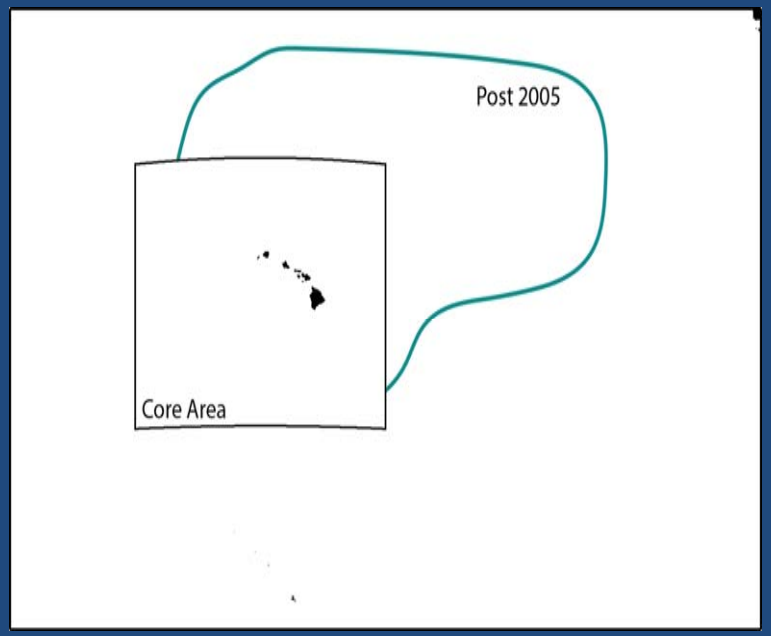
- Oceanographic (fronts, eddies)
- Topography (seamounts, banks, islands)
- Deep scattering layers



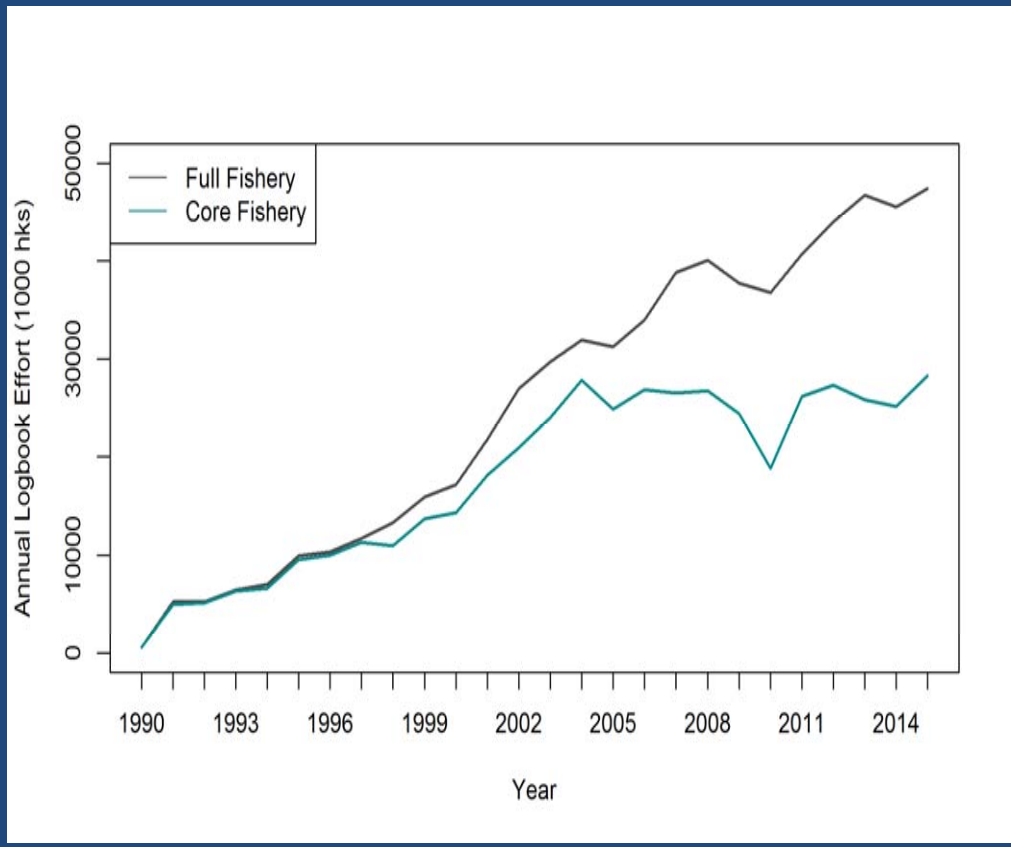
2015 Hawai‘i Longline Effort and Catch

- 142 vessels fished
- 48.7 million hooks set
- Fishing grounds approximately 13 million sq km
- 229,221 bigeye tuna
- 13,498 striped marlin
- 20,381 swordfish
- 101,054 sharks (kept 0.76%)
- 63,062 mahi mahi
- 29,507 opah
- 2015 revenue $94 million

Hawaii-based deepset longline grounds and effort



Core area 12-27 N latitude, 170-150 W longitude - 3.5 million sq km



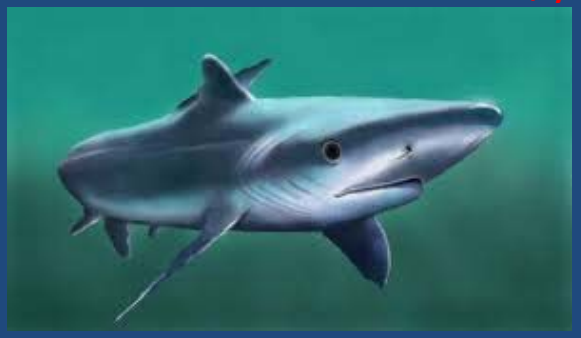
Over the period 1996-2012 many large apex species show substantial declines in annual CPUE

Bigeye tuna -2%/yr

Oceanic white-tip -7%/yr

Shortbill spearfish -4%/yr

Blue shark -4%/yr



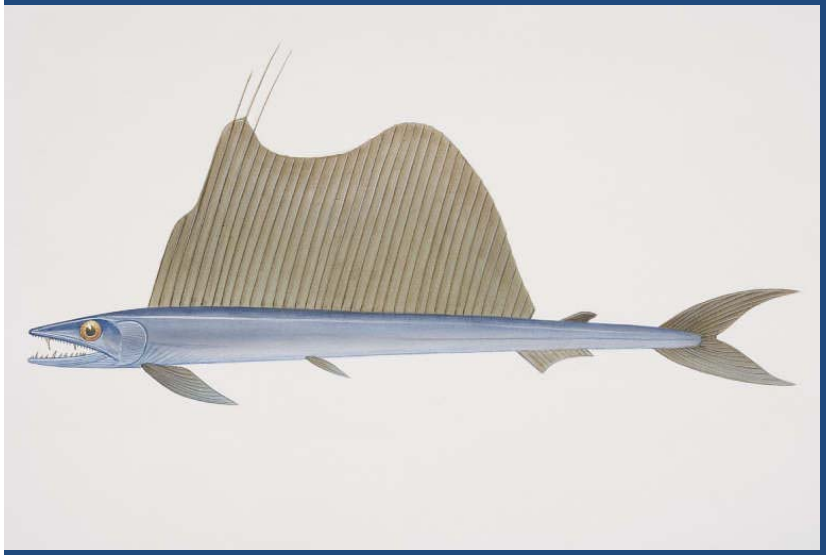
Blue marlin -5%/yr

Striped marlin -5%/yr

While smaller, mid-trophic species, show substantial increases

Mahimahi (*Coryphaena hippurus*) +7%/yr

Lancetfish (*Alepisaurus ferox*)+2%/yr



Escolar, walu, (*Lepidocybium flavobrunneum*)+12%/yr

Snake mackerel (*Gempylus serpens*)+15%/yr

Sickle pomfret (*Taractichthys steindachneri*) +6%/yr

Small and Large Size Groups

Small Fishes: 9 fishes with mean weight < 15 kg

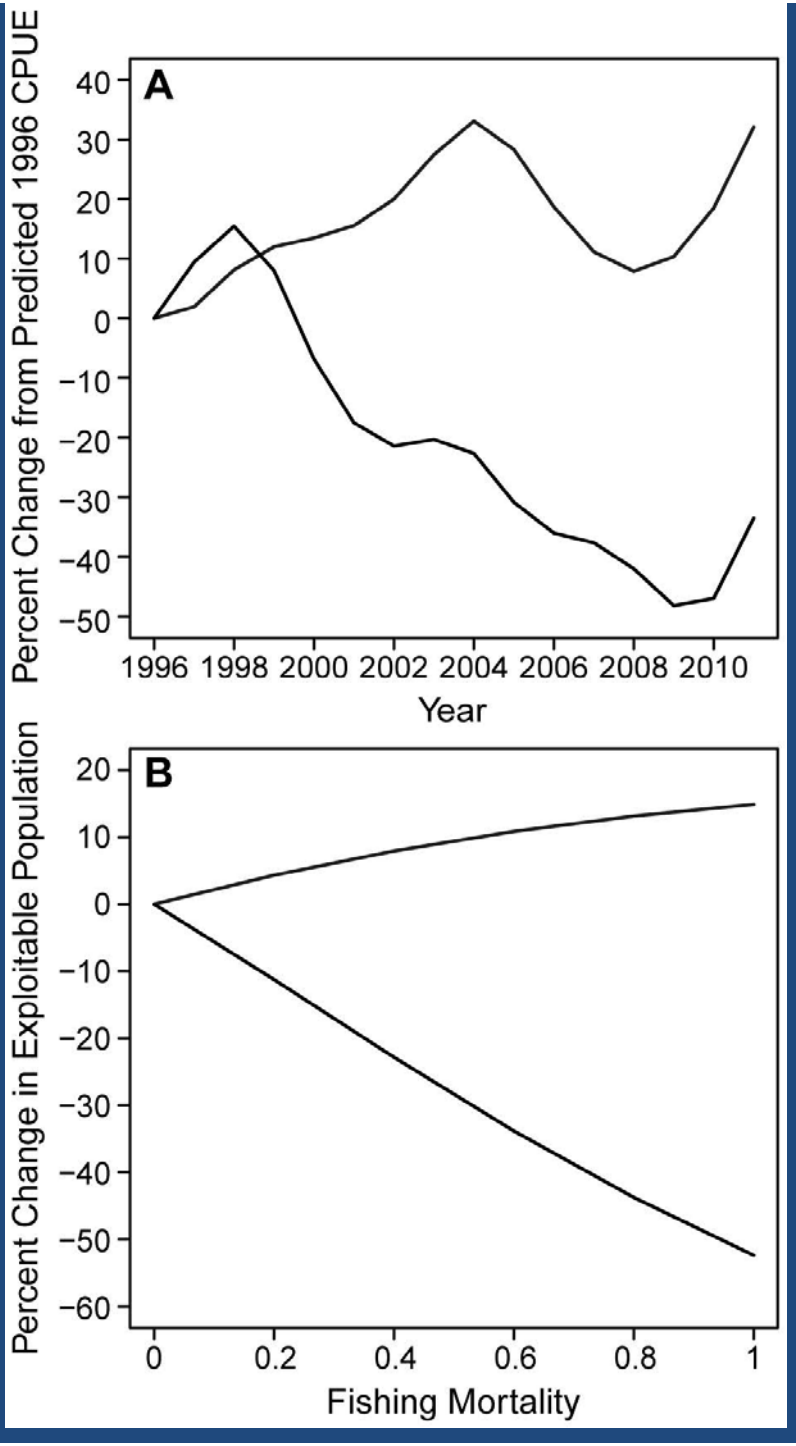
Escolar: 6.2 kg
Mola: 8.8 kg
Skipjack Tuna: 7.9 kg
Mahi Mahi: 7.4 kg
Lancetfish: 2.8 kg
Great Barracuda: 5.9 kg
Pomfrets: 4.9 kg
Pelagic Stingray: 3.0 kg
Snake Mackerel: 2.6 kg

Large Fishes: 14 fishes with mean weight ≥ 15 kg

Blue Marlin: 52.5 kg
Blue Shark: 106.4 kg
Striped Marlin: 26.3 kg
Shortbill Spearfish: 15.5 kg
Shortfin Mako Shark: 48.3 kg
Swordfish: 42.0 kg
Yellowfin Tuna: 33.5 kg
Opah: 30.2 kg
Bigeye Thresher Shark: 24.0 kg
Unidentified Tuna: 24.0 kg
Bigeye Tuna: 22.5 kg
Oceanic White-tip Shark: 19.0 kg
Albacore Tuna: 17.1 kg
Wahoo: 16.4 kg

(A) Percent change in generalized additive model (GAM) standardized CPUE for small fishes (<15 kg) (top line) and large fishes (>15kg) (bottom line).

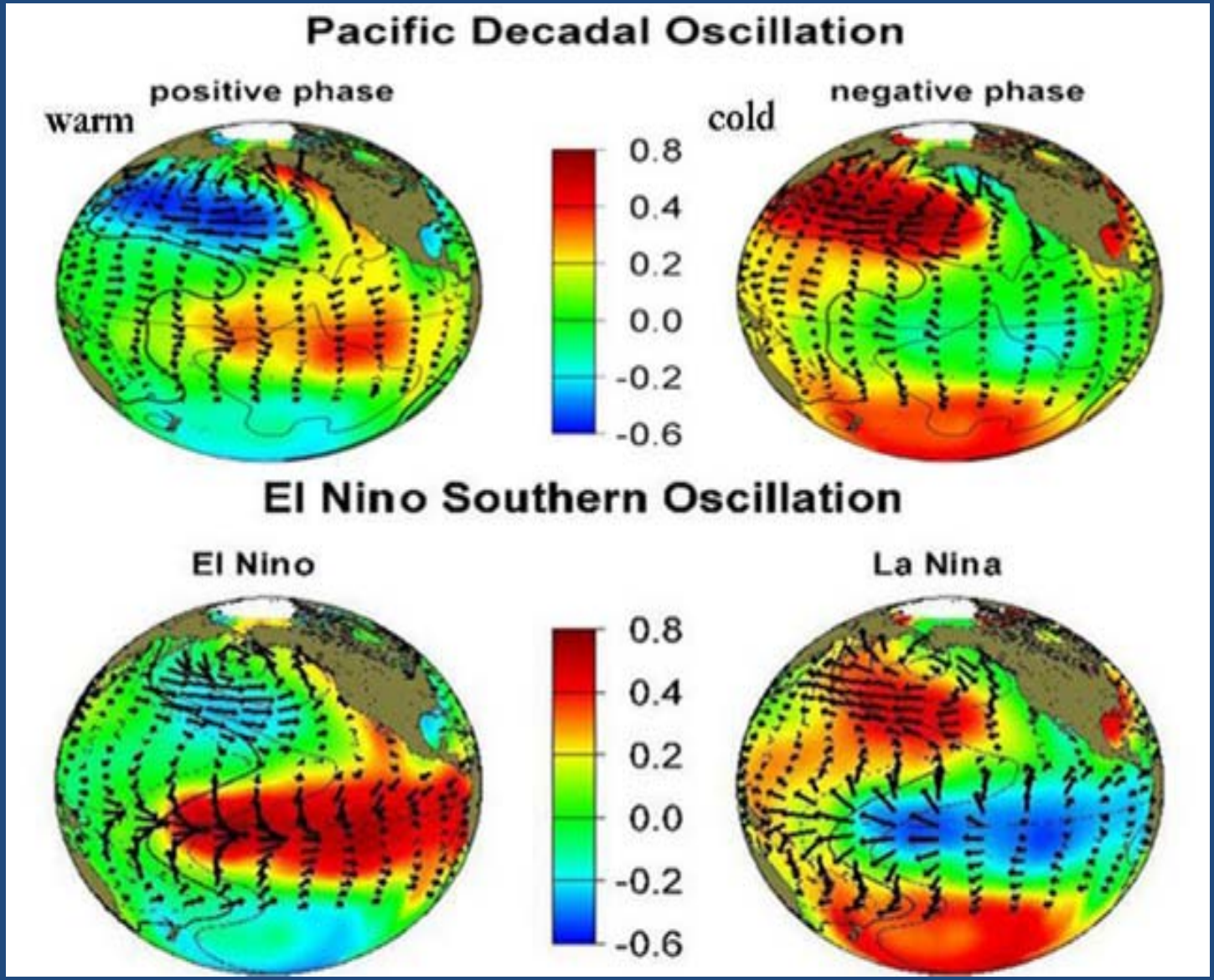
(**B**) change in size-based model estimated population size for small fishes (<15 kg) (top line), large fishes (>15 kg) (bottom line).



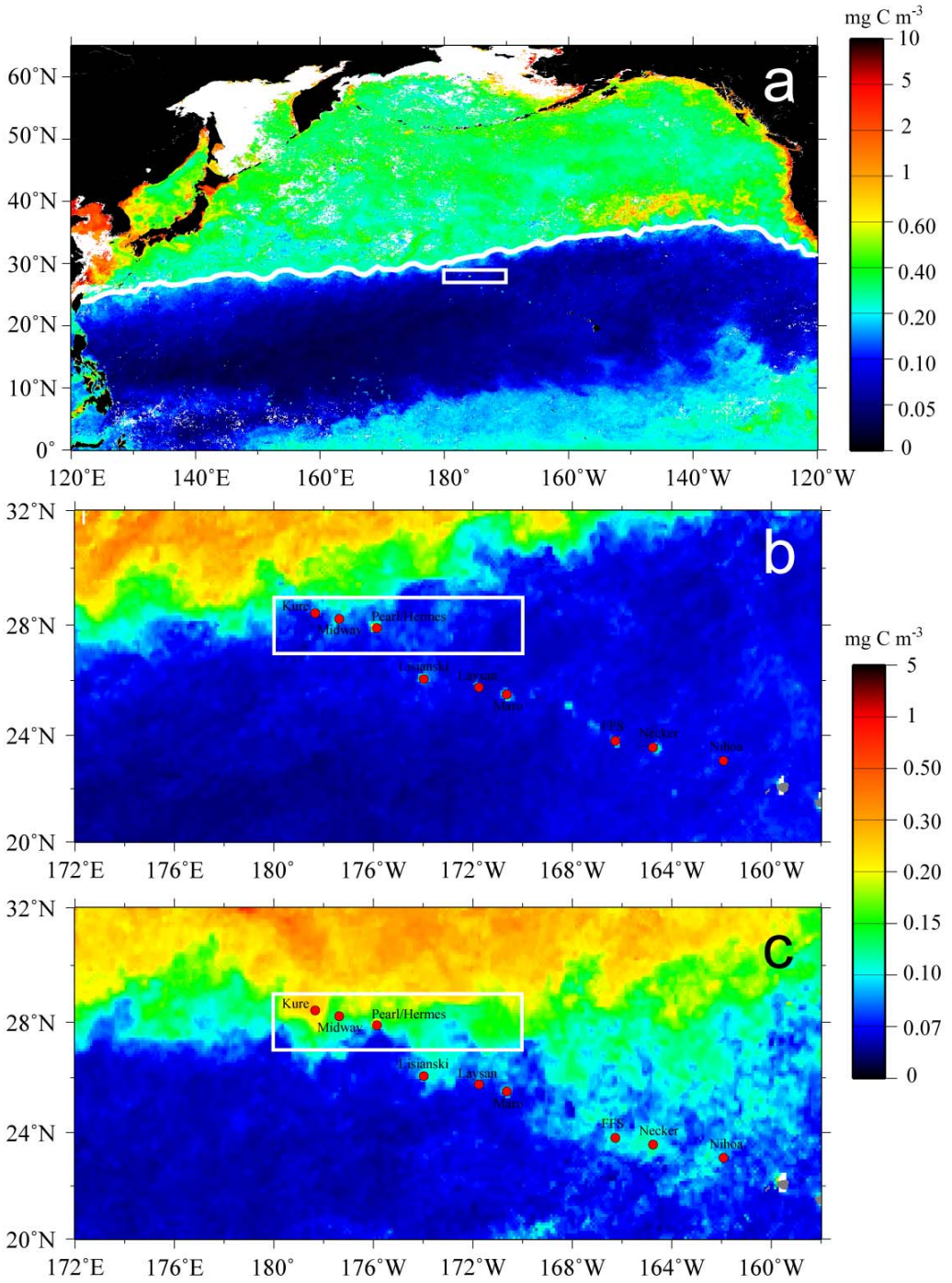
Ecosystem response to fishing

- Longline fishery changes the size structure and species composition of the ecosystem.
- Large, apex fish species decline, smaller lower trophic species increase. Could be beneficial for some marine mammals.
- Gear interactions with seabirds, sea turtles, and cetaceans.
- Current management sets harvest limits only for 3 species (bigeye and yellowfin tunas and striped marlin).
- May be a need for more of an ecosystem approach to set quota on total yield to limit changes in ecosystem structure and vulnerable species.

Two Modes of Oceanographic Variation in the Pacific

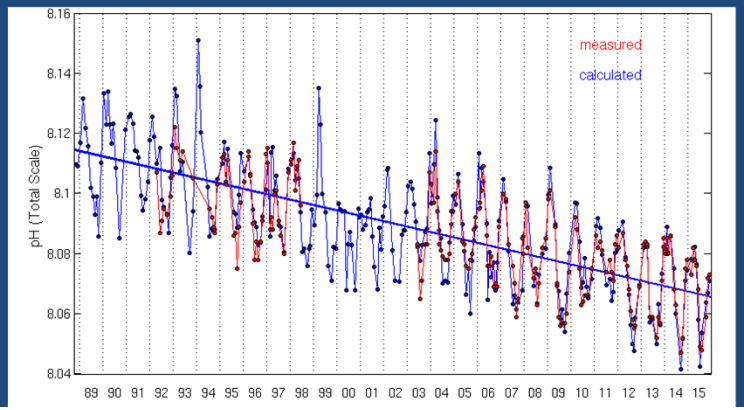


Satellite-derived winter Surface chlorophyll in March 2000 (top, middle) and March 2004 (bottom) provide an example of interannual variation in northern extent oligotrophic waters. (Baker et al. 2007)

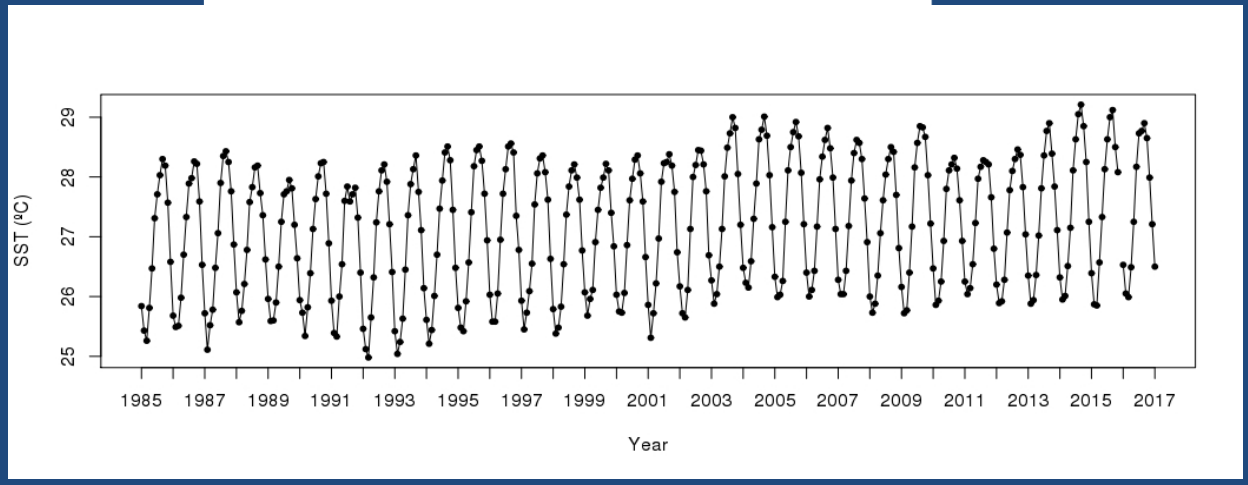


Climate change occurring now

1. Station Aloha pH

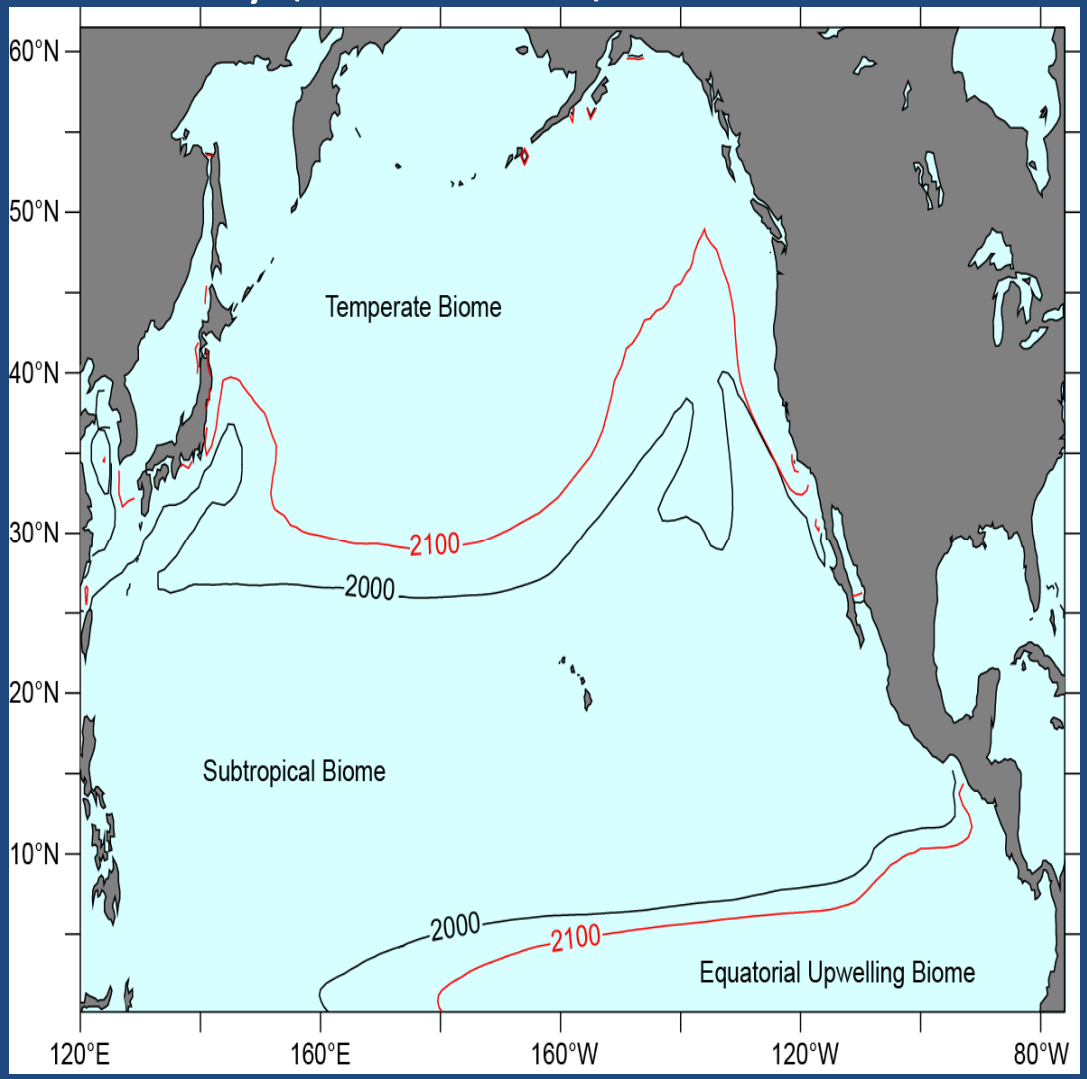


2. SST 0-30 N,
135 E-150W



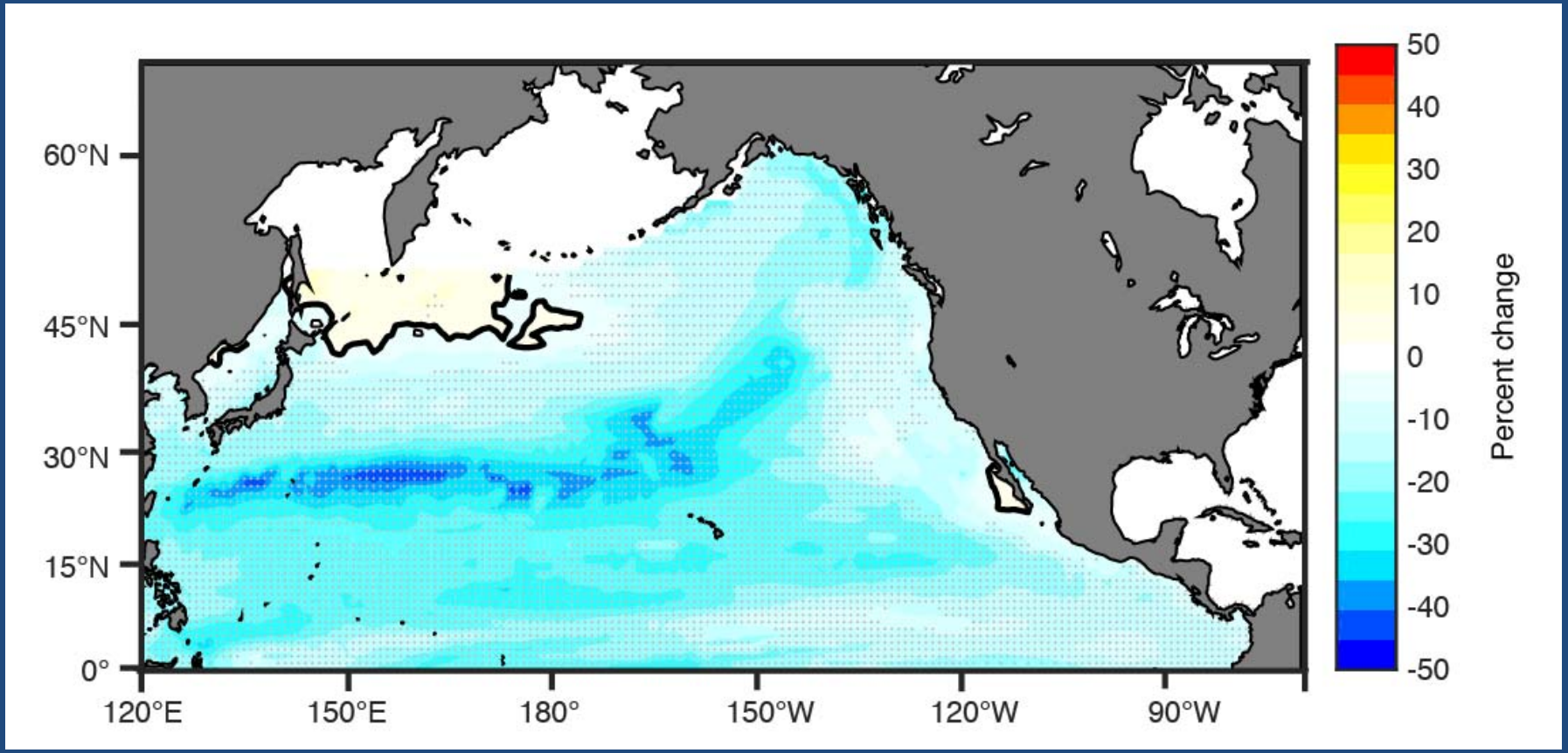
3. 2014-2016 coral reef bleaching

Expansion of the subtropical gyre between the beginning and end of the 21st Century (GFDL ESM2.1)



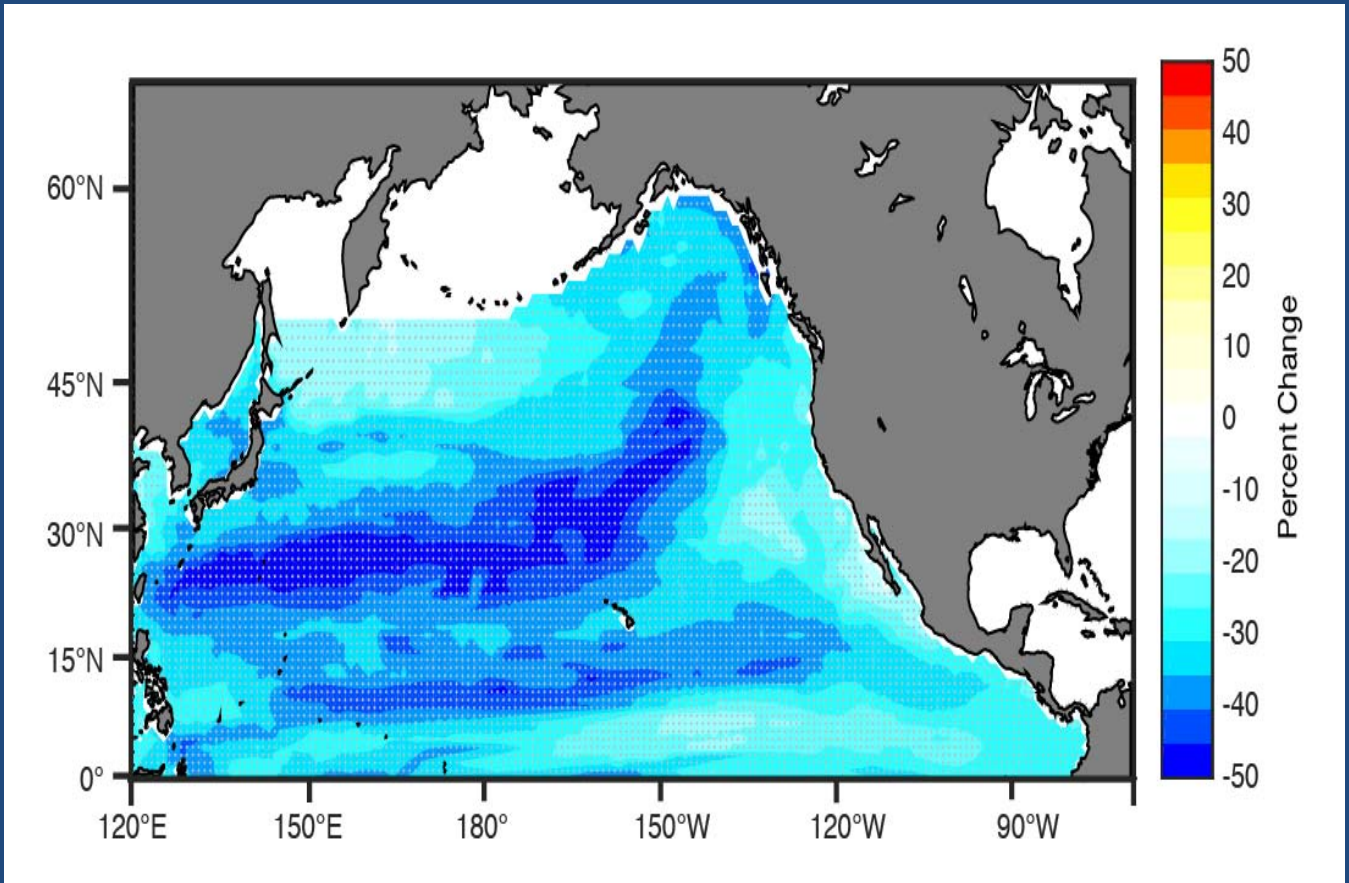
Polovina et al. 2011

Multi-model ensemble percent change in zooplankton density from beginning to end of the century



Woodworth-Jefcoats et al. 2016

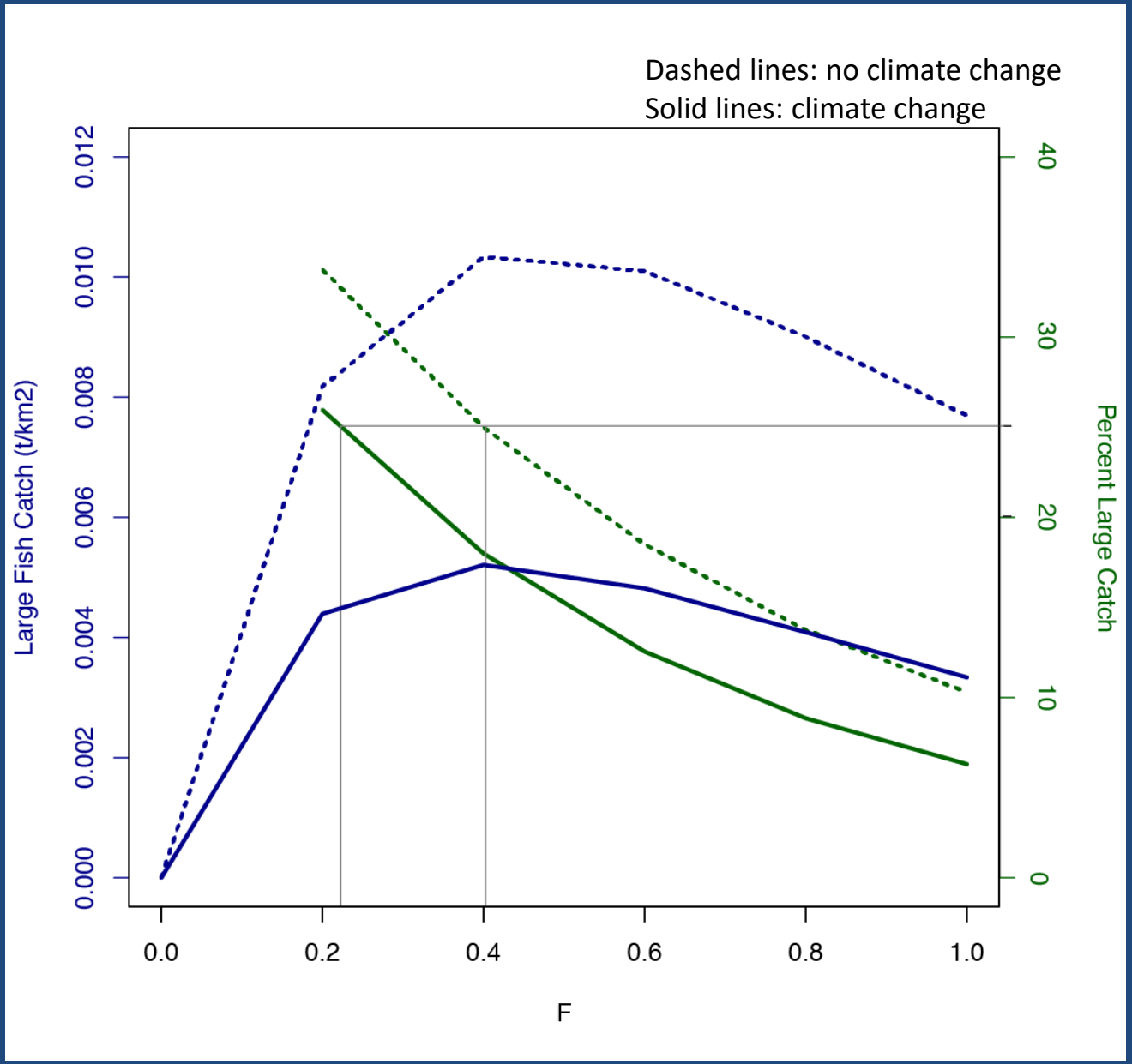
Climate change impacts on Carrying Capacity by the end of the 21st Century



11 CMIP5 model median projected change in potential Carrying Capacity F(Zooplankton density and T)

Woodworth-Jefcoats et al. 2016

Size-based food web model for large fish catch and % large fish in catch with and without climate change.



Ecosystem response to climate change

- Changes at the base of the ecosystem and rising temperature are projected to decrease fishery yields 2-5% per decade.
- Fishing and climate change impacts combine to shift the size/trophic structure to smaller sizes/lower trophic levels.
- Reductions in fishing effort may provide some adaptation to climate impacts at the base of the food web.
- While the rate of change in the STG due to climate change isn't as fast of northern latitudes, the impact to ecosystem services may be much greater in the STG.