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Regional fisheries and ocean climate information needs

Fisheries under climate variability and climate change

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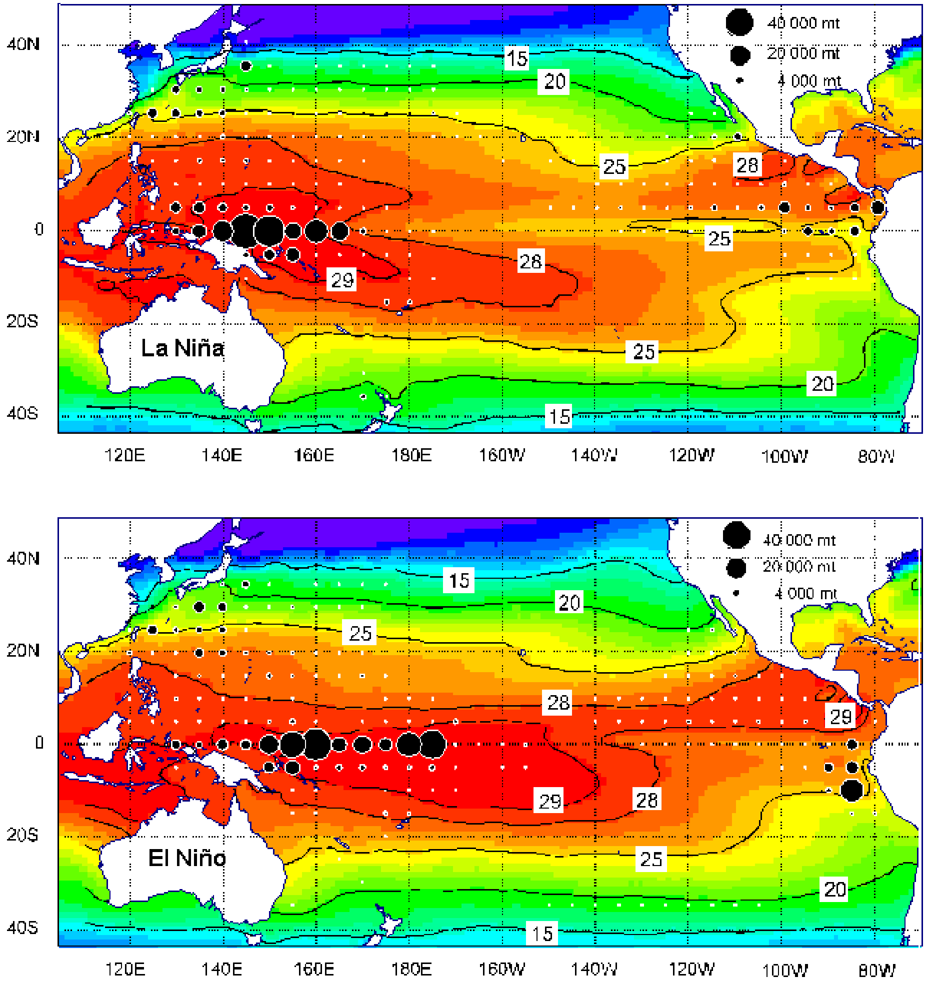
Pelagic fisheries

Climate variability and tuna fisheries: what can we predict? From which variables?

ENSO and Tuna: past observations

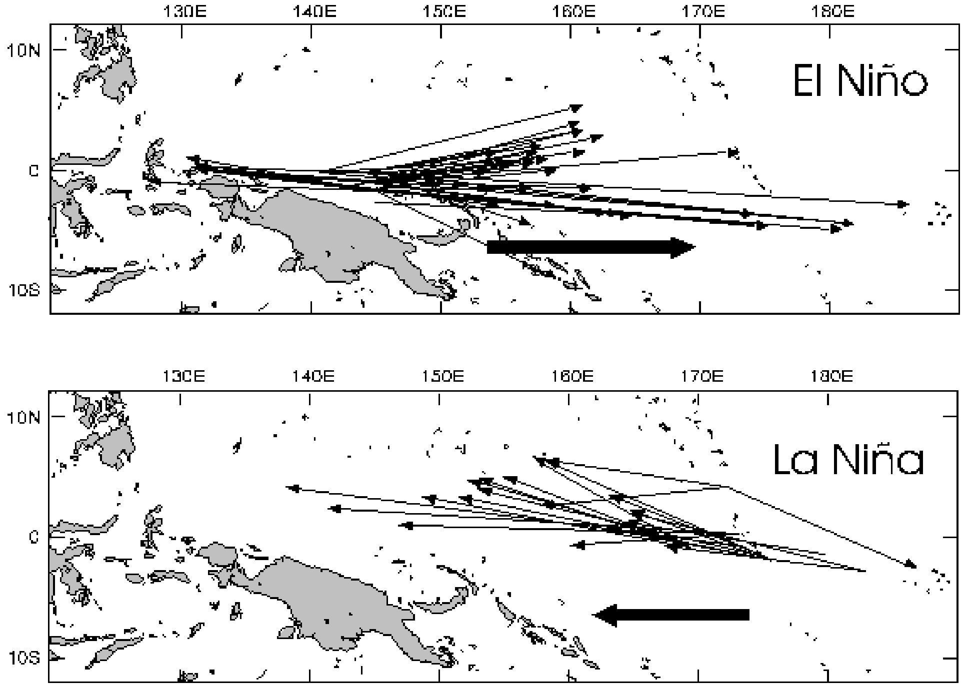
Purse seine skipjack catch and SST



Lehodey et al (1997)

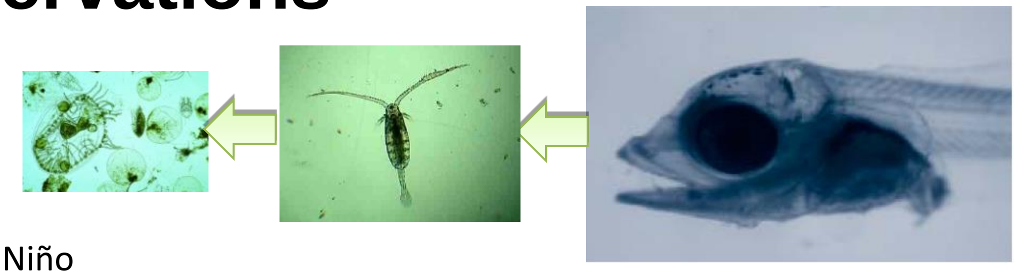
Eastward (El Nino) or westward (La Nina) shift of equatorial PS fishery correlated to expansion (contraction) of the Western Pacific Warmpool

Tagging data indicate that part of this change is due to fish movement, likely also under the change in equatorial circulation



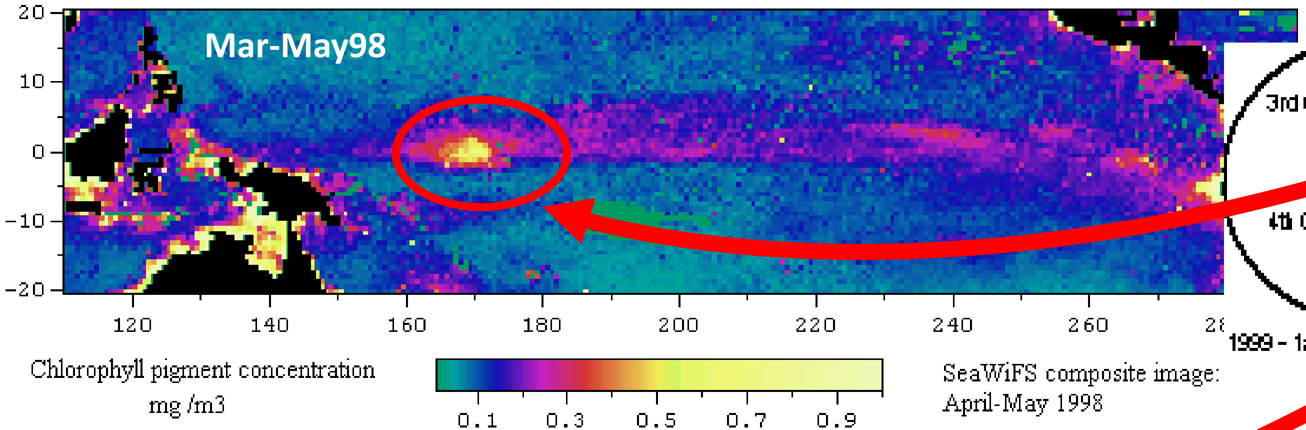
ENSO and Tuna: past observations

Tuna larvae feed on zooplankton that feed on phytoplankton



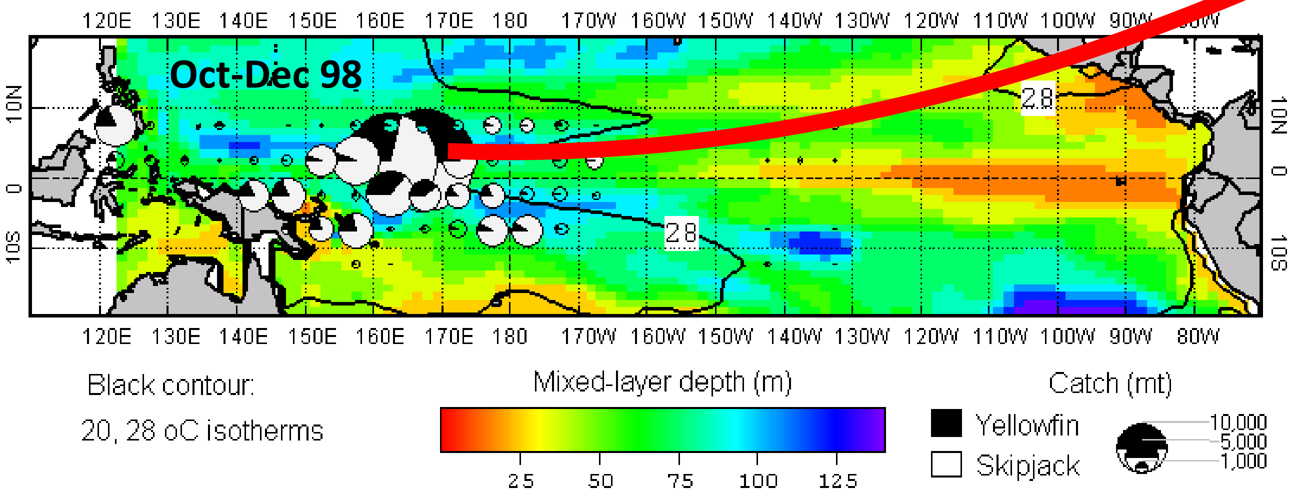
Bloom of phytoplankton at the end of 1997-98 El Niño

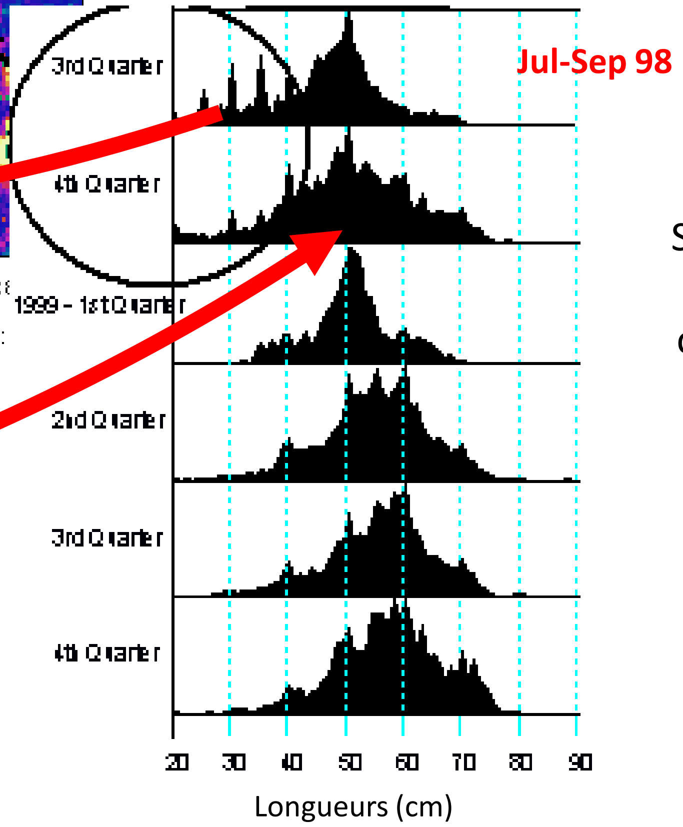
Satellite Chlorophyll



+ 7 months

Tuna catch by purse seiners



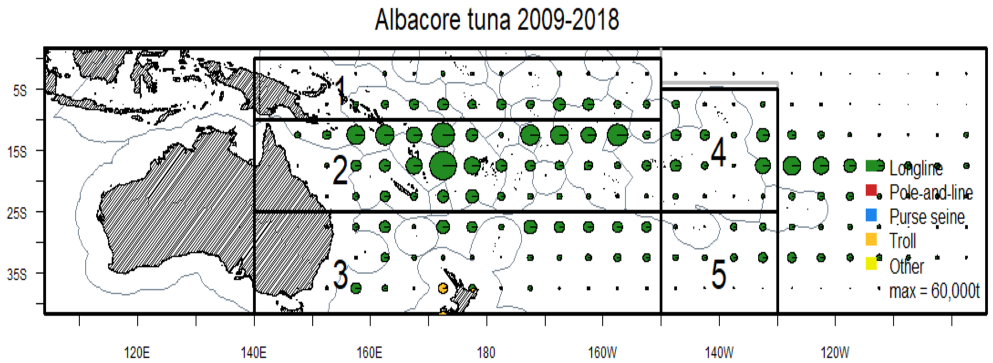


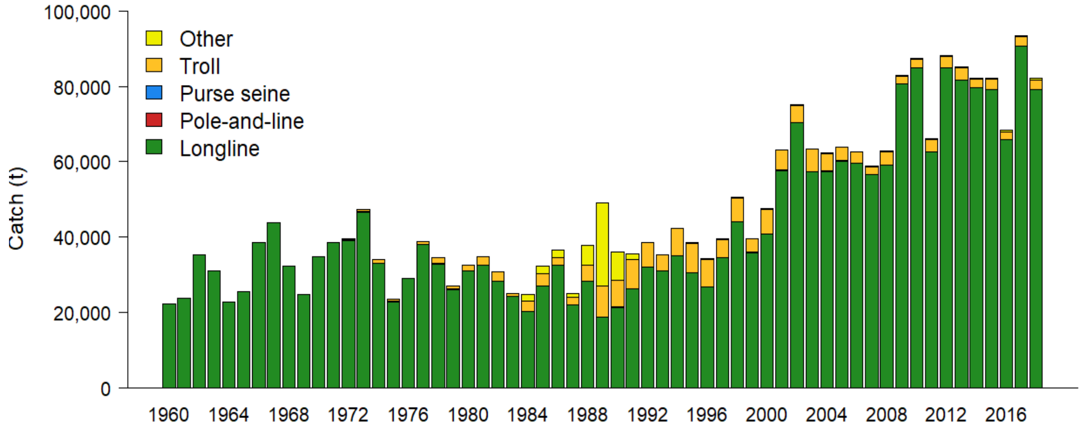
Size Frequencies of skipjack caught by purse seiners

Lehodey et al. (2011)

ENSO and Tuna: recent observations

South Pacific albacore

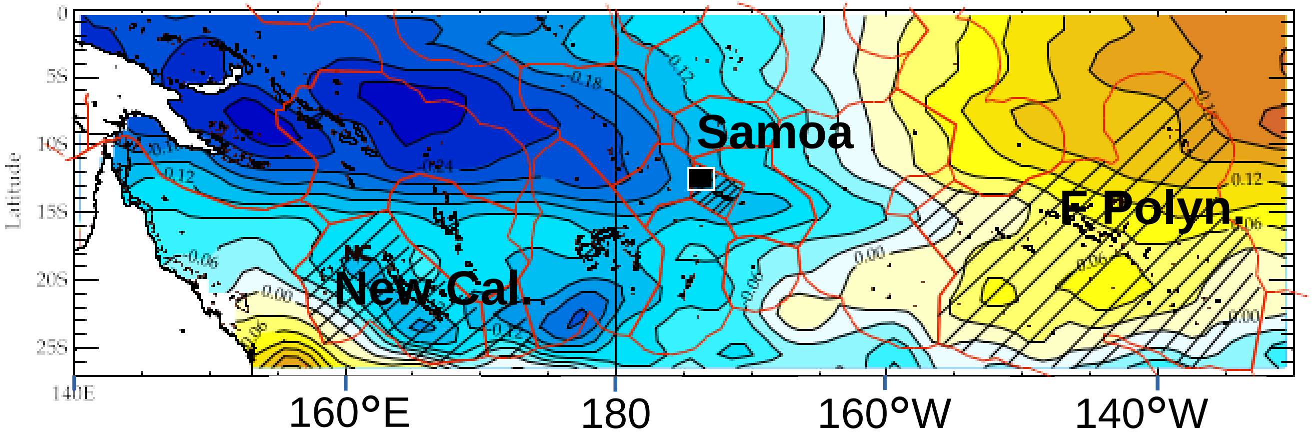




- Large catch (>90 % longline) increase since 2000
- More catch coming from east of 150°W in recent years

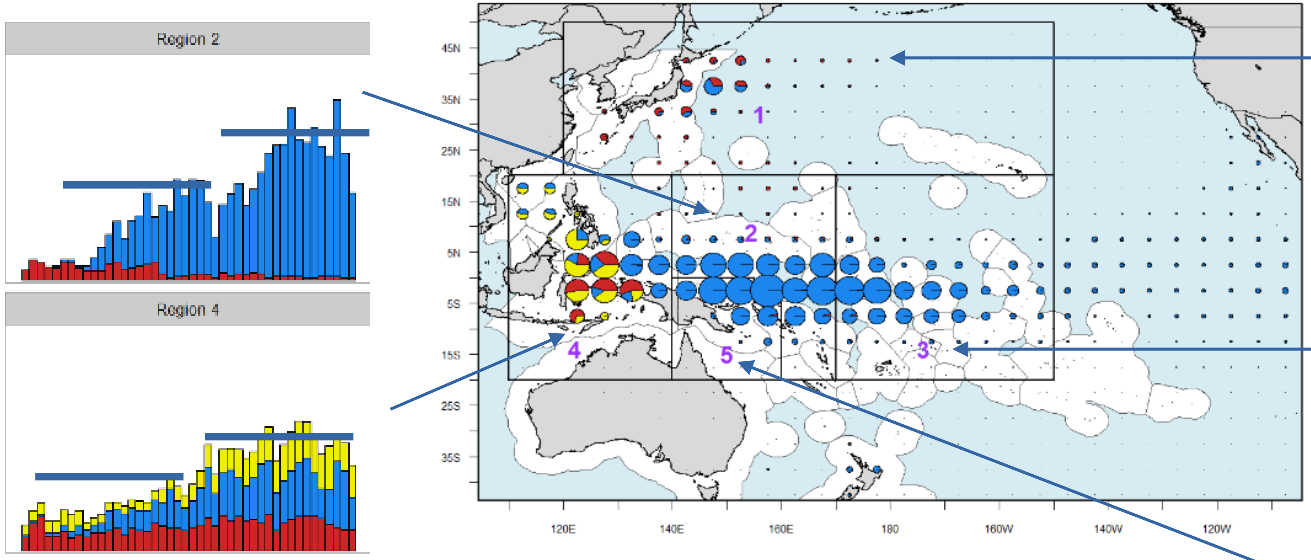
- Higher albacore CPUE occurs with El Niños in New Caledonia (shallower thermocline), lower CPUEs in Samoa and French Polynesia (deeper thermocline), with the reverse situation encountered during La Niña events

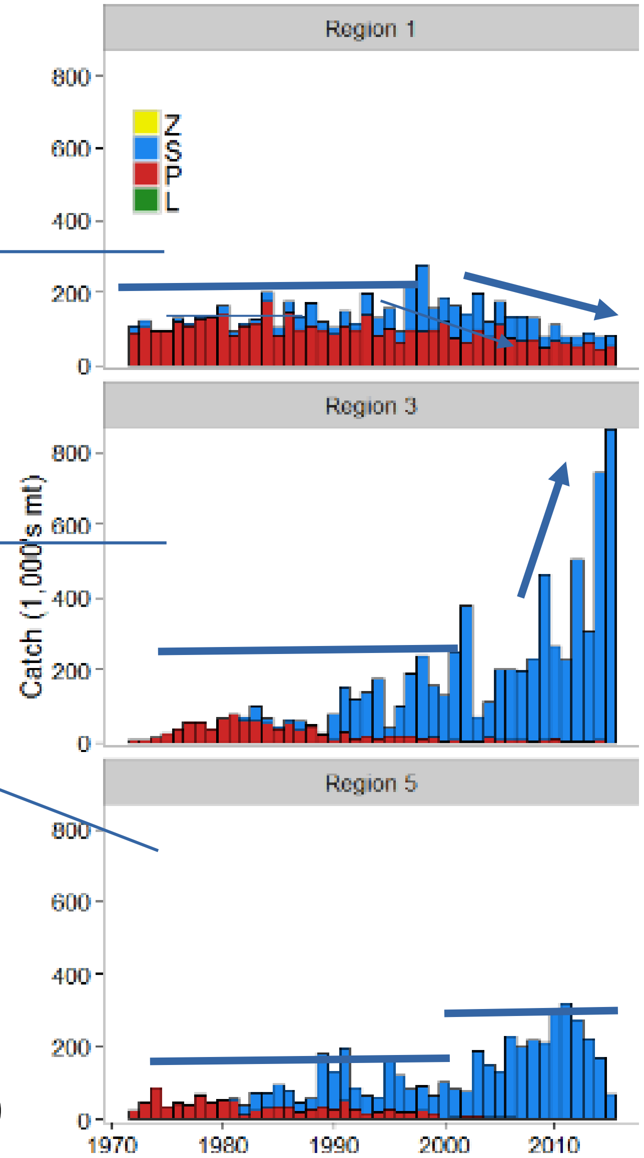
First EOF of 20°C isotherm depth (explaining 20% of the total variance)



ENSO and Tuna: variability in catch

Trends in Pacific skipjack catch





- <u>Decrease of catch: Japanese domestic fishery</u>
- <u>Increase of catch : Ph-Indo, WCPO equatorial in general</u>
- <u>Very large increase in Central Pacific</u>

Variability = change in fishing effort
+ environmental effect (R; Catchability; Distribution)

ENSO and Tuna: Models

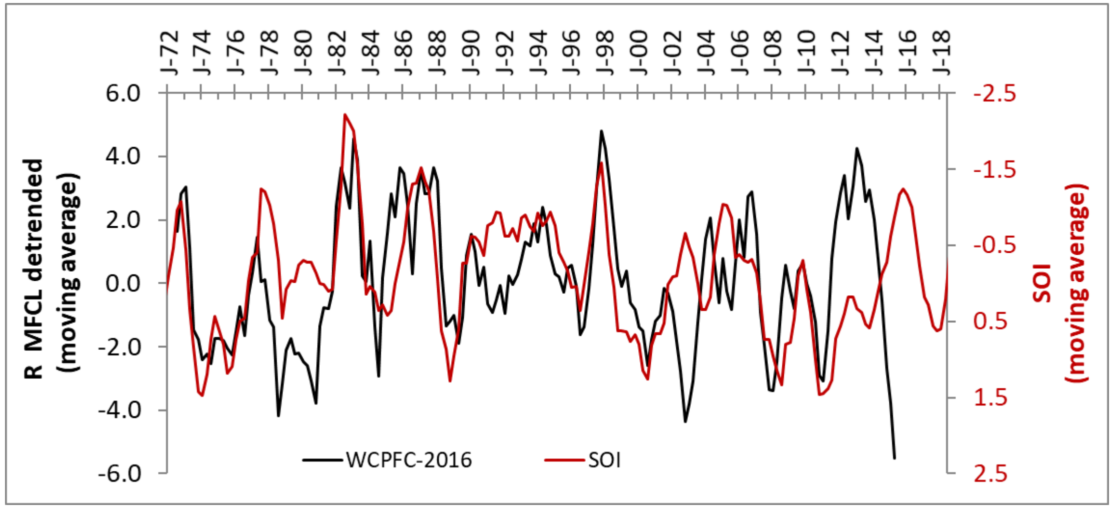
Skipjack

ENSO impacts both the recruitment

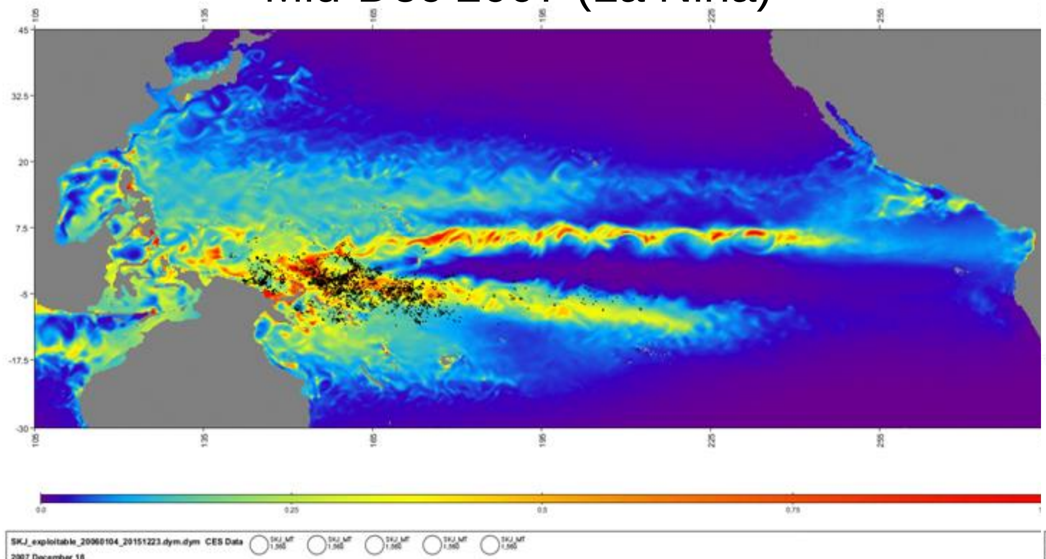
and the spatial distribution of skipjack tuna (and fisheries)

Lehodey et al. (in press). ENSO impact on fisheries and ecosystems. Chapter 19, AGU Books: *El Niño Southern Oscillation in a Changing Climate.* McPhaden, Santoso, Cai (Eds)

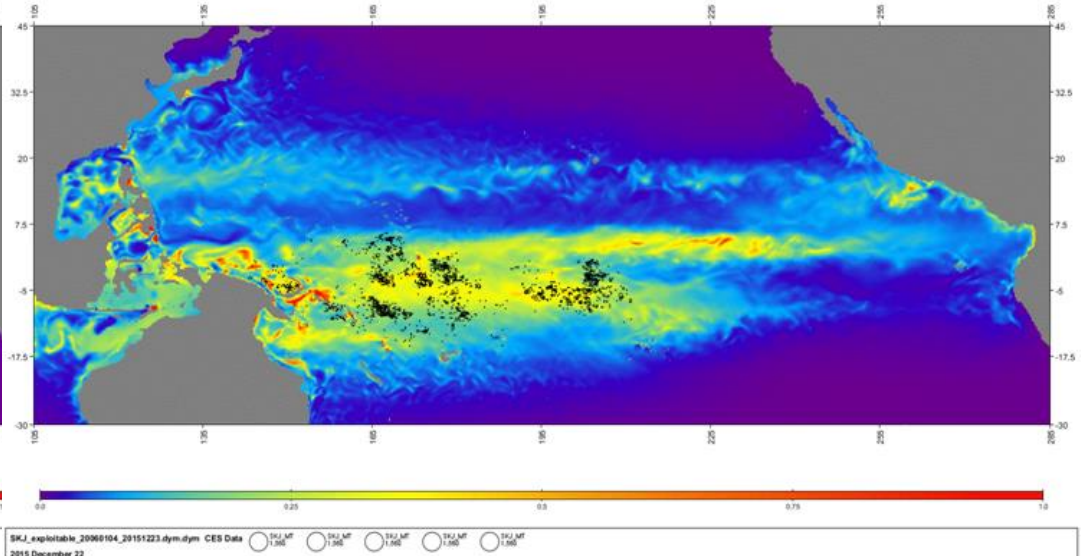
SOI and skipjack Recruitment from Stock Assessment MFCL model (<u>detrended</u>)



Mid-Dec 2007 (La Niña)



Mid-Dec 2015 (El Niño)

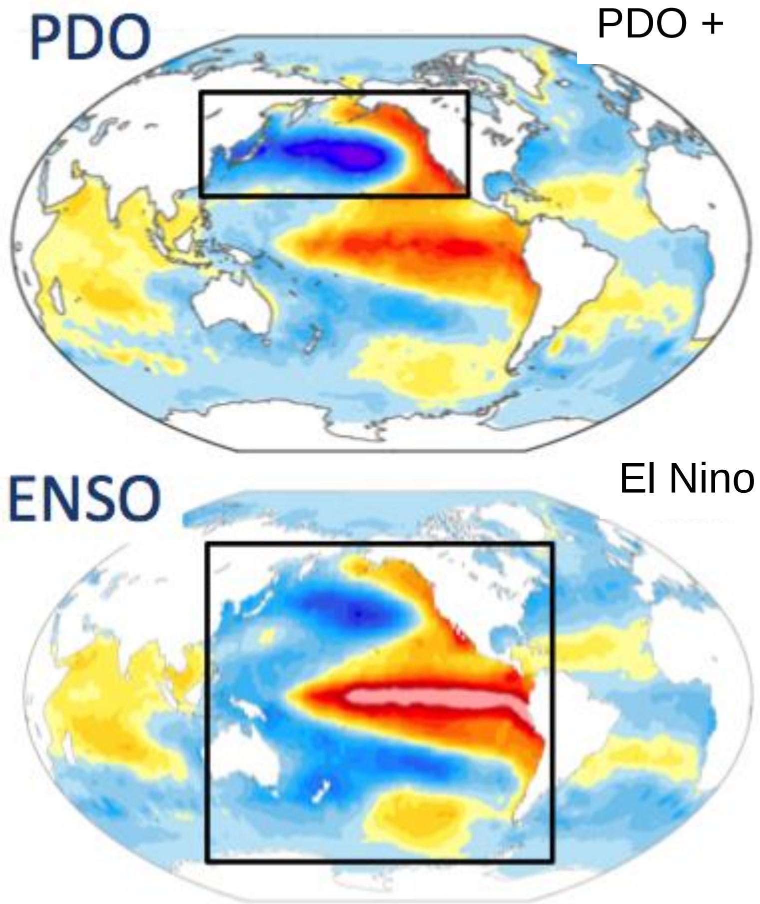


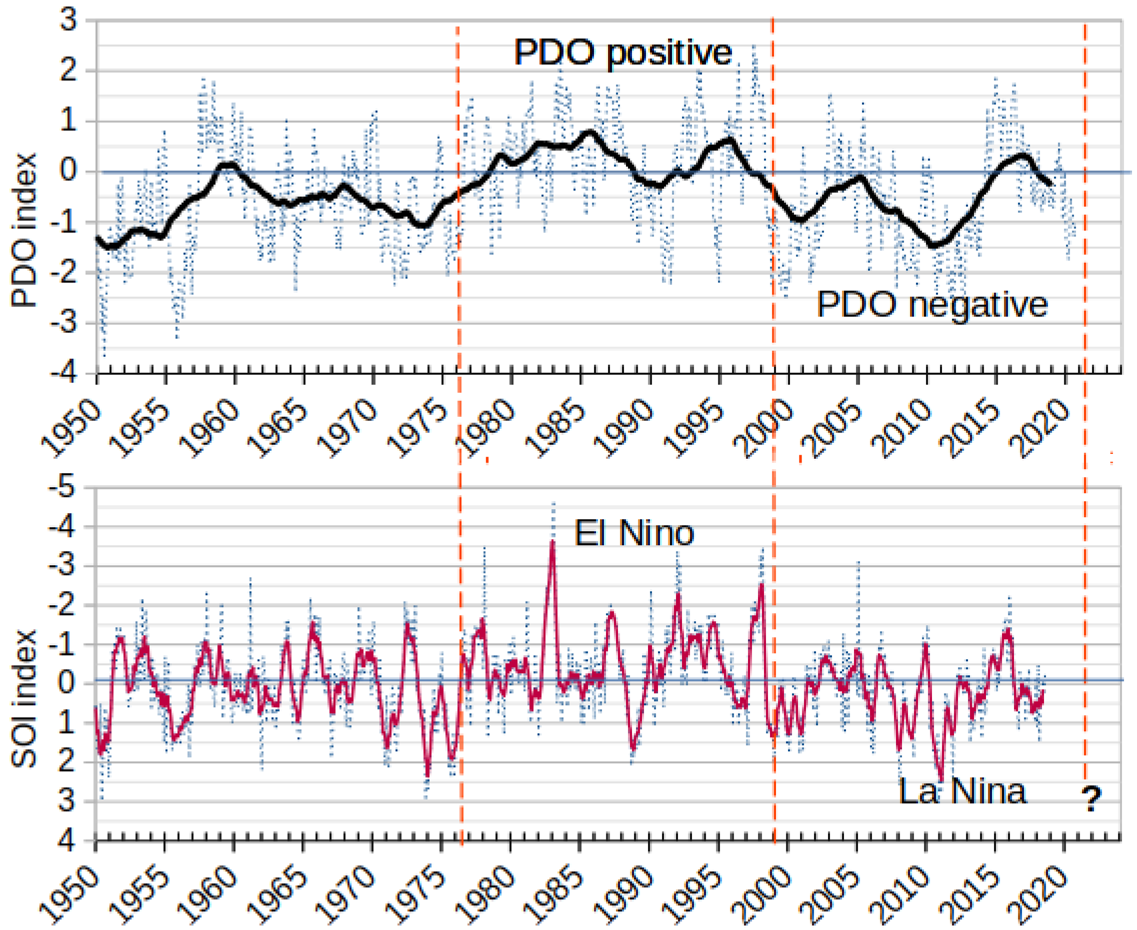
Skipjack biomass distribution from SEAPODYM and observed catch (black circles)

ENSO modulation at multi-decadal scale

Pacific Decadal Oscillation

The PDO is another climate oscillation over several decades (~ 25 to 50 years), with spatial pattern that resembles that of ENSO. The PDO index is statistically based on SST. More frequent El Nino (La Nina) occur during positive (negative) phase of PDO





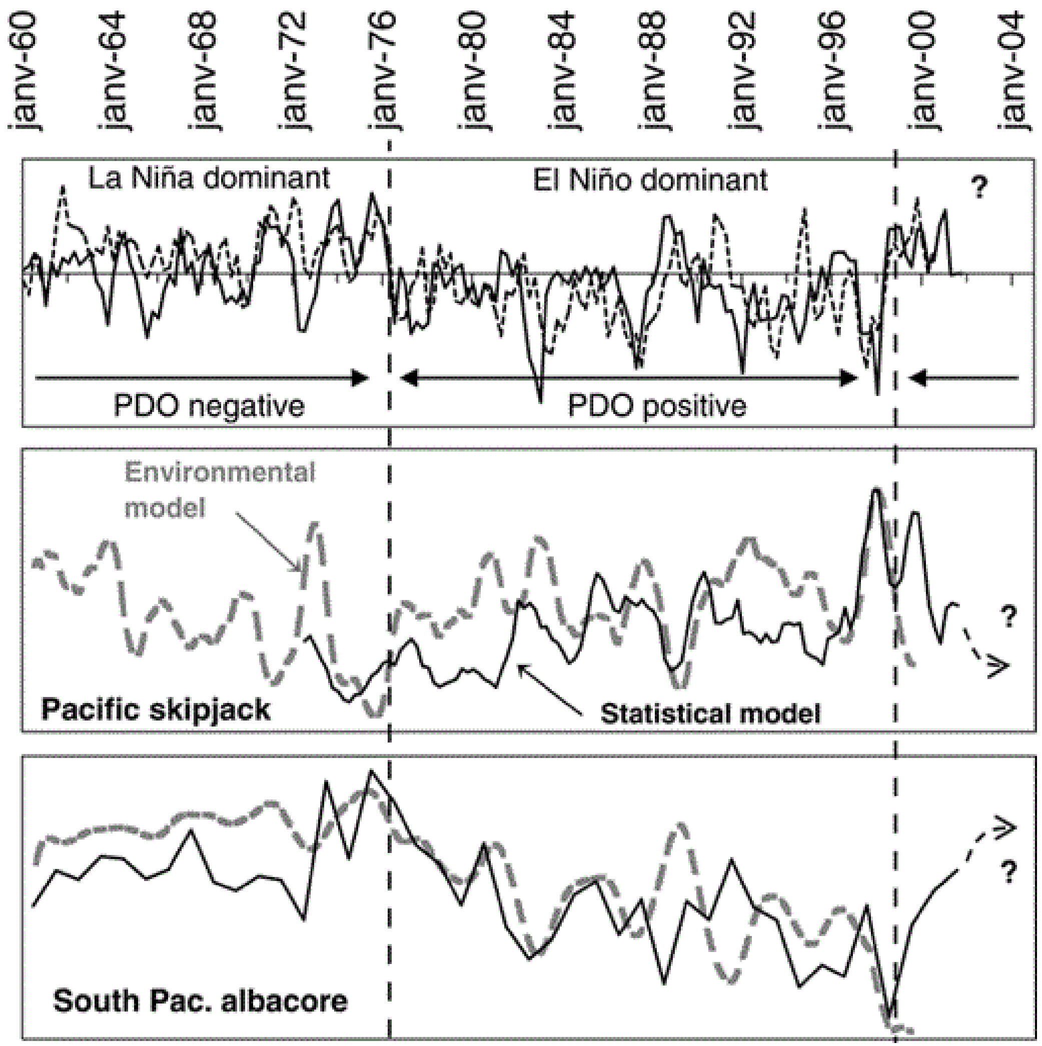
https://climatedataguide.ucar.edu/

ENSO and Tuna: Skipjack vs SP albacore

From past analyses and simulations (2003), it seemed that the relationship between ENSO and recruitment was the opposite for South Pacific albacore (La Nina favorable)

It was proposed that these relationships and the decadal regimes of ENSO in link with PDO phases lead to decadal productivity regimes in these tuna stocks, and thus generate a lower and higher regime of productivity after 1999, for skj and alb respectively.

15 years later, has this prediction been confirmed?



SOI, PDO and Recruitment of skipjack and South Pacific Albacore (relative indices) predicted from stock assessment model MULTIFAN-CL and spatial ecosystem model SEAPODYM (from Lehodey et al. 2003; 2006).

ENSO and Tuna: Skipjack vs SP albacore

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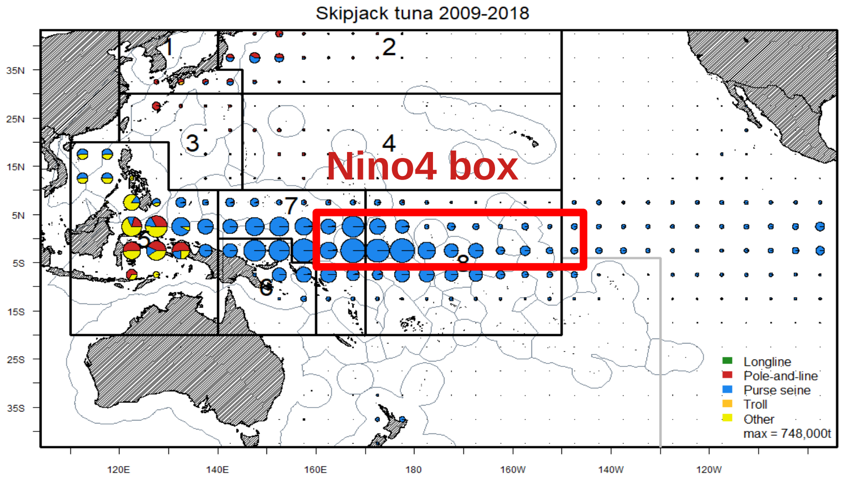
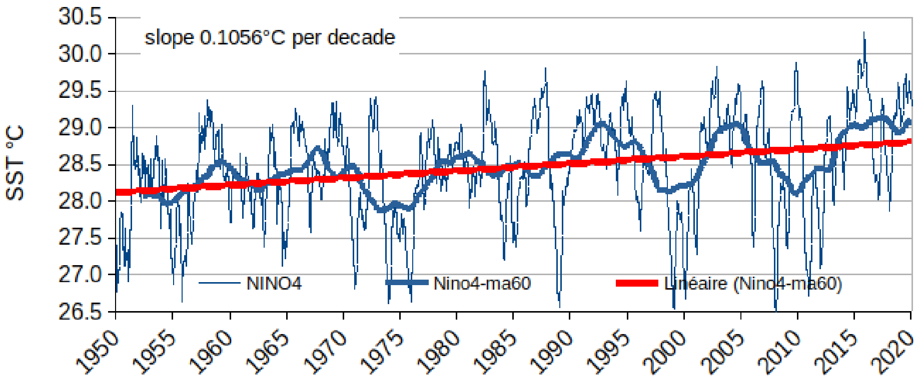
Skipjack

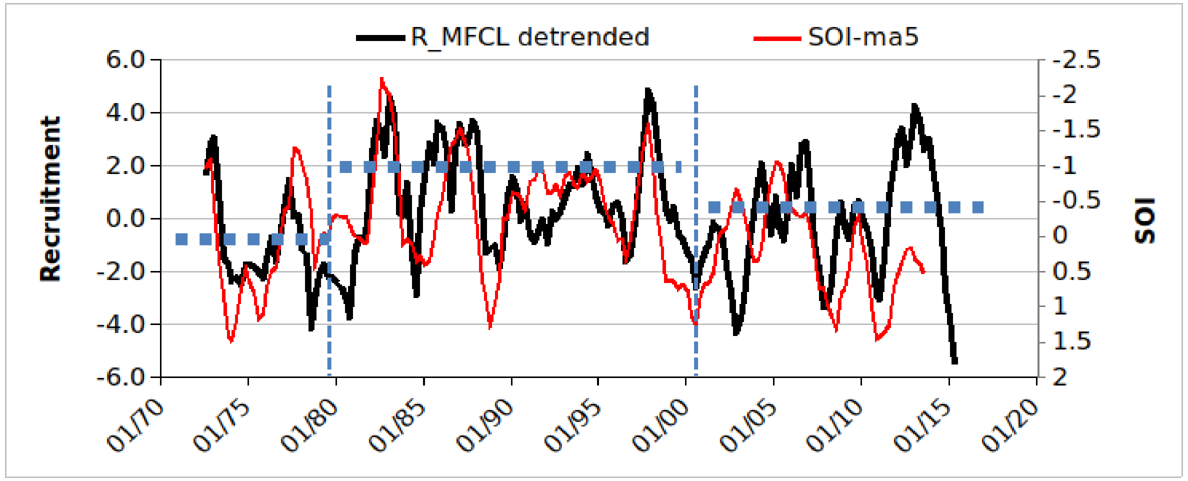


SST Nino4 long term trend

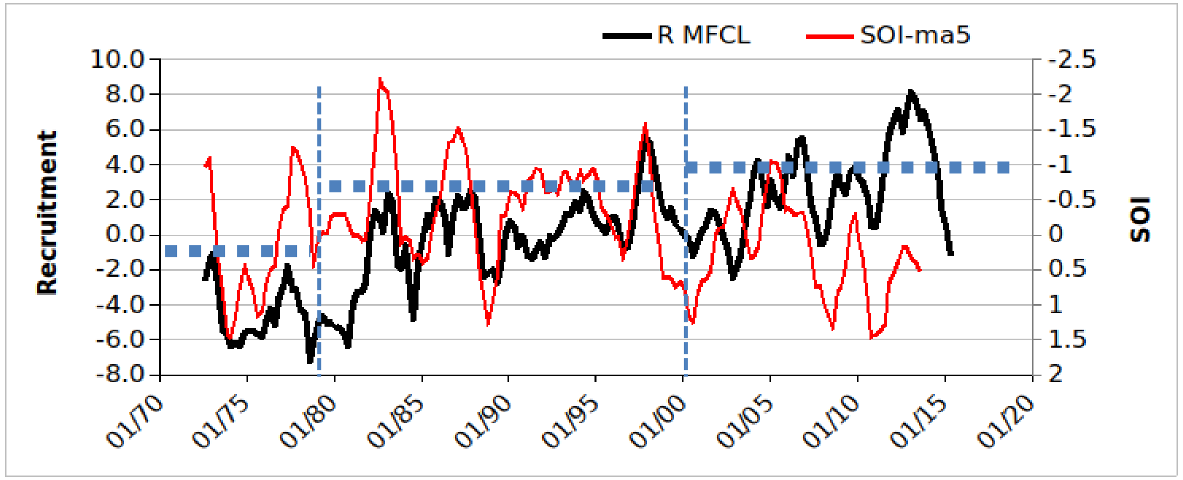


Interannual variability still linked to ENSO but over a positive long term trend => Climate change?

SOI and skipjack Recruitment from Stock Assessment MFCL model (**detrended**)

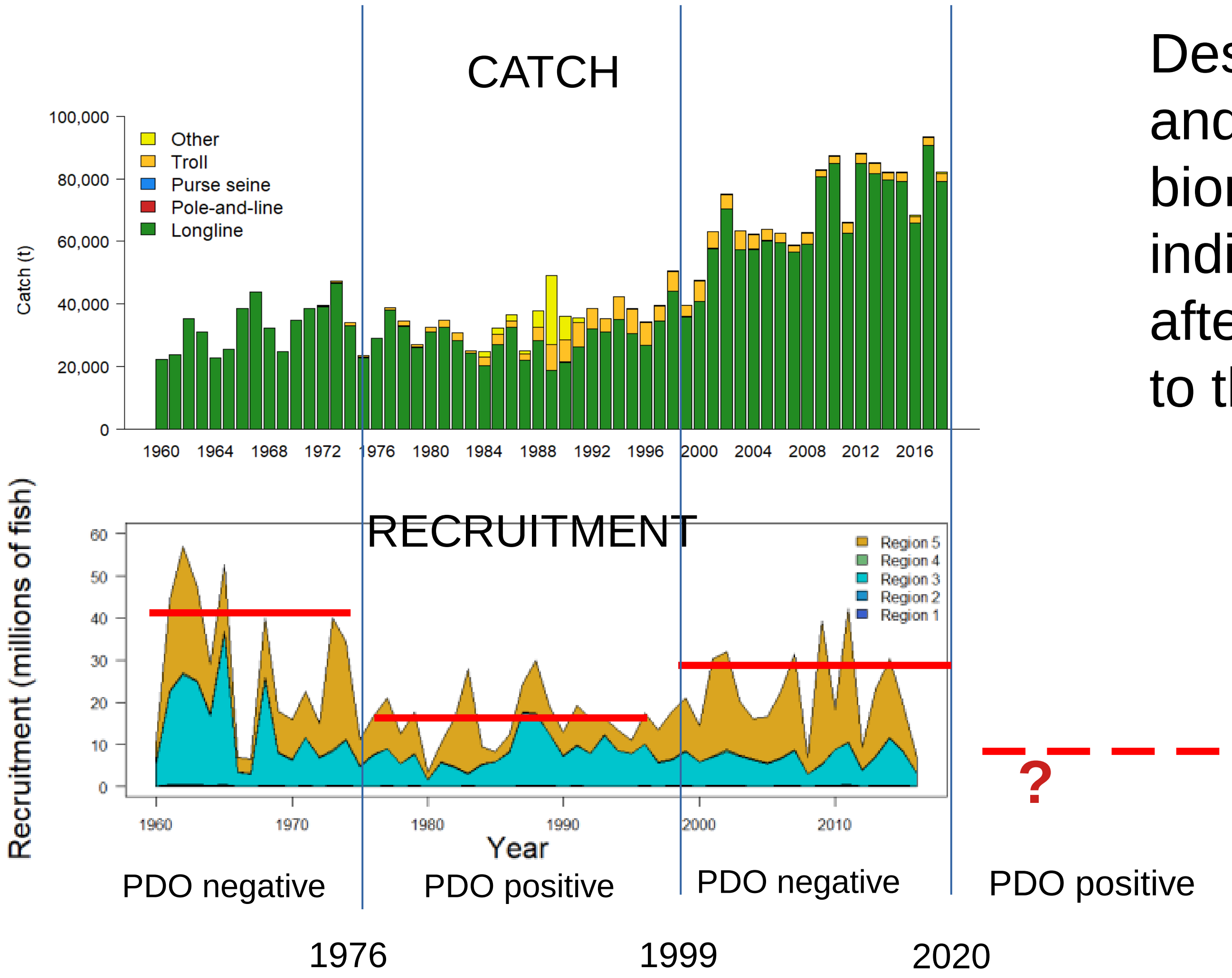


Actual estimate without detrending



ENSO and Tuna: Skipjack vs SP albacore

Albacore



Despite large increase in catch after 2000 and consecutively, a reduction in spawning biomass, the last stock assessment study indicates a favorable regime of recruitment after 2000 following a low regime associated to the positive phase of PDO 1976-1998.

WARNING: The next low regime that could be expected in the coming years with the future phase of positive PDO would occur in a different context with lower spawning biomass, and… climate change.

Conclusions on Pelagic fisheries

- With the current development of La Nina, classical patterns are expected to occur that could impact:

- The spatial distribution:
  The fishing ground of the PS equatorial fishery is shifted westward (PNG, Solomon, FSM). This spatial shift is strongly influenced by equatorial circulation.

- The catchability:
  Positive (negative) impact on longline CPUE could be associated to shoaling of the thermocline in the east (deepening in the west).
  The contraction of the skipjack habitat in the west should concentrate the resource; the deepening of the thermocline may have a negative effect on catchability.

- The recruitment:
  La Nina is usually favorable for South Pacific albacore (effect is delayed in the adult population by 4-5 years)
  La Nina is usually unfavourable to skipjack recruitment; but the effect is potentially dampened by the large-scale ocean warming providing an extended favourable spawning ground.

Needs: Improved historical simulations (hindcast/reanalyses) of physical-biogeochemical ocean conditions (temperature, currents, primary production, dissolved oxygen, pH) extended by seasonal to decadal forecasts.

Climate and Tropical Pacific Coastal Fisheries

ENSO impacts on coastal resources

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Pacific Island coastal ecosystems are impacted by ENSO variability with some extreme events generating:

- More frequent or powerful storms and cyclones
- warm/cold water temperature anomalies. Warm anomalies can induce severe coral bleaching events
- large variability in primary productivity cascading the foodweb
- Sea level drop that exposes shallow reefs, with higher coral mortality and consequences for shore protection as well as the coral fish community
- Flooding of coastal infrastructure used for subsistence fisheries

This natural variability has existed for thousands of years (e.g., Beaufort & Grelaud 2017) and coastal ecosystems, as well as Pacific Islanders, have adapted to these changes. However, the last El Nino (2014-16) was exceptional in intensity and consequences (see Rupic et al 2018; NOAA report). Is climate warming already at work to change the ENSO patterns?

ENSO impacts on coastal resources

- **The 2014/16 El Niño** was characterized by(Rupic et al 2018):
- A “wave” of extreme weather conditions moving from the Western Pacific to the Eastern Pacific;
  Heavy rainfall in the initial stages of the event, while extreme drought was observed in the final stages of the event;
- More numerous and intense tropical cyclones as cyclones season was prolonged across the region.

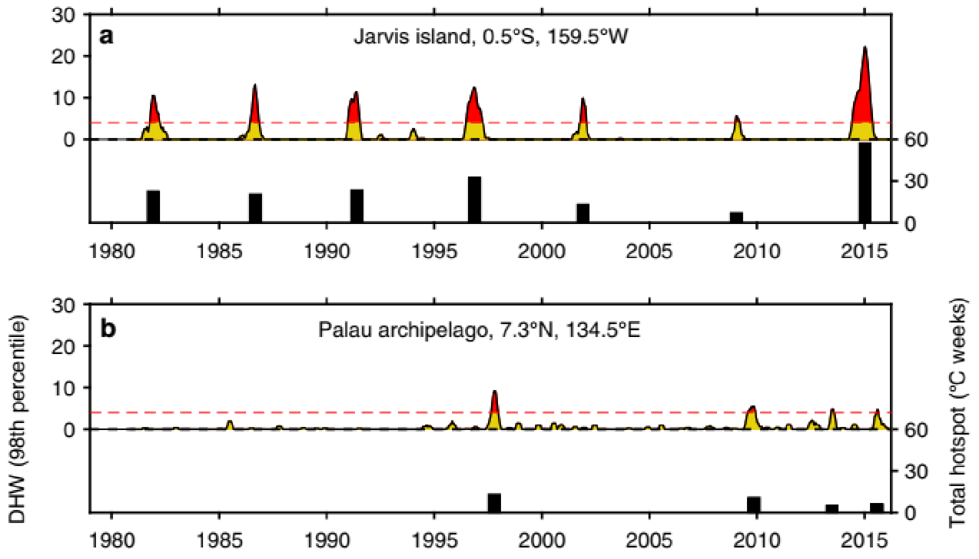
The unprecedented warm temperature anomaly in the central equatorial region is attributed in part to unusually warm condition in 2014 and to long-term background warming.

Unlike in previous strong El Niño events, the 2015–2016 event was not followed by a strong La Niña phase, depriving this region of a strong subsequent recovery of the equatorial upwelling and high productivity associated with it.

The biological consequences were dramatic on the ecosystems of Pacific islands in this central region. In Jarvis Island, on the equator south of Hawaii, the longest and most widespread coral bleaching event was recorded, with massive mortality, i.e. 95% of Jarvis corals were killed

Although it was not the first catastrophic bleaching event on Jarvis, it was unprecedented in magnitude (Barkley et al., 2018).

In the meantime, the biomass of planktivore and reef fishes significantly declined, as did the seabird abundance (Brainard et al., 2018)

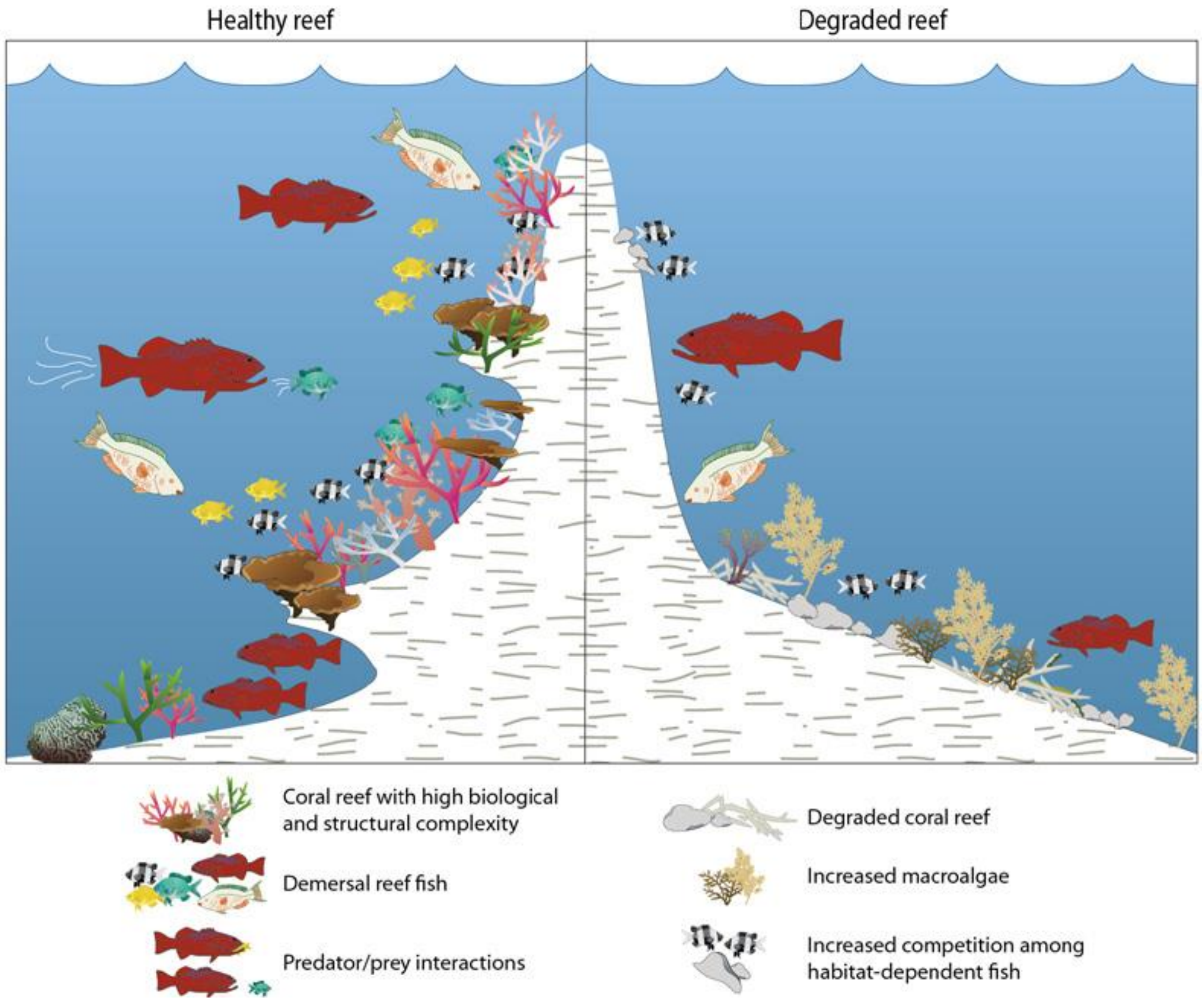


Thermal stress represented by Degree Heating Weeks (DHWs) and cumulative DHWs on a Jarvis Island, central equatorial Pacific, and b Palau, western tropical Pacific (from Barkley et al 2018)

climate change impacts on coastal resources

Some of the projected impacts of CC ressemble those observed during severe El Nino events

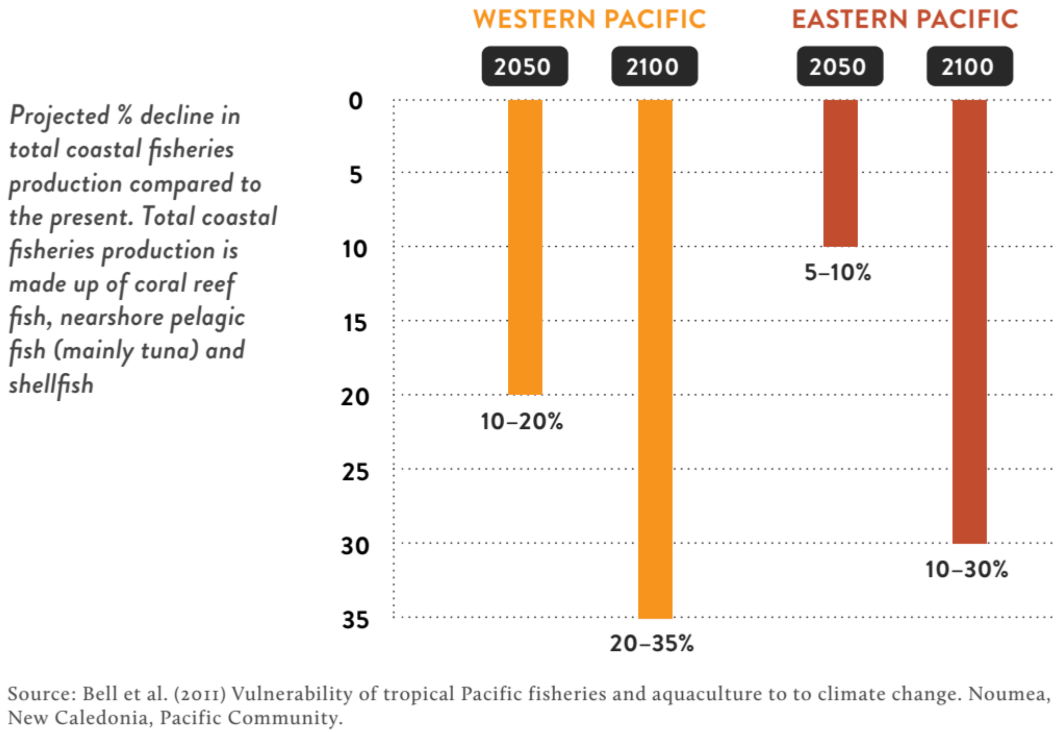
- Warming seas
  - Large-scale coral bleaching
  - Bigger Storms
- Sea level rise
  - Land loss
  - Loss of freshwater
  - Salt water intrusion – crop failures
- Acidification (impact much stronger in the temperate and high latitudes)
  - Weakening of CaCO3 structures
- Reduction in diversity of food from sea – food chains drastically altered.



climate change impacts on coastal resources

The future of tropical coastal fisheries is still largely unknown. First assessment in Bell et al. (2011) suggest a decrease in production by 5-30%.

A more recent studies based on 20 years of fish abundance catch and habitat (Robinson et al 2019) indicates a stable or even increasing total catch and mean catch rates after coral bleaching, consistent with increasing abundance of herbivorous target species in underwater surveys, particularly on macroalgal-dominated reefs. But higher instability in catch.



Total coastal fisheries production is projected to decline at different rates in the eastern and western Pacific

Ocean warming (+ El Ninos) generate successive bleaching events altering integrity of coral reef ecosystems. Already, some reefs have shifted to a new ecosystem type (eg in Greet Barrier Reef).

Conclusions on coastal fisheries

- The current development of La Nina is not expected to have detrimental effects on coral reef ecosystems since it should prevent warm anomalies and bleaching events (a pause in the surface warming of the central Pacific). Possible exceptions in Palau and FSM?

- In the western central equatorial Pacific, shoaling of thermocline and increased equatorial upwelling will increase biological productivity

- Still, there is urgent need to develop effective LOCAL management to reduce longer-terms impacts of climate change on coastal fisheries, e.g.:
  - Reverse or reduce local human-caused impacts that reduce the structural complexity and biological diversity of coastal habitats – pollution
  - Keep harvests of demersal finfish and invertebrates within sustainable limits, rebuild populations of over-exploited species
  - Diversify fishing activities (and livelihoods) to reduce pressure on fisheries species that are highly vulnerable to climate change (e.g. near-shore FADS)
  - Long-term monitoring and assessment of changes in health of coastal habitats and fisheries – greater investment in relevant departments.

Needs: Real time Monitoring and seasonal + decadal forecasts of key variables and derived indicators (anomalies): Wind, Rain, Seal Level, Temperature, O2, pH, chlorophyll, currents,…

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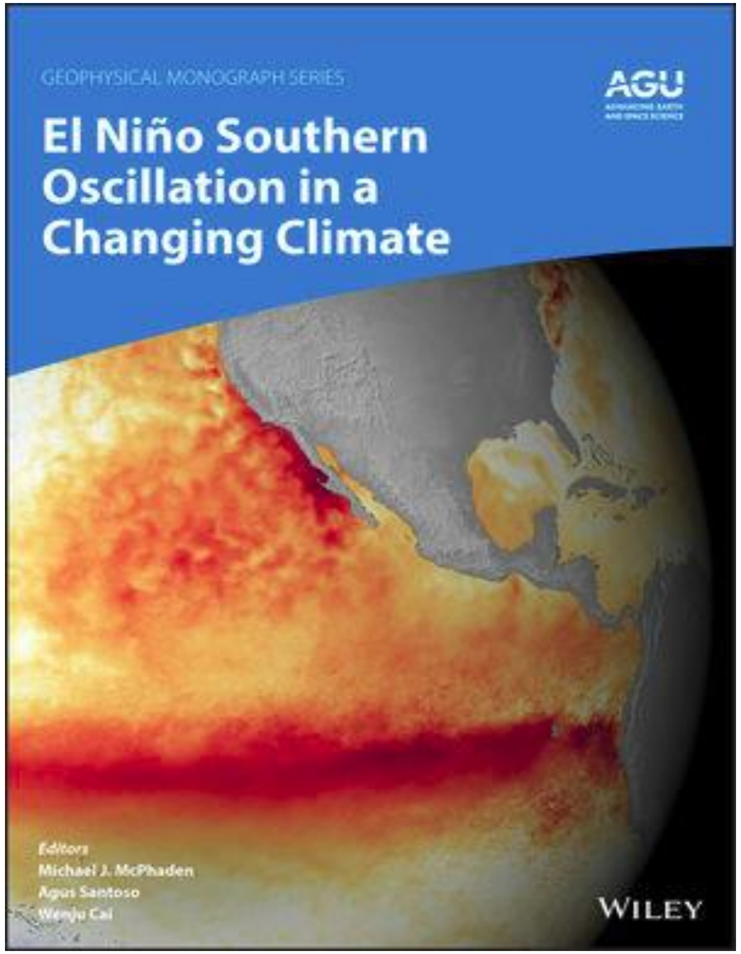
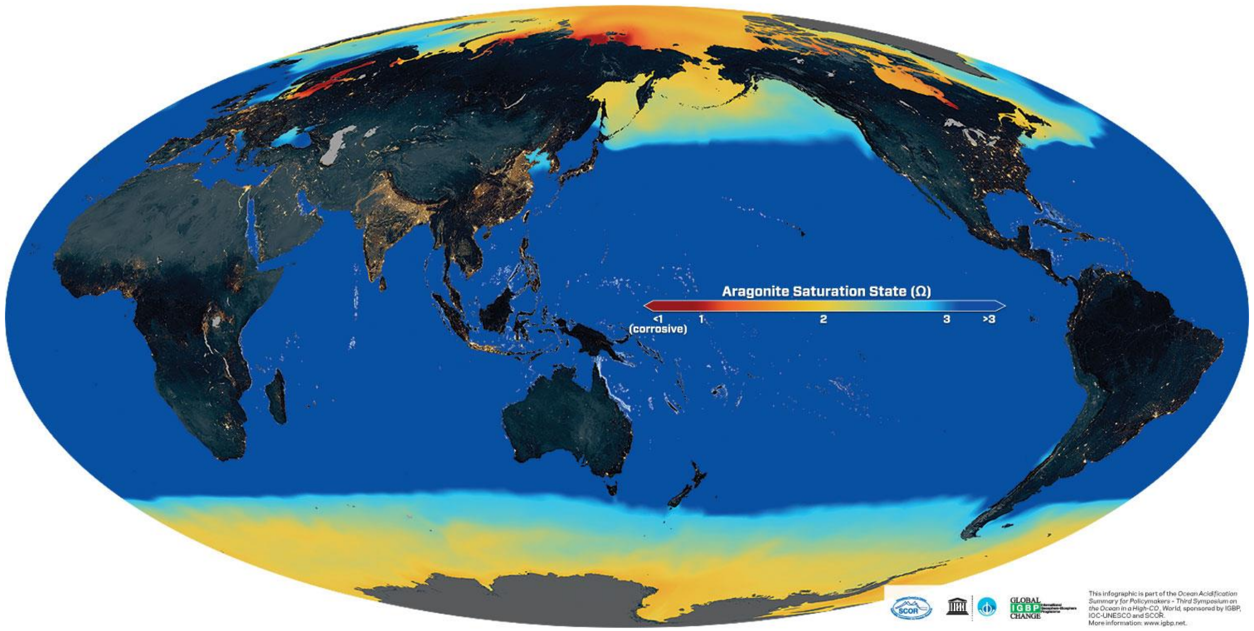


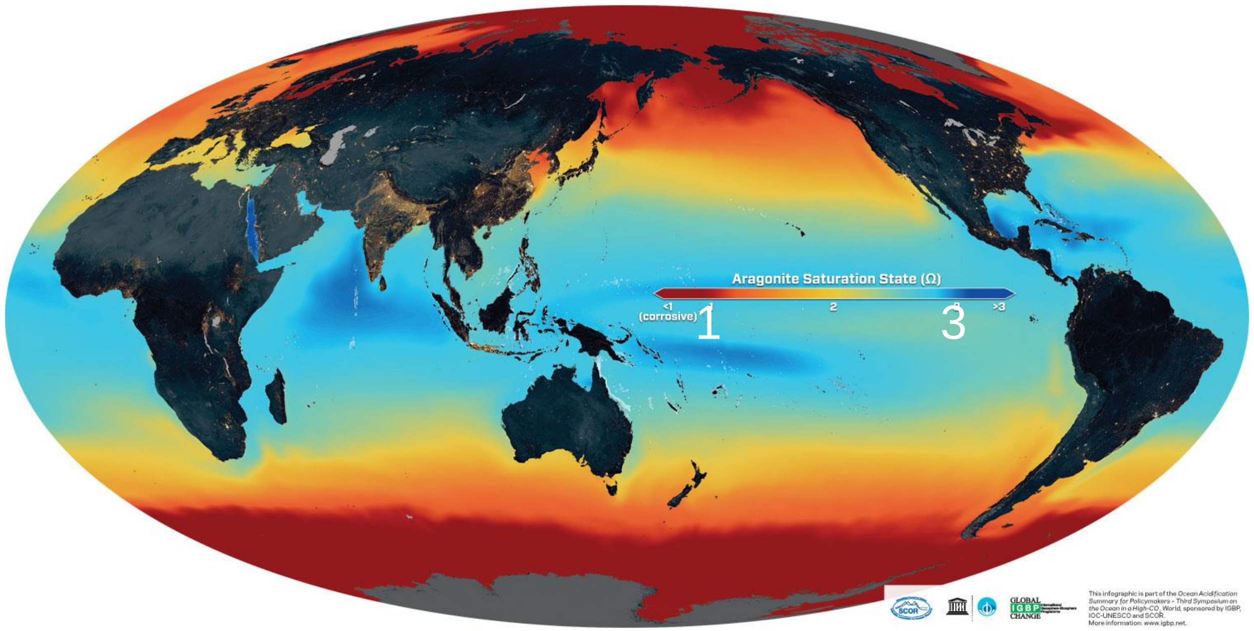
Extra slide

If **Ω** is less than 1, conditions are corrosive (undersaturated) for aragonite-based shells and skeletons. Coral growth benefits from **Ω**≥3

Aragonite saturation 1850-1860



Aragonite saturation in 2100



'Business as usual' Scenario (RCP8.5)

Bopp et al., 2013; http://ocean-acidification.net/