Pacific Community
Communauté du Pacifique

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ABSTRACT 170328

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El Niño revisited: the influence of El Niño Southern Oscillation on the world's largest tuna fisheries

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BACKGROUND

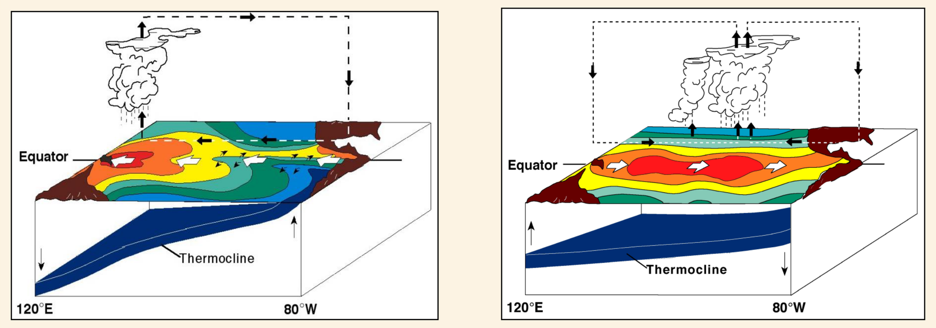


Fig. 1: Sea Surface Temperature (colors) in the Pacific Ocean during La Nina (left) and El Nino (right).

In the Pacific Ocean (PO), El Niño Southern Oscillation (ENSO) influences the dynamics of the world's largest tuna fisheries and ecosystem structure. During La Niña (cold phase), the warm pool is restricted to the far western equatorial Pacific whereas during El Niño (warm phase) it stretches to the eastern Pacific following the weakening of equatorial upwelling system (cold tongue).

The convergence zone between the warm-pool and cold-tongue is hypothesized to be an ecotone that provides abundant tuna forage. Higher catch rates (CPUE) of tuna purse-seiners follow the movement of this convergence zone.

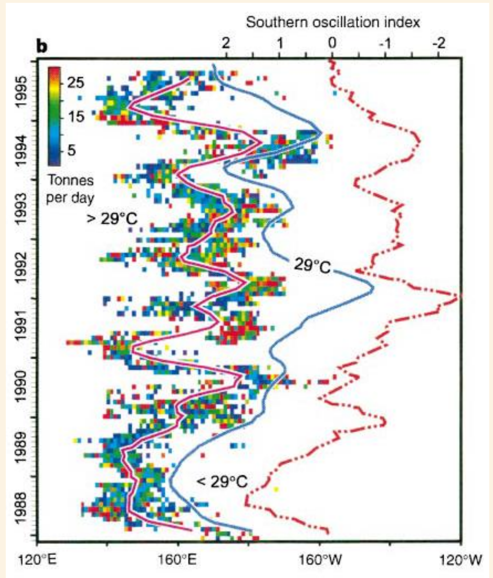


Fig. 2: Longitudinal gravity center of CPUE (pink), position of 29°C isotherm and SOI (broken red line)(index for ENSO).

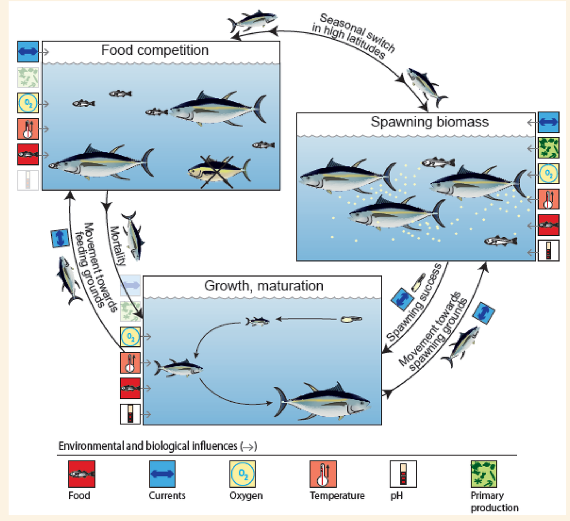


Fig. 3: SEAPODYM representation.

We use the SEAPODYM model to synthesize the population dynamics of skipjack and bigeye tuna in the PO, and investigate the response of these tuna species to the different phases of ENSO.

1 MATERIAL & METHOD

3 simulations
2 species
2 age classes
→ Detrending time series → Position proxies / Quantity proxies → Wavelet analysis → Temporal lags + ONI index → Correlation

Fig. 4 : Summary of different analyze steps.

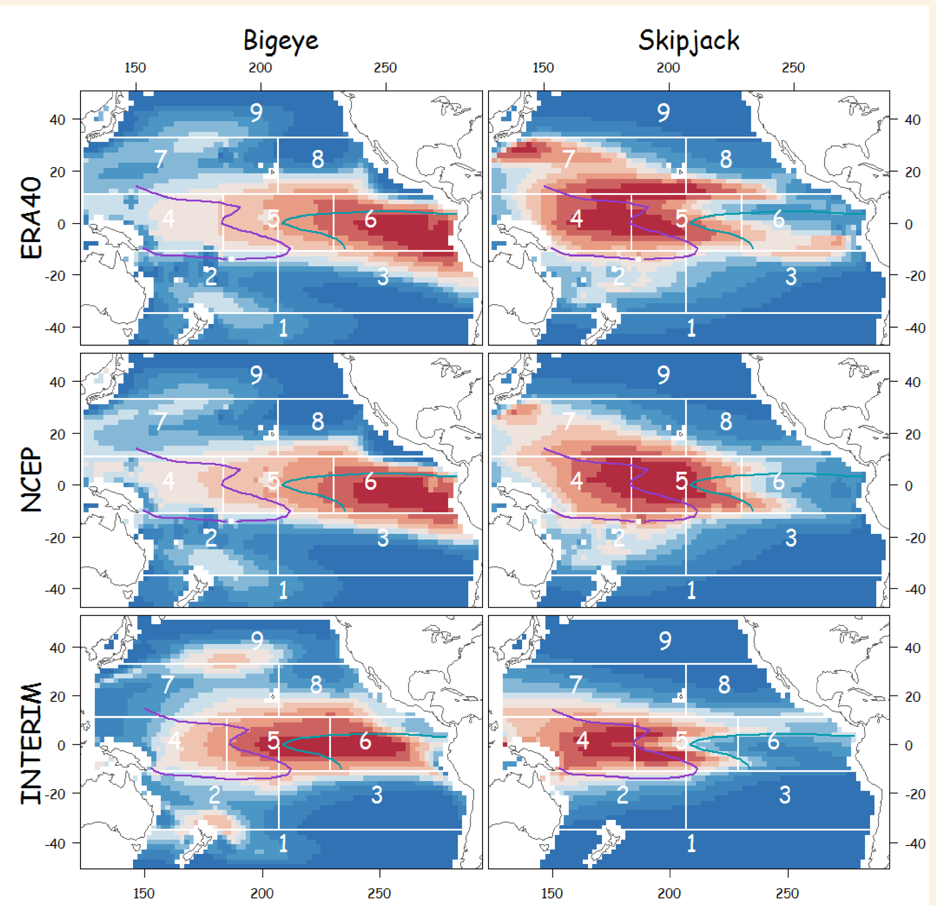


Fig. 5 : Biomass predicted by SEAPODYM both for Bigeye (left) and Skipjack (right) for the 3 simulations (ERA40, NCEP and ERA-INTERIM).

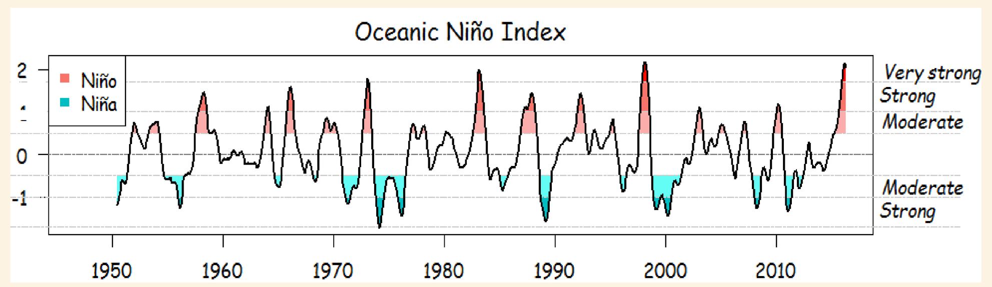


Fig. 6: Fluctuation of ONI (Oceanic Niño Index) between 1950 and 2016. Blue peak are La Niña event and orange peak El Niña events.

ONI is the running 3-month mean SST anomaly for the Niño 3.4 region (i.e. 5°N, 5°S, 120°W, 170°W). ONI is positive during El Niño and negative for La Niña. Values of ONI above 0.9 are classified as El Niño and those below -0.9 as La Niña. Values between 0.9 and 0.9 are classified as Neutral.

SEAPODYM is an age structured population model coupled with a physical-biogeochemical model for temperature, oxygen, currents and primary production. We used 3 simulations forced by NCEP, ERA-40 and ERA-INTERIM atmospheric reanalyses. Outputs (predicted fish biomass) are analyzed using the gravity center of biomass, the latitude of the edge pattern to quantify the spread, and the total abundance in 9 oceanic areas (Fig. 5) and the equatorial region (sum of areas 4, 5 and 6). Temporal variability of both explanatory and predicted (biomass) variables are characterized using wavelet analyses, and their time lag with ONI estimated.

2 RESULTS

Position — Abundance

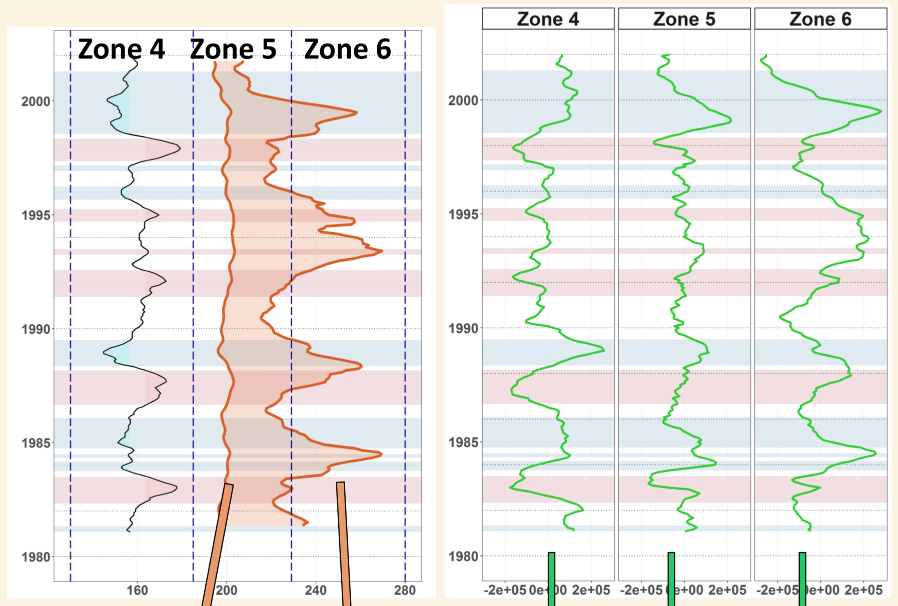


Fig. 7: Change over time of gravity center, eastern edge (orange lines) and ONI (black line) (left), and abundance by zone through time (right). Red (blue) bands show El Niño (La Niña) phases.

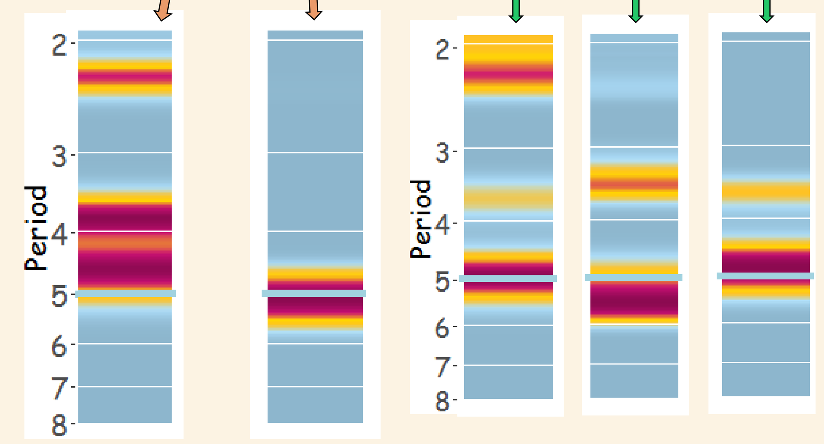


Fig. 8: Wavelet spectrum between different time series and ONI index. The period 5 years corresponds to ENSO cycle.

	Gravity center	Eastern edge	Q4	Q5	Q6
Lag (months)	- 10	- 17	- 3	- 17	- 16
Correlation	0.44	0.75	-0.59	0.62	0.7

Both skipjack abundance and distribution are impacted by ENSO. Biomass increases in area 6 approximately 16 months after El Niño onset. The same phenomenon occurs for skipjack juvenile with a shorter lag (~5 months).

Focus on 10 first months

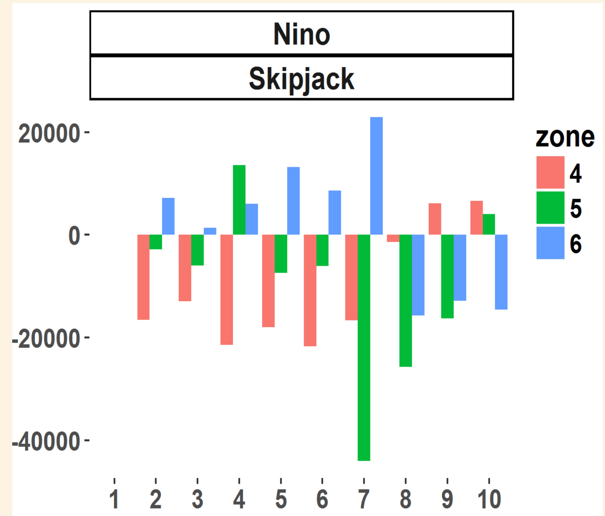
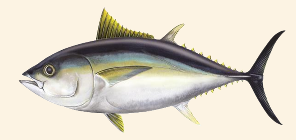


Fig. 9: Mean changes in modeled detrended biomass (i.e., difference between biomass of month i and i-1) by region during the first ten months after El Niño onset.

The portion of biomass predicted to move together with the warm pool as suggested from CPUE data is limited relatively to the total biomass (on average 200,000 t). For example, there is a biomass increase (~15,000 t) in the central Pacific (zone 5) and the eastern Pacific (zone 6) respectively 3 and 4 months after El Nino onset.



Abundance

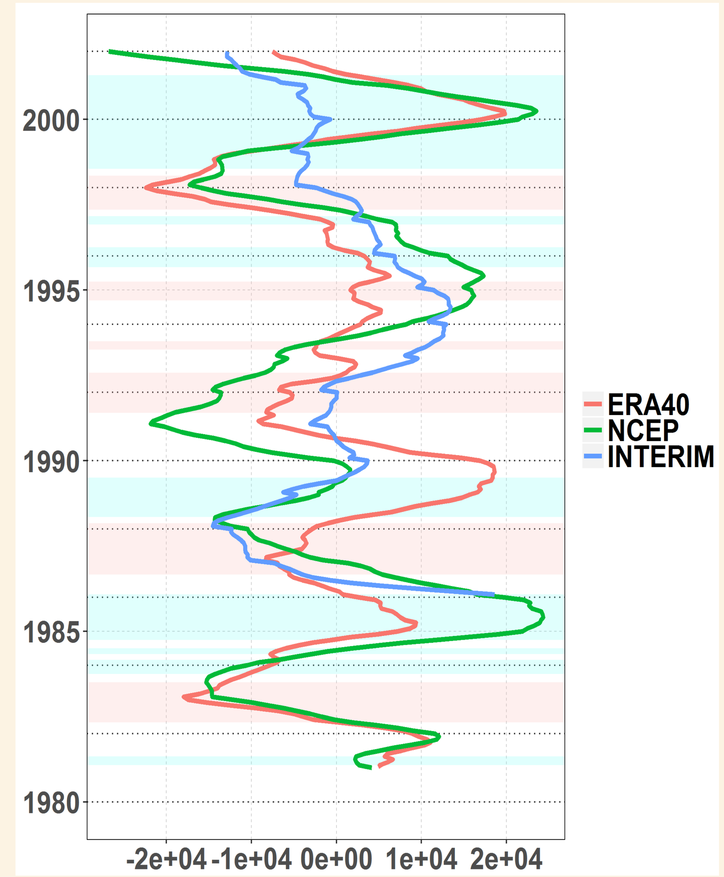


Fig. 10: Detrended bigeye biomass through time summed in zone 4, 5 and 6 predicted from 3 different forcings.

For bigeye, the 3 simulations predicted an oscillation of total biomass with a ENSO-like frequency of 5 years. There is a good correlation (0.8) between ONI and juvenile biomass in the area 6 nine months after El Niño onset. But time lags by region did not detect movement linked to ENSO.

3 DISCUSSION

Each tuna dynamics simulation is achieved using robust statistical parameter optimization fitting several hundred thousands data (catch and size of fish). However, these different solutions express similar impacts of ENSO on biomass distribution and abundance, with species and age characteristics.

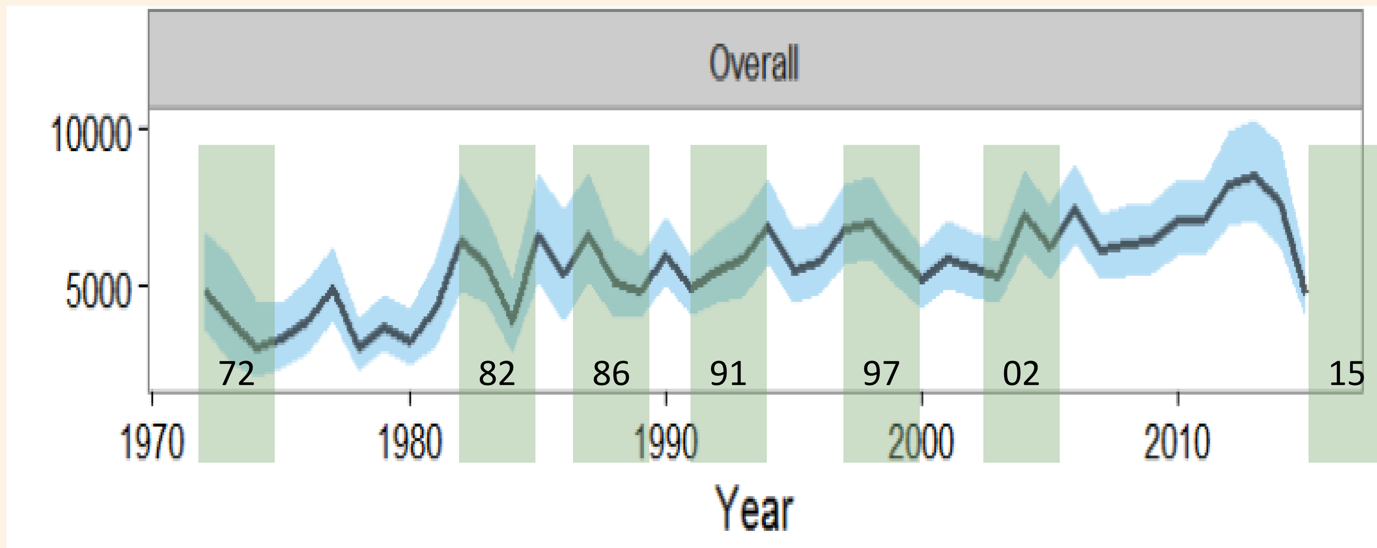


Fig. 11: Estimated temporal recruitment by MULTIFAN-CL (Fournier et al. 1998) for the skipjack stock assessment in the western and central Pacific. Green box are El Niño events. From McKechnie et al., 2016.

One year and half after an El Niño onset, the maximum impact is observed in skipjack biomass. This lag was due to better recruitment during El Niño (wider favorable spawning habitat). This association is not as emergent in other stock-assessment models (Fig. 11). Further independent datasets are needed to confirm these results, however they suggest that ENSO may be an important process explaining the resilience of skipjack to high exploitation rates.