Tropical Pacific-Wide Variability in Vertical Zooplankton and Micronekton Distributions Related to ENSO

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November 25, 2022

Abstract

Zooplankton and micronekton are key links in tropical Pacific food webs, which include tuna as top-level predators. Zooplankton and micronekton vertically migrate to deeper depths to avoid visual predators, including tuna, during the day and then return to shallower depths to feed at night. Vertical migration depths vary spatially in the tropical Pacific and are correlated with oxygen, light, and temperature. El Niño-Southern Oscillation (ENSO) causes vertical shifts in the thermocline and oxycline. The accessibility of prey during the day should therefore vary interannually depending on the ENSO phase. We use available acoustic doppler current profiler (ADCP) data from cruises within the tropical Pacific between 1990 and 2019 to investigate the timescales and potential drivers of variability in zooplankton and micronekton vertical distributions in this region. Preliminary results suggest that ENSO-associated variations in vertical migration depths differ across the Exclusive Economic Zones (EEZs) of small island nations in the tropical Pacific. These variations are compared to temperature and oxygen-driven tuna vertical habitat variability to assess potential impacts on tuna.

TROPICAL PACIFIC-WIDE VARIABILITY IN VERTICAL ZOOPLANKTON AND MICRONEKTON DISTRIBUTIONS RELATED TO ENSO

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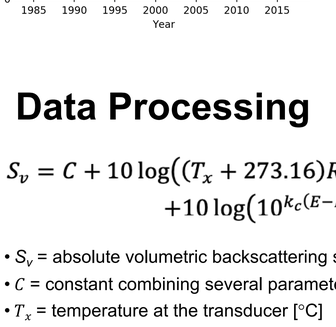
Background

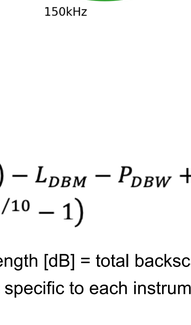
- El Niño-Southern Oscillation (ENSO) generates large swings in tropical Pacific climate, often with widespread socioeconomic impacts, including marked variations in tuna catches throughout the tropical Pacific.
- Past work has focused on temperature-related variations in tuna habitats associated with ENSO, but habitat favorability can also be affected by changes in prey availability.
- Changes and variability in vertical distributions of prey may have important effects on tuna fisheries and ecosystem dynamics.

Research Goals

- Characterize and map observed ENSO-driven variability in vertical zooplankton and micronekton distributions and availability within the tropical Pacific
- Compare and contrast different ways of automatically identifying diel vertical migrations (DVM) and sound scattering layers (SSL)
- Disseminate mapped DVM/SSL datasets to fisheries scientists to force stock assessment and other models
- Publish open-source software package for identifying DVMs and SSLs in Acoustic Doppler Current Profiler (ADCP) data
- Generate updated set of standardized metadata reporting requirements for ADCP data to be used for biological applications

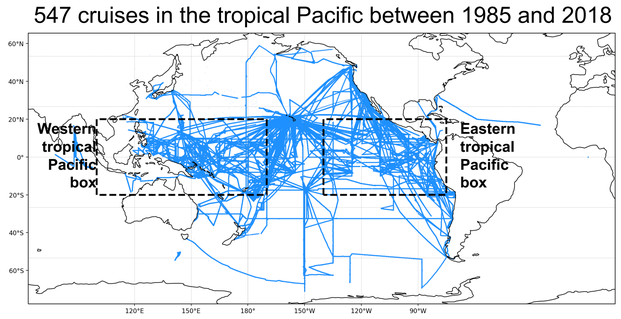
Data Source



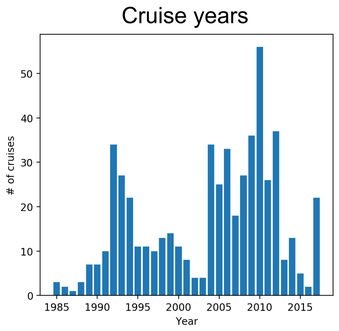


Joint Archive for Shipboard ADCP (JASADCP)

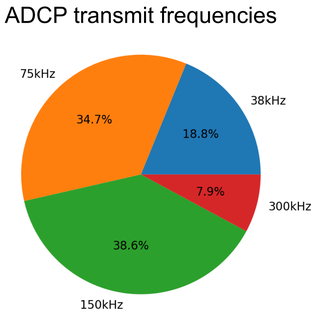
547 cruises in the tropical Pacific between 1985 and 2018



Cruise years



ADCP transmit frequencies

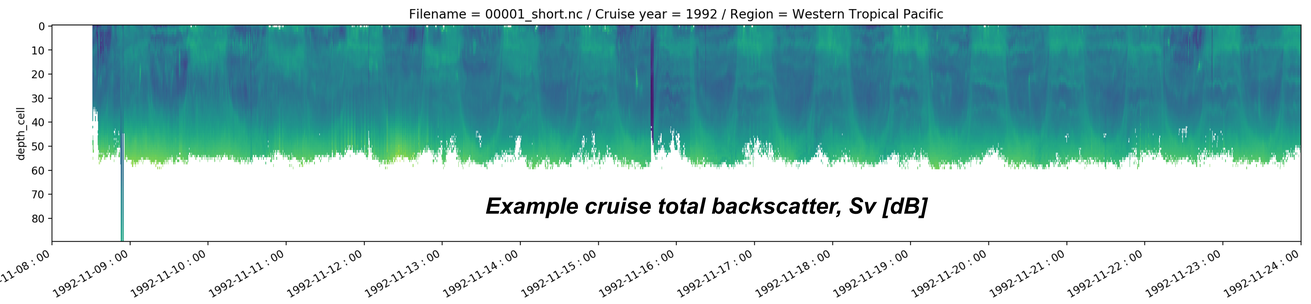


Data Processing

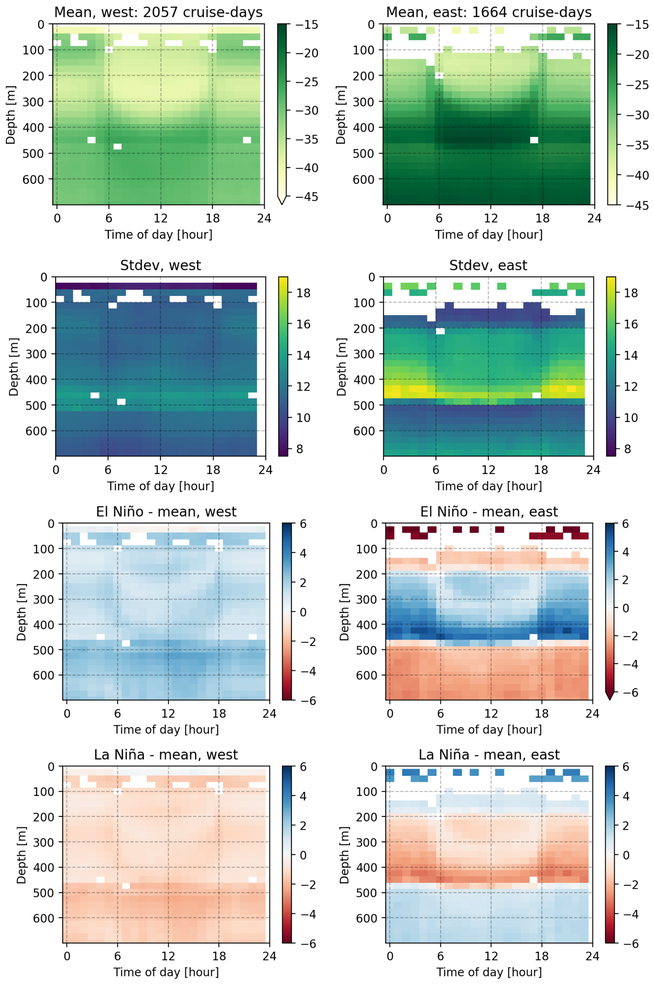
$$S_v = C + 10\log\left((T_x + 273.16)R^2\right) - L_{DBM} - P_{DBW} + 2\alpha R + 10\log\left(10^{k_c(E-E_r)/10} - 1\right)$$

- S_v = absolute volumetric backscattering strength [dB] = total backscatter
- C = constant combining several parameters specific to each instrument [dB]
- T_x = temperature at the transducer [°C]
- R = along-beam range to the measurement [m]
- L_{DBM} = 10log(transmit pulse length [m])
- P_{DBW} = 10log(transmit power [Watts])
- α = acoustic absorption coefficient [dB/m]
- E = measured Returned Signal Strength Indicator (RSSI) amplitude [counts]
- E_r = measured RSSI amplitude in absence of any signal (noise floor) [counts]
- k_c = conversion factor between RSSI counts and dB [dB/count]

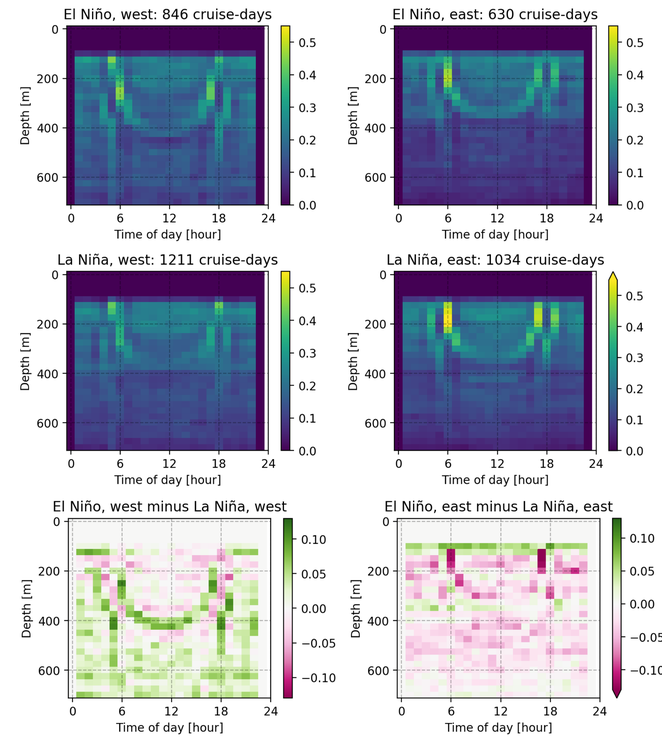
Results and Discussion



Total backscatter, Sv [dB]



Total backscatter + edge detection



Prey availability is **higher** and DVMs are **shallower** in the **east**

ENSO drives variability in vertical prey distributions **throughout the tropical Pacific**

ENSO-driven vertical variations in total backscatter are **substantial**

During **El Niño** (**La Niña**), backscatter is **greater** (**smaller**) in the west, with the opposite likely in the east

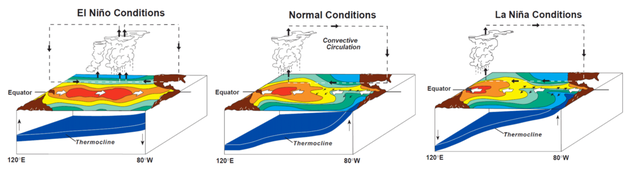


Image credit: NOAA/PMEL/TAO

During **El Niño**, more **pronounced** and **deeper** DVMs occur in the **west**, potentially due to **decreases in cloud cover**

During **La Niña**, **more pronounced**, but similarly deep DVMs occur in the **east**, potentially due to **decreases in cloud cover**

Conclusions

- The vertical distributions and availability of zooplankton and micronekton differ substantially between the eastern and western tropical Pacific, with shallower DVMs/SSLs and greater overall biomasses in the east
- ENSO drives substantial variability in the vertical distributions of zooplankton and micronekton throughout the tropical Pacific
- During El Niño, greater backscattering, along with more pronounced and deeper DVMs occur in the west compared to during La Niña and La Nada
- During La Niña, decreased backscattering (though missing data makes this uncertain), along with more pronounced, but similarly deep DVMs occur in the east compared to during El Niño and La Nada
- ENSO-induced changes in cloud cover and light availability may be the dominant cause of observed vertical variations in prey distributions; these variations in cloud cover counteract the effects of ENSO-induced changes in other variables such as temperature and oxygen
- Climate change effects on ENSO, cloud cover, and prey availability are uncertain
- Continued monitoring of prey availability and collection of ADCP data needed given socioeconomic importance of tuna and other pelagic predators

Future Work

- Quantification of the role of temperature, oxygen, and light in driving this variability
- Compilation of additional ADCP data from the Tropical Atmosphere Ocean (TAO) array
- Development of convolutional neural network from labeled profiles
- Compare more DVM/SSL identification methods against labeled profiles
- Quantify uncertainty and significance of both east-west and ENSO-driven differences
- Examine the effects of temperature and salinity on Sv calculations
- Conversion to biomass units
- Higher-resolution mapping and spatial averaging over more targeted areas of interest