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Acoustic backscatter observations of zooplankton: responses to environmental forcing in the equatorial Pacific from diurnal to interannual time-scales

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We use several (1996-2004) records of mean volume backscattering strength (S_v) derived from 150 kHz Acoustic Doppler Current Profilers (ADCPs) moored along the equator to retrieve qualitative information about the vertical distribution of zooplankton in upwelling mesotrophic conditions and in the warm pool oligotrophic ecosystem of the Pacific Ocean. ADCPs allow for gathering long time-series of non-intrusive information about zooplankton and micronekton at the same spatial and temporal scales as physical observations derived from the tropical Pacific mooring array.

The characteristic alternate pattern of low and high backscattering during day and night is observed in both ecosystems. In the upwelling, nighttime S_v is high above the middle of the thermocline and decreases below while a subsurface S_v maximum is observed in the upper part of the thermocline in oligotrophic conditions. Daytime S_v is more homogeneously distributed over the observed layer than nighttime S_v. Nighttime and daytime S_v are higher in mesotrophic than in oligotrophic ecosystems. Therefore, the eastern edge of the warm pool that separates warm and fresh water of the warm pool from cool and saltier water of the upwelling is also a transition in biomass and composition of zooplankton species. Our long time-series allows describing the evolution of migratory patterns during entire lunar cycles. Organisms sink when the moonlight is bright leading to low surface S_v and a deepening of the high S_v layer while surface S_v is high during darkness hours. The duration of observation of high surface S_v is related to the duration of deep night between sunset and moonrise or between moonset and sunrise. At intra-seasonal time scales, downwelling Kelvin waves that depress the thermocline also deepen the subsurface S_v maximum in oligotrophic conditions and the lower limit of the high S_v layer in mesotrophic conditions. In the same way, at interannual time scales, variations of the thermocline depth related to El Niño/La Niña phases correlate with variations of the base of the high S_v layer and of the depth of the subsurface S_v maximum. Such a behavior can be the consequence of stratification and temperature changes. Also, it can be related to food availability because the vertical structure of chlorophyll is closely linked to stratification in the equatorial Pacific. In the western basin at the 165°E site, our results suggest the influence of moderately mesotrophic waters that would be advected from the western warm pool during westerly wind events.

Despite their limitations, long time-series of ADCP backscattering signal in the tropical Pacific offer a potentially valuable complement to more traditional approaches of studying the poorly documented mid-trophic levels and population dynamics. In particular, it could help validating the mid-trophic level simulated by population dynamics models.