Small scale changes in zooplankton community in relation to stratification and phytoplankton thin layers

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Introduction:
Thin layers are dense aggregations of plankton occurring on scales of centimeters to a few meters in the vertical direction. Current understanding points to the importance of water column stratification as a convergent force leading to thin layer persistence. In Monterey Bay, upwelling-favorable (northerly) winds tend to keep surface water within Monterey Bay, creating thermal stratification, and thereby convergence at the density interface. While the mechanisms of thin layer formation are becoming better described, the biological implications of their formation are much less clear. As zones of high food concentrations for phytoplankton grazers, thin layers can potentially have an impact on trophic interactions in the plankton, but the effects of thin layers are poorly understood due in part to the difficulty in sampling phytoplankton grazers and their predators (gelatinous zooplankton) on a fine scale. In addition, gelatinous zooplankton have been seldom quantified in the field due to their fragility and vulnerability to destruction with traditional net-based sampling systems (e.g., MOCNESS). We deployed an imaging system, the In Situ Ichthyoplankton Imaging System (ISIS), under different scenarios of stratified (favorable to thin layer formation) and mixed conditions. The three goals of this study were:
1) To assess the physical environment across all days of sampling to see what conditions are associated with phytoplankton thin layers
2) To examine the spatio-temporal overlap of phytoplankton thin layers with primary (copepods and appendicularians) and secondary (gelatinous organisms) consumers.
3) To measure the aggregation properties of different gelatinous zooplankton taxa

Methods:
- Moored instruments (Seahorse profiler) at the center of array with 30 minute resolution
- ISIS sampling across the 20 m isobath for 10 lines, turns at surface
- Moves at a constant 2.5 m/s through the water, 4 – 5 undulations per line
- Images zooplankton 500 μm to 10 cm in size

For analysis, the ISIS tows were subsampled, and 30 vertical profiles were examined manually for gelatinous organisms, which were classified to the lowest taxonomic level possible. For smaller zooplankton (copepods and appendicularians), 1/50th of a frame was enumerated for zooplankton, and profiles were subsampled 1 out of 20 frames. 1 profile per transect was examined for small zooplankton, while 3 profiles per transect were examined for gelatinous zooplankton and spaced approximately evenly across each line (inshore, middle, and offshore). To examine the patchiness of the gelatinous zooplankton, the profiles were broken up into 1 m (or 7.7 second) bins, with each bin having a count for each taxonomic group and an associated average depth and fluorometry. A total of 24,650 gelatinous zooplankton were identified over 4 ISIS sampling days. Patchiness was determined using Lloyd’s index of patchiness on the concentrations of organisms per m². Lloyd’s index of patchiness = 1 + (Σp/n - 1)/np, where p is the number of organisms and n is the number of bins. Higher numbers indicate more aggregation of organisms because they typically experience a mean concentration of conspecifics much higher than the mean.

Results:
1) Physical oceanography
- Wind
- Tides
- Temperature
- Salinity
- Sigma-t
- Fluorometry
- Oxygen
- ISIS sampling occurred
- Phytoplankton thin layer present

2) Chlorophyll, small zooplankton (<5 mm), and jelly vertical distributions

3) Aggregation statistics of gelatinous zooplankton
Higher patchiness index indicates a more clumped distribution of jellies (random distribution = 1). Location refers to the position of the profile in relation to the 20m isobath (middle).

Conclusions:
Gelatinous zooplankton were found in high abundances throughout the study period, and until now have been an overlooked component of thin layer dynamics in Monterey Bay. There are a variety of conclusions we can draw from the results:
- Chlorophyll thin layers formed when thermal stratification was high, suggesting a buoyancy-driven mechanism.
- Copepod and appendicularian peak concentrations generally did not overlap spatially with the chlorophyll fluorescence peak. Newly formed stratification (7/5/2010) corresponded with the highest zooplankton abundances.
- Gelatinous zooplankton experienced an explosion in numbers over the course of the study but tended to be less concentrated in the shallowest 5m of the water column, a zone in which copepods were most abundant.
- Differences in the patchiness statistics of gelatinous zooplankton suggest that behavior may influence their fine scale distribution.

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