Diversity, Distribution, and Dynamics of Larval Cephalopods off of Northern California

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Introduction

Cephalopods are important members of their ecosystems due to their voracious appetites and manipulation of their surroundings. Too little is known about adult cephalopod distribution and dynamics as it is nearly impossible to monitor adults. Many cephalopods have a planktonic juvenile stage which can be used to assess not only where adults may be, but how the dynamics of the ocean are affecting them and the planktonic community as a whole.

The Trinidad Head Line (THL) has been sampled for planktonic communities since 2008 as a reference for ecosystem health and response of the Northern California Current (NCC). The THL is located in an area of strong seasonal upwelling in spring and summer, and downwelling, storms and freshwater input in the winter.

This study takes advantage of the warm water mass known as “the blob” that hit the THL in mid 2014 and continued through 2016. This event is clearly visible in the Pacific Decadal Oscillation (PDO), and Multivariate ENSO Index (MEI) (Fig. 4). We also see two cases of El Nino events along the THL, one in 2009 and another hitting during the middle of the high PDO event in 2015-2016.

A previous study by NOAA looking at the same plankton samples, but analyzing ichthyoplankton, euphausiid and copepod communities shows distinct shift in structure. Adding cephalopods to this list will add a new level of depth to NOAA research.

Oceanic Conditions

The marine heatwave of 2014-2016 provided a natural experiment for examining how the planktonic cephalopod community responds to warm conditions along the Trinidad Head Line off of Northern California. Contrasting the warm water phase of 2014-2016 with the preceding cooler water phase we see shifts in the distribution of off-shelf species coming closer to shore, and species showing up in numbers exceeding their normal abundances. As many cephalopods of the Pacific Northwest have planktonic juveniles, using relating plankton distributions and abundances to oceanographic conditions could inform population assessments,juvenes observed during the PCCOD cruises can serve as verification of species’ spawning. Our data do not address cephalopods in general, especially species that lack extensive larval stages. This is a perfect representation of why cephalopods pose such a problem to biologists and fishermen alike. This study sheds more light into the dynamic world of cephalopods and suggests that plankton research may be useful for addressing hypotheses about the dynamics of species that are otherwise challenging to sample in the field. Though further analysis would benefit these findings, preliminary results show how larval cephalopod distributions are affected by various environmental factors which may help fisheries and biologists understand adult movement of several taxa with planktonic larvae.

Spatial and Temporal Species Ordinations

Discussion

The marine heatwave of 2014-2016 provided a natural experiment for examining how the planktonic cephalopod community responds to warm conditions along the Trinidad Head Line off of Northern California. Contrasting the warm water phase of 2014-2016 with the preceding cooler water phase we see shifts in the distribution of off-shelf species coming closer to shore, and species showing up in numbers exceeding their normal abundances. As many cephalopods of the Pacific Northwest have planktonic juveniles, using relating plankton distributions and abundances to oceanographic conditions could inform population assessments, juvenes observed during the PCCOD cruises can serve as verification of species’ spawning. Our data do not address cephalopods in general, especially species that lack extensive larval stages. This is a perfect representation of why cephalopods pose such a problem to biologists and fishermen alike. This study sheds more light into the dynamic world of cephalopods and suggests that plankton research may be useful for addressing hypotheses about the dynamics of species that are otherwise challenging to sample in the field. Though further analysis would benefit these findings, preliminary results show how larval cephalopod distributions are affected by various environmental factors which may help fisheries and biologists understand adult movement of several taxa with planktonic larvae.

Comparison of Distributions

Fig. 4: Species distribution plots, colored with temperature, cruise, and station, as well as an abundance values and temporal arrangements of data for day of year and line source. Top two plots (left to right): Gonatidae, Octopoda (100m); bottom two (left to right): Doryteuthis opalescens, Gonatodes opalescens (KRASNODAR).

The Unmentioned

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References


Fig. 5: Species density plots, colored with temperature, cruise, and station, as well as an abundance values and temporal arrangements of data for day of year and line source. Top two plots (left to right): Gonatidae, Octopoda (100m); bottom two (left to right): Doryteuthis opalescens, Gonatodes opalescens (KRASNODAR).

Fig. 6: Nonmetric multidimensional scaling (NMDS) ordination techniques we are able to look at how our six target species are correlated with season, year, and station. There is strong correlation with some species and seasons that hit extreme exclusivity in Winter and Autumn. Gonatodes, Chiroteuthis and Doryteuthis opalescens are mostly in the summer.

Method

Samples were taken on cruises that occurred on a roughly monthly basis. Sampling would typically begin on the shelf stations in the late afternoon and progress to stations on the shelf break after sunset and into night. For each of the samples taken there was a corresponding CTD deployed to record station temperature, salinity, chlorophyll fluorescence and dissolved oxygen. Samples were taken at each station using a 0.7 meter bongo net fitted with a 505 um mesh and a General Oceanics fluorometer. Nets were deployed to within a few meters of the seafloor or 100 m at maximum. Samples were preserved immediately in 5% formalin in seawater. Later samples were sorted for target organisms (Copepods, Crab Larvae, Cephalopods, Eggs, Ichthyoplankton) and each set of target organisms was analyzed to quantify plankton community and identify individuals to species. Cephalopods that were either too undeveloped or too mangled for identification were not counted in analysis. Identiﬁcations were based on literature references and expert consultation.

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Fig. 3: Schematic overview of the ecosystem off of Northern California. Shading of the horizontal bars indicate temperature anomalies from the climatological mean. Source: {em}Journal of Geophysical Research-Oceans{em} 114 (2009).

Fig. 2: Species distribution plots, colored with temperature, cruise, and station, as well as an abundance values and temporal arrangements of data for day of year and line source. Top two plots (left to right): Gonatidae, Octopoda (100m); bottom two (left to right): Doryteuthis opalescens, Gonatodes opalescens (KRASNODAR).

Fig. 1: Species density plots, colored with temperature, cruise, and station, as well as an abundance values and temporal arrangements of data for day of year and line source. Top two plots (left to right): Gonatidae, Octopoda (100m); bottom two (left to right): Doryteuthis opalescens, Gonatodes opalescens (KRASNODAR).