

Zooplankton and Micronekton Distribution and Interaction with Predators at the Northwest Atlantic Shelf Break and its Canyons

Gareth L. Lawson, Andone C. Lavery, and Peter J. Wiebe
Woods Hole Oceanographic Institution
Woods Hole, MA 02543

phone: (508) 289-3713 fax: (508) 457-2134 email: glawson@whoi.edu
phone: (508) 289-2345 fax: (508) 457-2194 email: alavery@whoi.edu
phone: (508) 289-2313 fax: (508) 457-2169 email: pwiebe@whoi.edu

Award Number: N00014-12-1-0898
<http://www.whoi.edu/people/glawson>

LONG-TERM GOALS

Our long-term goal is to address the interaction of physical and biological processes determining the distribution, abundance, community composition, and association with predators, including marine mammals, seabirds, and fish, of zooplankton and micronekton at the northwest Atlantic continental shelf break and its canyons, inclusive of the role of inter-annual variability and the effects of Gulf Stream warm-core rings. In the mid- to long-term, we anticipate addressing these topics via inter-disciplinary projects integrating our work on lower trophic levels with that of colleagues with expertise in top predator ecology, physical oceanography, ocean acoustics, and bio-physical modeling.

OBJECTIVES

In advance of such a broad, inter-disciplinary effort, we have multiple valuable datasets already available that can be mined to inform future fieldwork, including top predator visual survey data, depth-stratified net samples, and multi-frequency acoustic data collected at the New England shelf break and its canyons in 2005 and 2009-2013. These existing data were all collected under small awards internal to WHOI for pilot work or as unfunded add-ons to other cruises or ships-of-opportunity, and have thus remained largely un-analyzed.

The specific objective of this project is to work up these existing samples and datasets in order to provide a synthesis of spatial and inter-annual patterns of variability in zooplankton and micronekton at New England shelf break canyons, and, where feasible, associations with marine mammals and other predators.

APPROACH

The datasets being examined in this project include:

1. Depth-stratified net samples from 1-m² MOCNESS tows (8 strata per tow) and multi-frequency acoustic and hydrographic data collected during a 10-day 2010 cruise on the R/V *Connecticut* to

Report Documentation Page			Form Approved OMB No. 0704-0188		
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 30 SEP 2013		2. REPORT TYPE		3. DATES COVERED 00-00-2013 to 00-00-2013	
4. TITLE AND SUBTITLE Zooplankton and Micronekton Distribution and Interaction with Predators at the Northwest Atlantic Shelf Break and its Canyons				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Woods Hole Oceanographic Institution, Woods Hole, MA, 02543				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 5	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Atlantis and Veatch Canyons, and neighboring non-canyon regions. At the time a warm-core ring was present influencing Atlantis Canyon (Figure 1), allowing for a comparison of canyon to non-canyon regions both influenced and not influenced by the ring.

2. Depth-stratified net samples from 1-m² MOCNESS tows and multi-frequency acoustic and hydrographic data collected during a 5-day 2005 cruise on the R/V *Endeavor* to Hudson Canyon aimed at examining the relative contributions to high-frequency volume backscattering of zooplankton vs. turbulent microstructure.
3. Depth-stratified Tucker trawl samples (2 strata per tow) collected each July during 2009 - 2013, at the head and mouth of Atlantis Canyon, by colleagues at the Sea Education Association (SEA) during annual cruises transiting across the shelf break on the SSV *Corwith Cramer*.
4. Visual survey data of the abundance and distribution of marine mammals, large surface-associated fish, and seabirds collected during the 10-day 2010 R/V *Connecticut* cruise to Atlantis and Veatch Canyons, and neighboring non-canyon regions.

Our approach has been to process net samples for the lengths, abundance, and biomass of different zooplankton taxa, in order first to examine zooplankton and micronekton distribution, abundance, and community composition within and between the three sampled canyons and time periods (2005, 2009-2012), paying particular attention to inter-annual variability, the influence of warm-core rings and hydrographic conditions, and differences between canyons. The results of net sample processing are being combined with analyses of the multi-frequency acoustic data (where available) in order to infer the taxonomic composition of scattering features and quantify the horizontal extent and vertical position of zooplankton and micronekton aggregations and layers. Finally, statistical analyses are being conducted of the distribution of top predators observed during the 2010 cruise, examining differences in the abundance of different taxa (especially marine mammals and seabirds) between survey sites and associations with environmental conditions, and estimates of the abundance and horizontal and vertical distribution of lower trophic levels derived from the combined analysis of acoustic and net data.

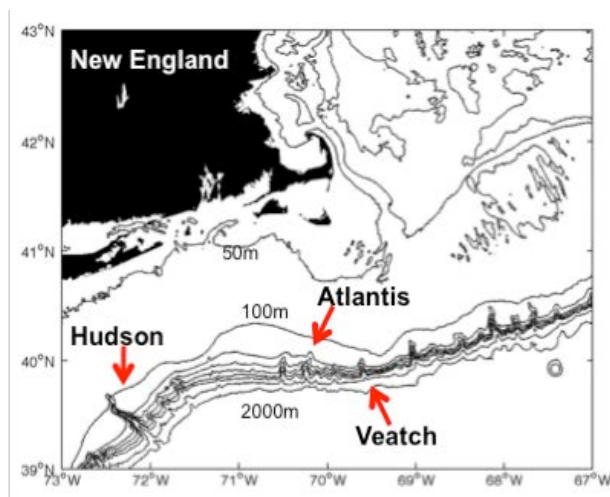


Figure 1 – Canyons of the New England shelf break. Arrows show the three canyons studied here, for which data are available.

WORK COMPLETED

Processing of the various net samples is complete, including the recent July 2013 SEA cruise. MOCNESS and Tucker trawl samples have been processed for euphausiid species composition, size, abundance, and biomass. Silhouette analyses of the size, abundance, and biomass of other zooplankton taxa have also been carried out for the MOCNESS samples. Multi-frequency acoustic data have been post-processed and ‘forward calculations’ comparing observed backscattering levels to predictions based on MOCNESS net samples and taxon-specific scattering models have been used to infer sources of scattering. Top predator survey data from the 2010 R/V *Connecticut* cruise have similarly been cleaned up and binned at spatial scales appropriate for removal of auto-correlation. Currently, our efforts are focused on statistical analyses and integration of these various datasets, as well as manuscript preparation.

RESULTS

Analysis of net samples collected with the MOCNESS system in 2005 and 2010 as well as with the Tucker trawl on the SEA cruises from 2009 through 2013 have indicated significant variation in the biomass, abundance, and species composition of euphausiids between regions, notably including between shallow (especially canyon head) and deep (especially canyon mouth) sites (Figure 2). The time-series of sampling at Atlantis Canyon from the SEA cruises also indicates significant inter-annual variation in euphausiid abundance, biomass, and species composition (Figure 3). Current efforts focus on cluster-type and multi-variate statistical analyses aimed at understanding this spatial and temporal variability in light of bathymetric features (especially canyons), the presence of warm-core rings, and other environmental data. A Master’s student from Cornell University, Robert Levine, hosted at WHOI through a new Cornell-WHOI Memorandum of Understanding, has been responsible for the net sample processing as well as subsequent statistical analyses. Mr. Levine is currently completing the statistical analyses and writing them up as a manuscript that will also constitute his Master’s thesis. The thesis is targeted for submission in early December 2013, with manuscript submission for journal publication targeted for early 2014.

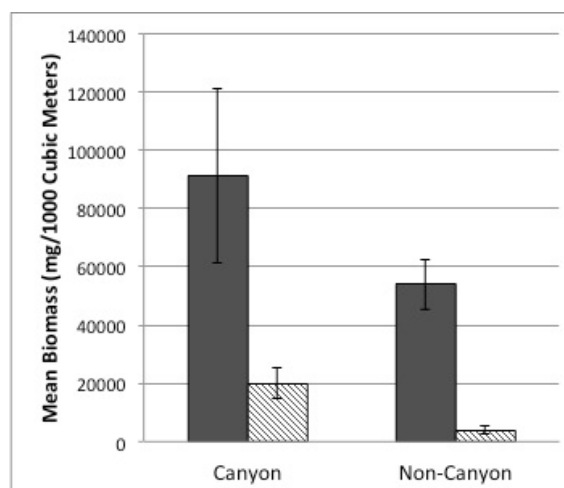


Figure 2 – Mean euphausiid biomass sampled at canyon heads (dark grey) and mouths (light hatched grey) and at locations of comparable shallow (dark grey) and deep (light hatched grey) depths at sites away from canyons

Acoustic data indicated extensive and dense scattering layers especially present at canyon heads, both in the summer R/V *Connecticut* 2010 and winter R/V *Endeavor* 2005 cruises. MOCNESS tows conducted concurrent to acoustic data collection sampled large numbers of copepods and lesser numbers of euphausiids; taxon- and size-specific scattering models, coupled with net samples of animal size and abundance, however, suggested that euphausiids were the dominant scatterer in these acoustic layers. A manuscript describing the distribution of backscattering and its likely sources for the 2010 summer cruise is currently in preparation.

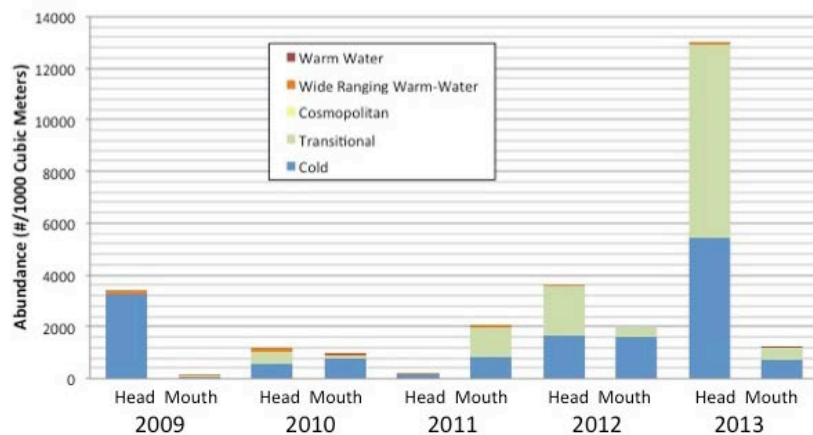


Figure 3 – Euphausiid abundance grouped by watermass type from SEA net tows targeting the head and mouth of Atlantis Canyon in 2009-2013

Analyses of the top predator abundance data collected during daytime visual surveys during the 2010 R/V *Connecticut* cruise focused initially on comparisons between shallow and deep portions of the four study sites (Atlantis Canyon, influenced by a warm-core ring; Veatch Canyon, outside of the ring; a region east of Veatch outside of the ring; and a region west of Atlantis influenced the ring). Small sample sizes have complicated statistical analyses, but odontocetes were found to be significantly more abundant at the canyon heads than at canyon mouths or non-canyon sites. The density of seabirds did not differ as clearly between study sites but did show strong patchiness, suggesting habitat associations at smaller spatial scales. Currently we are accumulating environmental datasets for top predator habitat modeling, including satellite sea surface temperature, fronts, chlorophyll, and dynamic topography. Initial analyses suggest an association of odontocetes and seabirds with fronts in the area, particularly the edge of the warm-core ring and the shelf-slope front (Figure 4). These environmental data will also be combined with indices of the abundance of different prey types in the upper water column derived from multi-frequency acoustic data, in order to examine the habitat associations of different predator types and identify ‘hotspots’ of high diversity. These analyses are led by Dr. Timothy White, a postdoctoral research associate at the City University of New York who participated in the 2010 cruise as part of the top predator observing team. A manuscript based on Dr. White’s analyses is in development and anticipated for submission in early 2014.

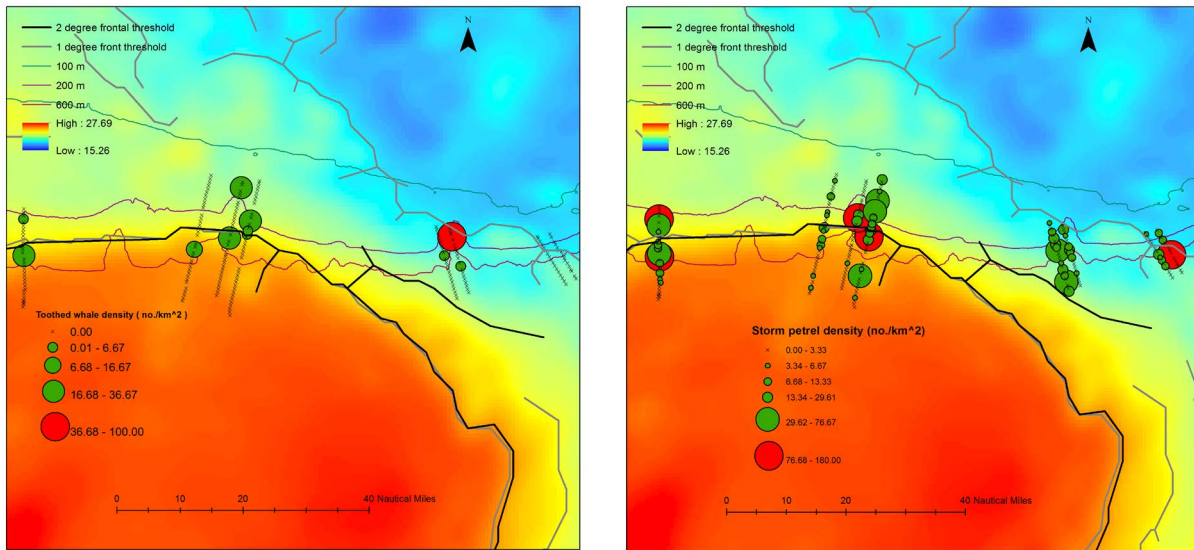


Figure 4 – Distribution of odontocetes (left panel) and storm petrels (right) observed during the 2010 R/V Connecticut shelfbreak survey plotted relative to satellite observations of sea surface temperature and derived estimates of the location of temperature fronts

IMPACT/APPLICATIONS

As noted above, in the longer term, we anticipate developing an inter-disciplinary research effort to address ecosystem dynamics at shelf break canyons. We envisage linking such an effort to both the ONR Ocean Acoustics Shelf Break/Slope/Canyon Field Experiment planned for 2016-2017 and to the NSF Ocean Observatory Initiative's Pioneer Array scheduled to become operational in 2014. The present project and resulting synthesis of patterns of variability in zooplankton/micronekton distribution at New England shelf break canyons and associations with higher predators will provide key information to generate future hypotheses and guide the development of such a broader effort.

RELATED PROJECTS

The top predator survey data to be analyzed here were collected as an unfunded add-on to a Woods Hole Sea Grant award to the present PIs from the 2010-2012 omnibus. The net sample and acoustic data were collected under a series of small projects through funds internal to WHOI.