

# Characterization of Zooplankton Community and Size Composition in Relation to Hydrography and Circulation in the Sea of Japan

Carin Ashjian  
Biology Department  
Woods Hole Oceanographic Institution  
Woods Hole, MA 02543  
phone: (508) 289-3457 fax: (508) 457-2134 email: [cashjian@whoi.edu](mailto:cashjian@whoi.edu)

Cabell Davis  
Biology Department  
Woods Hole Oceanographic Institution  
Woods Hole, MA 02543  
phone: (508) 289-2333 fax: (508) 457-2134 email: [cdavis@whoi.edu](mailto:cdavis@whoi.edu)

Scott Gallager  
Biology Department  
Woods Hole Oceanographic Institution  
Woods Hole, MA 02543  
phone: (508) 289-2783 fax: (508) 457-2158 email: [sgallager@whoi.edu](mailto:sgallager@whoi.edu)

Award #: N00014-98-1-0032  
[http://sam.ucsd.edu/onr\\_jes](http://sam.ucsd.edu/onr_jes)

## LONG-TERM GOAL

Our ultimate scientific goal is to understand both the biological (e.g., population structure and dynamics and behavior) and physical (e.g., advection, mesoscale physical processes, turbulence) mechanisms that act in concert to produce the observed distributions of plankton in the ocean. Our approach has been to conduct a combination of field, lab, and modeling studies. Field studies define the temporal changes in the distributional patterns of population structure resulting from population growth, swimming behavior, and physical transport. Laboratory studies yield insights into vital rates and behavioral patterns. Modeling ties together the vital rate and behavioral information with the population structure and transport data to determine the mechanisms responsible for observed population distributions.

## OBJECTIVES

- 1) To characterize the zooplankton community of the Japan Sea in terms of taxonomic composition and size structure.
- 2) To characterize the scales of variability in the zooplankton of the Japan Sea over distances from centimeters to hundreds of kilometers.

**DISTRIBUTION STATEMENT A**  
Approved for Public Release  
Distribution Unlimited

20001127 050

- 3) To determine the relationship between zooplankton taxa and their associated environmental variables over scales from centimeters to hundreds of kilometers. This information will provide insights into the origins of the different zooplankton taxa.
- 4) To consider the potential flux or exchange of zooplankton into and out of the Sea of Japan through the straits, so that the contribution of physical exchange to resident populations can be quantified.
- 5) To characterize the zooplankton taxonomic composition of the Ulleung Basin eddy in conjunction with the hydrographic analysis of VPR collected temperature and salinity data that will be conducted by S. Ramp.
- 6) To describe the distribution of acoustic scatterers across and along the subpolar front and other hydrographic features, to depths of 200-300 m, through analysis of acoustic backscatter intensity estimated using the acoustic Doppler current profiler that operated during the cruises to the JES.

## APPROACH

Our objectives require the ability to obtain high resolution temporally and spatially coincident measurements of both biological and physical characteristics, which then permits description of the coupling between biological and physical distributions and of the distributions of zooplankton and associated variables over scales from centimeters to hundreds of kilometers. To achieve this, we utilize a combination of new technology (the Video Plankton Recorder) coupled with more standard techniques (shipboard acoustic Doppler current profiler, net sampling). We obtained high resolution measurements of the basin-scale distributions of zooplankton abundance and taxonomic and size composition in relation to the hydrography, currents, light, fluorescence, and beam attenuation in the upper water column (80 m) using the Video Plankton Recorder (VPR) in the southern Japan Sea during June-July 1999. The VPR is essentially an underwater microscope which images plankton at two different magnifications. The instrument is mounted on a V-fin which is towed behind the ship, undulating between the surface and a selected depth. Video images and associated hydrographic and biological data are transmitted from the towed vehicle to the ship via fiber optic cable. In-focus images of plankton are extracted from the video and identified to taxa in real time. Plankton abundances and hydrography are plotted in real time. We collaborated substantially with Dr. Lynne Talley (SIO), who was chief scientist on the cruise and conducted basin-wide CTD measurements as part of the ONR Japan/East Sea DRI. We have initiated collaboration with Dr. Steven Ramp, who is examining the dynamics of the Ulleung Basin and East Korean Warm Current/North Korean Cold Current confluence, to describe the biological-physical associations in this region. We also will collaborate with Dr. Charles Flagg (BNL) who is processing the ADCP data. The work will provide a better understanding of how boreal and tropical zooplankton communities maintain themselves in a dynamic physical environment.

## WORK COMPLETED

The taxonomic and size composition of the zooplankton community in the upper 80 m of the Japan/East Sea was described and mapped in real time using the Video Plankton Recorder during June 17 - July 23, 1999 on Dr. Lynne Talley's cruise on the *R/V Roger Revelle*, surveying over both the northern and southern regions, the Subpolar Front between, and the Ulleung Basin. The instrument sampled between near surface and 80 m for much of the survey with an inter-profile distance of ~7

kilometers and an along-path resolution of centimeters. A total distance of 3562 kilometers was sampled and over 240 hours of video and associated data were collected and processed. Pressure, temperature, conductivity, fluorescence, light transmission, ambient light, P-Code GPS position and time (UTC) and Knudsen Echo Sounder depth data also were logged. Acoustic Doppler current profiler data were collected; velocity data have been entered into a database at Brookhaven National Laboratory under the supervision of Dr. Charles Flagg. During the cruise, hydrographic and taxon specific plankton distribution data were displayed in real time. In addition to the primary sampling with the VPR, fifteen plankton tows were conducted using a 1-m<sup>2</sup> (mouth area), 150 µm mesh ring net towed obliquely between the surface and 80 m.

Over 90% of the video images collected with the high magnification camera were analyzed at sea; the remaining 10% were analyzed shortly after the cruise. Eight taxa were identified from the low magnification camera; calanoid copepods, *Oithona* (a cyclopoid copepod), copepod nauplii, diatom chains, acantharia, sarcodina, larvaceans, and large protozoa. During the cruise, larger copepods such as *Calanus* spp. were observed to the north of the subpolar front with the low magnification camera (images not analyzed at sea); once the images are identified, these data will augment those collected using the high magnification camera. Identification of the video images from the low magnification camera that were collected along the N-S transect lines is 75% completed. Identification of low magnification images from the Ulleung Basin survey still must be accomplished; this involves extracting in-focus images from ~8 days of video records at actual collection speed (e.g., 2 hours of video per 2 hours of towing), followed by identification of these images to taxa in much faster than collection speed. Silhouette analyses of the plankton samples from the ring net tows (taxa specific sizes and abundances) are 90% completed.

Presently, we are merging the plankton data with hydrographic and velocity data in addressing how the physical environment (fronts, advection, water mass type) influences the plankton communities of this marginal sea. The results of this synthesis will shed light on the biological/physical interactions controlling zooplankton abundance and community structure in a semi-enclosed marginal sea and will allow us to better understand how zooplankton communities maintain themselves in a dynamic physical environment. We also are considering the plankton composition (taxa specific) and size distribution in the different hydrographic regions and portions of the water column. We are working towards two papers from these analyses: One describing the mesoscale distribution, size composition, and vertical distribution of zooplankton taxa in relation to hydrographic features using the VPR data and a second describing the zooplankton size, taxonomic, and biomass composition from the net tows.

#### **RESULTS TO DATE (Based on hydrographic and high magnification camera data only)**

1. The cruise track surveyed at least two hydrographic regions which had distinct temperature-salinity properties: the southern Japan Sea (south of the subpolar front) and the northern Japan Sea north of the subpolar front).
2. "Copepods" was the most numerous taxon identified in the video plankton recorder images from the high magnification camera.
3. Copepod vertical distribution was associated with the hydrographic structure of the water column but modified by diel vertical migration (Figure 1).

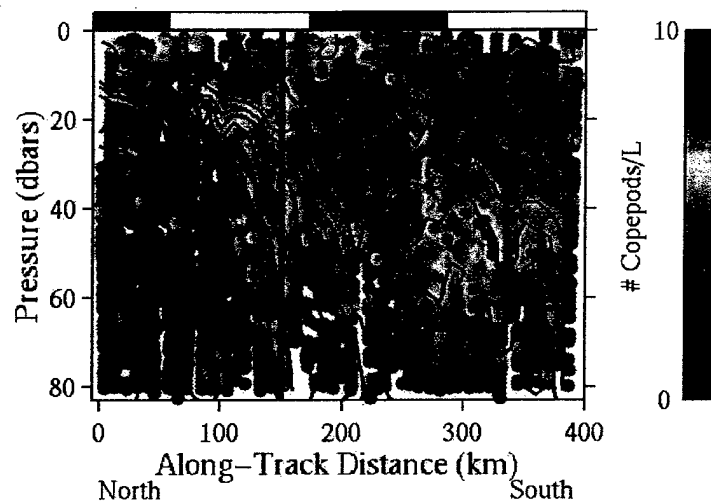


Figure 1. Distribution of copepods along a transect extending from the northern Japan Sea (left) across the Subpolar Front to the southern Japan Sea (right). Locations where copepods were observed are shown with the large symbols; color of the symbols indicates the concentration of copepods at that location. Along-track distance plotted on horizontal axis with location of Subpolar Front indicated with the heavy vertical line at ~150 km along-track distance. Temperature isotherms overlain with heavy dark lines; note deepening of isotherms moving from north to south across the Front. Periods of day and night indicated with black (night) and day (white) shading across top of figure. Copepods were found in the thermocline during the day but moved upwards into the upper 10 m during the night. Note that the depth of the daytime abundance maximum shoaled with the shoaling thermocline at locations north of the Front.

4. The size composition of the plankton, and copepods, varied according to hydrographic region and water mass type, with smallest plankton below the thermocline in water of less than 5 °C (Figure 2). Most of this latter type of water was found to the north of the subpolar front. This finding was unexpected; larger individuals are usually thought to be found in colder water. We expect that analysis of the low magnification camera images may modify this result.
5. The taxonomic composition (e.g., % copepods) of the plankton varied according to hydrographic region (Figure 2).
6. For copepods, copepod nauplii, and *Oithona*, little difference in water column abundance was observed between the regions immediately to the north and south of the subpolar front. All of these taxa were significantly more abundant off of Hokkaido. Large protozoa were most abundant immediately north of the subpolar front and off of Hokkaido.

Ongoing analyses include: 1) describing the size distribution of taxa in different hydrographic regions, 2) quantifying associations between different taxa and between taxa and environmental conditions, 3) examining the scale of variability of the distributions of zooplankton taxa, 4) incorporating instantaneous velocity measurements collected with the shipboard acoustic Doppler current profiler to estimate of flux of plankton between different hydrographic regions and in and out of the JES, and 5) gaining a greater understanding of spatial and temporal variation in the distribution of plankton across the Subpolar front through consideration of acoustic Doppler current profiler backscatter intensity.

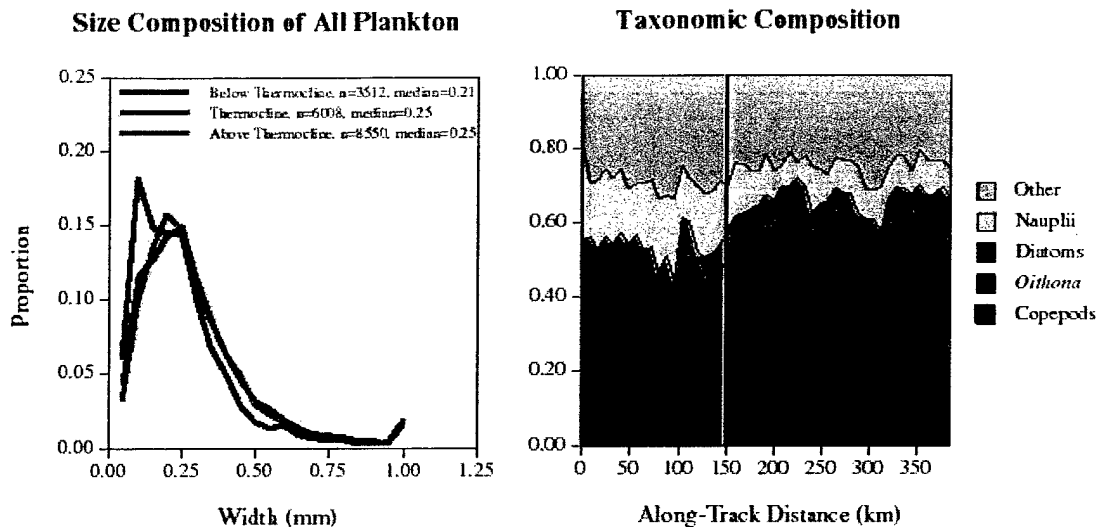


Figure 2. Size and taxonomic composition of all plankton from across the north-south transect shown in Figure 1. Plankton were significantly smaller below the thermocline (found primarily to the north of the Front) than in the thermocline or above the thermocline. Copepods (calanoid) were the most abundant taxa at all times, however were proportionally less abundant to the north of the front.

## IMPACT/APPLICATION

The proposed study will shed light on the biological/physical interactions controlling zooplankton abundance and community structure in a semi-enclosed marginal sea. We also will gain new insights into the impact of advective input of a tropical community into a boreal region. The mixture of the two communities and the potential establishment of a transitional community along the Subpolar Front will allow us to examine how the affinities of zooplankton communities change in response to advective transport over a broad range of scale and the roles of eddies and meanders in promoting exchange between different planktonic and hydrographic regimes. Such information will allow us to better understand how zooplankton communities maintain themselves in a dynamic physical environment.

## TRANSITIONS

Our findings will allow better predictions of how zooplankton and large phytoplankton abundance patterns change as a function of hydrography and currents in the Japan Sea. More generally, the findings will provide a better understanding of how plankton and physical properties are distributed in relation to each other over a broad range of scales in the vicinity of a sharp biogeographic frontal region. This information then can be used to better understand variability in sound and light scattering properties of the ocean.

## RELATED PROJECTS

1 – This work will be integrated with the Japan Sea DRI which involves many investigators in physical and optical oceanography, including S. Ramp (Ulleung Basin and NKCC/EKWC confluence).

2 – The Japan Sea findings will be compared with those from our GLOBEC Georges Bank VPR studies which are focusing on cross-frontal exchange of plankton.

## PUBLICATIONS

Ashjian, C.J., C.S. Davis, S.M. Gallagher, and P. Alatalo. Distribution of plankton, particles, and hydrographic features across Georges Bank described using the Video Plankton Recorder. *Deep-Sea Research II*, (In press).

Benfield, M.C., C.S. Davis, and S.M. Gallagher. 2000. Estimating the in-situ orientation of *Calanus finmarchicus* on Georges Bank using the Video Plankton Recorder. *Plankton Biology and Ecology* **47**: 69-72.

Davis, C.S., S.M. Gallagher, X. Tang, L. Vincent and C.J. Ashjian. Real-time automatic identification of plankton. *Mar. Ecol. Prog. Ser.* (Submitted, in revision).

Lynch, D.R., Naimie, C.E., Ip, J.T., Lewis, C.V., Werner, F.E., Luettich, R., Blanton, B.O., Quinlan, J., Gallagher, S.M., Ashjian, C.J., Lough, R.G., Manning, J., Flagg, C.N., Hannah, C.G., Groman, R.C. Real-Time Data Assimilative Modeling on Georges Bank. *Oceanography*, Submitted.

Solow, A., C. Davis, and Q. Hu. Estimating the composition of a sample when individuals are classified with error. *Mar. Ecol. Prog. Ser.*, Submitted.

Dennett, M. R., D. A. Caron, A. E. Michaels, M. Church, P. Countway, S. M. Gallagher, and C. S. Davis. Video Plankton Recorder reveals high abundance of colonial radiolaria in surface waters of the central north Pacific. (submitted, in revision).

Gallagher, S. M., H. Yamazaki, C. S. Davis. The contribution of finescale vertical structure and swimming behavior to the formation of plankton layers on Georges Bank. (submitted)

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of the collection of information, including suggestions for reducing the burden, to Washington Headquarters Services, Directorate for Information Operations & Reports 12 15 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, & to the Office of Management & Budget Paperwork Reduction Project, Washington, DC 20503.			
1. Agency Use Only	2. Report Date October 2000	3. Report Type and Dates Covered Progress Report - Year 3 - 10/1/99 - 9/30/00	
4. Title and Subtitle: Characterization of the Zooplankton Community and Size Composition in Relation to Hydrography in the Sea of Japan			5. Funding Numbers
6. Author(s) Dr. Carin J. Ashjian, Dr. Cabell S. Davis and Dr. Scott M. Gallager			
7. Performing Organization Name(s) and Address(es)  Woods Hole Oceanographic Institution			8. Performing Organization Report Number WHOI Proposal No. BI103002
9. Sponsoring/Monitoring Agency Name(s) and Address(es) Office of Naval Research Ballston Centre Tower One 800 N. Quincy Street Arlington, VA 22217-5660			10. Sponsoring/Monitoring Agency Report Number  Grant No. N00014-98-1-0032
11. Supplementary Notes			
12a. Distribution/Availability Statement  Approved for Public Release			12b. Distribution Code
13. Abstract: The northern and southern Japan Sea are hydrographically and biologically distinct, with the southern portion being more tropical/oligotrophic and the northern portion being more boreal/eutrophic. The plankton of the Japan Sea remains poorly understood, particularly with regard to high-resolution description of the distribution of planktonic taxa and environmental conditions. We described the taxonomic and size composition of the zooplankton community and associated hydrography of the JES during the summer of 1999 using the Video Plankton Recorder (VPR), surveying over both the northern and southern regions, the Subpolar Front between, and the Ulleung Basin. The VPR was towed between the near-surface and 80 m for over 240 hours and 3500 km., collecting over 600,000 images of plankton, and coincident hydrography. The distributions of identified taxa and hydrographic characteristics were plotted in near-real time at sea. Plankton also were collected at 15 selected stations using a ring net, for silhouette analysis of taxa and size. Dramatically different plankton compositions were observed in the various hydrographic regions.			
14. Subject Terms			15. Number of Pages
			16. Price Code
17. Security Classification of Report	18. Security Classification of this Page	19. Security Classification of Abstract	20. Limitation of Abstract