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14. ABSTRACT Regional zooplankton taxonomic and size compositions and abundance and the high resolution vertical distribution of plankton, fluorescence, and coincident hydrography were described using the Video Plankton Recorder (VPR) along a 7000 km survey of the upper 80 m of the JES during the summer of 1999. Plankton were collected at 15 stations using a net for analysis of taxa and size. Plankton images from the VPR were identified automatically at sea in real time using a neural network classifier. The most abundant taxa were copepods, copepod nauplii, protozoa, and diatoms, with copepods dominant numerically. The northern JES, southern JES, and North Korean Cold Current were distinct based on temperature-salinity properties and had different plankton taxonomic and size compositions. The vertical distributions of copepods and fluorescence were associated with hydrographic structure, especially at fronts. Plankton abundances varied with regional hydrographic region and environmental conditions, although strong associations were not always observed.					
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# REPORT OF INVENTIONS AND SUBCONTRACTS

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								b. FINAL	
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## SECTION I - SUBJECT INVENTIONS

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NAME(S) OF INVENTOR(S) (Last, First, Middle Initial)	TITLE OF INVENTION(S) b.	DISCLOSURE NUMBER, PATENT APPLICATION SERIAL NUMBER OR PATENT NUMBER c.	ELECTION TO FILE PATENT APPLICATIONS (X)				CONFIRMATORY INSTRUMENT OR ASSIGNMENT FORWARDED TO CONTRACTING OFFICER (X) e.
			(1) UNITED STATES		(2) FOREIGN		
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a.							


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I certify that the reporting party has procedures for prompt identification and timely disclosure of "Subject Inventions," that such procedures have been followed and that all "Subject Inventions" have been reported.			
a. NAME OF AUTHORIZED CONTRACTOR/SUBCONTRACTOR OFFICIAL (Last, First, Middle Initial) Ashjian, Carin J.	b. TITLE Associate Scientist	c. SIGNATURE 	d. DATE SIGNED 12/20/04



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

## **Final Report**

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### **LONG-TERM GOAL**

My 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. My approach has been to conduct a combination of field observations and experiments to measure vital rates (grazing, egg production). Observational studies define the temporal changes in the distributional patterns of population structure resulting from population growth, swimming behavior, and physical transport. Experimental work describes vital rates and how these rates may be impacted by the environment to determine the ultimate success of the population.

### **OBJECTIVES**

- 1) To characterize the zooplankton community of the Japan Sea in terms of taxonomic composition and size structure.
- 2) 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.
- 3) 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.
- 4) 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**

These 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, a combination of new technology (the Video Plankton Recorder) coupled with more standard techniques (shipboard acoustic Doppler current profiler, net sampling) was utilized. 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) were obtained using the Video Plankton Recorder (VPR) in the southern Japan Sea during June-July 1999 from the *R/V Roger Revelle*. The VPR is essentially an underwater microscope that images plankton at two different magnifications. The instrument is mounted on a V-fin that 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. Acoustic Doppler current profiler (ADCP) backscatter intensity data were collected using the hull-mounted ADCP on the *Revelle* during June-July 1999 and also on several other cruises conducted at different periods of the year (spring, winter). I 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. I collaborated also with Dr. Steven Ramp, who is examining the dynamics of the Ulleung Basin and East Korean Warm Current/North Korean Cold Current confluence using hydrographic data collected with the VPR, to describe the biological-physical associations in this region. I also collaborated with Dr. Charles Flagg (BNL) who processed the ADCP data, to describe the spatial distribution of backscatter intensity (a proxy for plankton or nekton abundance) across the Japan/East Sea.

## 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. Identification of the video images from the low magnification camera was completed post-cruise. Only two plankton types were observed/identified with the low magnification camera: unidentified copepods and copepods of the genus *Calanus*. Silhouette analyses of the plankton samples from the ring net tows (taxa specific sizes and abundances) was conducted. Qualitative assessment of the dominant copepod species present from net tows taken at selected important hydrographic locations (Tsushima Strait, NKCC, TWC, north of the SPF, SPF, northern JES) identified the presence of indicator species.



The plankton data from the VPR were merged with hydrographic and velocity data in addressing how the physical environment (fronts, advection, water mass type). Two papers have been completed based on the VPR work: one describing the hydrography of the Ulleung Basin (Ramp *et al.*) and a second describing characteristics of the zooplankton community of the JES Basin in association with hydrography using data from both VPR cameras and the net tows (Ashjian *et al.*). The Ashjian *et al.* paper was accepted for publication in the Deep-Sea Research II special issue on the JES on February 9, 2004; actual publication still is pending. Results from both analyses were presented at the 2001 AGU meeting in San Francisco; results from the VPR analysis was presented also at the 2002 Ocean Sciences meeting in Honolulu, HI. Processing of the acoustic backscatter intensity data from the ADCP has been completed by C. Flagg and M. Dunn at Brookhaven National Laboratory. Analysis of these data is ongoing.

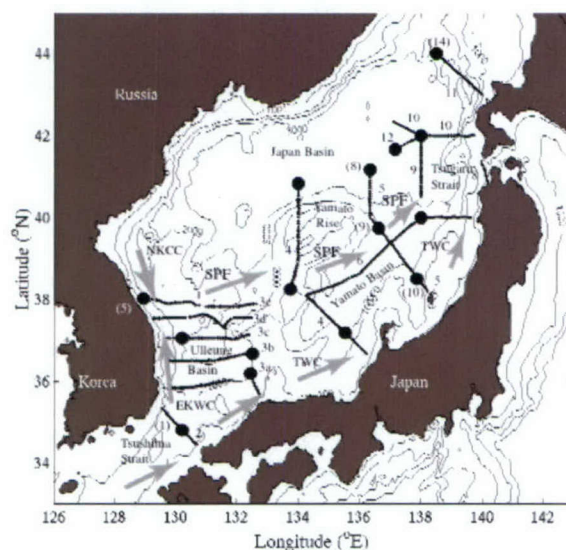


Figure 1. Cruise track in the Japan/East Sea. Locations where Video Plankton Recorder data were collected are shown as the dark line. Locations of ring net tows shown with the large dots; numbers in parentheses indicate locations of net tows analyzed qualitatively for species composition. Gray arrows show prevailing currents. SPF = Subpolar Front, EKWC = East Korean Warm Current, TWC=Tsuchima Warm Current, NKCC = North Korean Cold Current,

## RESULTS TO DATE

1. The cruise track surveyed two (three) hydrographic regions which had distinct temperature-salinity properties: the southern Japan Sea (south of the SPF), the northern Japan Sea north of the SPF), and the North Korean Cold Current off of Korea. Considerable mesoscale complexity in hydrography and circulation was observed.
2. "Copepods" was the most numerous taxon found with all instruments.
3. The taxonomic composition (e.g., % copepods) of the plankton varied according to hydrographic region.
4. Plankton abundances varied with hydrographic region, although strong associations were not always observed.
5. The size composition of the plankton varied according to hydrographic region and the size categories of plankton targeted by the each instrument.

6. The vertical distributions of copepods and fluorescence were associated with hydrographic structure. Depth distribution of biological variables changed with changing water column vertical structure, especially at fronts.

7. Because of the dynamic environment, differences in plankton size and taxonomic composition were less dramatic than had been hypothesized.

8. Different hydrographic locations were characterized by indicator copepod species, based only on qualitative assessment of relevant tows. Although plankton size and taxonomic composition was not particularly useful to demarcate hydrographic regions, species composition appears to be highly sensitive to such differentiation and to reflect mixing of different water types.

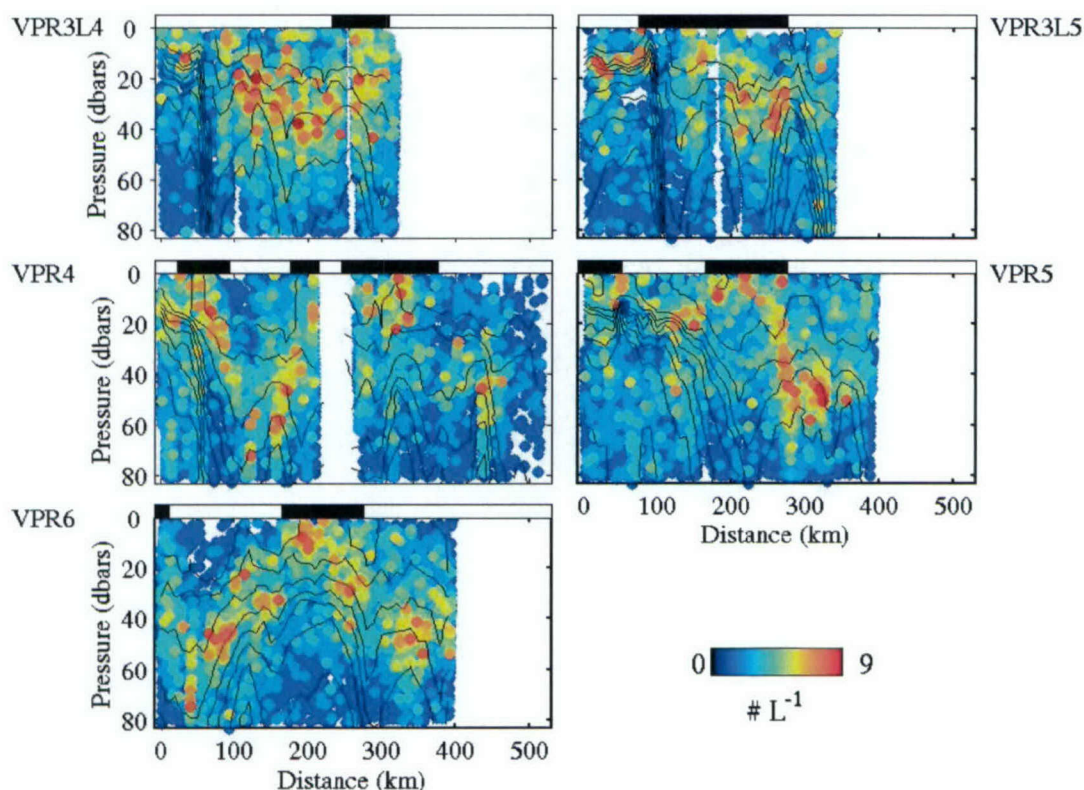


Figure 2. Vertical distribution of copepods across five transects of the Ulleung Basin (upper row) and across the Subpolar Front (middle row) and Yamato Basin (bottom row). For each transect, the across-transect – depth locations where copepods were observed are indicated by the dots; the color of the dots shows the concentrations of copepods at that location. The structure of the water column is demonstrated by the isotherms overlain as black contour lines. Periods of day and night are indicated by the white and black, respectively, bars across the top of the plot.

## IMPACT/APPLICATION

The study has shed light on the biological/physical interactions controlling zooplankton abundance and community structure in a semi-enclosed marginal sea. The very dynamic region along the subpolar front resulted in less differentiation between the two communities than had been hypothesized and suggests that plankton communities in highly dynamic regions may not be maintained as well as we believed. This is one of the first completed VPR studies utilizing the automated image analysis capabilities of the VPR system and hence is a milestone in plankton ecology.



## RELATED PROJECTS

This work compliments efforts of the other Japan Sea DRI which involves many investigators in physical and optical oceanography, including S. Ramp (Ulleung Basin and NKCC/EKWC confluence). The work also continues the ONR's support of the development of the VPR to this demonstration of the instrument's real-time capabilities and its use in the collection of very-high resolution data that was analyzed automatically. The work also compliments past and ongoing work by the PI in analysis of ADCP data and in use of the VPR to describe plankton and particle distributions and transport in very dynamic regions.

## PUBLICATIONS

Ashjian, C.J., Davis, C.S., Gallagher, S.M., Alatalo, P. Characterization of the zooplankton community, size composition, and distribution in relation to hydrography in the Japan/East Sea. Accepted, Deep-Sea Research II.

Ramp, S.R., F. L Bahr, C. J. Ashjian, and L. D. Talley. The upper-ocean circulation in the Ulleung Basin during June-July 1999. In Revision.

## PRESENTATIONS

Alatalo, P, C.J. Ashjian, C. S. Davis. Characterization of the zooplankton community and size composition and abundance in relation to hydrography and circulation in the Sea of Japan. Ocean Sciences Meeting, February 12, 2002, Honolulu, HI

Ashjian, C.J., C.S. Davis, S.M. Gallagher, and P. Alatalo. Characterization of the zooplankton community and size composition in relation to hydrography and circulation in the Sea of Japan. 2000 American Geophysical Union Fall Meeting, December 19, 2000, San Francisco, CA, EOS 81: F747.

Ramp, S. R., F.L. Bahr, C.J. Ashjian, C. Davis, L.D. Talley. The mesoscale structure of the Ulleung Basin during June 1999. American Geophysical Union Fall Meeting, December 19, 2000, San Francisco, CA, EOS 81: F767.