Physical and Optical Structures in the Upper Ocean of the East (Japan) Sea

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LONG-TERM GOALS

This study fits within our broader scientific efforts to understand:

- Physical and biological responses of the upper ocean to atmospheric forcing and how these penetrate to the interior.
- The dynamics and biological influences of instabilities, secondary circulations and vertical motions associated with upper ocean fronts.
- Physical and bio-optical transitions between coastal and central basin waters.

OBJECTIVES

We seek to understand the processes that control physical and bio-optical variability in the upper ocean of the East/Japan Sea. Specifically, we are interested in:

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- The upper ocean response to strong wintertime forcing (Siberian cold air outbreaks) at the subpolar front.
- The resulting formation, subduction, and spreading of intermediate waters.
- The dynamics of the subpolar front.
- Contrasting seasonal and coastal/central basin bio-optical variability.

APPROACH

Two cruises, one in May 1999 and the second in January 2000 will sample upper ocean and atmospheric boundary layer (C. Dorman, SIO) variability in the Japan/East Sea. The spring cruise will focus on studying frontal dynamics, characterizing bio-optical variability associated with the spring phytoplankton bloom and documenting the location, range and properties of water masses formed at the subpolar front during the preceding winter. The wintertime cruise will focus on documenting the upper ocean response to cold air outbreaks with particular attention to processes associated with water mass formation and subduction at the subpolar front. Both cruises will employ a towed, undulating profiler (SeaSoar) to make highly-resolved observations of the upper ocean. We will use real-time remotely sensed sea surface temperature and ocean color images (R. Arnone, NRL and scientists from the Korean Ocean Research and Development Institute, KORDI) to determine the location of the subpolar front and to select intensive survey locations. Real-time access to remotely sensed imagery will allow us to modify our sampling in response to changes in the front. Repeated “radiator” grid surveys will provide approximately synoptic, three-dimensional coverage while a sequence of longer sections will document oceanic and atmospheric boundary layer variability away from the front. In addition to the suite of physical and bio-optical sensors carried by SeaSoar, we will use a shipboard Acoustic Doppler Current Profiler (ADCP) and GPS navigation to measure upper ocean currents. We will also perform a limited number of hydrographic stations off the Korean coast and across the subpolar front. Professor S. Yang (Kwangju University) will perform additional biological and bio-optical sampling (e.g. nutrient analysis, pigments). Dr. M. Suk (KORDI) and colleagues will provide additional support.

WORK COMPLETED

We are currently preparing the SeaSoar and related systems for use in the Japan/East Sea. In early October, 1998, we successfully completed a three-day test cruise south of Georges Bank. Chief Scientist James Irish (WHOI) generously provided time for this testing as a secondary project in conjunction with his mooring work on Georges Bank. We deployed and tested SeaSoar in the configuration we intend to use in the Japan/East Sea, including the full suite of physical and bio-optical instrumentation (Figures 1 and 2). As we had not yet taken delivery on the winch purchased for this experiment, we used a smaller winch with a shorter cable. SeaSoar performed well and nearly all systems functioned as intended. The only malfunctions were caused by defects in the Wetlabs HiStar 100 and in the fast-response dissolved oxygen probe. Both of these sensors were immediately returned to their manufacturers for further testing and repair. We are currently working to complete preparations for the two upcoming science cruises and to analyze physical and bio-optical data from the test cruise. This analysis will provide data concerning the response of the various sensors and allow us to select between possible sensor placement options.

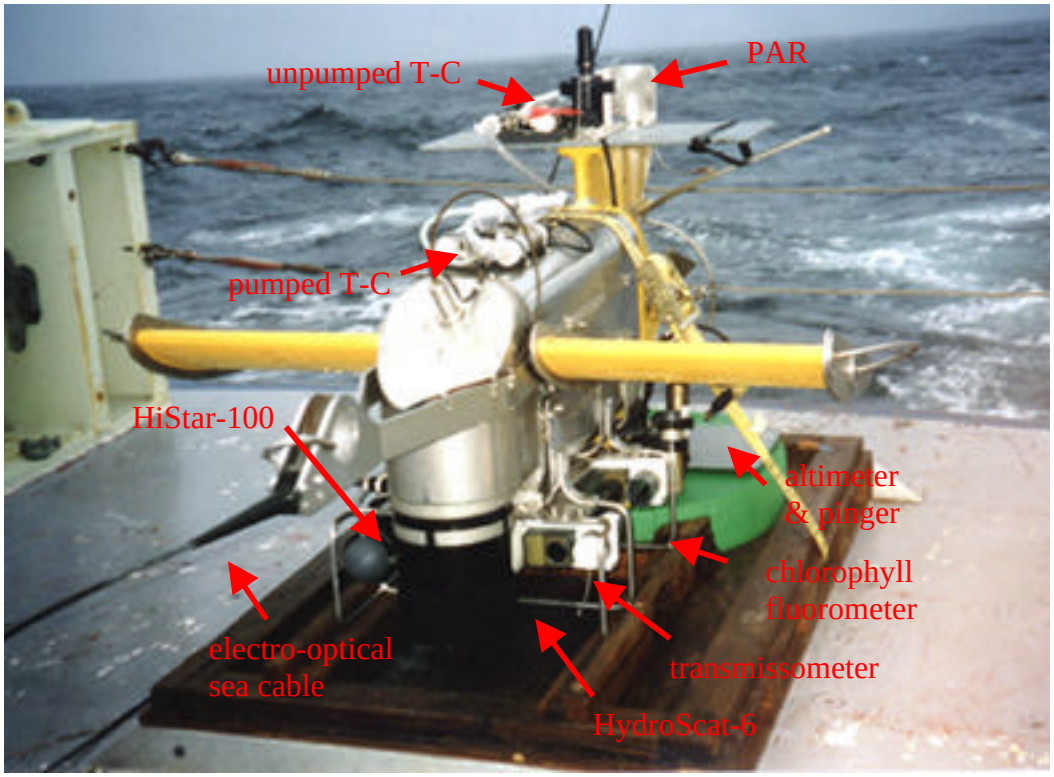

Figure 1. SeaSoar configured for the Japan/East Sea Experiment. Note the payload cage beneath the vehicle and the Hydroscat-6 mounted vertically in the nose assembly.

RESULTS

All results to date are engineering/technical achievements pertaining to the integration of two high-bandwidth bio-optical sensors (the Wetlabs HiStar and Hobi Labs Hydroscat) with the SeaSoar system.

IMPACT/APPLICATION

The combination of highly resolved, three-dimensional upper ocean measurements and intensive boundary layer meteorological observations (Dr. Clive Dorman, SIO) will provide a unique picture of convection and water mass formation in response to strong atmospheric forcing. Simultaneous measurements of bio-optical properties will contrast conditions on either side of the front and permit us to study the role of dynamics in controlling bio-optical variability. Both at the subpolar front and off the Korean coast, SeaSoar surveys will provide bio-optical measurements of unprecedented synopticity and horizontal resolution.

TRANSITIONS

The electro-optical sea cable system deployed for the Japan/East Sea program could easily be adapted for use by other towed profiler groups interested in operating high-bandwidth payloads with surface data acquisition and control. Similarly, the software developed for data logging and

vehicle/sensor control are available for use within the community. Our experiences using two state-of-the-art bio-optical packages to make quasi-synoptic, three-dimensional surveys should assist others seeking to make similar measurements and, hopefully, will help make such observations more commonplace.

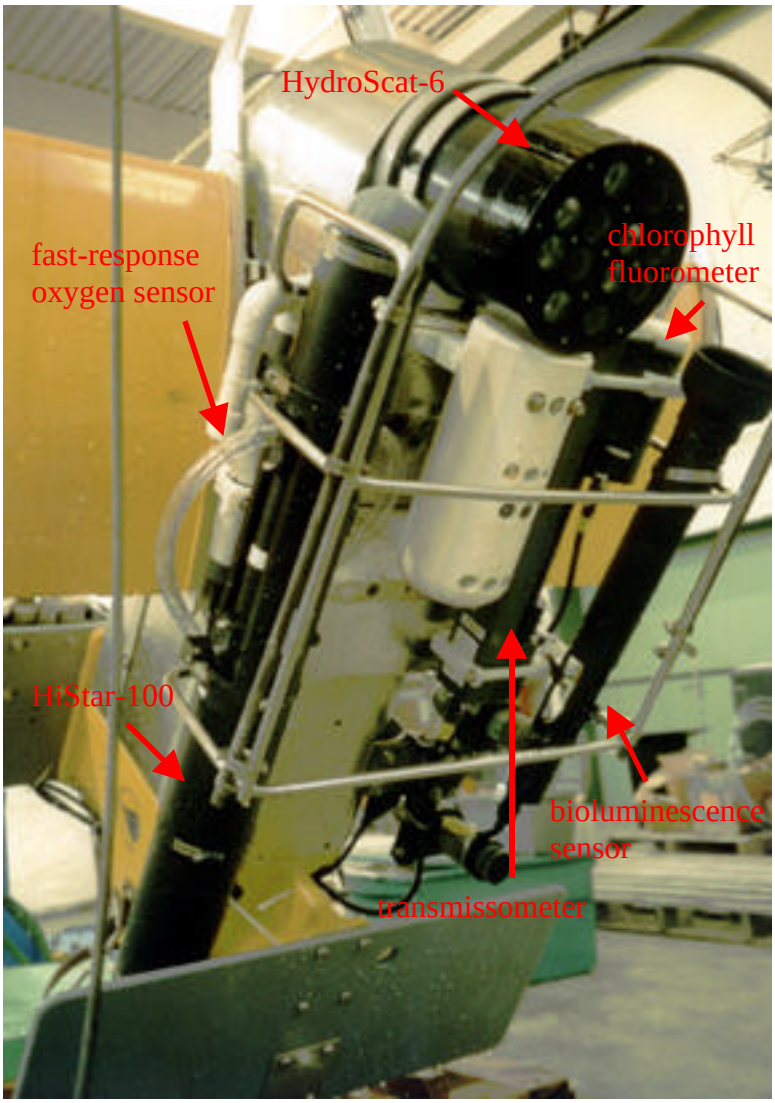

Figure 2. SeaSoar payload cage detail.

RELATED PROJECTS

Our efforts are part of an intensive, multi-investigator study of the Japan/East Sea. We intend to collaborate closely, both in the measurement and analysis phases, with other Japan/East Sea projects. In particular, we anticipate cooperation with the following components:

Satellite Characterization of Bio-Optical and Thermal Variability in the Japan/East Sea, B. Arnone, (NRL).

Atmospheric Forcing and its Spatial Variability over the Japan/East Sea, R. Beardsley, A. Rogerson (WHOI) and C. Dorman (SIO).

Studies of Physical and Biological Processes in the Japan/East Sea using Coupled Numerical Models, C. Paulson (Purdue University) and L. Kantha (University of Colorado).

Glider Surveys of the Japan/East Sea Circulation, C. Eriksen (University of Washington).

Optical Properties as Tracers of Water Mass Structure and Circulation, G. Mitchell, D. Stramski and P. Flatau (SIO).

Modeling Support for CREAMS II: Oceanic and Atmospheric Mesoscale Circulation and Marine Ecosystem Simulations for the Japan/East Sea, C. Mooers and S. Chen (University of Miami).

Wind Forcing of Currents in the Japan/East Sea, P. Niiler (S.I.O.), D. Lee (Pusan National University) and S. Hahn (National Fisheries Research and Development Institute).

Observations of Upper Ocean Hydrography and Currents in the Japan/East Sea using PALACE Floats, S. Riser (University of Washington).

Hydrographic Measurements in Support of Japan/East Sea Circulation, L. Talley (SIO).

Shallow and Deep Current Variability in the Southwestern Japan/East Sea, R. Watts and M. Wimbush (University of Rhode Island).