PROJECT TITLE: Environmental Oceanography of the Arctic Ocean and its Marginal Seas: continuation of Synthesis and Preparation for the Next Major Experiment

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OBJECTIVE

To understand the role of the Arctic Ocean and its marginal seas with regard to the global biogeochemical cycle of biogenic and lithogenic material.

APPROACH

The 1994 proposal to ONR consisted of 2 inter-related approaches: 1) to clarify Arctic export fluxes with reference to the halothermal dynamics of the Arctic Basin environment; and 2) to develop understanding of the Sea of Okhotsk taking a two-pronged approach: classic ice-ocean-hydrography research and generation of a resource-predictable model.

ACCOMPLISHMENTS

Arctic Ocean Basin Studies

After several years of challenge, consistent ONR support and recent collaboration with Japan Marine Science and Technology Center, a multi-sensor, telemetering Ice-Ocean Environmental Buoy (IOEB) (Krishfield *et al.*, 1993) that interactively measures critical Arctic environmental parameters and is now serving international high-latitude studies to its full capacity (Honjo *et al.*, 1995a, in press). Highlights are:

- The analyses of the continuously telemeter ADCP records reveal the detailed structure, frequency, location and seasonality of baroclinic eddies in the Beaufort Sea. The highest energy field of these baroclinic eddies is concentrated at about 100 m and penetrates through the halocline boundary to 200 m. At 250 m, no effect from eddies on ice-floe behavior was found.
- For the first time, and unexpectedly, it was found that a significant phytoplankton bloom takes place annually during the Arctic late afternoon (autumn) in the central Arctic Ocean while it is covered by thick multi-year ice.
- Under the central Transpolar Drift ice current, the upper 100 m layer is mixed by surface forcing driven by the rejection of brine into the water column when sea-ice is formed in openings between ice floes, such as leads.
- Along the Transpolar Drift, turbidity, caused by particulate matter at the bottom of the halocline layer (about 100 m) increases at the same time that the salinity increases. This suggests that particles and the rapidly-growing standing crop of plankton are removed to the deeper layers with settling saline water.

THE SEA OF OKHOTSK

The ONR-supported, first export flux measurement in the Sea of Okhotsk strongly supports the original hypothesis that the Sea of Okhotsk provides a large quantity of organic carbon to the bottom community maintaining the sea's large renewable demersal production (Honjo *et al.*, 1995, submitted). This finding has lead to another higher-step hypothesis: The Sea of Okhotsk is the most efficient ocean in the world for removal of atmospheric CO to the deep ocean sink. This outstanding biological pump is supported by a unique hydrography: the sub-zero dicothermal layer which covers the major part of this ocean (Honjo, 1995, submitted). This hypothesis and conclusion were rationalized by comparison with world-wide studies supported both by ONR's high-latitude program (e.g. Honjo, 1990) and NSF-JGOFS's low-latitude counterpart (e.g., Honjo *et al.* 1995b, in press).

A pilot model study, a modified version of the 1.5-dimensional coupled ocean-ice model, was conducted to examine key physical processes that maintain the unique oceanographic features in the Sea of Okhotsk and to explore plausible mechanisms for interannual variations. Although this first model was constrained by the scarceness of available relevant observational data, and despite the simplicity of the model, the resulting model (Yang and Honjo, submitted) successfully captured the main features of the Sea of Okhotsk.

These efforts have begun to depict where oceanographic research efforts should be focused toward understanding the Sea of Okhotsk and gaining a more realistic ability to predict global and industrial forcing within this ocean of rich resources. Reports of our efforts at a number of scientific meetings during 1994 and early 1995 have become guiding beams for new international investigators of the Sea of Okhotsk.

LITERATURE REFERENCES

Honjo, S., 1990. Particle Fluxes and Modern Sedimentation in the Polar Oceans, Chapter 13, In: Smith, W. O., Jr., (ed.), Polar Oceanography, Academic Press, New York, Vol. II: 322-353.

Krishfield, R., Honjo, S., Tucker III, W.B., Nakanishi, T., and Takizawa, T., 1993. Automated Ice-Ocean Environmental Buoys (IOEBs) for the Telemetry of Air, Ice and Ocean Data from the Polar Oceans, *IEEE Oceans '93 Conference Proceedings*, II-47-II-52.

Honjo, S., T. Takizawa, R. Krishfield, J. Kemp, and K. Hatakeyama, 1995a, in press, Drifting Buoys Make Discoveries About Interactive Processes in the Arctic Ocean, *EOS*..

Honjo, S, Dymond, J., Collier, R., and Manganini, S. J., 1995b, in press. Export Production of Particles to the Interior of Equatorial Pacific Ocean During 1992 EqPac Experiment, *Deep-Sea Research.*

Honjo, S., Honda, M., Manganini, S. J. and Ishii, H., 1995, submitted. Biogeochemical Cycles in the Sea of Okhotsk, a Temporarily Ice-Bound Large Marginal Sea, *Deep-Sea Research*.

Honjo, S., 1995b submitted. Fluxes of Particles to the Interior of Open Oceans, ***In:*** Ittekkot, V. and Honjo, S. (eds.) *Particle Fluxes in the Ocean*, Wiley Interscience, Munich.

Yang, J. and Honjo, S., 1995, submitted. Modeling the dicothermal layer of the Sea of Okhotsk. *Journal of Geophysical Research.*

APPLICATIONS

Because of its multi-sensor communication capability, longevity and durability in ice-fields, IOEB technology is applicable to many types of ocean science and naval research. The sub-zero dicothermal layer will be significant in acoustic application because of its unique refractivity.

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