3. Satellite and Ship Observations of Coastal Upwelling in the St. Lawrence Island Polynya (SLIP) Area in Summer, 1994 and 1995

Sei-ichi SAITOH[1], David L. ESLINGER[2], Hiroaki SASAKI[1], Naonobu SHIGA[1], Tsuneo ODATE[3] and Takako MIYOI[1]

[1] *Faculty of Fisheries, Hokkaido University, Hakodate, Hokkaido 041-8611, Japan*
[2] *Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, Alaska, U. S. A.*
[3] *National Institute of Polar Research, Kaga, Itabashi-Ku, Tokyo, Japan*

Abstract

The St. Lawrence Island Polynya (SLIP) area is a unique ecosystem with high biological productivity. In late July 1994 and 1995, we conducted synoptic ship observation in this region. We observed a phytoplankton bloom in the southern coastal water of St. Lawrence Island on July 25, 1995. This bloom should be associated with nutrient rich water supply due to coastal upwelling. This phenomena was examined by using a time series of sea surface temperature images from NOAA Advanced Very High Resolution Radiometer (AVHRR) data and wind data. Southeasterly wind were dominant in 1994 and northwesterly wind were dominant in 1995. Cold water was distributing widely along the south coast of the St. Lawrence Island and the St. Matthew Island in 1995, compared with the cold water distribution in 1994. A dominant northwesterly wind blowing along the coast of St. Lawrence Island and St. Matthew Island, promotes coastal upwelling along the southern coast of the islands. On the other hand, a dominant southeasterly wind blowing along the coast of St. Matthew Island promotes coastal upwelling along the northern coast of the island. This coastal upwelling might contribute to enhanced primary production, therefore year-to-year variability of coastal upwelling should be monitored to understand the variation of primary production in this shelf region.

Introduction

The Bering Sea Shelf is one of the most productive regions of the world. In the past, marine ecosystem studies in this shelf region including the Chukchi Sea have been conducted through the PROBES project in the 1970s (McRoy et al., 1986) and the ISHTAR project in the 1980s (McRoy, 1993). We started the ecological study of the St. Lawrence Island Polynya (SLIP) area, which is a unique ecosystem with high biological productivity (Grebmeier and Cooper, 1995) in 1994, using the T/S *Oshoro Maru* research cruise activities. In late July 1994 and 1995, we conducted synoptic ship observations in this region. We observed strong coastal upwelling near St. Lawrence Island in 1995. This phenomena was examined by using a time series of sea surface temperature images of NOAA Advanced Very High Resolution Radiometer (AVHRR) data. A northwesterly wind blew along the coast of St. Lawrence Island and St. Matthew Island in summer promoting coastal upwelling along the southern coast of these islands.

Satellite and Ship observations

Temporal and spatial distribution of sea surface temperature in the study area were analyzed by using NOAA Advanced Very High Resolution Radiometer (AVHRR) data which had been received at the Geophysical Institute, University of Alaska Fairbanks. Cloud-free images were selected from browse image data sets for July and August of 1994 and 1995. Image analysis and data processing were carried out using Tera-Scan system from Sea Space Inc.

Synoptic ship observations were carried out by T/S *Oshoro Maru* during the period July 18 to July 24, 1994 and July 25 to July 29, 1995 (Fig. 1). Salinity, temperature, and depth were measured using a CTD profiler. Water samples for chlorophyll *a* and phaeopigment determinations were collected using Niskin bottles attached to rosette on the CTD. Chlorophyll samples were collected in 200-mL bottles and filtered through a Whatman GF/F filter on board. Filtered samples were put into glass vials containing 10ml of N,N-dimethylformamide, for extraction of chlorophyll *a*, and stored in a freezer. Chlorophyll *a* and pheophytin were determined by the fluorometric method (Parsons et al., 1984) with the Turner Designs Fluorometer.

In order to examine winds and coastal upwelling, wind direction and speed at St.

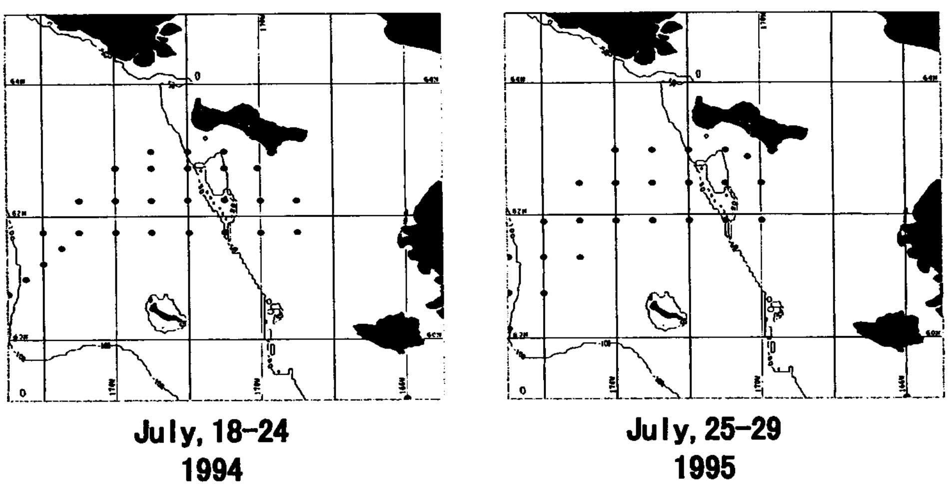

Fig.1. Ship observation stations of T/S *Oshoro Maru* in 1994 and 1995.

Paul Island in July were obtained from twice daily North Pacific weather map.

Results and Discussion

East by southeasterly, southeasterly and south by southeasterly winds were dominant in 1994. In contrast, west by northwesterly, northwesterly and north by northwesterly winds were dominant in 1995 (Fig.2). Satellite thermal infrared images show the cold water distribution as an indicator of coastal upwelling. Cold water was distributing widely along the south coast of St. Lawrence Island and St. Matthew Island in 1995 (Fig.3), compared with cold water distribution in 1994(Fig.4). The dominant northwesterly wind blowing along the coast of St. Lawrence and St. Matthew Island, is promoting coastal upwelling along the southern coast of these islands. Cold water was more widely distributed along the north coast of St. Matthew Island in 1994 (Fig.5), compared to 1995(Fig.3). The dominante southeasterly wind blowing along the coast of St. Matthew Island, is promoting coastal upwelling along the northern coast of the island.

On July 25, 1995, we observed a phytoplankton bloom at the stations located in the southern coastal water off St. Lawrence Island. High chlorophyll *a* concentration of the range 16 - 20 mg/m^3 were observed from surface to the depth of 20 m. There was no such bloom observed in late July, 1994. This bloom was associated with nutrient rich water supplied by coastal upwelling and this distribution correspond to the cold water distribution detected by satellite images. This cold water mass had been observed for at least 10 days in

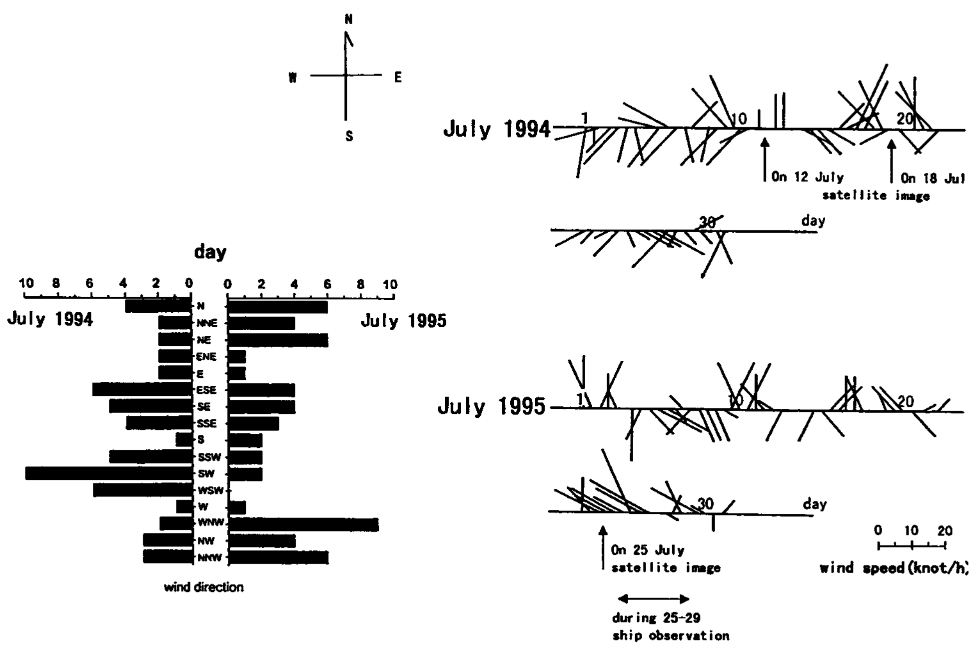

Fig.2. Wind data at the St. Paul Island in July of 1994 and 1995.

advance of 2 days of ship observation. This bloom might contribute to the primary production system in this region. Miyake et al.(1994) reported that there was an upwelling phenomenon only in 1991 during the summer of 1990 to 1992. We must consider year-to-year variability of coastal upwelling which should be monitored for understanding the variation of primary production in this SLIP area.

Walsh et al. (1997) shows year-to-year variability of phytoplankton pigment distribution off the St. Lawrence Island using Coastal Zone Color Scanner (CZCS) images. Nihoul et al. (1993) developed a three-dimensional ecohydrodynamics model of the Northern Bering Sea and pointed out that the strong upwelling located along the Siberian coast contribute to primary and secondary production near SLIP area. In future studies, we are expecting to utilize ocean color data from a new series of sensors, SeaWiFS (Sea-viewing Wide Field-of-viewing Sensor) on SeaStar (Hooker et al., 1992) which was successfully launched in August 1, 1997. The data will improve our understanding not only year-to-year variability but also month-to-month variability of biological process by providing more accurate phytoplankton pigment concentration estimates with more frequent temporal coverage than possible by ship, even though this area is one of the most cloudy

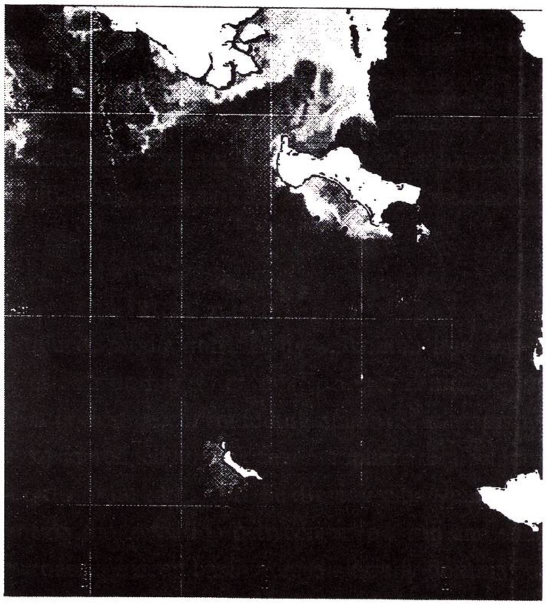

Fig.3. Satellite MCSST image taken on July 25 of 1995. Ship observation stations of T/S *Oshoro Maru* overlaid on the image. The dark shades of gray represent the warm water.

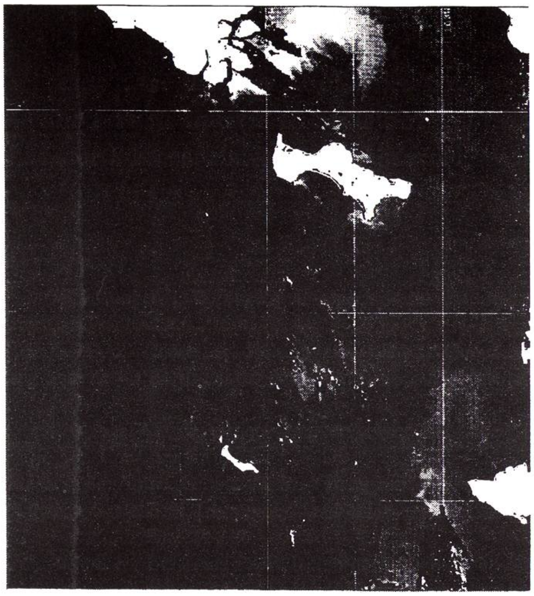

Fig.4. Satellite MCSST image taken on July 12 of 1994. Ship observation stations of T/S *Oshoro Maru* overlaid on the image. The dark shades of gray represent the warm water.

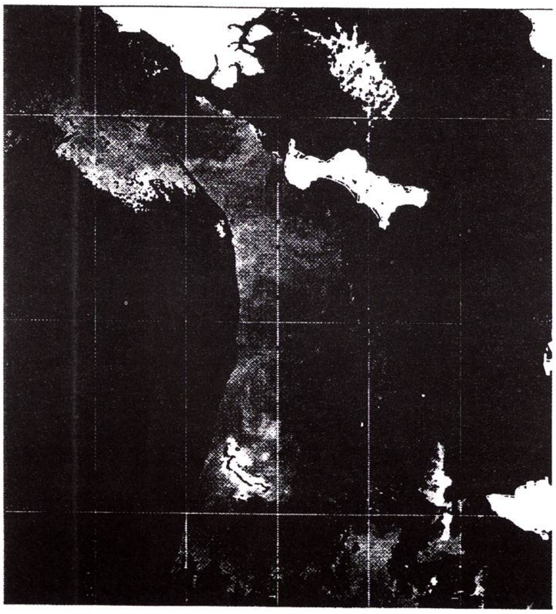

Fig.5. Satellite MCSST image taken on July 18 of 1994. Ship observation stations of T/S *Oshoro Maru* overlaid on the image. The dark shades of gray represent the warm water.

regions in the world.

Acknowledgements

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