2. Coastal Oyashio Multidisciplinary and Advanced Study (COMPAS) Program Using New Ocean Color Remote Sensing and Intensive Ship Observations

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Abstract

Temporal and spatial distributions of chlorophyll *a* and sea surface temperature in Funka Bay and adjacent waters were analyzed using the ADEOS Ocean Color and Temperature Scanner (OCTS) and NOAA Advanced Very High Resolution Radiometer (AVHRR) data. The AVHRR data were received at the Faculty of Fisheries, Hokkaido University, and the OCTS data were provided by NASDA. Cloud-free images were selected from browse image data sets during the period January to March 1997. Synoptic and intensive ship observations were carried out by the R/V *Ushio Maru* and T/S *Oshoro Maru* during the period January 22 to March 19, 1997 and March 5 to 13, 1997, respectively.

There was no strong intrusion of Coastal Oyashio Water into Funka Bay, and the spring bloom in this region started in mid-March 1997. The time series OCTS images demonstrated the usefulness of satellite ocean color remote sensing for monitoring temporal and spatial variability of chlorophyll *a* distribution during the spring bloom.

Introduction

Recently, there has been an advance in understanding, not only of a relationship between year-to-year variability of Coastal Oyashio intrusion and magnitude of spring bloom in Funka Bay and adjacent waters, but also of the temporal and spatial variability of Coastal Oyashio Water. However, some questions still remain about the contribution of Coastal Oyashio Water to the spring bloom. Development of satellite ocean color remote sensing is useful for studying the temporal and spatial variability of spring bloom with a synoptic scale. Using this new tool, we came to realize that it is difficult to clarify the temporal and spatial variability of a spring bloom without a synoptic and multidisciplinary approach. In January 1997, we started the Coastal Oyashio Multidisciplinary and Advanced Study (COMPAS) program to assess the contribution of Coastal Oyashio to spring bloom, and to clarify the relationship between the year-to-year variability in Coastal Oyashio intrusion and the magnitude of spring bloom. Synoptic ship observation and satellite observations were carried out in Funka Bay and the adjacent waters near Hokkaido, Japan, between late January and late March 1997.

The objective of this study was to clarify temporal and spatial variability and vertical

structure of the spring bloom in Funka Bay and adjacent waters.

Intensive Ship and Satellite Observations

Intensive Ship Observation and Data Analysis

Synoptic and intensive ship observations were carried out by the R/V *Ushio Maru* once a week during the period January 22 to March 19, 1997 (Fig. 1a). Another research cruise by the T/S *Oshoro Maru* was carried out during March 5-13, 1997 (Fig. 1b).

Salinity, temperature, and depth were measured using a CTD profiler. Water samples for chlorophyll *a* and pheopigment determinations were collected using Niskin bottles attached to a rosette on the CTD. Chlorophyll samples were collected in 200 ml bottles and filtered through a Whatman GF/F filter onboard. Filtered samples were put into glass vials containing 10 ml of N, N-dimethylformamide for extraction of chlorophyll *a* and stored in a freezer. Chlorophyll *a* and pheophytin were measured using the fluorometric

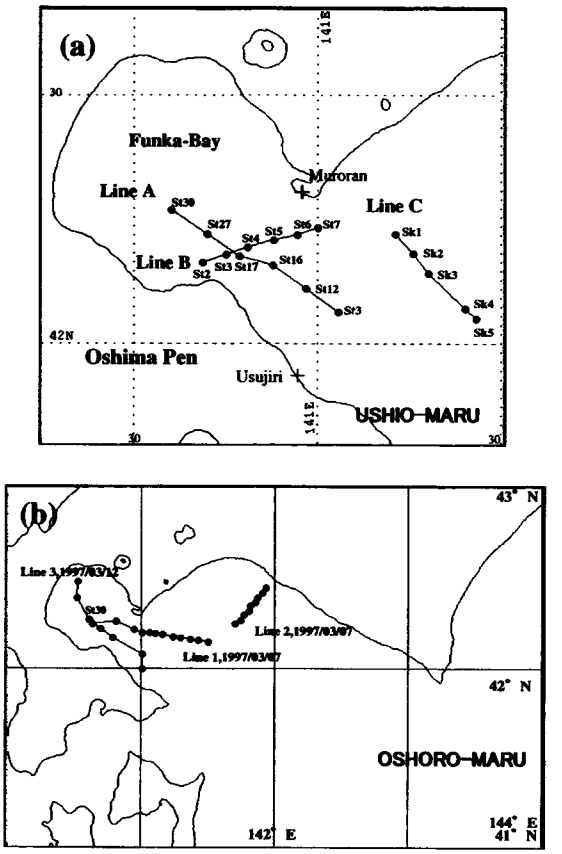


Fig.1. Sip observation station of R/V *Ushio maru*(a) and T/S *Oshoro maru*(b).

method (Parsons et al., 1984) with a Turner Designs Fluorometer.

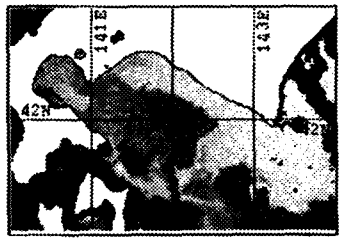
Satellite Observation and Image Analysis

Temporal and spatial distribution of chlorophyll *a* and sea surface temperature in the study area were analyzed using OCTS (Saitoh, 1995b) and AVHRR (Saitoh, 1995a). The AVHRR data was received at the Faculty of Fisheries, Hokkaido University, and the OCTS data was provided by NASDA. Cloud-free images were selected from browse image data sets during the period January to March 1997. NOAA-12 and NOAA-14 AVHRR data were collected from January to March 1997. For the AVHRR thermal infrared data, in-flight calibration was carried out and the calibrated data was then processed to remove geometric distortions. A digitized coast line and geographic mark were superimposed on the geometric corrected image.

Results and Discussion

Coastal Oyashio Water reached the mouth of Funka Bay in early February and mid-March according to time series SST images (Fig. 2). However, no intrusion pattern of Coastal Oyashio into the bay was seen in satellite SST images. Hydrographic data at St. 17, which is located at the mouth of Funka Bay, indicates that arrival of Coastal Oyashio is identified with a decline in water temperature (under 4°C) and salinity (under 33.2psu). The start of spring bloom is shown by an increase in chlorophyll *a* concentration (over 2.0 mg/m^3) from the middle of March (Fig. 3). Time series OCTS chlorophyll *a* images show the development of spring bloom in the bay and adjacent waters from March 13 to March 26 (Fig. 4). On March 18 and 19, patches of high chlorophyll *a* concentration were apparent in the middle of the mouth of the bay. On March 20, phytoplankton bloom had developed throughout the entire bay, and high chlorophyll *a* concentrations were apparent along the northwestern coastal region and the mouth of the bay. High chlorophyll *a* water was spreading on the western side of the thermal front between the Coastal Oyashio Water and the waters in the mouth of the bay (Fig. 5). However, there was relatively low chlorophyll *a* concentration around the northeastern part of the bay. According to past numerical modeling studies of circulation in the bay (Ohshima and Miyake, 1990; Shimizu and Isoda, 1997), northwesterly wind in winter should generate a vortex pair with clockwise and anti-clockwise circulation. ADCP observation results on March 18 and 19 were overlaid on the chlorophyll *a* image for March 19 (Fig. 5). We have identified a current flow in a northwest direction in the bay. We assume that this low chlorophyll *a* area might be generated by downwelling in the clockwise circulation which is vortex pair formed by northwesterly wind in the period from early to mid-March before satellite observation.

There was no strong intrusion of Coastal Oyashio Water into Funka Bay. The spring bloom in this region started in mid-March 1997. The time series of OCTS images demonstrated the usefulness of satellite ocean color remote sensing for monitoring temporal and spatial variability of chlorophyll *a* distribution during the spring bloom.



NOAA/AVHRR MCSST
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NOAA/AVHRR MCSST
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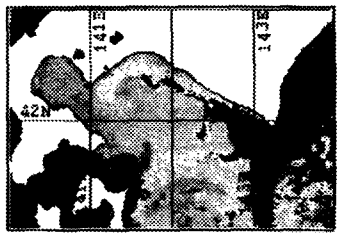

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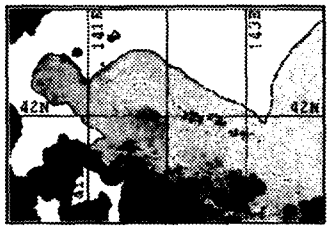

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Fig.2. Time series NOAA/AVHRR MCSST images.

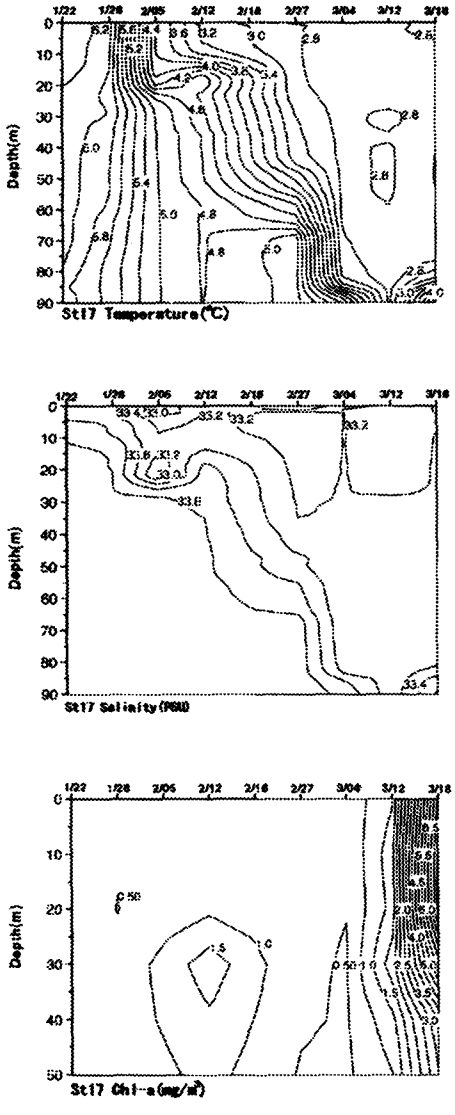

Fig.3. Isopleth of temperature, salinity and chlorophyll *a* from surface to bottom at St. 17 in the period from January 22 to March 18, 1997.

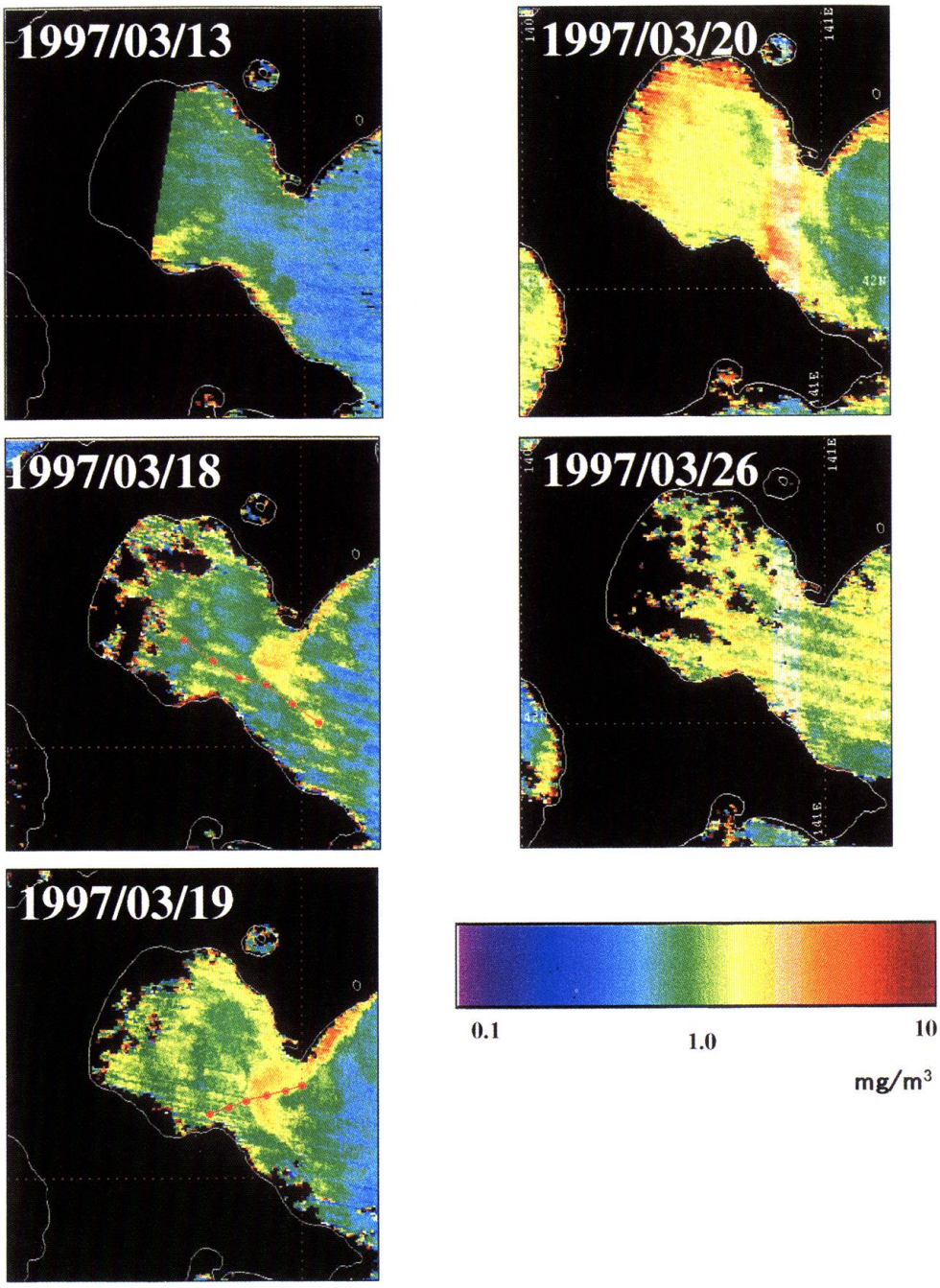

Fig.4. Time series ADEOS/OCTS chlorophyll *a* images.

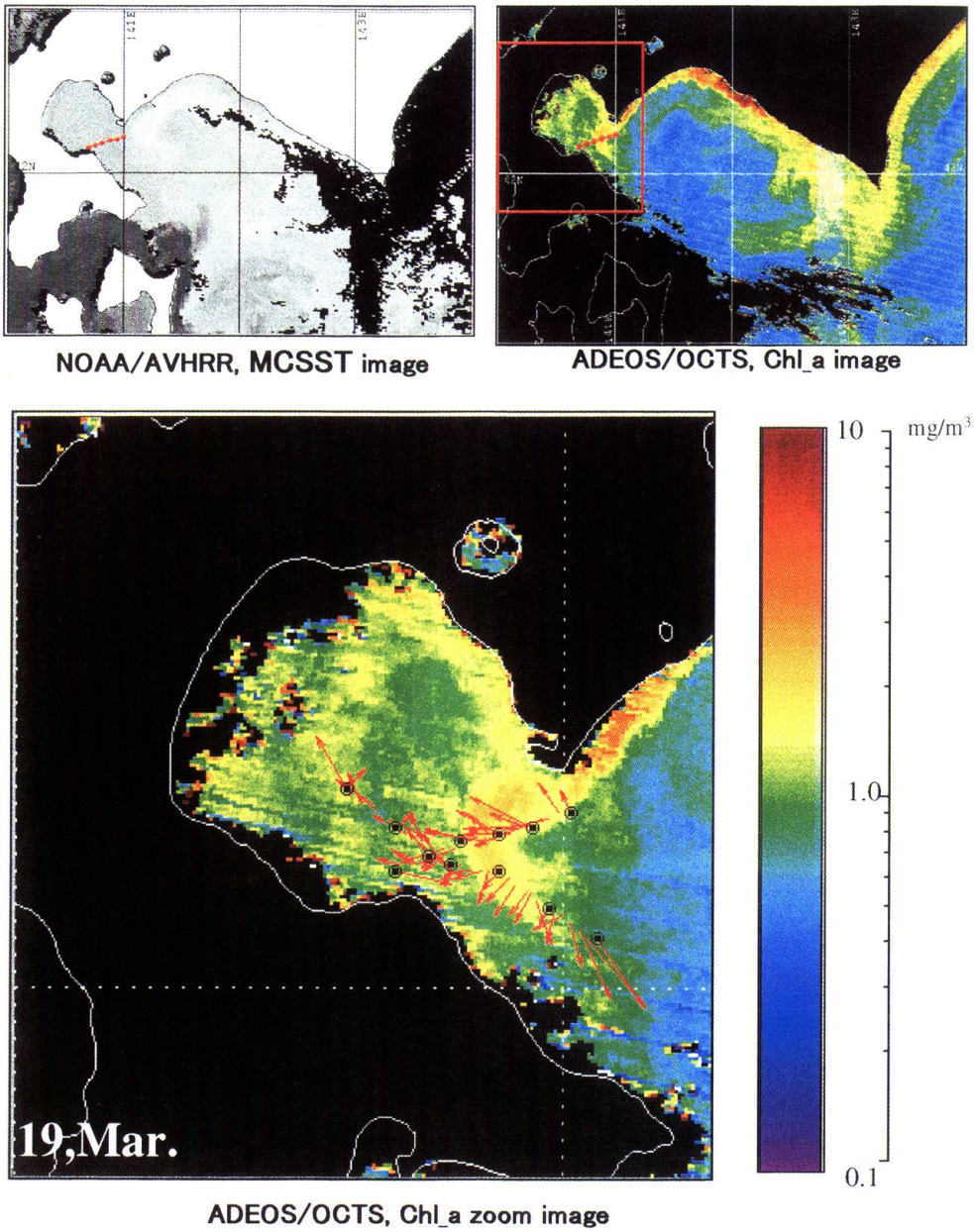

Fig.5. OCTS chlorophyll *a* image on March 19,1997 overlaid current vectors at the depth of 5m observed by ADCP on March 18 and 19,1997.

In future studies, we expect to utilize ocean color data from a new series sensor, SeaWiFS (Sea-viewing Wide Field-of-viewing Sensor) on SeaStar (Hooker and Esaias, 1993). This was successfully launched on August 1, 1997. These data will improve our quantitative understanding of temporal and spatial variability of biological process by providing more accurate phytoplankton pigment concentration estimates with frequent temporal coverage.

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