The state of the western North Pacific in the first half of 1998

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Mr. Satoshi Sugimoto is a Scientific Officer of the Oceanographical Division of the Climate and Marine Department at the Japan Meteorological Agency (JMA). He is working as a member of a group in charge of monitoring and forecasting sea surface temperature and sea surface current in the western North Pacific. Based on in situ and satellite data, this group provides various oceanographical products. One of the main products is the "Monthly Ocean Report", which is published and distributed by JMA every month. Mr. Sugimoto is now involved in developing a new analysis system for sea surface and subsurface temperature to improve sea surface temperature forecasts in the western North Pacific.

Sea Surface Temperature

Figure 1 shows monthly mean sea surface temperature (SST) anomalies in the western North Pacific from January to June 1998, computed with respect to the JMA's 1961-90 climatology. JMA operationally produces SST analysis for 1x1 degree grid points over the western North Pacific, using *in situ* observations. Other daily SST analysis is performed in seas around Japan, between 20˚N and 50˚N from 110˚E to 160˚E. In analysis, satellite-derived SST (NOAA/AVHRR) and *in situ* observations are both used. JMA adopted SST of this new analysis for that region from January 1998.

It is remarkable that SST was below normal along 40˚N throughout the first half of 1998. In particular, negative SST anomalies exceeding -1˚C were observed in June. On the other hand, SST was above normal along 30˚N throughout this period, and more than 2˚C above normal south of Japan in May. In the western tropical Pacific, positive SST anomalies exceeding +0.5˚C were present in the seas around the Philippines to 145˚E in June. Positive SST anomalies exceeding +1˚C were found in the South China Sea from January to March.

Oyashio and Kuroshio

Figure 2 shows the temperature distribution at the depth of 100 m east of Japan in February and April 1998. These charts are based on JMA's objective 100m water temperature analysis for 0.25 x 0.25 degree grid point values in seas adjacent to Japan. Temperatures colder than 5˚C are recognized as the Oyashio cold water. In February, the Oyashio cold water extended southward, reflecting its seasonal variation. It widely extended southward reaching 38˚N in March and April. *Figure 3* shows the location of the Kuroshio axes in May and June 1998. The Kuroshio retained a non-large-meander path south of Japan. A small meander of the Kuroshio was found near 135˚E at the end of May, after which it moved eastward. Its southernmost position was near 32˚N, 138˚E in the last 10 days of June.

Sea Ice in the Sea of Okhotsk

The first and last dates of drift ice appearance along the coast of Hokkaido are shown in Table 1, with location of the stations in *Figure 4*. The first dates of drift ice on shore and the first dates of shore lead appearance are also included. The sea ice extent in the Sea of Okhotsk was almost the same as normal (the 20-year averaged values from 1971-90) in this sea ice season, except it was below normal in late January. The sea ice extent was largest on March 5, when it was slightly above normal, though the maximum sea ice extent was below normal for the last 10 years. Drift ice began to flow into the Pacific through the Kunashiri Pass in early February, through the Nemuro Straits in mid-February, and through the Etorofu Straits in mid-March. The flow into the Pacific came to an end in early April.

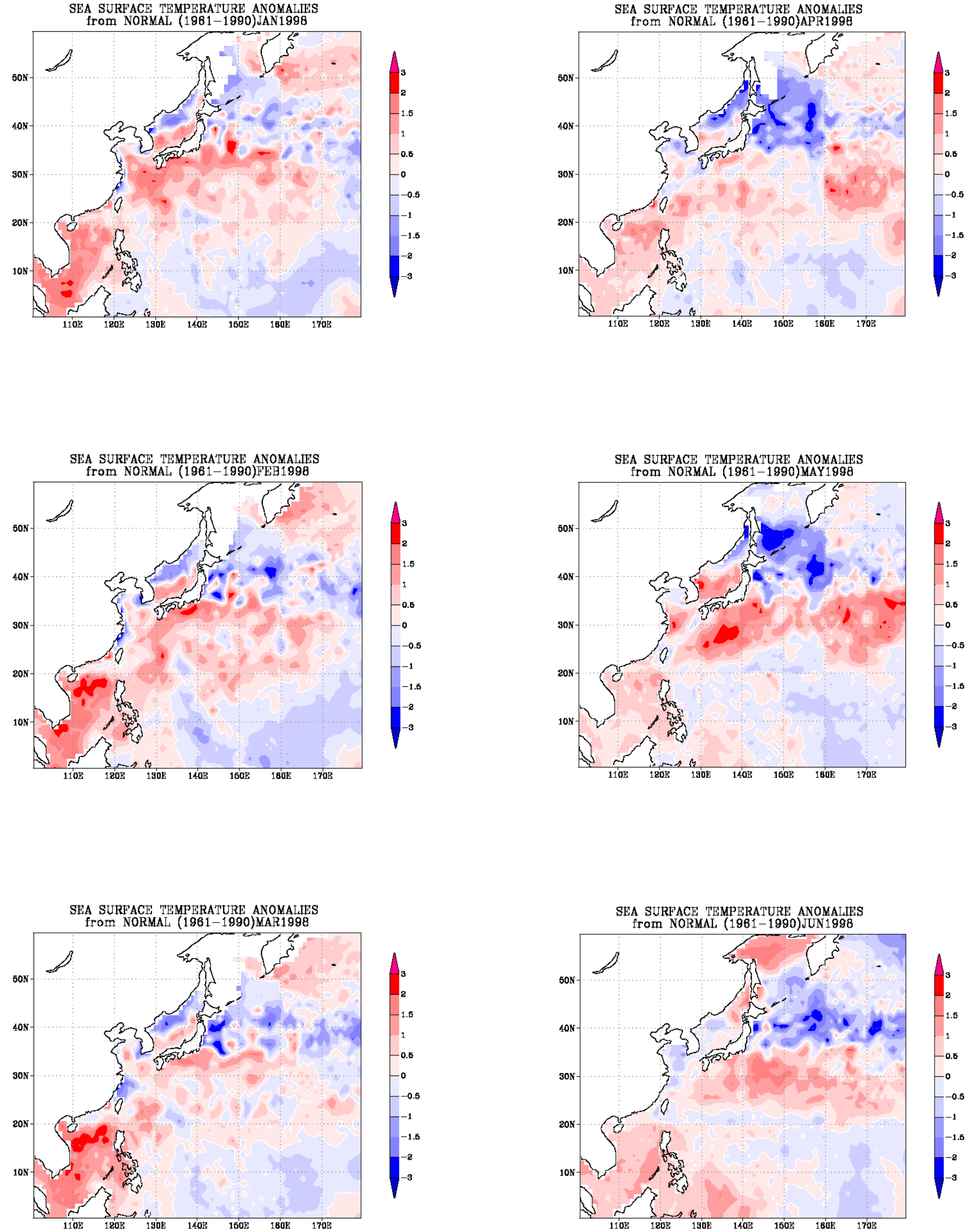

Fig. 1 Monthly mean sea surface temperature anomalies (˚C). Anomalies are departures from the JMA's 1961-1990 climatology.

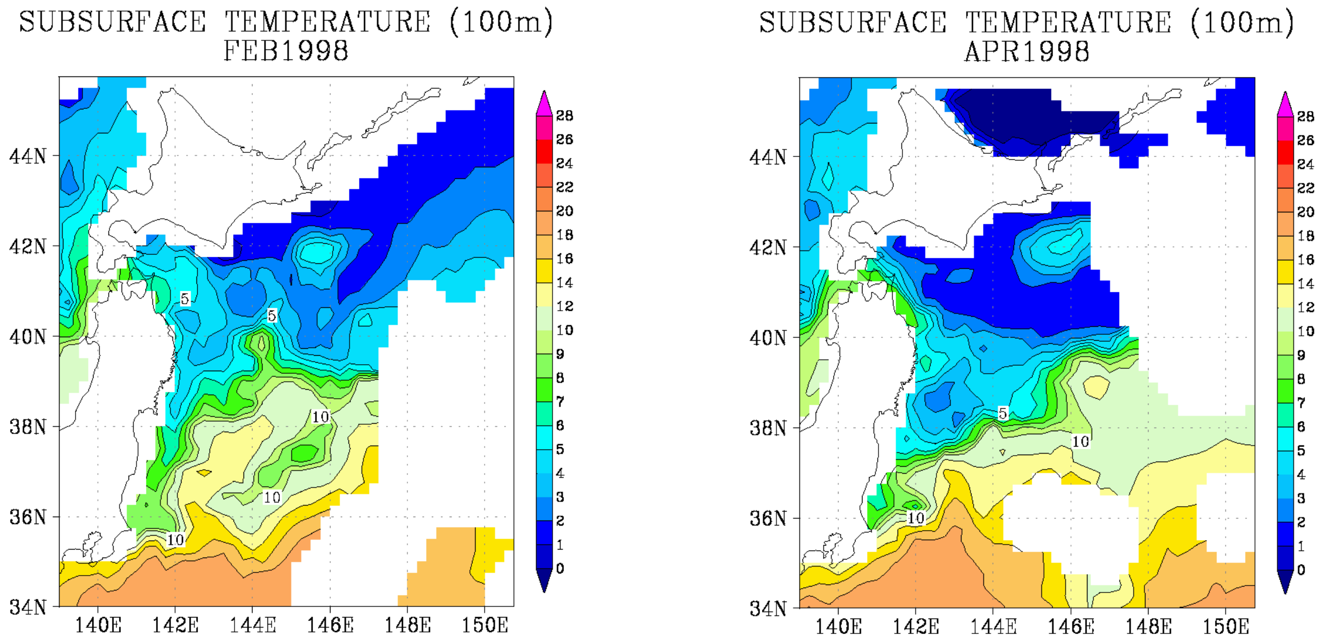

Fig. 2 *Temperature (˚C) at the depth of 100m east of Japan in February (left) and April (right) 1998.*

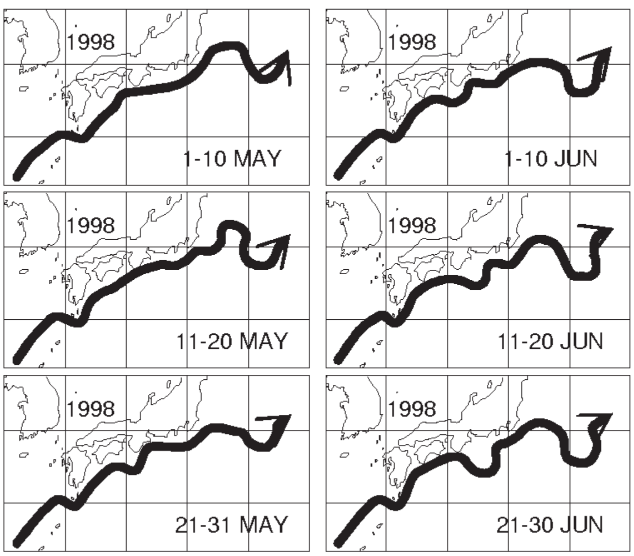

Fig. 3 *Location of the Kuroshio axis in May and June 1998.*

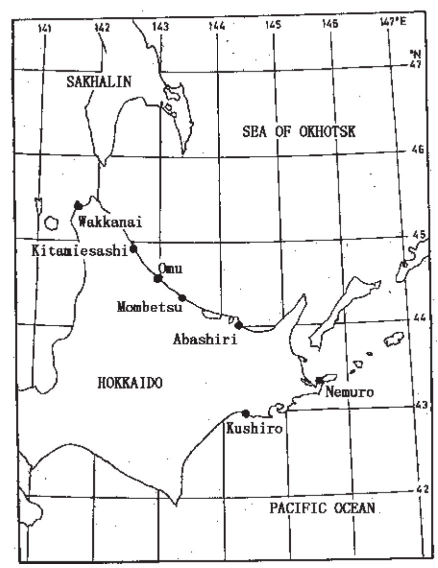

Fig. 4 *Location of the sea ice stations along the coast of Hokkaido.*

Table 1

Station	Drift Ice				First date of drift ice on shore	First date of shore lead appearance
	First date	Last date	Period	Days		
WAKKANAI	-	-	-	0(-15)	-	*
KITAMIESASHI	1.27(+7)	3.20(-11)	53(-18)	37(-15)	2.07(+11)	3.02(+11)
OMU	1.27(+8)	3.11(-26)	44(-34)	38(-23)	2.08(+11)	3.06(-8)
MOMBETSU	1.17(-1)	3.20(-18)	63(-17)	53(-11)	2.06(+7)	3.20(+3)
ABASHIRI	1.16(-1)	3.26(-23)	70(-22)	63(-20)	1.27(-1)	3.19(-5)
NEMURO	2.11(+2)	3.27(-6)	45(-8)	38(+4)	2.16(+2)	*
KUSHIRO	-	-	-	*	-	*

( ) : deviation from normal for the period from 1961 to 1990; * : no observations, - : no phenomenon
+ : earlier or more than normal; - : later or less than normal

Subsurface Temperature along 137˚E

JMA conducted oceanographic observations along the 137˚E in the western North Pacific on board the *R/V Ryofu Maru* in summer and winter. The depth of the thermocline along 137˚E varies with ENSO conditions (*Figure 5*). After the onset of the 1997/98 El Niño, the thermocline was shallower than normal, and negative anomalies exceeding -5˚C were found from 5˚N to 7˚N. However, positive anomalies prevailed between 4˚N and 10˚N in June/July 1998, in association with the weakening of the El Niño.

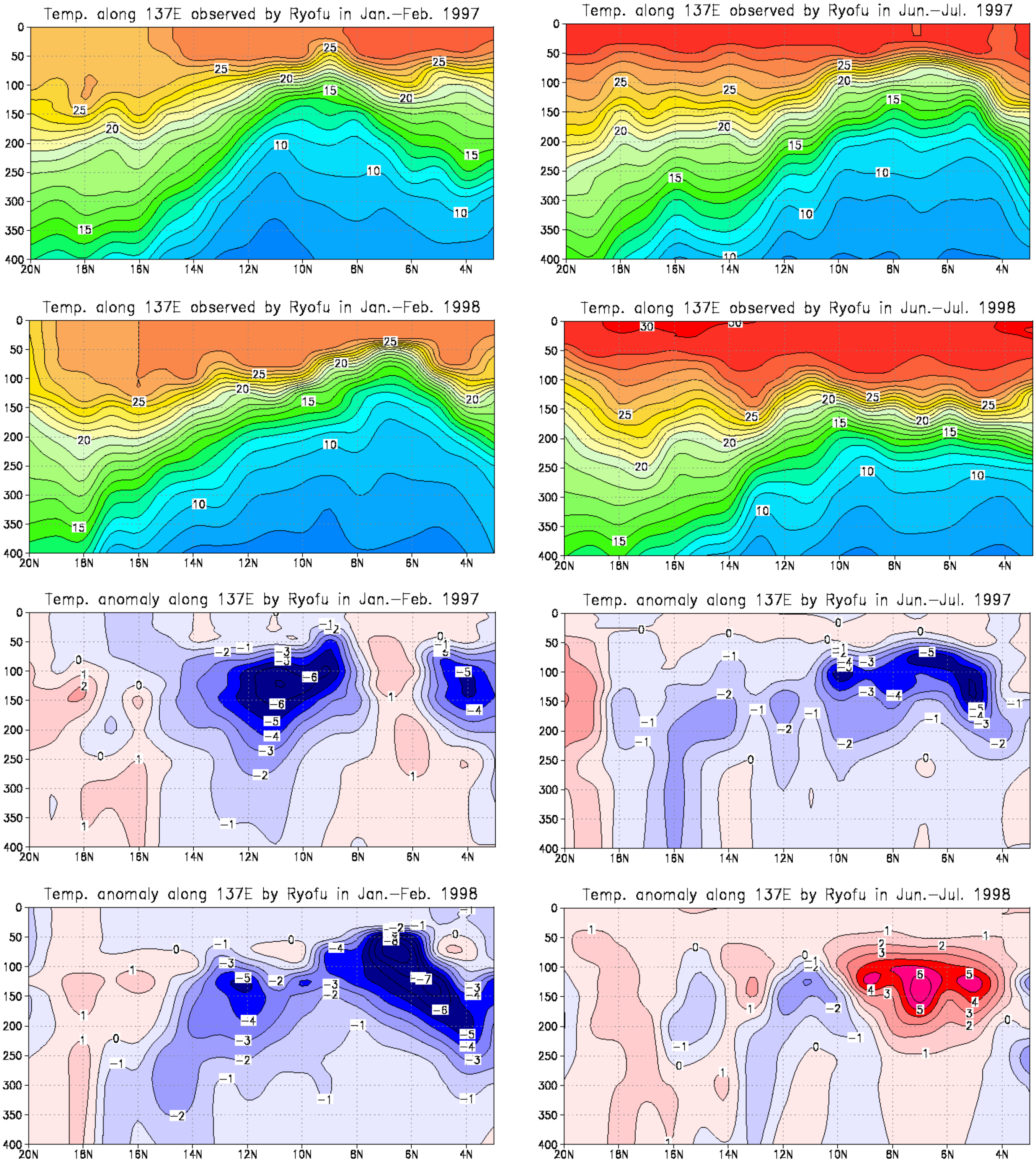

Fig. 5 Vertical sections of water temperature along 137˚E in the tropical regions observed by the R/V Ryofu Maru from January 1997 to July 1998.

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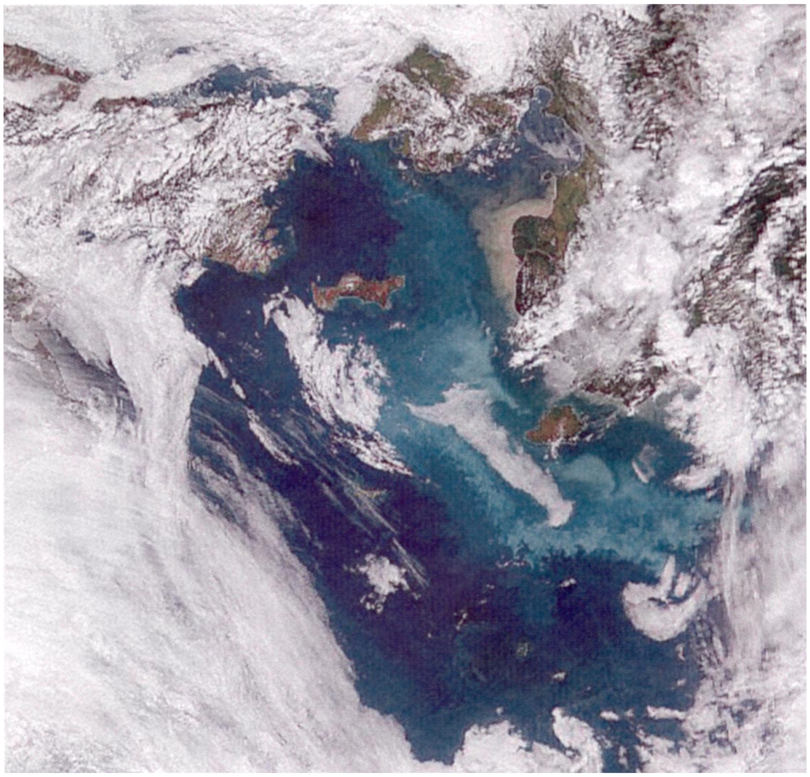

Fig. 3 SeaWiFs composite true color image (July 20, 1998) showing the extent of the aquamarine water which indicates the coccolithophorid bloom. Bering Strait is near the center at the top of the figure, with St. Lawrence Island just below. Runoff from the Yukon River is evident along the coast of Alaska. Figure provided by SeaWiFS Project, NASA/Goddard Space Flight Center.

An image in April shows the bloom covering much of the shelf. Satellite images (*Figure 3*) show the presence of a dense population of coccolithophores over the shelf in July 1998. The coccolithophores likely over-wintered due to mild temperatures on the shelf during this last winter. The 1998 bloom was more extensive than that observed in 1997, stretching north through Bering Strait. Cruises during July and August reported the aquamarine color, although it was not evident to personnel on cruises earlier in the year. Thus it appears that satellites can reveal coccolithophores in lower concentrations than the human eye can detect onboard ships.

The number of salmon returning to Bristol Bay during the last two years was far below expected. Traditionally it has been viewed that most salmon mortality occurs in early life, but research in the 1980s indicates the importance on early marine life. A recent paper by Kruse (Kruse, G. H., Salmon run failures in 1997-1998: A link to anomalous ocean conditions. Alaska Fishery Research Bulletin, 55-63, 1998.) discusses the Bering Sea salmon failures in 1997 and 1998 in detail. He concludes that marine environment contributed to the weaker than expected salmon runs in the last two years. Changing conditions have been observed during the last two years in the Bering Sea. Hopefully, the observations being made presently in the Bering Sea will be sufficient to elucidate the mechanisms that are resulting in the changes in the physical and biological environment of this productive ecosystem.

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Carbon Dioxide

JMA observed the distribution of carbon dioxide (CO_2) in the western North Pacific onboard the *R/V Ryofu Maru* from January 27 to March 2, 1998 (*Figure 6*). The CO_2 concentration (partial pressure, $pCO_{2,sea}$) in the surface water were 20 µatm higher than those in February 1997, in the western equtorial Pacific (3˚N, 137˚E), and this area was a source for atmospheric CO_2. At 3˚N, 137˚E, the SST was about 1.1˚C lower (which corresponds to a decrease in $pCO_{2,\ sea}$ of about 20 µatm), whereas total inorganic carbon (TIC) concentration was 70 µmol/l higher (an increase in $pCO_{2,\ sea}$ of about 40 µatm), as compared to those observed in February 1997. The difference in $pCO_{2,\ sea}$ between the two years can be quantitatively explained by the reduction of the SST and the elevated TIC concentration. It is also evident that the elevated TIC concentration contributed to the increase in $pCO_{2,\ sea}$.

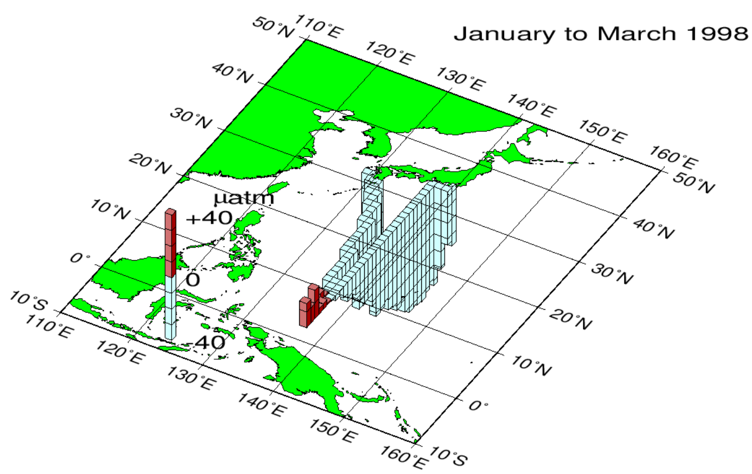

Fig. 6 CO_2 concentration difference between sea surface water and air in January - March 1998. Red upward bars indicate that the ocean emits CO_2 and blue downward bars indicate atmospheric CO_2 absorption by the ocean.