

Temperature, Salinity, Dissolved Oxygen and Water Masses of Vietnamese Waters

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ABSTRACT

During April and May 1999, An MV SEAFDEC cruise was carried out in Vietnamese waters for the SEAFDEC Interdepartmental Collaborative Research Program on Marine Fishery Resources. Data on temperature, salinity and dissolved oxygen concentration of water in the area were collected using the Integrated CTD instrument. The survey period was in April to May which is the transition period between the Northeast monsoon to the Southwest monsoon, the feature from the study seem to mix under the influence of both monsoon seasons. The Northern part of the survey was still under the influence of the Northeast Monsoon as shown by the lower temperatures and higher salinity water of water along the coast from Da Nang to Nha Trang than those off shore. In the southern part of the area, the Southwest monsoon started to prevail as shown by the occurrence of weak upwelling off the Nha Trang coast, the shallow mix layer and the covering of mixed layer of the outer Gulf of Thailand station by the Thailand Gulf mixed layer water. The runoff from the Red and the Mekong River also plays an important role in the characteristics of the water in the study area, as shown from the distribution of low salinity and low oxygen off coast near the river. There was an intrusion of subsurface water (10-15 m) from off the Mekong River station to the subsurface water of station no.56 and 57 in the outer Gulf of Thailand. Temperatures between 29.5-30°C and salinity of about 33.2-33.5 PSU characterize the water.

Six water masses, Continental shelf water, Open sea water, Maximum salinity water, Seasonal thermocline water, Permanent thermocline water and Deep water, were found during the survey period.

Key words: Vietnamese water, Temperature, Salinity, Dissolved Oxygen, Water Masses, SW Monsoon, NE Monsoon

Introduction

This study is the forth area in the series of the Interdepartmental Collaborative Research Program on the Marine Fisheries Resources in the South China Sea, which has been continuously carried out since 1995. The program aims to collect and analyze the information necessary for management through collaboration among Southeast Asian Fisheries Development member countries and other organizations concerned.

The survey was conducted off Vietnam by MV.SEAFDEC between 30 April and 29 May 1999. The study area covers from latitude 7 °N to 21 °N and Longitude 103 °E to 112 °E. in the western part of the South China Sea (SCS).

The seasonally reversing monsoon winds play an important role in the hydrological features and the general circulation of the SCS. (Uu and Brankart, 1997, Shaw and Chao, 1994,etc.) The beginning

of northeast monsoon (winter season) is in September in the sea north of 20 °N while south of that latitude, the southwest monsoon still prevails. In October, the northeast monsoon expands southward to diminish the southwest monsoon. The northeast monsoon reaches its maximum strength and covers the entire area in December finishing in April. The first appearance of the southwest monsoon in the central South China Sea basin is in May and expands to cover the entire basin during July and August. Ocean circulation off the coast of Vietnam is the most significant in response to the changing wind. During the northeast monsoon, a strong southerly current develops along the coast of Vietnam with the main thermocline deeper nearer the coast than offshore, during the southwest monsoon the current of the area become northeasterly (Shaw and Chao, 1994).

Materials and Methods

Data were collected at Fifty-eight oceanographic stations (Fig.1) measuring conductivity, temperature and dissolved oxygen using the onboard Falmouth Integrated CTD instrument. At station no. 42-44, there were no CTD data, because of a problem with the connection between the sensor and the winch. According to the manufacturer's specification, the instrument has an accuracy of ± 0.003 mmhn, ± 0.003 °C, $\pm 0.03\%$ and ± 100 ppm for conductivity, temperature, pressure, and dissolved oxygen respectively. The CTD was equipped with twelve 2.5 liter bottles for *in situ* water sampling. Water samples were determined for dissolved oxygen by a modification of the Winkler procedure (Parsons, Maita and Lilli, 1984) for validating with oxygen sensor data. The CTD unit was last sent for calibration and deck testing by the manufacturer in April 1997.

The maximum depth for CTD casting was about 1500 meters depth, because of the limitation of the length of armored sea cable. The efficiency of the oxygen sensor is limited in shallow water, the lowest dissolved oxygen data collecting depth was not reached nor the depth for temperature and salinity.

Raw counts of each variable were calculated and raw data were average at every 1 dbar interval, for reducing data noise, using the FSI post acquisition data analysis software. All CTD data were checked using quality control methods by the excessive gradient checks method of the National Oceanographic data center.

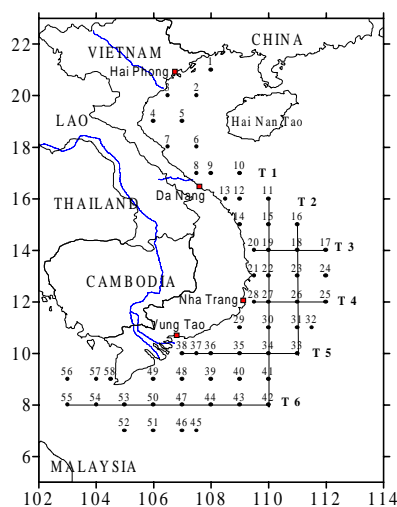


Fig. 1. Oceanographic stations location and six selected transects.

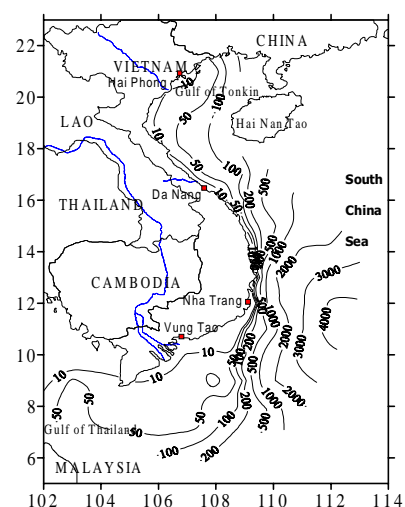


Fig. 2. Bottom topography of the study area.

Results and Discussions

The topography of the area, which interpolated from echo sounding data, was as shown in Fig. 2. with board shelves shallower than 100 m, the maximum depth reaching about 4000 m.

The Distribution of Temperature, Salinity and Dissolved Oxygen

Temperature, salinity and dissolved oxygen of surface water (5 m) was between 24.04 to 30.31 °C, 30.35 to 33.97 PSU and 3.71 to 4.63 ml/l with the average about 28.21 °C, 33.04 PSU and 4.01 ml/l respectively. Low temperatures were found in the high latitude area from latitude 20 to 21 °N. Water temperature increases following the decrease of latitude (Fig. 3). Low salinity water was found near the Red and the Mekong River mouth (Fig.4), these are influenced by river run off.

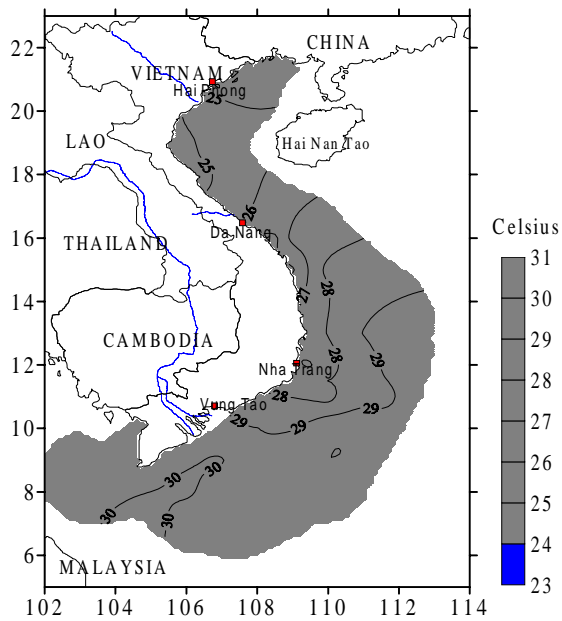


Fig. 3. Temperature at 5 m depth.

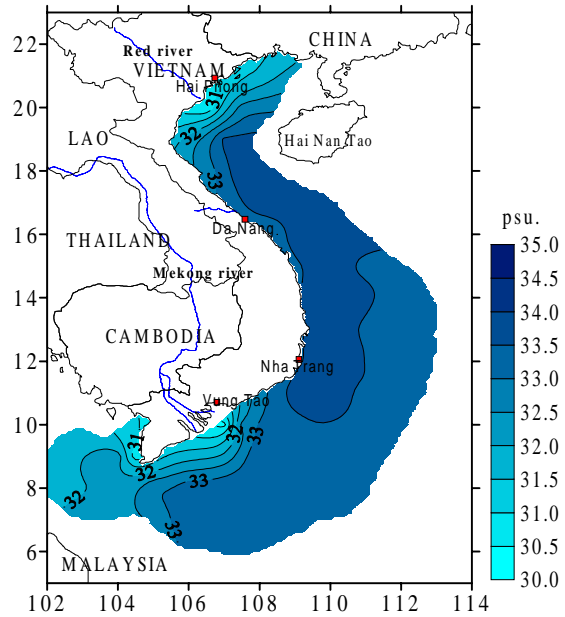


Fig. 4. Salinity at 5 m depth.

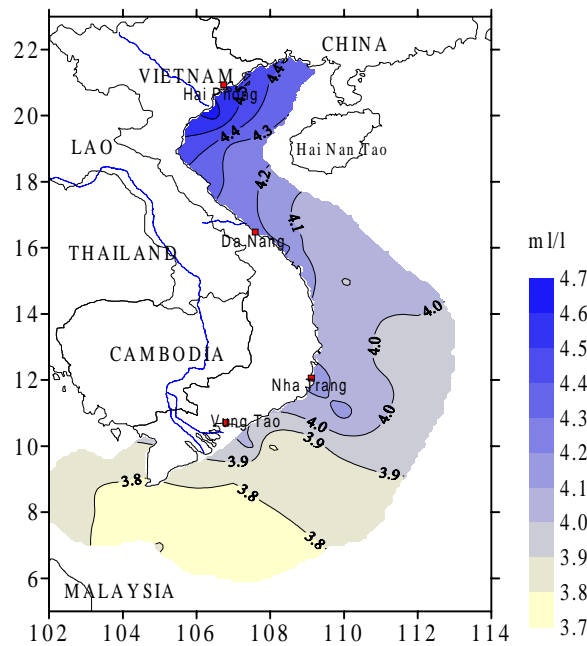


Fig. 5. Dissolved oxygen at 5 m depth.

Water temperatures in the coastal area from Da Nang to Nha Trang from the surface to 50 meters depth were lower than off shore by 0.5-2.5 °C (Fig.3 and 6 Transect 4), while salinity distribution shows a pattern like a tongue of more saline water from north of Da Nang to the coast of Nha Trang (Fig.4). The 33.5 PSU isohaline and 29 °C isotherm at the surface closely matched (Fig.3 and 4), this shows the area of the water mass that is distributed from the North under the influence of the latter period of the Northeast monsoon wind. Generally, the Northeast monsoon will induce some colder water to flow from the north into the coastal area (Lafond, 1963 and Marine Resources Study in Vietnam, Main Report, 1998). This coastal water contains more dissolved oxygen, more nutrient and dissolved organic substances and commonly has a higher concentration of plankton, benthos and fish than off shore water (Lafond, 1963)

The cross section plot (Fig.6 and 7) presents a pattern of weak upwelling in the area of off Nha Trang with lower temperatures and higher salinity than the nearby areas. This is the same as that found by Uu and Brankart, 1997 and Lafond, 1963 that during the Southwest monsoon season the occurrence of upwelling is at a maximum at the coast of Vietnam near Nha Trang province (from 11 °to 15 °N and westward of 110 °E). This upwelling carries high salinity and low temperature water rising from the seasonal thermocline. At the same time, surface current flow offshore and the continental shelf water from the Thailand Gulf mixing with low salinity waters from the Mekong river moves along the coastal line of Vietnam to 10 °30-11 °N. The hydrological front formed between those two waters determines a high level of biological production and fish stocks in the southern shelf of Vietnam.

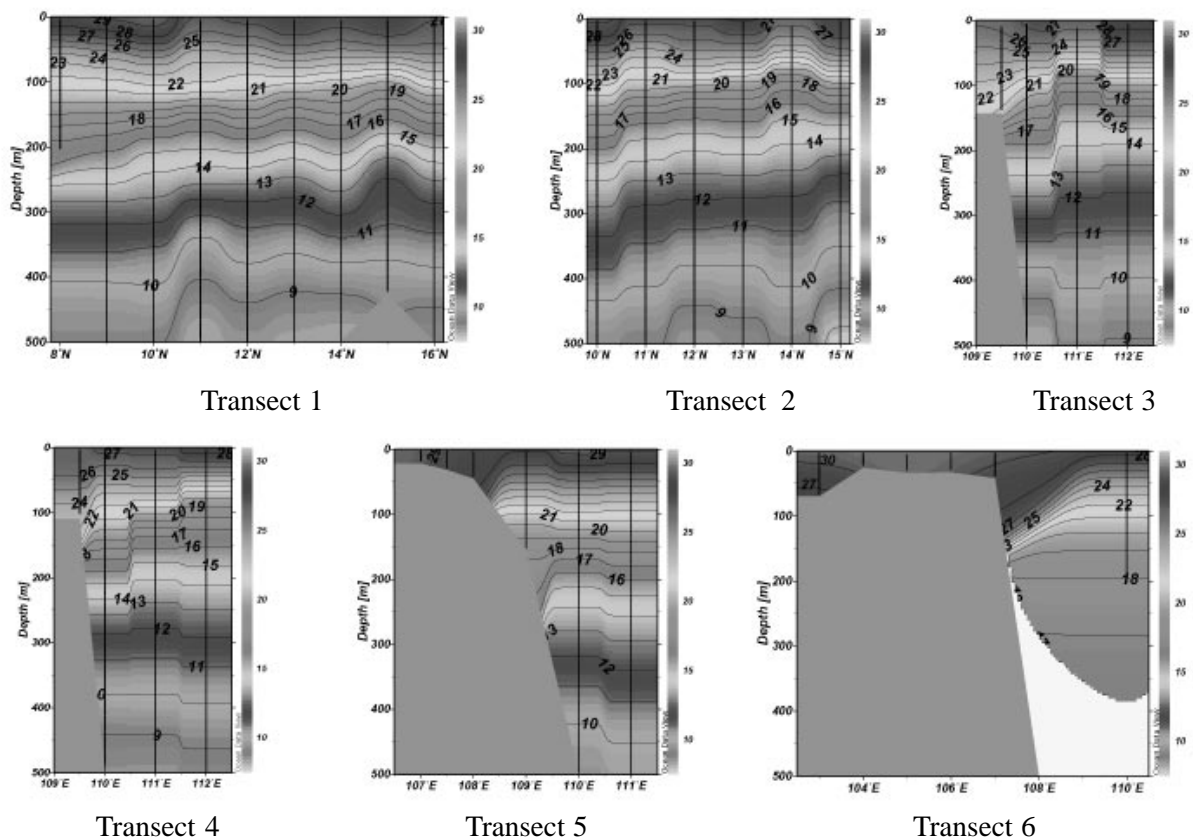


Fig. 6. Temperature (°C) along a section of transect 1 to 6.

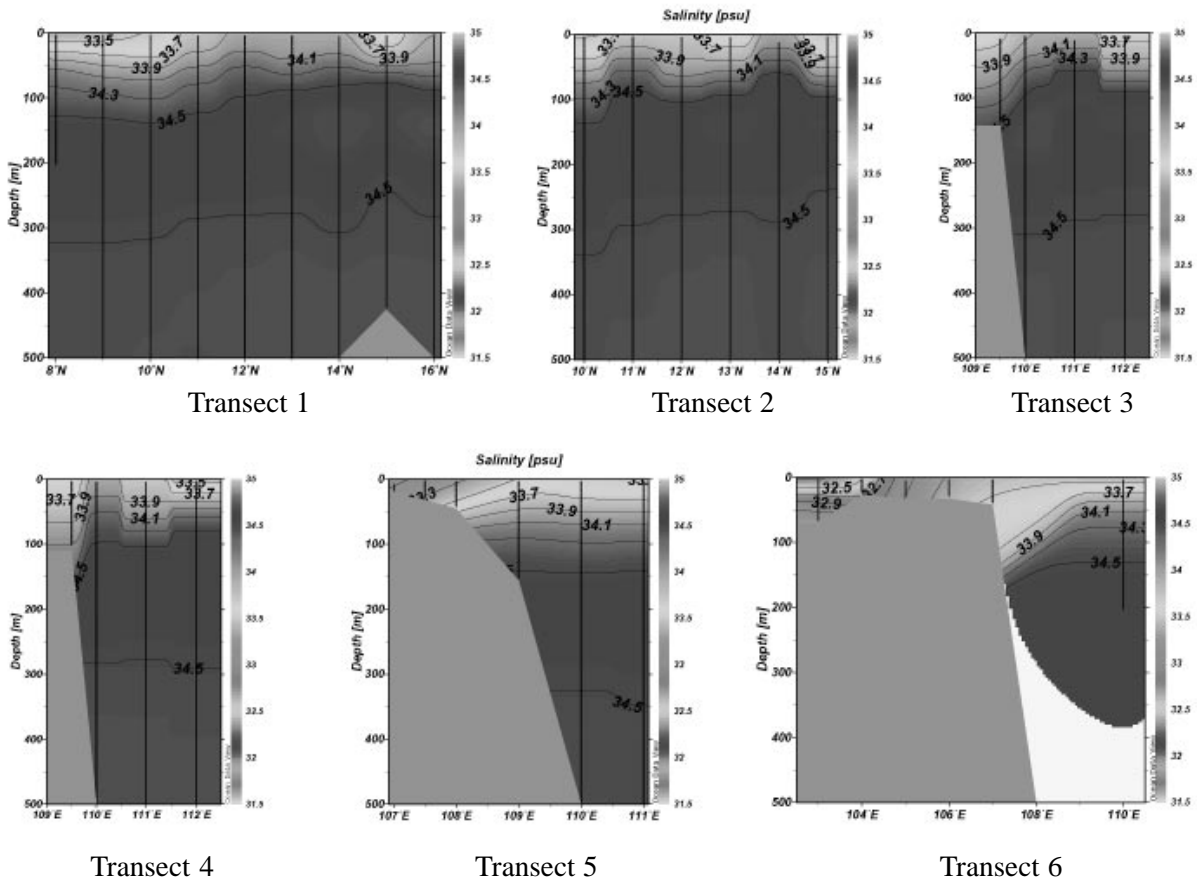


Fig. 7. Salinity (PSU) along a section of transect 1 to 6.

The most prominent features of dissolved oxygen distribution in the upper ocean waters were the highest concentration at the northern part and the lowest concentration in front of Mekong River mouth from the surface down to the 25-meter depth (Fig.5 and 8). The highest dissolved oxygen concentration area coincide with the low temperature area while low dissolved oxygen concentrations were found in front of the Mekong Delta which should be an influence of the high decomposition rate of organic matter and nutrient from the river.

Vertical profiles of temperature, salinity and dissolved oxygen show that the mixed layers of the area were shallow, between 15-50 m from surface (The catalogue of Oceanographic Data in the South China Sea: Vietnamese Water, 2000). This shallow homogeneous layer was found only during the southwest monsoon. During the Northeast monsoon, the homogeneous layer is at 70 to 90 m.

The profile of station no.56 and 57 were different from the usual (st. 53 show as a common pattern). The temperatures were increasing at a depth of about 25 m and 20 m for st. 56 and 57 respectively (Fig. 9). The characteristics of this higher temperature subsurface water and also high salinity are similar to the water that is found at 10-15 m of st. 49 and 5-10 m of st. 48, that near the Mekong River mouth, with temperatures between 29.5-30°C and salinity about 33.2-33.5 PSU (Fig. 9 and 10). The upper layer and lower layer of the high temperature subsurface water are similar to the waters of the Gulf of Thailand (Saadon *et al*, 1998). These occurrences show that water from the Mekong River mouth still has an influence on the outer Gulf of Thailand at the subsurface layer. The mixed layer of the outer Gulf of Thailand station (st 54,55,56 and 57) is above the Thailand Gulf mixed layer which is the feature of the early period of Southwest monsoon season.

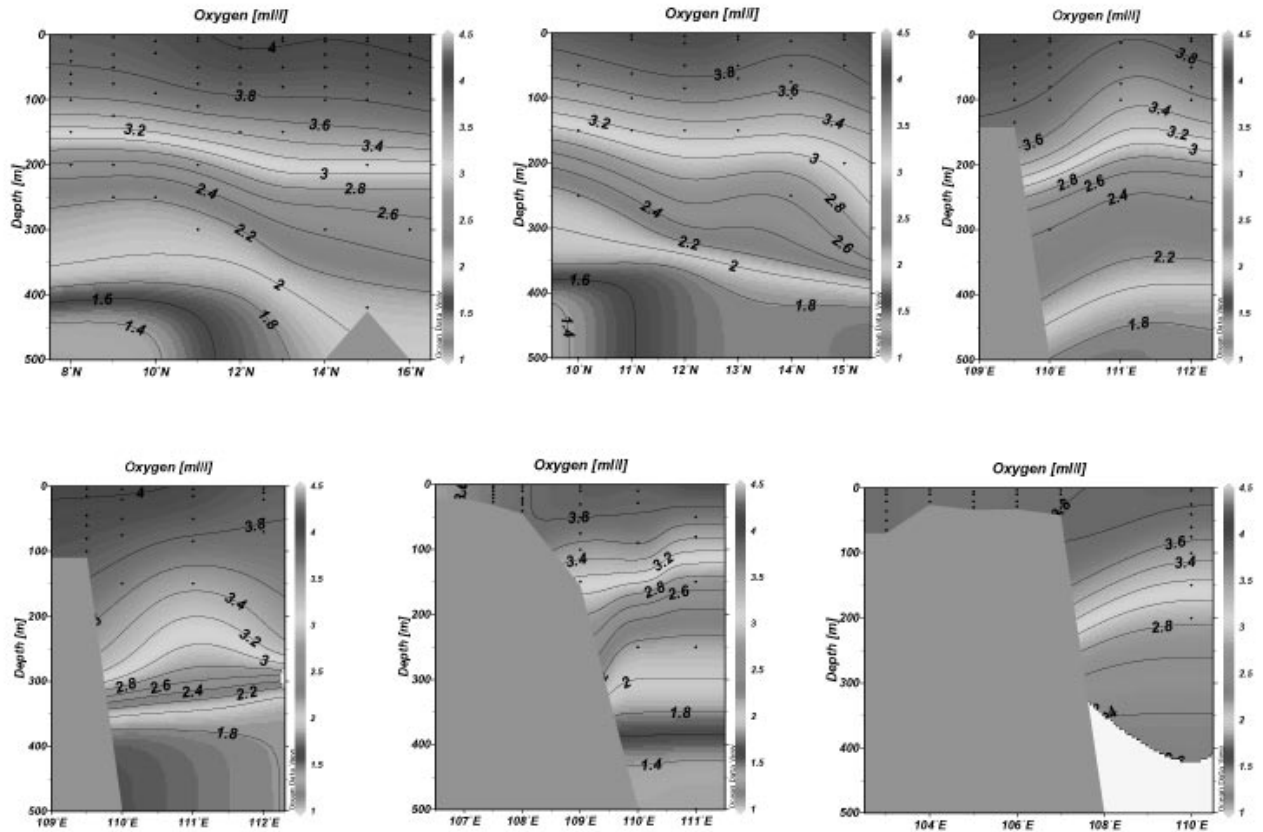


Fig. 8. Dissolved oxygen (ml/l) along a section of transect 1 to 6.

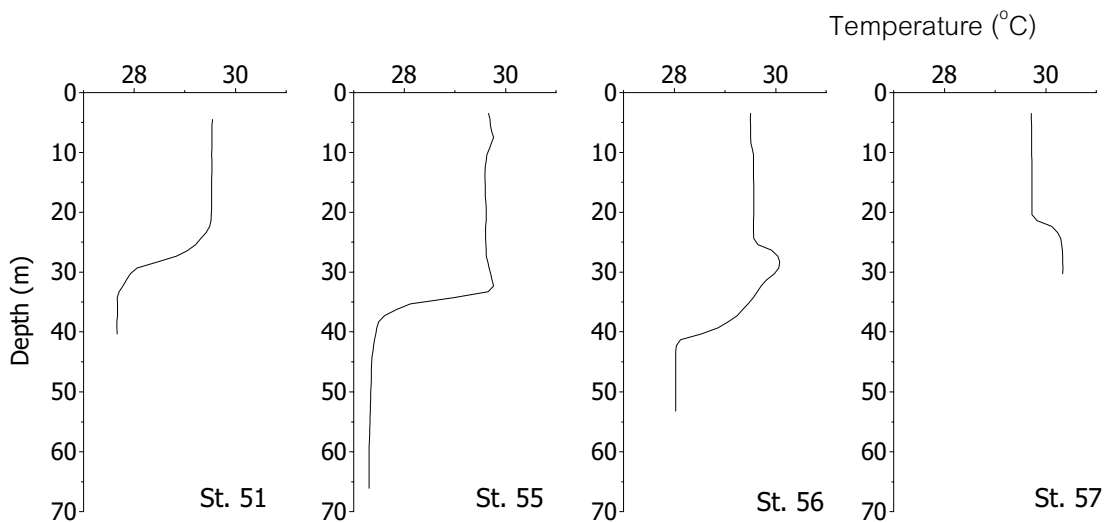


Fig. 9. Vertical profiles of temperature st.48 (near Mekong river mouth), st.51(common pattern temperature profile), st.56 and 57 (the irregular pattern temperature profile).

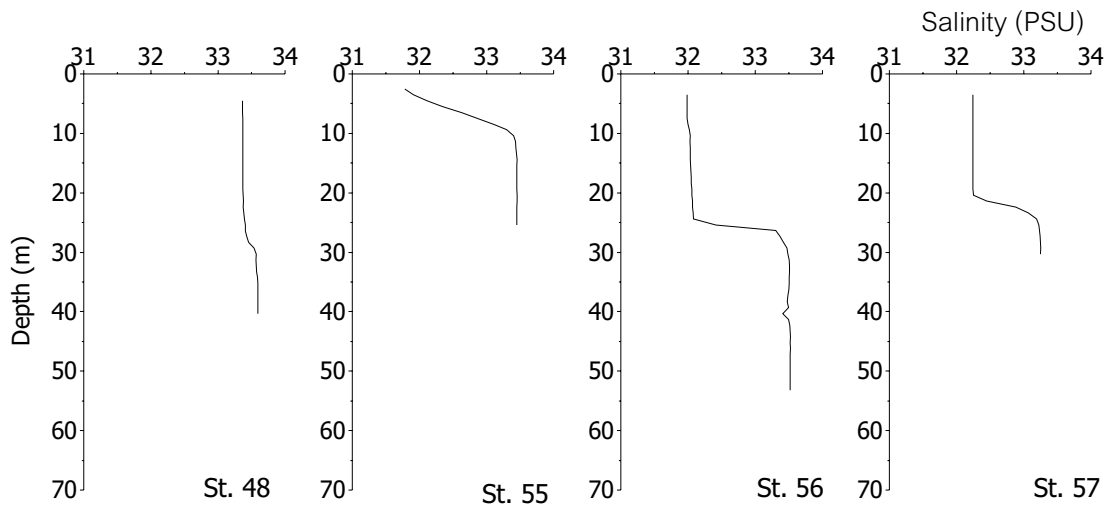


Fig. 10. Vertical profile of salinity st.48 , st. 51, st.56 and st. 57 .

Water Mass

The following water masses were obtained from the T-S diagram plot. The upper waters (0-50 meter depth) were covered by two distinct water masses: continental shelf water (CSW) and open seawater (OSW). The continental shelf water was characterized by temperatures between 23 to 27 °C and salinity between 31 to 33 PSU for the northern part and temperatures between 29 to 31 °C and salinity between 27 to 33 PSU for the southern part (Fig.11 and 12). This water occupied the coastal area that is shallower than 30 meters with a thickness from 10 to 30 meter depending on the area. The continental shelf water of the southern part is the top layer, both in the Gulf of Thailand and in the water off the Mekong River mouth. This shows the exchange between these two areas.

The open sea waters, in the region where the depth is greater than 40 m, are characterized by temperatures between 25 to 29 °C and salinity between 33 to 34 PSU. This water mass occupies about 70% of the upper layer of the survey area (Fig. 12) and from the surface down to about 50 meters.

There are the other four water masses: the seasonal thermocline water, the maximum salinity water (MSW) , the permanent thermocline water and deep water. Seasonal thermocline water occupied the levels between 50 to 150 meter depth of the entire region that is deeper than 100 meters. The temperatures of this water is vast varying from 20 to 27 °C at different depths while the salinity is stable in the range of 34 to 35 PSU. The maximum salinity water was characterized by temperatures between 15-20 °C and salinity greater than 34.5 PSU. This water is located under the seasonal thermocline, varying in the range of 100 to 200 meter depth. The permanent thermocline water was under the MSW at 180 to 400 meter depth, with temperatures between 10 to 15 °C and the salinity between 34 to 35 PSU (Fig.11).

The last water mass is deep water (DW), located at a depth greater than 900 meter, its temperature was between 2.5 to 5 °C with a salinity between 34 to 35 PSU (Fig.11).

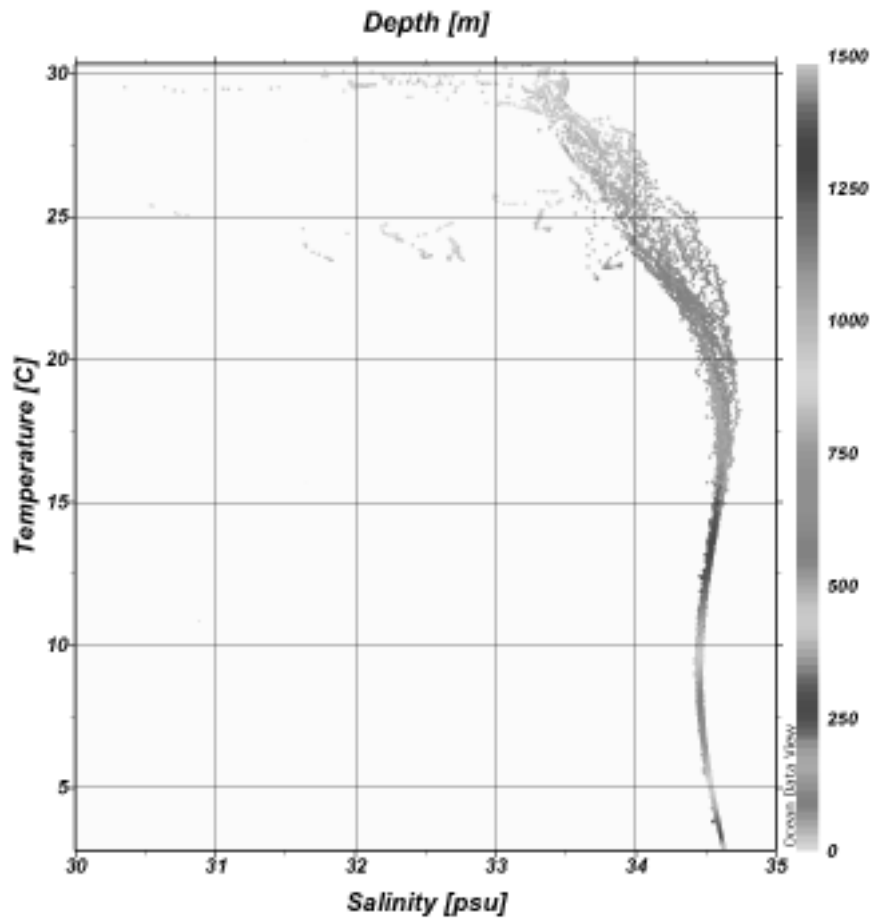


Fig. 11. TS-diagram of all stations.

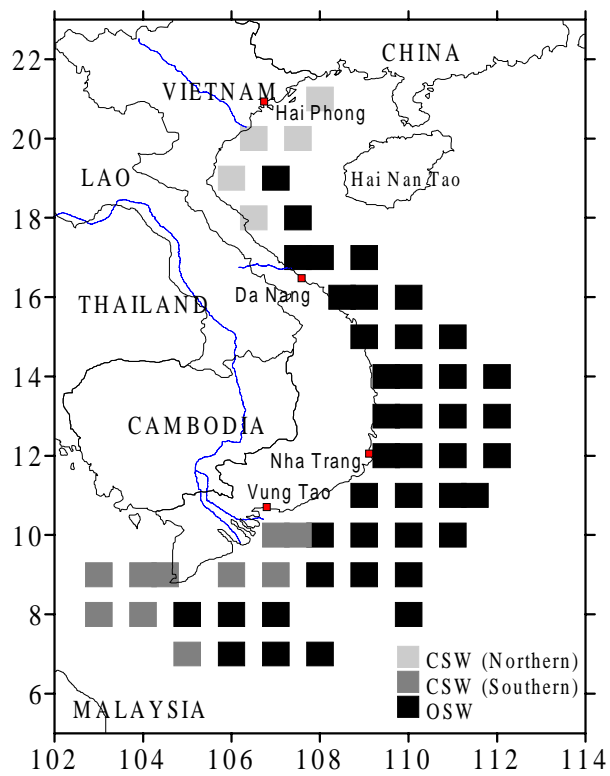


Fig. 12. Distribution of water mass in the upper area.

Conclusion

Since the survey period is in April to May which is the transition period from Northeast monsoon to Southwest monsoon winds in the area, the feature of the study seem to mix under the influence of both monsoon seasons. In this survey, the Northern part of the survey still had an influence from the Northeast Monsoon as shown by the lower temperatures and higher salinity water along the coast from Da Nang to Nha Trang than those off shore. The relative surface current plot from acoustic Doppler current indicator as installed on board MV. SEAFDEC also confirm the current direction of the northern area still flowing southward (Fig.13). The southern part, the Southwest monsoon started to prevail as shown by the occurrence of upwelling off Nha Trang, the shallow mixed layer and the covering of mixed layer of the outer Gulf of Thailand station by the Thailand Gulf mixed layer water.

The runoff from the Red and the Mekong Rivers are another factor that influences the water characteristics off Vietnam, as shown from the low salinity water off the coasts of the Red and Mekong River mouths (Fig.4) and low dissolved oxygen in front of Mekong Delta which is probably an influence of the high decomposition rate of organic matter and nutrient from the river.

The characteristics of upper layer water (0-50 meter) of southern Vietnam and in the outer Gulf of Thailand was quite similar that shows an exchange between the Gulf of Thailand water and the South China Sea water. For this survey there was an intrusion of subsurface water (10-15 m) from the Mekong River station to the subsurface water of station no.56 and 57. The water characterized by temperatures between 29.5-30°C and salinity about 33.2-33.5 PSU.

Six water masses, Continental shelf water, Open sea water, Maximum salinity water, Seasonal thermocline water, Permanent thermocline water and Deep water, were found during the survey period.

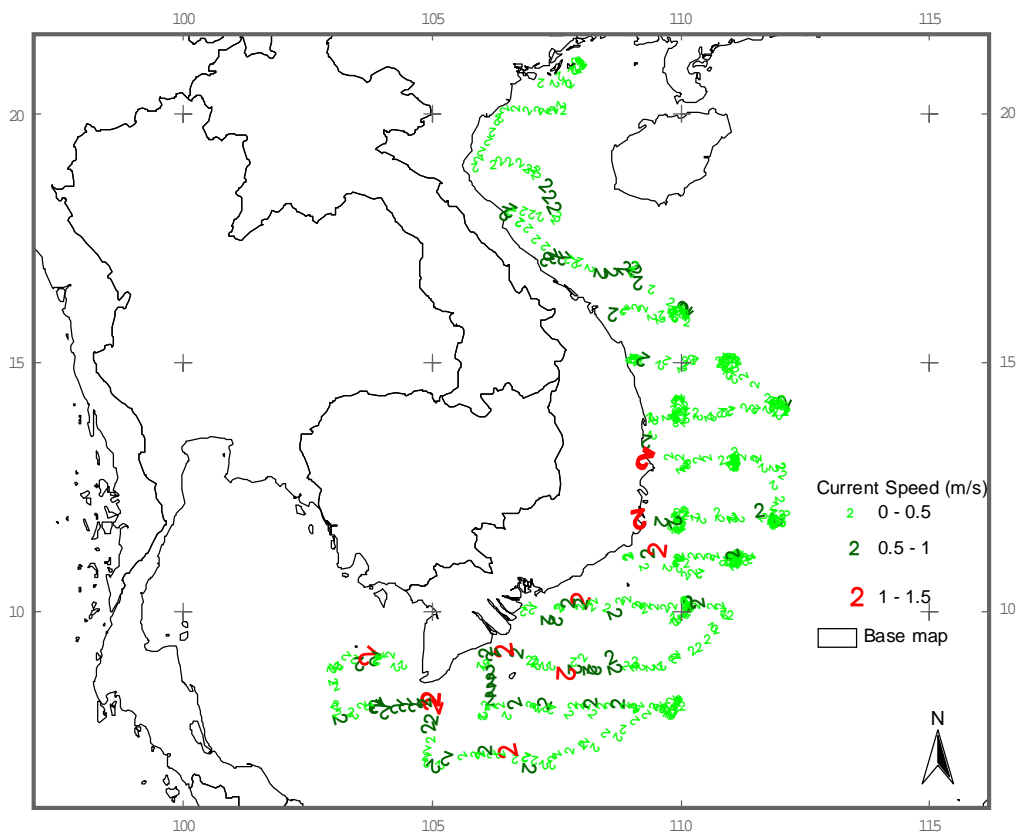


Fig. 13. Surface current along the cruise track from dropper current indicator.

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