

Patterns and variation of seawater characteristics over Cambodian territorial Water

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ABSTRACT

Horizontal and vertical distributions of salinity, temperature, and density (sigma-t) over Cambodian water at 11 stations in Cambodian water, were investigated during 18 - 26 November, 2005. The data were collected from 11 stations, covering the area from 09°15' to 10°45' N and 102°27' to 103°30' E. All the parameters were measured on board of the ship M.V. SEAFDEC2 using conductivity-temperature-depth sensor (CTD; SBE19). The results show that temperature was stable from surface to 15 - 20 m depth and rapidly increased by 0.5°C between the depth at 20 and 30 m. Temperature decreased again below this depth at all sampling stations, except at station 11 in the offshore area. The salinity and density profiles exhibit a similar pattern with stable values from surface to 15-20 m depth. The surface salinity was around 30.1 psu and surface density was 18.3 kg/m³. However, sudden changes in those parameters were observed in subsurface layer at 20 – 30 m water depth, below which they became stable again with salinity 33.7 - 33.8 psu and density 20.5 - 21.0 kg/m³. At nearshore station, due to river discharge, the salinity (29.8 psu) and density (18.3 kg/m³) were less than those of offshore station with salinity 30.5 psu and density 18.75 kg/m³. The results indicate that main factors influencing water characteristics during the survey period were river runoff, water intrusion and weak upwelling. In this period, Cambodian water can be separated into 2 layers. First layer is diluted water which covered from the surface down to the depth at 20-25 m with strong dilution near the Samit point. Subsurface layer approximately below 25 m is considered non-diluted water, affecting by the intrusion of water mass from South China Sea.

Key words: salinity distribution, temperature distribution, cambodia waters, weak upwelling

INTRODUCTION

Most parts of Cambodian maritime territorial water (42000 km²) are located east of the Gulf of Thailand neighboring the South China Sea. In this area, a large number of fish species and other organisms have been harvested over a long period of time. Unfortunately, many commercial species are becoming endangered by

a number of factors, such as over fishing and degrading environment. Therefore, it is necessary to study physical and chemical characteristics of the seawater with emphasis on horizontal and vertical distribution of temperature, salinity and density (sigma-t). Those features would provide a clear and systematic description of the ocean ranging from fish population to oceanographic environment. However, the only record available

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was from the NAGA's Gulf of Thailand expedition held in 1959-1961, but it did not focus on Cambodian water.

This report describes the oceanographic environment in Cambodian water obtained from a recent survey. The objective of this survey is to describe certain physical and chemical characteristics of the seawater for future application.

MATERIALS AND METHODS

Field observations were carried out on-board the ship M.V. SEAFDEC2 at 11 sampling stations, covering the area from 09°15' to 10°45' N and 102°27' to 103°30' E in Cambodian territorial water (Figure 1) during the period from 18 to 26 November 2005. A iCTD probe was

deployed at each station for measuring vertical profile of water temperature, salinity and density at 1-meter intervals throughout the water column from surface to approximately 5 m above the sea floor. The probe was lowered and retrieved at a constant velocity of 0.5 m/s.

Data obtained from the survey were analyzed and used to construct vertical and horizontal distributions of each parameter. The first analysis was to plot vertical profiles of each parameter at each station. The second step was to plot the horizontal distribution in surface layer at 5-m depth and subsurface layer at 30-m depth. The distribution for deeper water could not be analyzed because of limited depth at some stations. The contour interval for temperature was 0.25 °C; that for salinity was 0.2 psu and that for density was 0.25 kg/m³. Finally, vertical cross-sections were

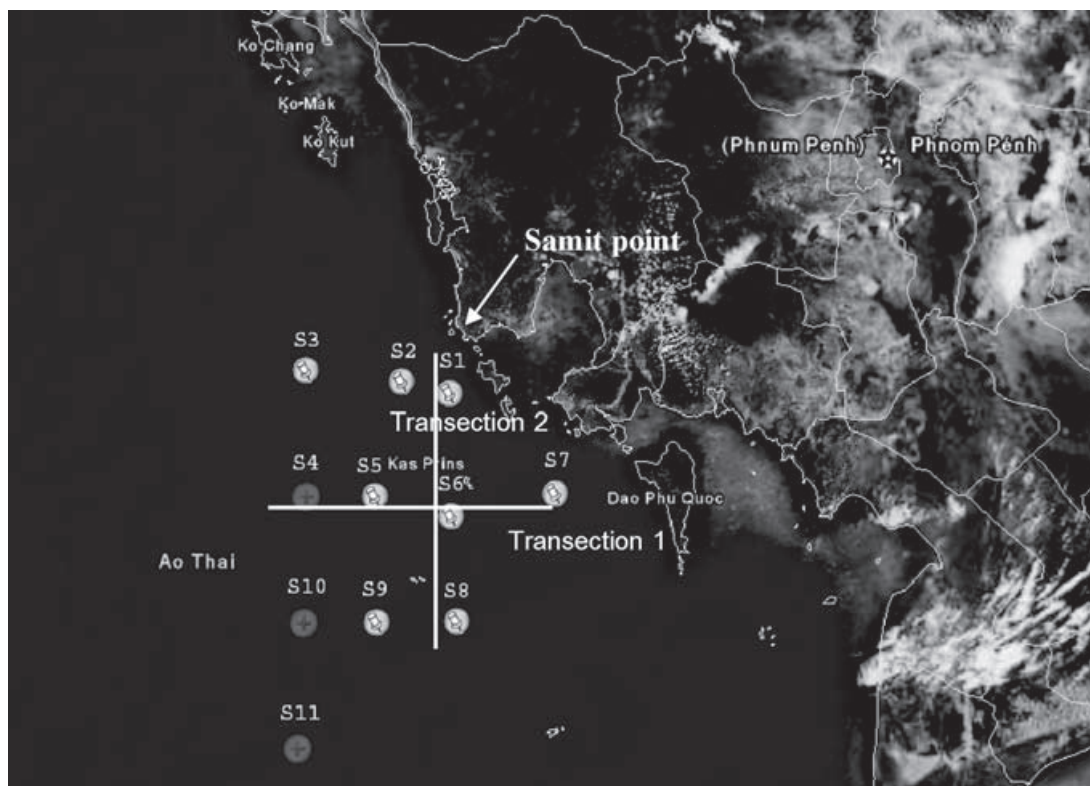


Figure 1 Positions of oceanographic survey in Cambodian water.
(Base map from: www.googleearth.com)

done with the contour interval of 0.25 °C for temperature, 0.5 psu for salinity and 0.25 kg/m³ for density.

Remark: The Temperature and Depth Recorder (COMPACT-TD;ATD-HR) was used at stations number 4, 11 and 12 due to unfavorable sea conditions and the ICTD could not be used. Therefore, the temperature chart covered more widely than salinity and density distributions.

RESULTS

The expedition took place during the early months of the northeast monsoon. The

prevailing wind direction varied from NE to N at variable speed from 8 to 22 knots, with an average value greater than 14 knots. Rainfall squalls occurred from time to time. The survey area was relatively shallow ranging from 30 to 70 m with a mean depth of 50 m.

Vertical profiles

The temperature profiles at most stations were different from the normal pattern (high near the surface and then decrease with depth) except at St.11. The vertical profile of temperature was stable from surface to 15 - 20 m and rapidly increased by 0.5 C from 20 to 30 m and decreased slightly in deeper water. The maximum

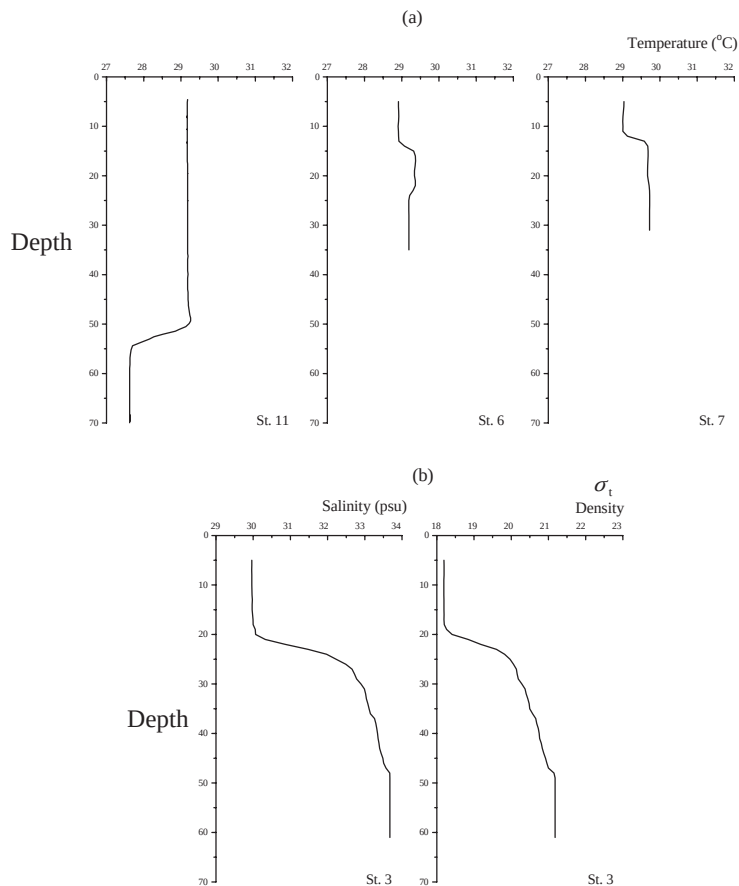


Figure 2 (a): Vertical profile of temperature at St. 11 (common pattern in temperature profile), St.6 and St. 7 (irregular pattern temperature profile)
(b): Vertical profile of salinity and σ_t at St. 3

temperature occurred at the depth of 20 - 30 m (Figure 2a).

The salinity and density profiles exhibit a similar pattern. It was found that salinity and density were stable from the surface to 15 - 20 m depth with an average value of 30.1 psu and 1018.3 kg/m³, respectively. However, those values increased sharply in subsurface layer at 20 - 30 m and increased slightly towards deeper layer (>30 m) with salinity reaching 33.7 - 33.8 psu and density 1020.5 - 1021.0 kg/m³ (Figure 2b).

Horizontal distribution

The horizontal temperature distribution at the surface and subsurface layers shows a similar pattern with the surface temperature ranging from 29°C to 29.5°C and slightly lower by approximately 0.25 °C than those of the subsurface layer (ranging from 29.25°C to 29.75°C). The highest temperature was found near Samit point in northeastern part of the surveyed area; the low temperature occurred in the area from east to south adjacent to the mouth of the Gulf of Thailand and lowest temperature was found at St. 6. The horizontal distribution of water temperature is shown in Figure 3.

The surface salinity distribution shows a tongue-like pattern with salinity increasing from northeast to southwest direction. Salinity at near shore stations in the northeast was less than 29.8 psu. The value increased slightly in the central area to approximately 30.0 psu and was higher than 30.5 psu in the southwest area (Figure 4 left). However, salinity distribution at 30-m depth exhibits a different pattern. It was found that water with lower salinity (< 32 psu) entered the area from the east and southeast of the survey area, and encountered water with higher salinity (> 33 psu) at the center, st.6. The prevailing salinity in the survey area ranged between 32 and 33 psu (Figure 4 right).

The horizontal density distribution shows a similarly pattern as that of salinity distribution

in both surface and subsurface layers. The density value in surface water in the northeast area was less than 18 kg/m³ and it increased to higher than 18.75 kg/m³ in the southwest area. The distribution at 30-m depth demonstrates that the low density water (< 19.75 kg/m³) entered the survey area from the east and southeast, and it reached the highest density (> 20.5 kg/m³) at the center (station 6); while density in most survey area was between 19 and 20 kg/m³. The horizontal distribution of water density is shown in Figure 5.

Vertical distribution

The vertical distribution of water temperature was not much different throughout the water column with temperature higher than 28°C. This distribution pattern was similar to that found in Naga's expedition in 1960. It reported that stratification was weakened in October and water was well mixed in December. But it appeared irregular with slightly higher temperature at 29.5 - 30°C in the 20-30 m layer. A similar result was also reported by Rojana-anawat *et al.* (2001), who found that the temperature increased at the depth of about 20 - 25 m in the western Vietnamese water adjacent to the Gulf of Thailand.

The composite vertical distribution showed that low salinity (below 31.5 psu) was confined to the layer less than 25 m thick, except in one area at the southern end of Transect 2 where the low salinity water extended to the bottom. Water with high salinity (above 33.0 psu) was found only at depth greater than 30 m.

Vertical distribution of water density illustrated two-layer water column with low density (<1018 kg/m³) density water lying on top of denser (>1021 kg/m³) water. Low density water was found at nearshore station in northern end of Transect 2 while high density water was found in deep-water area. The vertical distribution of water temperature, salinity and density in transects 1 and 2 are shown in Figure 6.

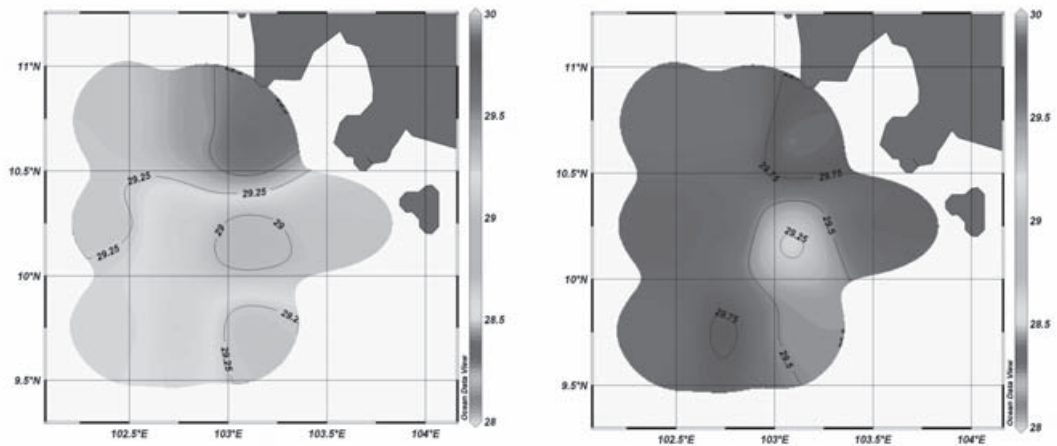
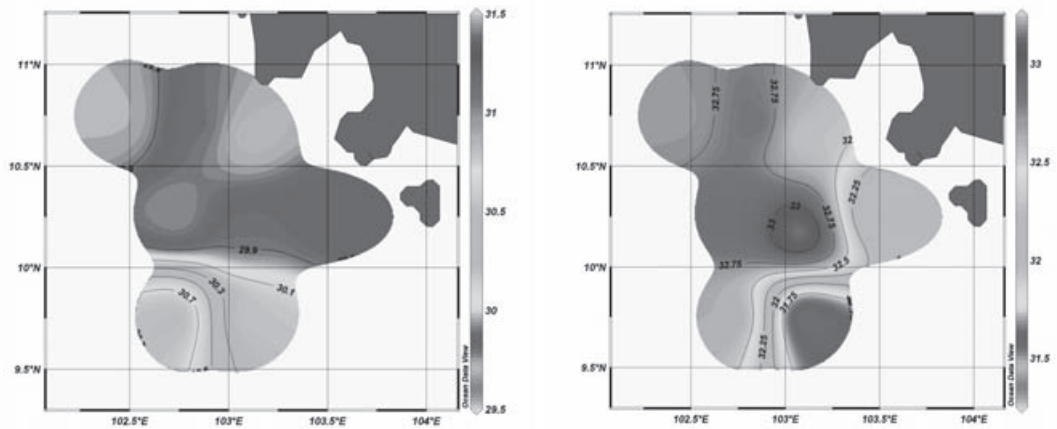


Figure 3 horizontal temperature distributions at 5-m and 30-m depth.



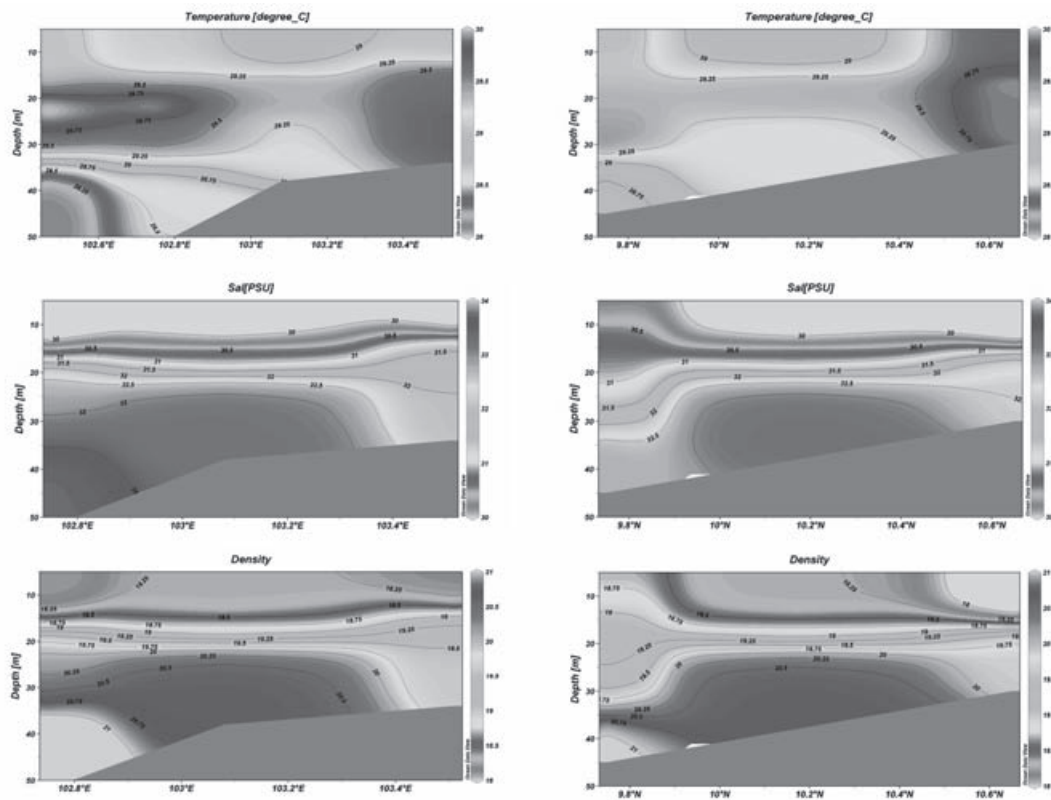


Figure 6 The vertical distribution of temperature, salinity and density in transect 1 (right) and transect 2 (left).

DISCUSSIONS AND CONCLUSIONS

Water characteristics in Cambodian water, which was shallow and well mixed during the survey period, were analyzed with small spatial intervals in order to understand the significant factors affecting the survey area. The results indicate that the main factors influencing the water characteristics during the survey period were river runoff, water intrusion and weak upwelling.

NAGA's expedition (1974) reported that the salinity of surface water in the Gulf of Thailand generally ranged between 32 and 33 ppt except where the seawater was diluted by river runoff or rainfall. Siripong, (1986) reported that mean salinity in sea surface was maximum in winter season (33.36 ppt) and minimum after rainy season (31.56 ppt). Therefore, the salinity of 31.5 psu was

used as a criterion to distinguish diluted and non-diluted seawater in the Gulf. According to the results, the characteristics of Cambodian water were composed of both diluted water and non-diluted water.

The diluted water covered from the surface down to the depth of 20-25 m with strong dilution near the Samit point. This was probably due to the influence of river runoff by many of rivers in the western side of Cambodian such Krassop river, De Sre Umbel river and Dat Sap river. Those river mouths were far from survey station number 1,2,3,6 and 7 about 20-40 miles. A similar discussion was reported by Yanagi *et al.* (2001), who found that the effect of river discharge on the stratification was expected to be strong from September to December due to large discharged volume. This dilution caused low



Figure 7 The prevailing current direction and velocity in November as shown in the JODC data.
(From: <http://www.jodc.go.jp/>)

salinity and density in surface water to the depth of 20-25 m.

The non-diluted water occurred in the subsurface layer approximately below 25 m, but it is interesting to note that the water from the east to southeast was slightly less saline (Figure 3, 4 and 6). This phenomenon was possible due to the intrusion of water mass with lower salinity and temperature into Cambodian water from South China Sea. This intrusion was also observed by other researchers who explained that in rainy season the southwestward current brought cold water from the Pacific Ocean and flowed into the South China Sea and passed the coast of Vietnam before intruding the eastern Gulf of Thailand (Siripong, 1986). This fact coincides with the STATISTICS OF OCEAN CURRENT in JODC data, which shows that the currents moved from South China Sea into the Gulf of Thailand via Cambodia during the northeast monsoon (Figure 7). Rojana-anawat *et al.* (2001) referring to Saadon *et al.* (1998) reported that the

Vietnamese water was similar to the water in the Gulf of Thailand, indicating that the water from the Mekong River still influenced the subsurface water in the outer Gulf of Thailand. During autumn, low salinity occurred in coastal water of South China Sea due to the high volume of inflow of river runoff and it was kept nearshore by the northeast wind (Pinyoporn, 1986).

As a result of weak upwelling at st. 6, the surface-water temperature was slightly lower than the subsurface layer (Figure 6). The horizontal plots of temperature and salinity indicate the occurrence of the weak upwelling caused lower temperature and higher salinity than the nearby area (Figure 3-Left and Figure 4-Right). This weak upwelling carried low temperature water to surface (Figure 6-Right) and raised the salinity (> 32.5 psu) (Figure 6-Left). The evidence of upwelling was also shown by the high salinity and low oxygen water around the eastern side of the Gulf between Phu Quoc Island and Samit Point (Robinson, 1974).

Lastly, the data show that the density distribution shows a greater similarity with salinity distribution than the temperature indicating that the density was mainly affected by the salinity and to a less degree by the temperature in Cambodian water.

ACKNOWLEDGEMENT

The authors are especially grateful to Dr. Somboon Siriraksophon and Mr. Pratakphol Prajakjitt. We thank all research division staffs at SEAFDEC and crew of the M.V. SEAFDEC 2 for their assistance and support to this research survey. Lastly, Miss Penchan Raongmanee and Dr. Chang-Kwei Lin are gratefully acknowledged for their useful suggestions on the manuscript.

LITERATURE CITED

- Pinyoporn, W. 1986. **Seasonal Variation of Characteristic of Water Masses in the Gulf of Thailand and South China Sea** (M.S. Thesis). Bangkok, Chulalongkorn University; Bangkok.163p.
- Rojana-anawat, P., S. Pradit, N. Sukramongkol and S. Siriraksophon. 2001. Temperature, salinity, dissolved oxygen and water masses. pp.346-355. *In: Proceedings of the 4th technical seminar on marine fisheries survey in the South China Sea*. Bangkok: Southeast asian fisheries development center.
- Siripong, A. 1986. Characteristic of temperature and salinity of water masses in the Gulf of Thailand and South China Sea in four seasons. **Proceeding of the 3rd conference on analysis of sea water and marine resource, 1984 Mar 26-28**, Bangsan, Chonburi. Bangkok.
- Yanangi T, S. I. Sachoemar, T. Takao and S. Fujiwara. 2001. Seasonal variation of stratification in the Gulf of Thailand. **Oceanography** 57: 461-470.
- Robinson M K. 1974. **Scientific results of marine investigations of the South China Sea and the Gulf of Thailand 1959-1961**. In, Naga Report, Vol. 3. California: University of California.125p.
<http://www.jodc.go.jp/>