สภาวะมวลน้ำในแนวดิ่งในเขตน่านน้ำกัมพูชาในเดือนพฤศจิกายน 2557
Water Column Conditions in the Cambodian Water in November 2014

อนุกูล บูรณประทีปรัตน์[1]*, พนธิภา เลือดนักรบ[2] และ ศักดิ์ชาย อานุภาพบุญ[2]

Anukul Buranapratheprat[1]*, Pontipa Luadnakrob[2] and Sakchai Arnupapboon[1]

[1]ภาควิชาวาริชศาสตร์ คณะวิทยาศาสตร์ มหาวิทยาลัยบูรพา

[1]Department of Aquatic Science, Faculty of Science, Burapha University

[2]ศูนย์พัฒนาประมงแห่งเอเชียตะวันออกเฉียงใต้ ฝ่ายฝึกอบรม

[2]Southeast Asian Fisheries Development Center, Training Department

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บทคัดย่อ

ข้อมูลสมุทรศาสตร์ที่ตรวจวัดได้ในระหว่างการสำรวจน่านน้ำกัมพูชาโดยเรือ RV Koyo Maru ระหว่างวันที่ 21 - 27 พฤศจิกายน 2557 ถูกนำมาใช้ในศึกษาเกี่ยวกับสาเหตุและผลกระทบที่เกิดขึ้นจากสภาวะของมวลน้ำในแนวดิ่ง ผลการวิเคราะห์แสดงให้เห็นการเกิด thermocline, halocline และ pycnocline ที่ระดับความลึกประมาณ 40 - 55 เมตร ในทะเลบริเวณนอกชายฝั่ง การแบ่งชั้นน้ำมีความความซับซ้อนมากขึ้นในทะเลบริเวณใกล้ชายฝั่งที่ได้รับอิทธิพลจากน้ำจืดจากบริเวณข้างเคียงและในบริเวณที่น้ำจากทะเลจีนใต้แทรกตัวเข้าไปถึง การแบ่งชั้นน้ำส่งผลให้ออกซิเจนละลายน้ำในน้ำชั้นล่างมีค่าต่ำเกือบทั่วทั้งพื้นที่ สถานการณ์ที่ออกซิเจนละลายน้ำมีค่าต่ำมีความรุนแรงมากขึ้นในพื้นที่ที่น้ำใกล้ผิวทะเลมีความเค็มต่ำและมีการแทรกตัวของมวลน้ำอุ่นใต้ชั้นน้ำเข้ามาในพื้นที่ในบริเวณใกล้ชายฝั่ง

คำสำคัญ : สภาวะมวลน้ำในแนวดิ่ง น่านน้ำกัมพูชา อ่าวไทย

Abstract

The oceanographic data measured during a survey by RV Koyo Maru in the Cambodian water during 21 – 27 November 2014 were used to investigate water column conditions, their causes and results. The analyses showed that thermocline, halocline and pycnocline developed at the depths of about 40 – 55 m in the offshore area. Water stratification became more complex in nearshore region where the influence of local freshwater inputs and subsurface warm water intrusion were observed. The resulted stratification generated low dissolved oxygen in near bottom water almost throughout the study area. The situation of low dissolved oxygen became intense in nearshore area where surface salinity was very low due to local freshwater sources and subsurface warm water intrusion.

Key words : water column conditions, the Cambodian water, the Gulf of Thailand

***Corresponding author. E-mail:** anukul@buu.ac.th

Introduction

Water column conditions, in the forms of stratification or vertical mixing, are important to the environmental conditions of water mass. Phytoplankton needs recycling nutrients from water mixing but also needs water column stability for photosynthesis in well lid layer. Hypoxia in water occurs because of the decomposition process of organic materials by bacteria. This condition is enhanced by water stratification. When gas exchanges between water and air are limited, hypoxia in near bottom water will be intense. Water column conditions in a coastal water are typically controlled by 4 factors including wind and tidal stirrings, surface heat and freshwater fluxes. The difference in the balances of these factors lead to temporal and spatial variations in water column condition in each study area (Buranapratheprat *et al*., 2016).

The Cambodian water covers the area of approximately 42,000 km^2 (Rizvi & Singer, 2011) located in the east of the Gulf of Thailand and in the middle of Thai and Vietnamese waters (Figure 1). This area has plenty of resources including mangrove, coral reef, sea grass and fisheries. However, oceanographic studies in this area have been rarely conducted since the NAGA expedition for the whole Gulf of Thailand in 1959-1961 (Robinson, 1974). SEAFDEC has carried out surveys in the Gulf of Thailand in 1995 – 1996 (SEAFDEC, 1997) and 2013 (SEAFDEC, 2015), but just in the western area. Only one survey on fisheries and oceanographic studies was carried out in the Cambodian water in November 2005 (SEAFDEC, 2008). The oceanographic study at that time addressed the influence of salinity on water density, water intrusion from the South China Sea and weak upwelling in this area (Arnupapboon & Phaksopa, 2008). Our study will re-investigate oceanographic conditions during the same survey period but this time is focusing on the mechanism of water column conditions, their causes and results. This will be another milestone for oceanographic study not only in the Cambodian water but also in the whole Gulf of Thailand.

Methods

The profiles of parameters including temperature, salinity, Sigma-t and dissolved oxygen (DO) were measured at 23 stations in the Cambodian water (Figure 1) using an enhanced CTD (Conductivity-Salinity-Depth) system (Sea-Bird Electronics: SBE911) installed onboard RV Koyo Maru. The boundary of the study area covers geographic positions from 102° E to 103° 37'40" E and 9° 04' 51" N to 11° 14' 49" N. The observation was carried out during 21 – 27 November 2014, which was the early northeast monsoon period. The details of observation points including geographic positions, date and start time for CTD deployment and water depths were summarized in Table 1. We have not done the observations at Station 16, 17 and 18 because that area is very close to Cambodia-Vietnam border. The measured oceanographic parameters were used to draw profile plots, horizontal and vertical contours by using Ocean Data View software (Schlitzer, 2007) for water column analysis.

Table 1 Geographic positions, date and start time for CTD deployment and water depths of observation points

Station	Geographic Positions [degrees]		Date	Start Time	Water Depth [m]
	Latitude	Longitude			
1	11° 14' 49"	102° 49' 58"	23/11/2014	11:43	30
2	10° 58' 44"	102° 56' 45"	23/11/2014	08:56	30
3	10° 59' 49"	102° 39' 57"	23/11/2014	15:00	41
4	10° 39' 43"	102° 25' 04"	26/11/2014	16:28	67
5	10° 39' 50"	102° 40' 08"	24/11/2014	05:57	53
6	10° 31' 51"	102° 56' 20"	21/11/2014	16:52	40
7	10° 22' 11"	103° 37' 40"	22/11/2014	10:55	26
8	10° 19' 58"	103° 20' 05"	22/11/2014	13:39	25
9	10° 18' 50"	103° 00' 46"	21/11/2014	13:09	44
10	10° 20' 31"	102° 40' 01"	24/11/2014	08:54	56
11	10° 20' 02"	102° 19' 55"	26/11/2014	10:32	67
12	9° 59' 41"	101° 59' 52"	27/11/2014	08:00	73
13	10° 00' 18"	102° 19' 47"	26/11/2014	07:57	70
14	10° 00' 03"	102° 40' 01"	24/11/2014	12:03	57
15	10° 00' 07"	102° 59' 52"	21/11/2014	10:14	41
19	9° 40' 08"	103° 00' 07"	21/11/2014	06:06	53
20	9° 38' 38"	102° 40' 12"	24/11/2014	16:48	60
21	9° 40' 08"	102° 20' 09"	25/11/2014	16:33	71
22	9° 40' 26"	101° 59' 52"	27/11/2014	12:02	72
23	9° 20' 23"	102° 04' 58"	27/11/2014	16:01	72
24	9° 20' 06"	102° 19' 58"	25/11/2014	13:39	69
25	9° 20' 06"	102° 39' 54"	25/11/2014	07:57	65
26	9° 04' 51"	102° 20' 05"	25/11/2014	11:31	69

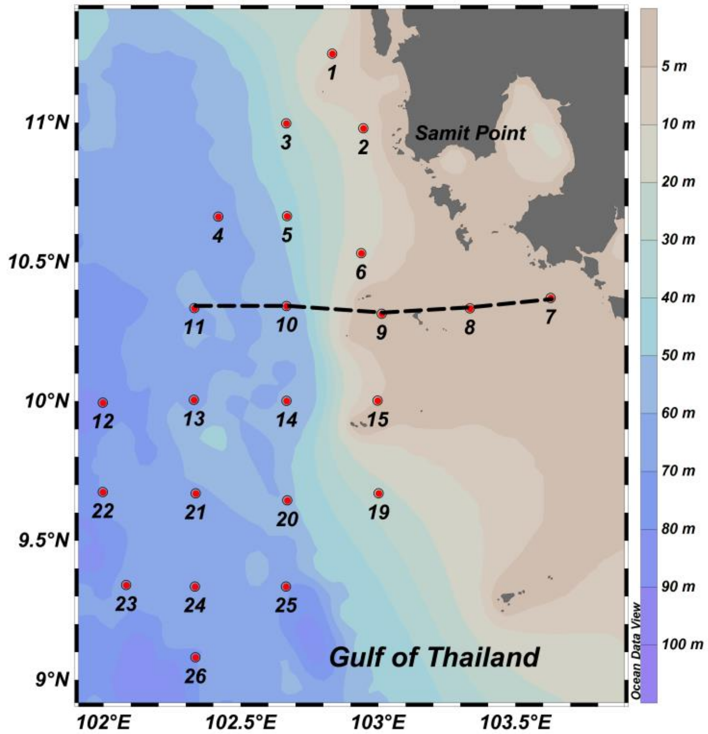

Figure 1 The Cambodian water showing the positions of oceanographic survey and the broken line for vertical contour plots

Results and Discussions

The profiles of temperature, salinity, Sigma-t and DO from Station 10 and Station 21 are shown in Figure 2. Both stations are chosen to represent as complex and simple data profiles, respectively. The parameter profiles of Station 21, located in the southern offshore, indicate simple two-layer stratification. Thermocline, halocline and pycnocline locate at the same depths of about 40 – 55 m with the ranges of temperature, salinity and Sigma-t of about 3°C, 1.5 psu and 2 kg/m^3, respectively. Low DO water is observed in near bottom layer where DO is as low as 2.7 ml/l while that in the surface layer is still over 4 ml/l. On the other hand, the profiles of Station 10 in the central north area show more complex patterns. Temperature profile illustrates three water layers by having a warm water mass with temperature over 30°C intruding at depth around 20 – 35 m. Compared to Station 21, low salinity layer from the sea surface to depth about 30 m can be observed in the salinity profile of Station 10. The Sigma-t profile is also modified in the same way but more complex due to the combination effects of temperature and salinity resulting in multiple water layers. The DO profile at Station 10 also seems to be more complex with lower DO (2.5 ml/l) in near bottom water than that of Station 21. Complex profiles are also found at Stations 2, 3, 4, 5, 6, 9, 11, 14, 15, 19, 20 and 25 while simple profiles are found at the others. The explanation why this phenomenon happens will be discussed later.

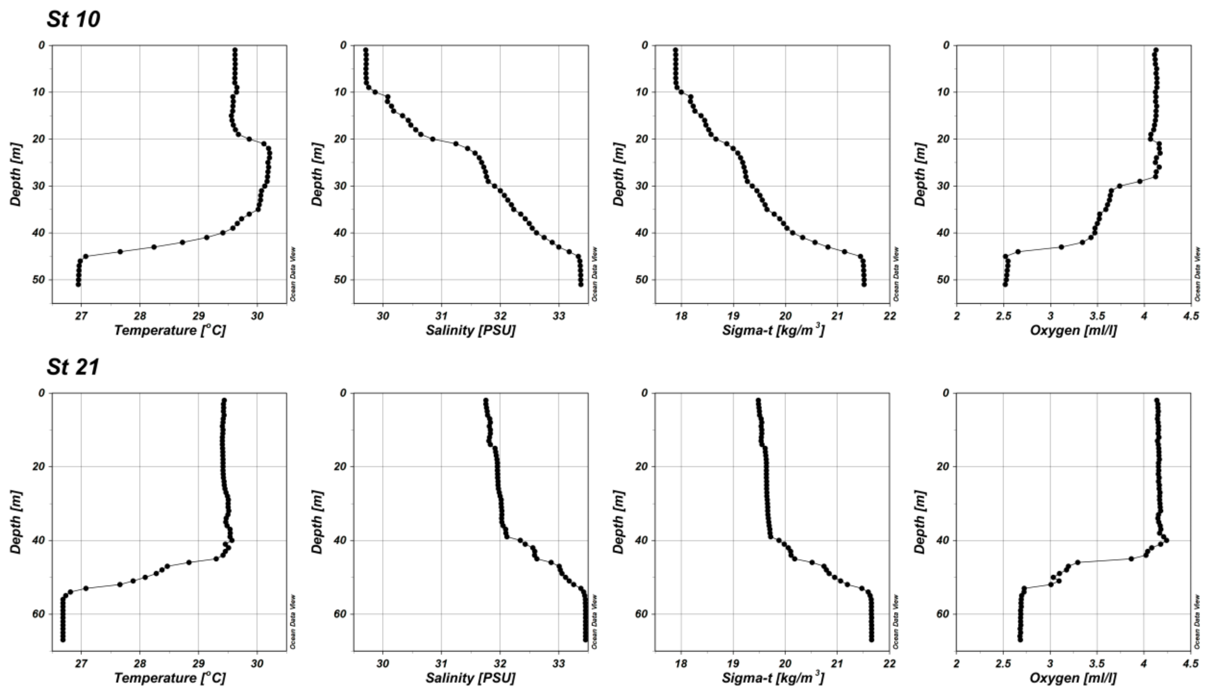

Figure 2 The profiles of temperature, salinity, Sigma-t and DO from Station 10 and Station 21

Horizontal distributions of temperature, salinity and DO at depth 5 m and near the sea bottom (Figure 3) reveal water column stratification in another aspect. Temperature near the sea surface (5 m depth) is as high as around 29.5 – 30.0 °C throughout the area. Compared to the sea surface, temperature near the sea bottom is low with high gradient, which is related to the water depth – the greater depth, the lower temperature. Lowest temperature of about 26.5 °C is observed in the deep offshore area while higher temperature of about 29 – 30 °C is found in shallow nearshore zone. The distribution of salinity near the sea surface clearly illustrate the plume of low salinity water (29.5 – 30 psu) in the central-north area. Surface salinity in all the entire area is lower than that near the sea bottom and the largest surface-bottom salinity differences are located at Station 3, 5, 6, 10 and 11 (Figure 4) where the lowest salinity appears (Figure 3). DO near the sea surface is over 4 ml/l while that near the sea bottom is much lower than that especially where the water stratification is strong. Lowest bottom DO around 2.3 ml/l occurs near the location of lowest surface salinity and strongest stratification. It is clearly observed that strong stratification in water density and DO in nearshore area is controlled by surface freshwater plume (Figure 4).

Vertical distribution of temperature along the central stations (broken line in Figure 1) clearly shows the intrusion of warm water mass at depth about 20 – 40 m at Station 10 (Figure 5), previously observed in the profile in Figure 2. Thermocline layer appears at the depth around 40 – 50 m. Another warm water mass near the sea surface is also captured in the shallow area close to Station 8 where the elevation of salinity contours also locates. This may be resulted from upwelling or vertical mixing and can be seen in the surface distributions of salinity and temperature in Figure 3 where the small regions of high temperature and high salinity locate near Station 8. Vertical distribution of temperature at this station is different from that of salinity because halocline is shallower than thermocline. The reason why these vertical movements increase the sea surface temperature will be discussed in following section.

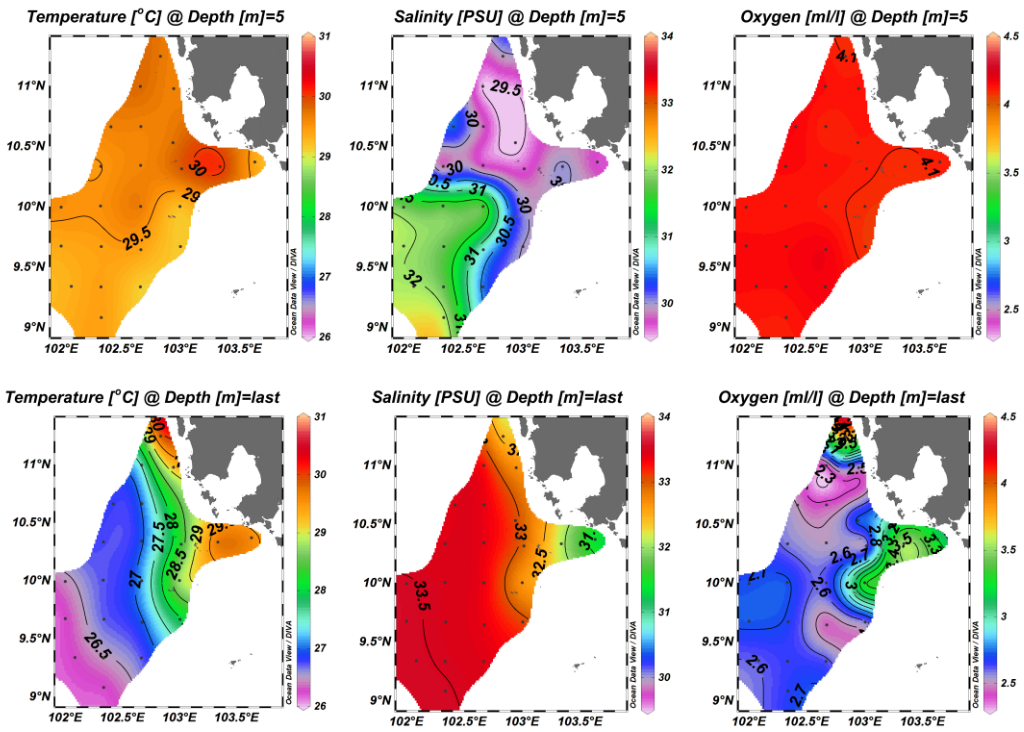

Figure 3 Horizontal distributions of temperature, salinity and DO at depth 5 m and near the sea bottom

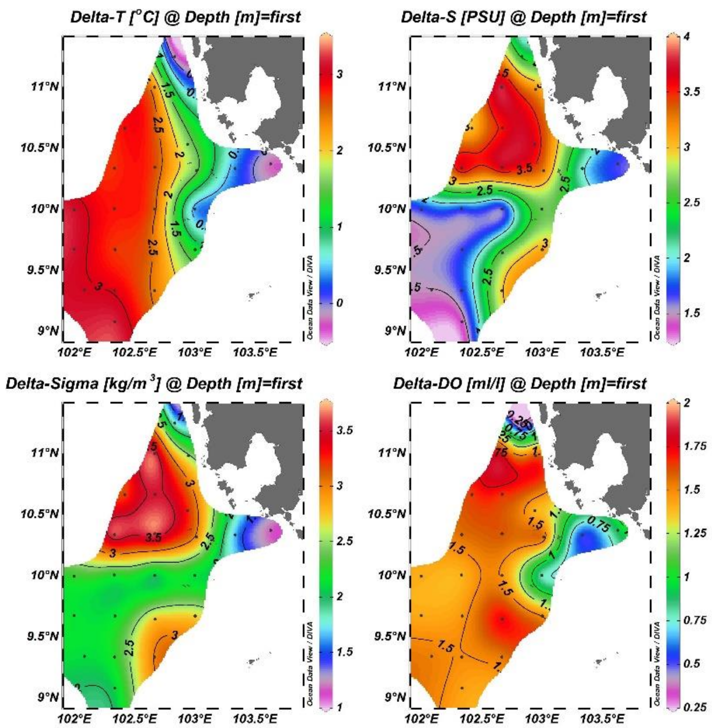

Figure 4 Horizontal distributions of the differences between temperature, salinity, Sigma-t and DO at depth 5 m and near the sea bottom

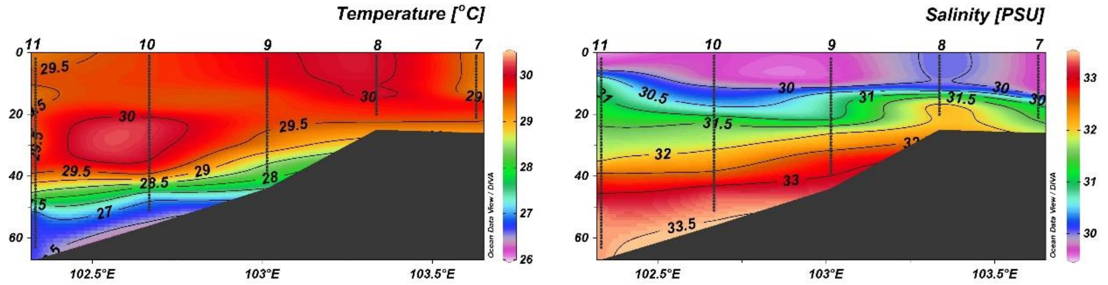

Figure 5 Vertical distributions of temperature and salinity along the broken line in Figure 1

It is possible that there is the intrusion of subsurface warm water into the central area from the northern part. The horizontal distributions of temperature at several depths (Figure 6) are used to revel this phenomenon. The intrusion is clearly seen at depth 25 and 30 m where the tongue of warm water about 30 °C coming from the north to the central area locates. This is used to explain why the temperature profiles at Station 10 (Figure 2) and surrounding stations are complex where this warm water mass pass through them. This subsurface warm water is also used to explain why sea surface temperature is high in upwelling region around Station 8. This can be clearly observed in the horizontal distributions of temperature at depth 5 and 10 m. Moderate complex profile patterns also occur at Station 20 and 25, farther in the south where relatively strong stratification occurs (Figure 4).

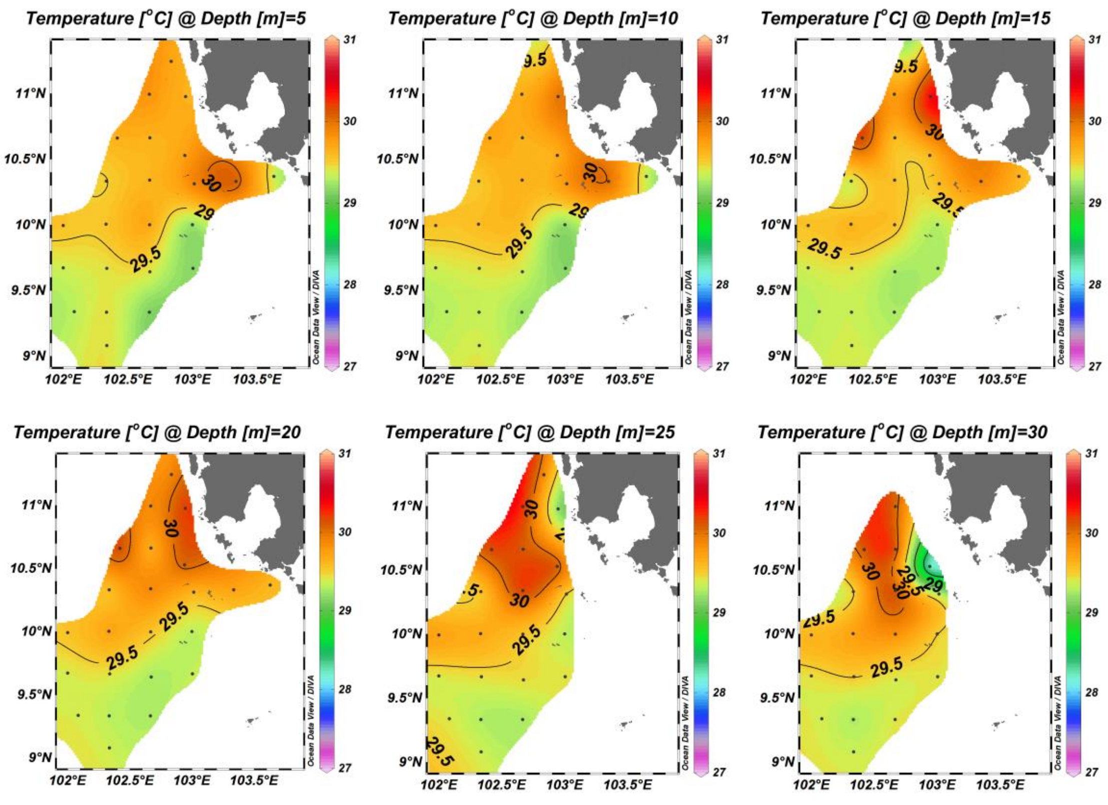

Figure 6 Horizontal distributions of temperature at depth 5, 10, 15, 20, 25 and 30 m

Water stratification in the offshore area of the Cambodian water or in the Gulf of Thailand during the time of observation still remains. However, strong wind and low surface heat flux deepen thermocline to be near the sea bottom in this early northeast monsoon period. Salinity in the surface mixed layer is still low because of freshwater input delivered from land after the peak of wet season in this region (Yanagi *et al*., 2001; Stansfield & Garrett, 1997) through local rivers including the Meteuk River, the Preat River, the Preak Klang Yai River, the Preak Piphot River and the Sre Ambel River. Low temperature, high salinity water in the lower layer is the remaining water from the South China Sea that intruded into the Gulf of Thailand from the early southwest monsoon season (Buranapratheprat *et al*., 2016). The resulting stratification generates low DO in near bottom water as observed by this study. The situation becomes intense in nearshore area where surface salinity is very low due to local freshwater sources and subsurface warm water intrusion locates (Figure 3). Compared to the study of Arnupapboon & Phaksopa (2008), the stratification in this year (2014) is more complex than that in 2005. Upwelling or vertical mixing was developed at the same location, however, it was obviously stronger in 2005 than that in 2014. Further studies are needed to investigate causes and effects of these phenomena on marine environments in this region in the near future.

Conclusions

The oceanographic survey in the Cambodian Water from 21 to 27 November 2014 revealed strong water column stratification almost throughout the study area. This phenomenon is evidently related to near bottom water intrusion from SCS and local freshwater runoff. Low DO in near bottom water was clearly observed where water stratification was intense.

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