# INTRODUCTION TO FISHERIES RESOURCES SURVEY IN THE CAMBODIAN WATER

BY

Somboon Siriraksophon

# PRELIMINARY REPORT ON FISHERIES RESOURCE SURVEY IN THE CAMBODIAN WATER

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Fisheries Resources Survey in the Cambodian water by MV SEAFDEC2 is a national research program in collaboration with SEAFDEC/Training Department. The survey plan was formulated incorporation with the Department of Fisheries, Cambodia. With the survey designs were covered four mains subjects; fisheries resources, oceanography, primary production and biology. The details of survey are as follows;

**1. Cruise No.** : M.V.SEAFDEC2 No. 16-10/2005

**2. Period** : 18-26 November 2005 (9 days)

**3. Area of Operation** : Maritime area of Cambodia

**4. Port of Call** : Sihanouville port, Cambodia

**5. Scope of Research** : in Cambodian water are as follows;

*Fishing Operation*: Fish samplings to investigate abundance and distribution of demersal fish will be conducted using bottom trawl.

*Fishery Oceanography*: Water temperature, salinity, pH, dissolved oxygen, fluorescence, light intensity, current, water transparency, sea color, etc. will be collected.

*Primary Production*: Distribution, abundance and composition of phytoplankton, sub-thermo cline chlorophyll maxima will be collected and analyzed. Survey stations are the same as fishery oceanographic survey stations.

*Fishery Biology*: Distribution, abundance and composition of priority species from fishing operation and from larvae samplings and benthos will be analyzed.

**6. Schedule**:

18 November2005, (Fri.)

0900 hrs. : M.V. SEAFDEC2 leave SEAFDEC/TD for Sihanoukville port.

19 November2005, (Sat.)

1300 hrs : Arrival of M.V.SEAFDEC 2 to Sihanoukville port.

1300-1500 hrs. : Port Clearance and refill fresh water and provision.

1500-1600 hrs. : All local researchers embark M.V. SEAFDEC 2 and discussion.

20 November 2005, (Sun.)

1000 hrs : Leave Sihanoukville Port for the survey Area.

1330-1530 hrs. : Data collection at Station #1.

1730-1930 hrs. : Data collection at Station #2.

21 November 2005, (Mon.)

0600-0800 hrs. : Data collection at Station #3.

1100-1300 hrs. : Data collection at Station #4.

1630-1830 hrs. : Data collection at Station #5.

22 November 2005, (Tue.)

0600-0800 hrs. : Data collection at Station #6.

1100-1300 hrs. : Data collection at Station #7.

1730-1930 hrs. : Data collection at Station #8.

23 November 2005, (Wed.)

0600-0800 hrs. : Data collection at Station #9.

1100-1300 hrs. : Data collection at Station #10.

1730-1930 hrs. : Data collection at Station #11.

1930 hrs. : Proceed to Sihanoukville port.

24 November 2005, (Thu.)

0700 hrs. : Arrive at Sihanoukville port.

25 November 2005, (Fri.)

1000 hrs. : Leave Sihanoukviile port for SEAFDEC/TD.

26 November 2005, (Sat.)

1400 hrs. : Arriving SEAFDEC/TD and finishing the cruise.

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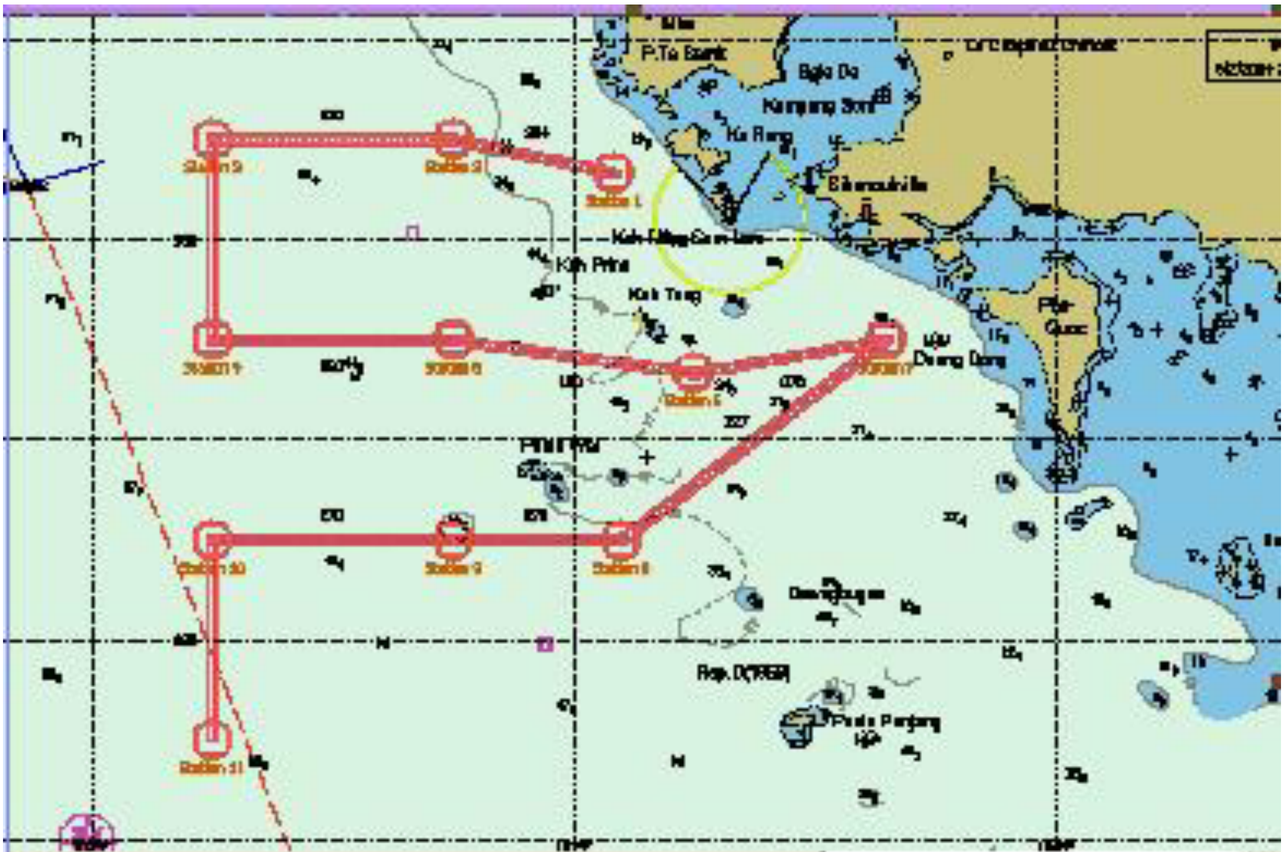


Waypoints

| N° | Name | Position | Route | Range | Remains | Total Range |
|---|---|---|---|---|---|---|
| 1 | Station 1 | 10°40'000 N - 103°05'000 E | | | 287.9 nm | 0.0000 m |
| 2 | Station 2 | 10°45'000 N - 102°45'000 E | 284.3° | 20.28 nm | 267.6 nm | 20.28 nm |
| 3 | Station 3 | 10°45'000 N - 102°15'000 E | 270.0° | 29.47 nm | 238.1 nm | 49.75 nm |
| 4 | Station 4 | 10°15'000 N - 102°15'000 E | 180.0° | 30.00 nm | 208.1 nm | 79.75 nm |
| 5 | Station 5 | 10°15'000 N - 102°45'000 E | 090.0° | 29.52 nm | 178.6 nm | 109.3 nm |
| 6 | Station 6 | 10°10'000 N - 103°15'000 E | 099.6° | 29.95 nm | 148.6 nm | 139.2 nm |
| 7 | Station 7 | 10°15'000 N - 103°39'000 E | 078.0° | 24.14 nm | 124.5 nm | 163.4 nm |
| 8 | Station 8 | 09°45'000 N - 103°06'000 E | 227.3° | 44.23 nm | 80.26 nm | 207.6 nm |
| 9 | Station 9 | 09°45'000 N - 102°45'000 E | 270.0° | 20.70 nm | 59.57 nm | 228.3 nm |
| 10 | Station 10 | 09°45'000 N - 102°15'000 E | 270.0° | 29.57 nm | 30.00 nm | 257.9 nm |
| 11 | Station 11 | 09°15'000 N - 102°15'000 E | 180.0° | 30.00 nm | 0.0000 m | 287.9 nm |

**Figure 1.** Survey Map and Position of Survey Station

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# SPECIES COMPOSITION OF LARVAL FISH IN THE CAMBODIAN WATER

By

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## Abstract

An ichthyoplankton survey was conducted in the Cambodian water aimed to collect data for planning and action for sustainable fisheries in the region. Species composition of larval fish reported in this paper is based upon plankton samples taken by a pair of bongo nets at 10 stations in November 2005. A total of 26 eggs and 2,969 larvae representing 32 families were collected in the samples which shows a moderate diversity. The abundance of larvae was dominated by the Gobiidae species, followed by the Engraulidae and Bothidae. The Gobiidae species are cryptic fish that play an important role in fisheries as some species have symbiotic relationships with invertebrate (e.g. shrimp) and others are known to remove ecto-parasites from other fishes. Amongst the 32 families, 10 appeared to be commercially important and they are inhabit inshore as adult fish. A map of distribution of total larvae and the top five most abundant families are presented. Further study with a longer sampling period is needed to confirm if the investigated area is a spawning ground.

**Key words:** Cambodian water, larval fish, composition

## Introduction

Ichthyoplankton survey provides important information on fishery biology as it is used to estimate the size of a spawning stock from the number of eggs or larvae produced (Rankine and Bailey, 1987). Ahlstrom and Moser (1976) stated that ichthyoplankton surveys are used to evaluate fish resources in general. Since the plankton net used is not selective it collects eggs and larvae of all kinds of fish. It provides information on unexploited and exploited resources. In fact, with few exceptions, it provides information on a whole spectrum of fishes in the area being surveyed. In Cambodian water very little work on ichthyoplankton has been carried out. Thus, the ichthyoplankton survey in the Cambodian water was conducted.

Cambodian coast covers a length of some 435 km along Gulf of Thailand, and the EEZ of approximately 55,600 km$^2$ is overlapped with the adjacent countries. The Gulf of Thailand adjacent to the coast of Cambodia is relatively shallow with mud/sand bottom that allows trawler operations (CFDO-IMM, 2005 cited after Karenne Tun *et al*., 2004). There are some 520 species of marine fish found in the coastal waters of Cambodia (CFDO-IMM, 2005 cited after Karenne Tun *et al*., 2004)

## Objective

The objectives of this study were:

1. To determine species composition of fish larvae;

2. To determine the abundance and spatial distribution of total number of fish larvae and of the top five most abundant families.

## Materials and Methods

**Sampling Procedure.**

Ichthyoplankton samples were collected at 11 stations in Cambodian water ( 9° 12′ - 10° 48′ N and 02° 24′ E - 103° 36′ E) (Fig. 1) during November 20 - 23, 2005 using the vessel M.V. *SEAFDEC* 2. All plankton tows were made during the day from dawn till dusk (see Appendix 1). Double oblique plankton tows of about 10 min duration were taken at each station with a pair of bongo nets - 60-cm mouth diameter with 500- m mesh for ichthyoplankton samples and 330- m mesh for zooplankton samples. The tows were made from near bottom to the surface at a speed of approximately 2-3 knots. The volume of water filtered through each net was measured with a calibrated flow meter fitted at the mouth of each net. At the completion of each tow, the nets were thoroughly washed, and the samples were immediately preserved in 5-10% formalin-seawater solution.

**Laboratory Procedure.**

All fish larvae from each sample were sorted with the aid of a dissecting microscope and then stored in 70% alcohol. Larvae were identified mainly to the family level based upon descriptions given in a number of reference for larval fishes (Fahay 1983, Moser *et al.* 1984, Nishikawa and Rimmer 1987, Okiyama 1988, Neira *et al.* 1998, Leis and Carson-Ewart 2000). The term larva used in this paper includes the preflexion, flexion and postflexion stages as described by Ahlstrom and Ball (1954). Larvae that could not be identified even to family level were placed in two categories: 1) the damaged larvae category includes damaged specimens and tiny preflexion larvae with questionable identification, and 2) the unidentified category includes larvae in good condition but could not be identified (Table 1).

**Data Analysis.**

Since the sample taken from station 1 was missing due to technical problems during sampling, the data analysis included only 10 stations. Prior to analysis, the number of fish larvae per sample were converted to abundance, i.e. number per 1000 $m^3$ of water volume filtered. The number of total fish larvae and the top five most abundant families were then mapped for their spatial distribution.

## Results and Discussions

**Composition and abundance of fish larvae**

In all, the samples included 26 eggs and 2,969 larvae belonging to 32 identified families with 4 genera (Table 1). The Gobiidae was the most abundant family contributing 24.0% of the total number of larvae and the Engraulidae was the second most abundant family contributing 19.3%. The additional 3 families ranked in the top 5 in occurrence or abundance were Bothidae, Bregmacerotidae and Nemipteridae of which each contributed between 12.1 and 3.7% of the total number. Most larvae were nearshore fishes dominating the study area and were the common groups found among both offshore and nearshore fishes e.g. Gobiidae, Engraulidae, Apogonidae, Carangidae and Nemipteridae; few were offshore fishes, e.g.

Scombridae. The dominance of nearshore fishes reflects the coastal character of the area. From previous studies conducted by several researchers from 1975 to 2004 in Thai waters in the Gulf of Thailand showed that the Gobiidae was predominant (Vatanachai, 1978; Tangkasaranee, 1980, 1982, 1983; Chayakul and Uttrapong, 1983; Chamchang, 1986, 1991; Songjitsawat, 1989; Jantaraskul, 1988; Siri, 2005). This pattern was consistent with the present study. The Gobiidae is not commercial fish, but it is the largest group of fish, including more than 700 species in the world (Fritzsche, 1978), mostly distributed in tropical and subtropical areas in fresh water and sea water (LarvalBase, 2005). With unique physiological properties Gobiidae can live transiently on the muddy flat or aerial conditions. As they are able to live in diverse, euryhaline habitats the Gobiidae larvae are found ubiquitously throughout the Gulf of Thailand. The Engraulidae, a commercial fish was found as the second dominant family in the present study and also in previous studies in Thai waters in the Gulf of Thailand

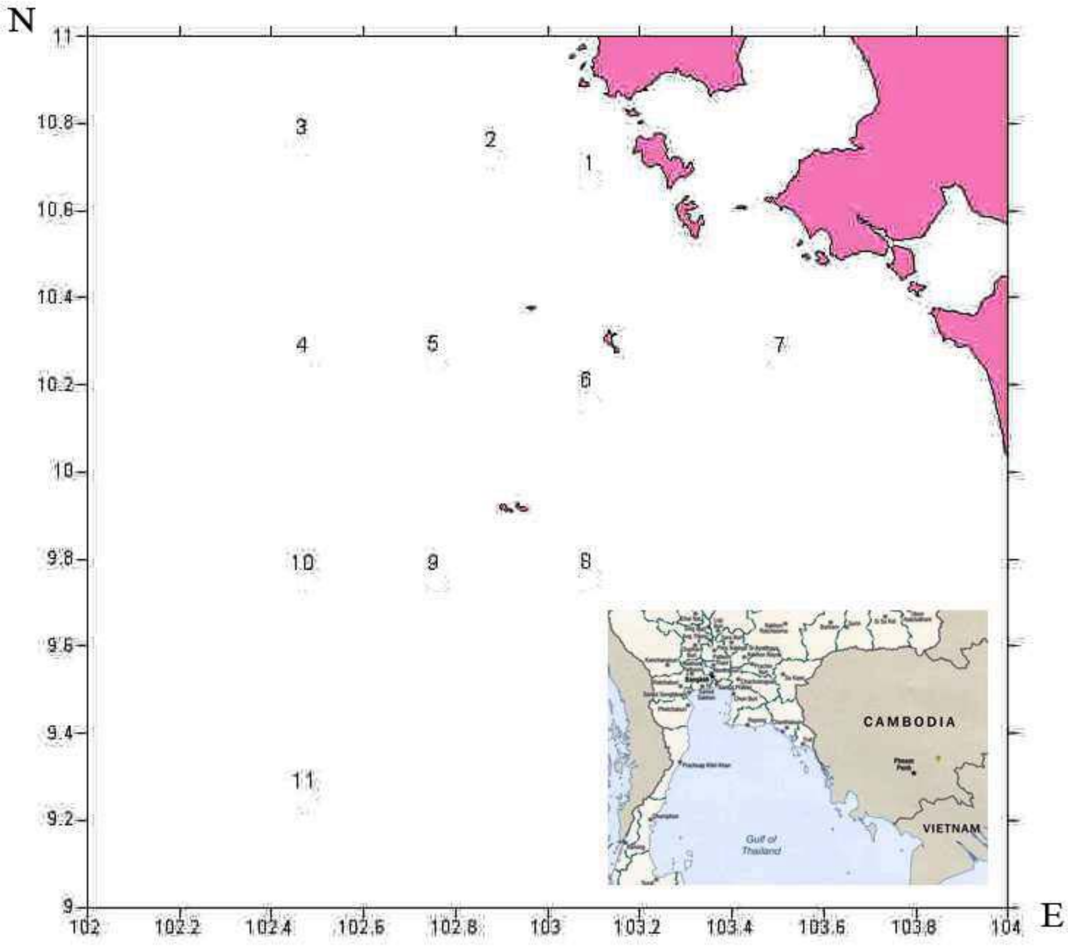


**Figure 1.** Ichthyoplankton sampling stations (stations are numbered) in Cambodian water in November 2005. Inset: Location of study area in the Gulf of Thailand.

Fish Base (2005) listed 83 families and 411 fish species occurring in Cambodian water while the present study collected only 32 families of larvae with intermediate diversity. This low number was likely due to the short sampling period (3 sampling days). However, the studies conducted in Thai waters in the eastern Gulf of Thailand adjacent to Cambodian water reported a similar number of larval families between 27 and 38 families in a longer sampling period than the present study (Chatarasakul, 1988; Songchitsawat, 1989; Siri, 2005). This suggests that the eastern Gulf of Thailand might not be main spawning ground. The main spawning ground is reported to be in the west coast of the Gulf of Thailand with higher diversity of larvae of 47 – 59 families (Tangkasaranee, 1980, 1982, 1983; Chayakul and Uttrapong, 1983; Chamchang, 1986, 1991).

**Spatial distribution of total fish larvae and the top ten family accounts**

**1. Total fish larvae**

Fish larvae were collected in every net tow with highly variable abundance. The number of fish larvae per haul differed substantially between stations ranging from 0 to 783 larvae (Fig. 2. and Appendix 1). The greatest total number of larvae occurred at station 8 (n = 783), followed by station 9 (n = 620) due largely to a high abundance of the Gobiidae (Appendix 1). Station 7 and 5 had more than 300 larvae per station, while station 10, 6, 3 and 4 had 100- 300, but none at station 2. All fish larvae tend to be widely distributed but not densely.

**2. Gobiidae**

Gobiidae larvae were the most abundant of any family and occurred at every station with 721 larvae recorded (mean = 66 ± 83.6 larvae) and its greatest abundance was found at station 8 with 274 larvae, followed by station 5 with 145 larvae collected (Fig. 2 and Appendix 1). They appeared to be widely distributed in the present study area. Gobies are cryptic bottom dwelling carnivores, although they are not commercial fish but some species have symbiotic relationships with invertebrate (e.g. shrimp) and others are known to remove ecto-parasites from other fishes (Fishbase, 2005). In the Indo-Pacific, gobies are frequently the most abundant larvae in coastal plankton tows (Hoese, 1984; Birdsong, *et al.,* 1988 cited after Leis and Carson-Ewart, 2000).

**3. Engraulidae**

The engraulids are key components of coastal fisheries and are very important commercially. As forage fish (Leis and Carson-Ewart, 2000), its larvae were the second most abundant family of fish larvae collected in this study (mean = 53    62.5 larvae). The engraulid larvae were observed at 7 out of 10 sampling stations with the greatest number recorded at station 8 (190 larvae), followed by station 9 with 97 larvae. No engraulid larvae were collected at station 2, 3 and 4. In summary, engraulid larvae were more concentrated in the middle of the sampling area (Fig. 2 and Appendix 1).

**4. Bothidae**

Bothids are sinistral (left-eyed) flatfish which are benthic carnivores occurring in soft bottom at various depths (Norman, 1934; Hensley, 1986; Fukui, 1997 cited after Leis and Carson-Ewart, 2000). Bothids have commercial value ant its larval abundance (%) was ranked $3^{rd}$ in this study. They were largely distributed at stations close to the shore, i.e. station 7 (103 larvae), followed by station 6 and 8 (Fig 2. and Appendix 1).

**5. Bregmacerotidae**

Bregmacerotids are small, pelagic fishes, frequently regarded as an oceanic inhabitant. But about half of the species complete their life cycle with great abundance in the continental shelves or in estuaries. The family has a single genus with about 15 species (Cohen *et al.,* 1990 cited after Leis and Carson-Ewart, 2000). Larval bregmacerotids were found most abundantly at station 9 (113 larvae) and station 7 (103 larvae); were less than 100 larvae at the rest stations (Fig. 3 and Appendix 1).

**6. Nemipteridae**

Adult nemipterids are small to moderate sized fishes. The family is confined to the Indo-Pacific and the species occurrence is generally associated with soft bottom. Nemipterids are important in both commercial and artisanal fisheries. Larval nemipterids were ranked 5$^{th}$ in percentage in occurrence; they were observed in 5 out of 10 sampling stations with the number less than 50 larvae (Fig. 3 and Appendix 1).

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## Summary

The results show that the occurrence of larval fish was intermediately diverse in species and their population density was low. The species diversity among larvae of demersal fish was considerably higher than the diversity among larvae of pelagic fish, a pattern also observed in other tropical collections. The study area cannot be confirmed as spawning ground of the collected larvae because the present study period was too short. Thus, a longer sampling period is needed to confirm the status as spawning ground.

## Acknowledgements

I would like to thank all crew members of the SEAFDEC research vessel and all the staff of SEAFDEC/TD working at sea in collecting and providing me with the samples. I would also like to thank Mr. Peera Uasomwang for his great help in computer work

**Table 1.** Numbers of the different taxon of larval fish caught (number of larvae/1000 $m^3$ sea water volume) in Cambodian water in November 2005 (family names arranged by rank).

| Taxa | Common name | Habitat | Total | Mean | SD | Percentage | Rank |
|---|---|---|---|---|---|---|---|
| Gobiidae[mc] | Gobies | Demersal, | 721 | 66 | 83.6 | 24 | 1 |
| Engraulidae[c] | Anchovies | Inshore pelagic | 580 | 53 | 62.5 | 19.3 | 2 |
| Bothidae | Lefteye flounders | Demersal | 366 | 33 | 29.2 | 12.1 | 3 |
| Bregmacerotidae | Pelagic codlets | Pelagic | 339 | 31 | 43.8 | 11.3 | 4 |
| Nemipteridae[c] | Thread-fin Breams, Monocle Breams | Demersal | 110 | 10 | 15.6 | 3.7 | 5 |
| Monacanthidae[c] | Leatherjackets, Filefishes | Demersal and reef associated | 103 | 9 | 13.5 | 3.4 | 6 |
| Tetraodontidae | Puffers, Swellfishes, Tobies | Reef associated | 92 | 8 | 10 | 3.1 | 7 |
| Apogonidae | Cardinal fishes | Reef associated | 75 | 7 | 11.5 | 2.5 | 8 |
| Synodontidae | Lizardfishes | Demersal | 73 | 7 | 15.3 | 2.4 | 9 |
| Lutjanidae[c] | Snappers and Fusiliers | Demersal and reef associated | 53 | 5 | 8.2 | 1.8 | 10 |
| Callionymidae | Dragonets | Demersal and reef associated | 42 | 4 | 6.4 | 1.4 | 11 |
| Elopidae | Tenpounders | | 35 | 3 | 5.1 | 1.2 | 12 |
| Carangidae[c] | Jacks, Pompanos, Trevalleys | Pelagic and reef associated | 31 | 3 | 5.6 | 1 | 13 |
| Priacanthidae[c] | Bigeyes | Epibenthic and reef associated | 27 | 2 | 5.9 | 0.9 | 14 |
| Scombridae[c] | Mackerels, Tunas, Bonitoes | Pelagic | 26 | 2 | 5 | 0.9 | 14 |
| Tuna | | | 6 | 1 | 1.8 | 0.2 | |
| *Rastrelliger* spp. | | | 20 | 2 | 4.9 | 0.7 | |
| Scorpaenidae | Scorpionfishes, Stonefishes | Demersal and reef associated | 26 | 2 | 5 | 0.9 | 14 |
| Scorpaenidae spp. | | | 18 | 2 | 3 | 0.6 | |
| *Minous* sp. | | | 8 | 1 | 2.4 | 0.3 | |
| Cynoglossidae | Tongue Soles | Demersal | 25 | 2 | 5.7 | 0.8 | 17 |
| Fistulariidae | Cornetfishes, Flutemouths | Reef associated | 23 | 2 | 5.1 | 0.8 | 17 |
| Leiognathidae | Ponyfishes | Nearshore demersal | 23 | 2 | 5.1 | 0.8 | 17 |
| Mullidae | Goatfishes, Red Mullets | reef associated | 23 | 2 | 5.7 | 0.8 | 17 |
| Champsodontidae | Gapers | Demersal | 20 | 2 | 3.4 | 0.7 | 21 |
| Platycephalidae | Flatheads | Demersal and reef associated | 15 | 1 | 4.8 | 0.5 | 22 |
| Scorpaeniformes | | | 14 | 1 | 2.9 | 0.5 | 22 |
| Lethrinidae[c] | Emperors and Large-eye Breams | Demersal and reef associated | 12 | 1 | 2.7 | 0.4 | 24 |
| Teraponidae[c] | Grunters | Inshore pelagic | 9 | 1 | 2.8 | 0.3 | 25 |
| Aploactinidae | Velvetfishes | Demersal | 9 | 1 | 2.8 | 0.3 | 25 |

**Table 1.** (continued)

| Taxa | Common name | Habitat | Total | Mean | SD | Percentage | Rank |
|---|---|---|---|---|---|---|---|
| Muraenesocidae | Pike congers | Demersal | 8 | 1 | 2.4 | 0.3 | 25 |
| Ophichthidae | Snake eels | Demersal | 8 | 1 | 2.4 | 0.3 | 25 |
| Sphyraenidae | Barracadas | Pelagic and reef associated | 7 | 1 | 2.4 | 0.2 | 29 |
| Labridae | Wrasses | Reef associated | 6 | 1 | 1.8 | 0.2 | 29 |
| Diodontidae | Porcupine fishes | Demersal | 6 | 1 | 1.8 | 0.2 | 29 |
| Congiopodidae | Racehorses or pigfishes | Demersal | 5 | 0 | 1.5 | 0.2 | 32 |
| Antennariidae | Anglerfishes, Frogfishes | Reef associated | 5 | 0 | 1.5 | 0.2 | 32 |
| Damaged larvae | | | 84 | 8 | 9.9 | 2.8 | |
| Unidentified | | | 23 | 1 | 3.3 | 0.5 | |
| **Total fish larvae** | | | **2969** | **270** | **238.7** | **100** | |
| **Total fish eggs** | | | **26** | **2** | **5.6** | **100** | |

Note: c: commercial
mc: minor commercia

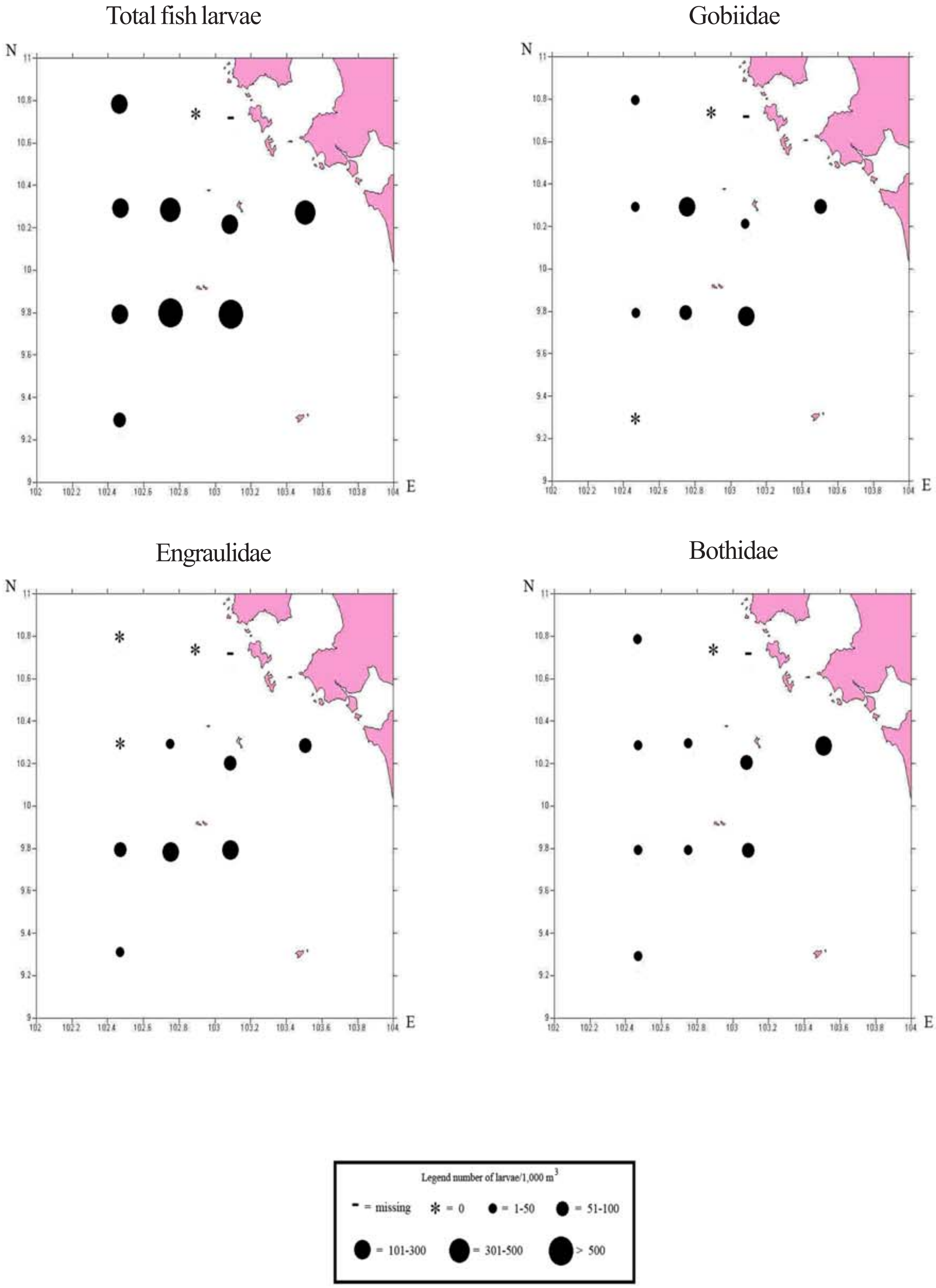


**Figure 2.** The distribution of total fish larvae, gobiid, engraulid and bothid larval catches in Cambodian water in November 2005.

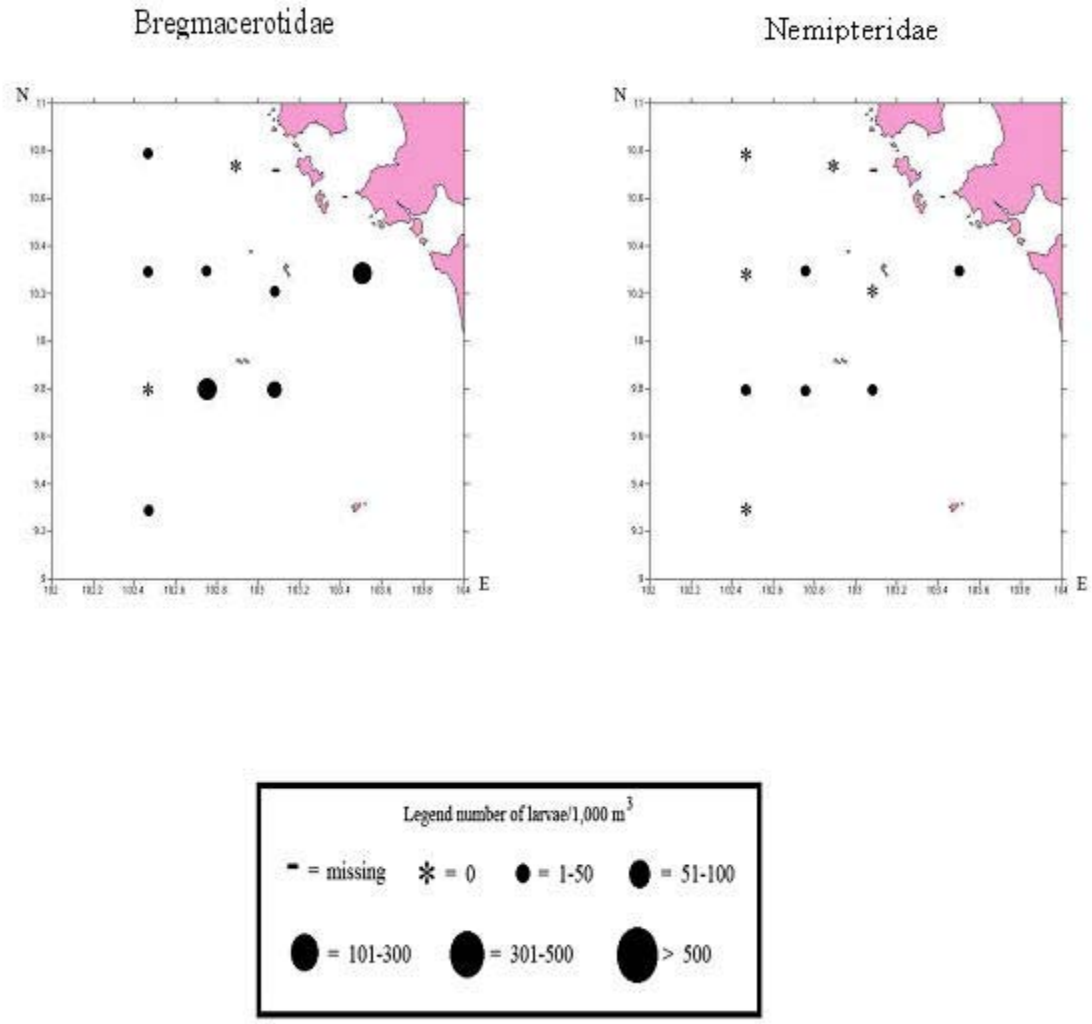


**Figure 3.** Distribution of bregmacerotid and nemipterid larval catches in Cambodian water in November 2005.

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**Appendix 1.** Species composition and abundance of fish larvae and fish eggs (number of larvae / 1000 m$^3$ sea water volume) in Cambodian water in November 2004.

| | | | | | | Station | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Taxa** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| | | | | | | | | | | |
| Gobiidae | 0 | 34 | 23 | 145 | 36 | 69 | 274 | 97 | 45 | 0 |
| Engraulidae | 0 | 0 | 0 | 39 | 89 | 52 | 190 | 129 | 60 | 22 |
| Bothidae | 0 | 34 | 23 | 29 | 53 | 103 | 53 | 40 | 7 | 22 |
| Bregmacerotidae | 0 | 17 | 11 | 10 | 9 | 103 | 68 | 113 | 0 | 7 |
| *Bregmaceros* spp. | | | | | | | | | | |
| Nemipteridae | 0 | 0 | 0 | 14.5 | 0 | 17 | 23 | 48 | 7 | 0 |
| Monacanthidae | 0 | 23 | 39 | 0 | 0 | 17 | 0 | 16 | 7 | 0 |
| Tetraodontidae | 0 | 11 | 6 | 19 | 9 | 0 | 8 | 32 | 7 | 0 |
| Apogonidae | 0 | 0 | 0 | 5 | 18 | 0 | 30 | 0 | 22 | 0 |
| Syndodontidae | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 48 | 15 | 0 |
| Lutjanidae | 5 | 0 | 0 | 0 | 0 | 17 | 0 | 8 | 22 | 0 |
| Callionymeidae | 0 | 6 | 0 | 5 | 0 | 0 | 15 | 16 | 0 | 0 |
| Elopidae | 0 | 0 | 0 | 5 | 0 | 0 | 8 | 0 | 7 | 15 |
| Carangidae | 0 | 0 | 6 | 10 | 0 | 0 | 0 | 16 | 0 | 0 |
| Priacanthidae | 0 | 0 | 0 | 10 | 0 | 17 | 0 | 0 | 0 | 0 |
| Cynoglossidae | 0 | 0 | 0 | 0 | 0 | 17 | 8 | 0 | 0 | 0 |
| Fisturiidae | | | | | | | | | | |
| *Fisturalia* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 15 | 0 |
| Leiognathidae | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 7 | 0 |
| Mullidae | 0 | 0 | 0 | 5 | 18 | 0 | 0 | 0 | 0 | 0 |
| Champsodontidae | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 8 | 7 | 0 |
| Scombridae | | | | | | | | | | |
| Tuna | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Rastrelliger* spp. | 0 | 0 | 0 | 5 | 0 | 0 | 15 | 0 | 0 | 0 |
| Platycephalidae | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 |
| Lethrinidae | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 7 | 0 |
| Scorpaenidae | 0 | 6 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Minous sp. | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 |
| Teraponidae | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 |
| Aploactinidae | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 |
| Scorpaeniformes | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 |
| Muraenesocidae | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 |
| Ophichthidae | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 |
| Sphyraenidae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| Labridae | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Diodontidae | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Antenariidae | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Congiopodidae | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unidentified larvae | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 8 | 7 | 0 |
| Damaged larvae | 0 | 0 | 23 | 14 | 0 | 0 | 15 | 24 | 7 | 0 |
| Total larvae | 0 | 142 | 136 | 348 | 249 | 413 | 783 | 620 | 254 | 74 |
| Total eggs | 11 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 |

# SPECIES COMPOSITION AND DISTRIBUTION IN THE CAMBODIAN WATER

By

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# SPECIES COMPOSITION AND DISTRIBUTION OF PHYTOPLANKTON IN THE CAMBODIAN WATER

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## Abstract

Thirty-eight samples of phytoplankton were collected from 11 stations in Cambodian water during 18-26 November 2005 to examine species composition and distribution of phytoplankton. A total of 210 species were identified, consisting of 2 species of blue-green algae, 121 species of diatoms, 54 species of dinoflagellates and 1 genus of silicoflagellate. The population density of phytoplankton was relatively high below the sea surface and the highest density was 13,003 cells/L found at the 20-m deep offshore station. The common species found were *Thalassionema frauenfeldii, Oscillatoria erythraea* and *Coscinodiscus radiatus,* with *Thalassionema frauenfeldii* predominating almost the entire study area. Toxic species of phytoplankton were present in low cell densities.

**Key words :** phytoplankton, South China sea, Cambodian water

## Introduction

The phytoplankton investigation in the South China Sea has been conducted since 1995 as a part of the Interdepartmental Collaborative Program. The areas studied were Area I: The Gulf of Thailand and east coast of Peninsular Malaysia, Area II: Sabah, Sarawak and Brunei Darussalam, Area III: the western Philippines, and Area IV : Vietnamese waters ( Boonyapiwat, 1999a, 1999b, 2000, 2001). The Cambodia water is a part of the Gulf of Thailand, however it was not previously included in the AreaI (Boonyaptwat, 1999a). Thus the present survey would fulfill the phytoplankton studies for the whole Gulf of Thailand and the South China Sea.

The information on phytoplankton in Cambodian water has been very scanty. The earliest observation near this area was in Koh Chang reported by Schmidt (1901) and Ostenfeld (1902). Thus, this study was specific for Cambodian water and the results of this investigation will be beneficial for marine fisheries and marine ecosystem of Cambodia, Thailand and neighboring countries.

The purpose of this study is to identify phytoplankton species and describe their distribution in Cambodian water.

## Materials and Methods

The sampling for phytoplankton survey was carried out on board M.V. SEAFDEC 2 during 18-26 November, 2005. The samples were collected from 11 stations in Cambodian water (Fig.1) with sea depth ranging from 30 to 69 m. The Van Dorn water sampler was used to take 38 samples at 15-20 m intervals from surface to near bottom. Each water sample containing 30-40 liters was filtered through

20 m-mesh phytoplankton net and preserved with 1-2 % formalin immediately. The samples were concentrated by sedimentation. Cell count and identification were made using a small counting slide (0.25 ml) under a compound microscope fitted with a phase contrast device. The species difficult to be identified were examined with an electron microscope. Filament count was done for blue-green algae.

The sampling stations for vertical distribution studies were set along two transect. The transect 1 were the offshore stations situated north to south (St 3, 4,10 & 11) and transect 2 started from offshore to near shore including St 4,5,6 &7 (Fig. 1).

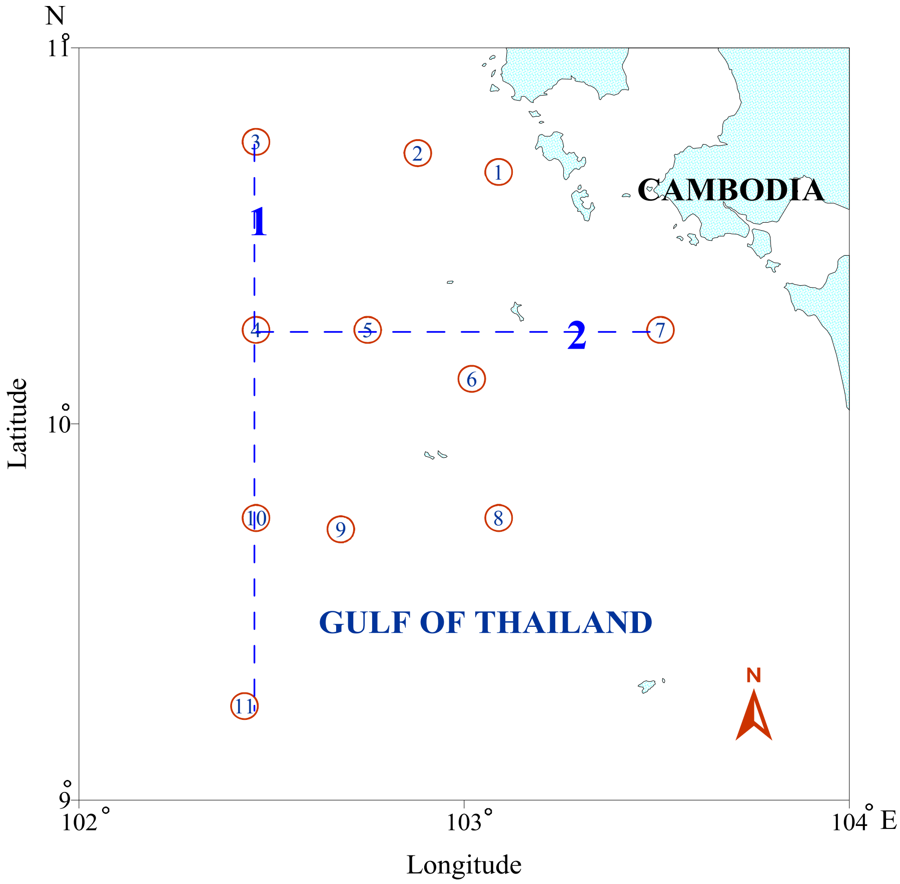


**Figure 1.** Location of sampling stations
- - - - - - Transect for vertical section studies

## Results

### Identification

A total of 210 taxa, composed of 2 genera, 2 species of blue-green alga, 54 genera, 121 species of diatoms, 23 genera, 54 species of dinoflagellates and 1 genus of silicoflagellate, were identified from 38 samples at 11 stations., The taxonomic list is given along with the occurrence at each station as shown in Table 1.

**Distribution and abundance**

The vertical distribution shows that the phytoplankton density was relatively high in sub-surface water except St 9. The highest density was 13,003 cells/L found at 20 m depth at St 9, while the lowest with a cell count of 2,243 cells/L was observed in surface water at St 6 (Table 2). In the surface layer, phytoplankton density was low at the eastern part of the study area near the Cambodian coast. The population density was high at offshore stations. Fig. 2 shows the distinct lowest density area existing closely to the highest density area offshore.

The vertical distribution of phytoplankton of offshore stations along the transect 1 is shown in Fig. 3. The phytoplankton density in northern part of the study area was low. The highest density with the cell count of 10,402 cells/L occurred near the bottom at St 10. Fig. 4 shows the vertical distribution of phytoplankton from offshore to coastal stations along the transect 2. The vertical distribution of phytoplankton density exhibits a multi-layer but irregular pattern along the transect. The density near the bottom was persistently high with the highest at 12,379 cells/L found at St 7.

**Dominant species**

Among 38 samples, *Thalassionema frauenfeldii*, *Oscillatoria erythraea* and *Coscinodiscus radiatus* was dominant in 28, 9 and 1 samples, respectively. The relative abundance was in the range of 12.14- 57.64 % (Table 2). *Thalassionema frauenfeldii* distributed predominantly from surface to the bottom almost throughout the study area. *Oscillatoria erythraea* was dominant in the coastal area (St 1&2) and offshore area (St 11). *Coscinodiscus radiatus* occurred as dominant species at the bottom of the offshore station (St 11). However, no distinct bloom of phytoplankton occurred during this period of survey.

**Occurrence of toxic species**

The phytoplankton species considered to be toxic occurred in low cell densities. *Alexandrium* is a genus of dinoflagellate selected for study on its distribution (Fig. 5). *Alexandrium* spp. was observed in the range of 18-309 cells/L with highest cell count occurring near the bottom of St 2 (coastal area).

## Discussion and Conclusion

The number of phytoplankton species found in the present study was lower than those in Thai waters of the Gulf of Thailand as reported by Boonyapiwat (1999a), which covered a larger observation area in Thai waters. The other reason for its low number was that the samples were collected in November during the northeast monsoon, which affected phytoplankton distribution, especially in the surface water layer. Low density of phytoplankton near coastal area in the eastern part may have been caused by rainfall and its runoff from the land. This water mass flowed towards offshore approaching high density area.

It is evident that the phytoplankton density was higher near the bottom. Snidvongs (1998) noted that the phytoplankton population in the main body of the Gulf is most abundant at the sub-pycnocline chlorophyll maxima which is usually 40-60 m below the surface. Boonyapiwat (1999a) revealed that *Thalassionema frauenfeldii* occurred predominantly at the east coast of the Gulf of Thailand where the sampling stations were adjacent to those of the present study. It seems that little change in phytoplankton has occurred for the last 10 years.

For toxic dinoflagellate, the density of *Alexandrium* spp. was higher in the studied area than other areas in the South China Sea as reported by Boonyapiwat (1999a, 1999b, 2000, 2001). However, *Alexandrium* can either to be toxic or non-toxic depending on its locality (Balech, 1995).

It is concluded that the phytoplankton density in Cambodian water during November 2005 was relatively higher near the bottom. The density in the surface layer in the coastal area was low, which might be caused by the rainfall and its runoff water. *Thalassionema frauenfeldii* was the main dominant species and the toxic dinoflagellates were found in low densities.

## Acknowledgement

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| Species | Stations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| **Division Cyanophyta** | | | | | | | | | | | |
| **Class Cyanophyceae** | | | | | | | | | | | |
| **(Blue-green algae)** | | | | | | | | | | | |
| *Calothrix crustacea* | - | - | - | x | - | - | - | - | - | x | x |
| *Oscillatoria erythraea* | x | x | x | x | x | x | x | x | x | x | x |
| **Division Chromophyta** | | | | | | | | | | | |
| **Class Bacillariophyceae** | | | | | | | | | | | |
| **( Diatom )** | | | | | | | | | | | |
| *Actinocyclus* spp. | x | x | x | x | - | x | x | x | x | x | x |
| *Actinoptychus senarius* | x | - | - | - | - | - | - | - | - | x | - |
| *Actinoptychus* spp. | - | - | - | - | - | x | - | - | x | - | - |
| *Asteromphalus flabellatus* | - | - | - | - | - | - | - | x | - | - | - |
| *A. heptactis* | x | - | x | - | - | - | x | - | x | - | - |
| *Azpeitia nodulifera* | x | x | x | x | - | x | x | x | x | x | x |
| *Bacillaria paxillifera* | x | - | - | x | x | x | x | - | x | x | x |
| *Bacteriastrum comosum* | x | x | x | x | x | - | - | x | x | x | x |
| *B. delicatulum* | x | x | x | x | x | x | x | x | x | x | x |
| *B. furcatum* | - | - | x | x | x | - | - | - | x | - | x |
| *B. mediterraneum* | - | - | - | - | - | - | - | x | - | - | - |
| *B. minus* | x | - | - | - | - | - | - | - | - | - | - |
| *Campylodiscus* spp. | x | - | - | - | - | - | - | - | x | - | x |
| *Campylosira* spp. | - | - | x | - | - | - | - | - | - | - | - |
| *Cerataulina bicornis* | x | - | - | - | - | - | - | x | x | - | - |
| *C. pelagica* | - | - | x | - | - | - | - | x | x | - | - |
| *Chaetoceros aequatorialis* | - | x | x | - | - | - | x | - | - | x | x |
| *C. affinis* | x | - | x | x | x | x | x | x | x | x | x |
| *C. atlanticus* | - | - | - | x | - | - | - | - | - | - | - |
| *C. brevis* | - | - | - | - | - | - | - | - | x | - | - |
| *C. coarctatus* | x | - | x | x | - | x | x | - | x | x | - |
| *C. compressus* | x | x | x | x | - | - | - | x | x | x | x |
| *C. costatus* | - | - | x | - | - | - | - | - | - | - | - |
| *C. curvisetus* | x | - | - | - | - | - | - | - | - | x | - |
| *C. dadayi* | - | x | - | - | - | - | - | - | - | - | - |
| *C. danicus* | - | - | - | - | - | - | - | - | - | x | - |
| *C. decipiens* | - | - | x | - | - | - | - | - | x | - | x |
| *C. densus* | - | - | - | - | - | - | - | - | - | x | - |
| *C. denticulatus* | - | - | - | x | - | - | - | x | - | - | - |
| *C. diadema* | - | - | - | - | - | - | - | - | - | x | x |
| *C. dichaeta* | - | - | - | x | - | - | - | - | - | - | - |
| *C. didymus* | - | - | - | - | - | x | - | x | x | - | x |
| *C. diversus* | - | - | - | x | x | x | x | x | x | - | - |
| *C. holsaticus* | - | - | x | - | - | - | - | - | - | - | - |

**Table. 1 (Cont.)**

| Species | Stations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| *Chaetoceros laciniosus* | x | - | x | - | - | - | - | - | x | x | - |
| *C. laevis* | x | x | x | - | - | - | x | x | x | - | - |
| *C. lorenzianus* | x | x | x | x | x | x | - | x | x | x | x |
| *C. messanensis* | - | - | x | x | - | x | - | x | x | x | - |
| *C. paradoxus* | x | - | - | - | x | - | x | x | x | x | - |
| *C. peruvianus* | x | x | x | x | x | x | x | x | x | x | x |
| *C. pseudocurvisetus* | x | - | - | - | - | - | x | x | - | - | - |
| *C. pseudodichaeta* | x | - | - | x | x | x | - | x | x | x | - |
| *C. rostratus* | - | - | - | - | - | - | - | - | - | x | - |
| *C. socialis* | - | - | - | - | - | - | - | x | - | - | - |
| *C. subtilis* | - | - | - | - | - | - | - | - | - | - | x |
| *C. tetrastichon* | - | - | - | x | x | x | x | - | x | x | x |
| *C. weissflogii* | - | x | - | - | - | - | - | - | x | - | - |
| *Chaetoceros* spp. | x | x | x | x | x | x | x | x | x | x | x |
| *Climacodium biconcavum* | x | x | - | x | x | - | - | - | x | x | x |
| *C. frauenfeldianum* | - | - | x | - | - | - | - | - | - | x | - |
| *C. membranacea* | - | - | - | - | - | - | - | - | - | x | x |
| *Corethron hystrix* | x | - | x | - | x | - | - | - | - | x | - |
| *Corethron* sp. | - | - | - | x | - | - | x | - | x | x | - |
| *Coscinodiscus asteromphalus* | x | - | - | - | - | - | - | - | - | - | - |
| *C. centralis* | - | - | - | - | - | x | - | - | x | x | x |
| *C. concinniformis* | x | - | - | - | x | - | x | - | x | - | x |
| *C. jonesianus* | x | - | x | - | x | x | x | x | x | x | x |
| *C. perforatus* | x | - | - | x | - | x | x | x | x | - | x |
| *C. radiatus* | x | - | - | - | x | - | x | - | - | x | x |
| *Coscinodiscus* spp. | x | - | - | x | x | x | - | - | x | x | x |
| *Cyclotella* spp. | x | - | - | - | - | - | x | x | - | - | x |
| *Cylindrotheca closterium* | - | - | - | x | - | - | x | - | x | - | x |
| *Dactyliosolen antarcticus* | - | - | - | - | - | - | - | - | - | x | - |
| *D. blavyanus* | x | x | x | x | x | x | - | x | x | x | x |
| *D. phuketensis* | x | - | - | x | - | - | x | - | - | - | - |
| *Detonula pumila* | x | - | - | x | x | - | - | - | x | x | - |
| *Diploneis* sp. | - | x | - | - | - | - | x | - | x | - | - |
| *Ditylum sol* | x | - | - | x | x | x | x | x | x | x | - |
| *Entomoneis* spp. | x | - | - | x | x | x | - | x | x | x | - |
| *Eucampia cornuta* | x | - | - | - | - | - | - | - | - | - | - |
| *E. zodiacus* | x | - | - | - | - | x | x | - | - | - | - |
| *Fragilariopsis oceanica* | - | - | - | - | - | - | - | - | x | - | - |
| *Fragillaria striatula* | - | - | - | - | - | - | - | - | - | x | x |
| *Fragillaria* spp. | - | x | x | x | x | - | - | - | - | - | x |
| *Gossleriella tropica* | x | - | - | - | x | - | - | - | x | x | - |
| *Guinardia cylindrus* | - | - | - | - | - | - | - | - | - | x | x |
| *G. delicatula* | - | - | - | - | - | - | x | - | - | - | - |
| *G. flaccida* | x | - | - | - | - | - | x | - | - | - | - |

**Table. 1 (Cont.)**

| Species | Stations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| *Guinardia striata* | - | - | x | x | - | - | - | - | x | x | x |
| *Haslea gigantea* | - | - | - | - | - | - | x | - | x | - | - |
| *H. wawrikae* | x | - | x | x | - | - | - | - | x | x | x |
| *Haslea* spp. | - | x | - | - | x | - | - | - | - | - | - |
| *Hemiaulus hauckii* | - | - | - | - | - | - | - | - | x | - | x |
| *H. indicus* | x | - | - | - | - | - | - | - | - | - | x |
| *H. membranacea* | x | x | - | - | - | - | x | - | x | - | - |
| *H. sinensis* | x | - | x | x | - | - | - | - | x | x | x |
| *Hemidiscus cuneiformis* | x | - | - | - | - | - | x | x | - | - | - |
| *Lauderia annulata* | x | - | x | - | - | - | x | x | - | x | x |
| *Leptocylindrus danicus* | x | x | - | x | - | - | x | - | x | - | x |
| *L. mediterraneus* | - | - | x | x | x | - | - | - | x | x | x |
| *Licmophora gracilis* | - | - | - | - | - | - | - | - | x | - | - |
| *Lioloma delicatulum* | x | x | x | - | - | - | - | - | x | - | - |
| *Melosira nummuloides* | x | - | - | - | - | - | - | - | x | - | - |
| *Meuniera membranacea* | - | - | - | - | - | - | - | x | - | x | - |
| *Navicula distans* | x | - | - | - | - | x | - | - | - | - | - |
| *N. transitrans* | - | - | - | - | - | x | - | - | - | - | - |
| *Navicula* spp. | - | - | - | - | x | x | x | x | x | x | x |
| *Nitzschia frigida* | - | - | - | - | - | - | x | x | - | - | x |
| *N. longissima* | - | - | - | - | - | - | - | - | x | x | x |
| *Nitzschia* spp. | - | - | x | - | - | x | x | - | x | - | x |
| *Odontella mobiliensis* | - | - | - | - | x | x | x | x | - | x | - |
| *O. sinensis* | x | x | x | x | x | x | x | x | - | x | - |
| *Palmeria hardmaniana* | - | - | - | x | - | x | - | - | - | x | - |
| *Paralia sulcata* | - | - | - | - | - | - | x | - | - | - | x |
| *Pauliella taeniata* | - | - | - | - | - | - | - | - | - | - | x |
| *Planktoniella blanda* | x | - | - | x | x | x | x | x | x | x | - |
| *P. sol* | x | - | - | - | x | - | - | - | x | - | - |
| *Pleurosigma* spp. | x | - | - | x | x | x | x | x | x | x | x |
| *Proboscia alata* | x | x | x | x | x | x | x | x | x | x | x |
| *Pseudoguinardia recta* | x | - | - | x | - | - | - | - | - | - | - |
| *Pseudo-nitzschia pseudodelicatissima* | - | - | - | x | - | - | - | - | - | - | x |
| *P. pungens* | - | - | - | x | - | - | - | - | x | - | x |
| *Pseudosolenia calcar-avis* | x | x | x | x | x | x | - | x | x | x | x |
| *Rhizosolenia acuminata* | x | - | - | - | - | - | - | - | - | - | x |
| *R. bergonii* | x | - | x | - | - | - | - | - | x | - | x |
| *R. castracanei* | - | - | - | - | - | - | - | - | - | - | x |
| *R. clevei* | - | - | - | - | - | - | - | - | - | - | x |
| *R. debyana* | - | - | - | - | - | - | - | - | - | - | x |
| *R. fallax* | x | - | - | - | - | - | - | - | - | - | - |
| *R. formosa* | - | x | - | - | - | - | x | x | x | x | x |
| *R. hebetata* | - | - | - | - | - | - | - | - | - | x | - |
| *R. hyalina* | - | - | - | - | - | - | - | - | - | x | - |

**Table. 1 (Cont.)**

| Species | Stations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| *Rhizosolenia imbricata* | x | - | x | - | - | x | x | x | x | x | x |
| *R. robusta* | x | x | - | - | x | x | x | x | - | - | - |
| *R. setigara* | - | - | x | - | x | - | x | x | x | - | - |
| *R. shrubsolei* | - | - | - | - | - | - | - | - | - | - | x |
| *R. styliformis* | - | - | - | x | - | - | - | - | - | x | x |
| *Skeletonema costatum* | x | - | - | x | - | - | - | - | x | - | - |
| *Stephanopyxis palmeriana* | - | - | - | - | - | - | - | - | x | - | - |
| *Striatella unipunctata* | - | - | - | - | - | - | - | - | - | x | - |
| *Surirella* spp. | - | - | - | - | - | - | - | x | - | - | - |
| *Thalassionema frauenfeldii* | x | x | x | x | x | x | x | x | x | x | x |
| *T. nitzschioides* | x | x | x | x | x | x | x | x | x | x | x |
| *Thalassiosira anguste-lineata* | x | - | - | - | - | - | - | x | - | - | - |
| *T. bingensis* | x | - | - | - | - | - | - | - | - | - | - |
| *T. dipporocyclus* | - | - | - | - | - | - | - | x | - | - | - |
| *T. eccentrica* | x | x | - | x | - | - | - | x | x | x | - |
| *T. oestrupii* | x | - | - | - | - | - | - | - | - | - | - |
| *T. subtilis* | x | - | - | - | - | - | - | - | - | x | x |
| *Thalassiosira* spp. | x | x | x | x | x | x | x | x | x | x | x |
| *Thalassiothrix longissima* | - | - | x | x | - | - | - | x | - | x | - |
| *Triceratium* spp. | - | - | - | - | - | - | x | - | - | - | - |
| Pennate Diatom | x | - | x | - | - | - | - | - | - | - | - |
| **Class Dinophyceae** | | | | | | | | | | | |
| **(Dinoflagellate)** | | | | | | | | | | | |
| *Alexandrium tamiyavanichi* | - | x | - | - | - | - | x | - | - | - | - |
| *Alexandrium* spp. | x | x | x | - | - | - | - | x | x | x | x |
| *Amphisolenia bidentata* | - | - | x | - | - | - | - | - | - | x | - |
| *A. schauinslandi* | - | - | - | - | - | - | - | - | - | x | - |
| *Ceratium breve* | x | - | - | - | - | - | x | - | - | - | - |
| *C. contortum* | - | - | - | - | - | - | - | - | - | - | x |
| *C. deflexum* | x | - | x | - | - | - | - | - | - | - | - |
| *C. furca* | - | - | - | - | - | x | x | - | - | - | - |
| *C. fusus* | x | - | x | x | - | - | - | - | - | x | x |
| *C. gibberum* | - | - | - | x | - | - | - | - | - | - | - |
| *C. hexacanthum* | - | x | - | - | - | - | - | - | - | - | - |
| *C. horridum* | - | - | - | x | - | - | - | - | x | - | - |
| *C. kofoidii* | - | - | x | - | - | - | - | - | x | - | - |
| *C. macroceros* | x | x | - | x | - | - | x | - | - | - | - |
| *C. massiliense* | x | - | - | x | - | - | - | x | - | - | x |
| *C. trichoceros* | x | - | x | x | - | x | - | - | x | x | x |
| *C. tripos* | x | - | - | x | x | - | - | - | - | x | - |
| *Ceratocorys horrida* | - | - | - | - | - | - | - | x | - | - | - |
| *Corythodinium tesselatum* | - | - | - | - | - | - | - | - | - | x | - |
| *Dinophysis miles* | x | - | - | x | - | x | x | - | x | - | - |
| *Dinophysis* spp. | - | x | - | - | - | - | - | - | - | - | - |

**Table. 1 (Cont.)**

| Species | Stations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| *Diplopsalis lenticulata* | - | x | - | - | - | - | - | - | - | - | - |
| *Diplopsalis* spp. | - | x | - | - | - | - | - | - | - | - | - |
| *Fragilidium* spp. | - | x | - | x | - | - | - | - | - | - | - |
| *Goniodoma polyedricum* | x | x | - | - | - | - | - | - | x | - | - |
| *Gonyaulax digitale* | - | - | - | - | - | - | - | - | - | - | x |
| *G. fragilis* | - | - | - | - | - | - | - | - | - | x | - |
| *G. grindleyi* | - | - | - | x | - | - | - | - | - | - | - |
| *G. hyalina* | - | - | - | - | - | - | - | - | - | x | x |
| *G. polygramma* | x | - | - | - | - | x | - | - | - | - | - |
| *G. spinifera* | - | - | - | - | - | - | x | - | - | - | - |
| *Gonyaulax* spp. | - | x | - | x | - | - | - | - | x | x | x |
| *Gymnodinium* spp. | x | x | x | x | x | x | - | - | x | x | x |
| *Noctiluca scintillans* | - | x | - | - | x | - | - | - | - | - | - |
| *Ornithocercus magnificus* | x | - | x | - | - | - | - | - | x | x | - |
| *Oxytoxum scolopax* | - | - | - | x | - | - | - | - | - | - | - |
| *Phalacroma rotundatum* | - | - | - | x | - | - | - | - | - | - | - |
| *Podolampas bipes* | - | - | - | - | - | - | - | - | - | x | - |
| *P. elegans* | - | - | - | - | - | - | - | - | - | - | x |
| *P. palmipes* | - | - | x | x | - | - | - | - | x | - | - |
| *P. spinifera* | - | - | - | - | - | - | - | - | - | - | x |
| *Pronoctiluca* spp. | x | - | - | - | - | - | - | - | - | - | - |
| *Prorocentrum compressum* | - | x | - | - | x | - | - | - | - | - | - |
| *P. mexicanum* | - | - | - | - | - | - | - | - | - | x | - |
| *P. micans* | - | - | - | x | - | - | - | - | - | - | - |
| *P. scutellum* | - | - | - | - | - | - | - | - | - | x | - |
| *P. triestinum* | - | x | - | - | - | - | - | - | - | - | - |
| *Prorocentrum* spp. | x | - | - | - | x | - | - | x | - | - | - |
| *Protoperidinium acutipes* | - | - | - | - | - | - | - | - | - | x | - |
| *P. conicum* | - | - | - | - | - | - | - | - | - | x | - |
| *P. depressum* | x | - | x | x | - | - | - | - | x | - | - |
| *P. divergens* | - | - | - | - | - | - | - | - | - | - | x |
| *P. elegans* | - | - | - | - | - | - | - | - | - | x | - |
| *P. grande* | - | - | - | - | - | - | - | - | - | x | - |
| *P. latispinum* | x | - | - | - | - | - | - | - | x | - | - |
| *P. oceanicum* | x | - | - | - | - | - | - | - | - | - | - |
| *P. spinulosum* | x | - | - | - | - | - | - | - | - | - | - |
| *Protoperidinium* spp. | - | x | - | x | - | - | x | x | x | - | x |
| *Pyrocystis fusiformis* | - | - | - | - | - | - | - | - | - | x | - |
| *P. lunula* | - | - | - | - | - | - | x | - | - | x | - |
| *P. noctiluca* | x | - | - | x | x | - | - | x | - | x | - |
| *Pyrophacus horologium* | - | - | x | - | - | - | - | - | x | - | - |
| *Scripsiella trochoidea* | x | x | - | x | x | - | - | - | - | x | x |
| *Scripsiella* spp. | - | - | x | - | - | - | - | - | - | - | x |
| **Class Dictyochophyceae** | | | | | | | | | | | |
| **(Silicoflagelate)** | | | | | | | | | | | |
| *Dictyocha* spp. | x | - | - | x | - | - | - | - | x | - | - |

**Table 2. Phytoplankton densities and dominant species in Cambodian waters**

| Station | Sea depth (m) | Sampling depth (m) | Phyto. density (cells/L) | Dominant species | % |
|---|---|---|---|---|---|
| 1 | 30 | 5 | 5639 | *Oscillatoria erythraea* | 19.67 |
| | | 15 | 2878 | *Oscillatoria erythraea* | 43.96 |
| | | 25 | 2237 | *Oscillatoria erythraea* | 40.27 |
| | | 35 | 10854 | *Thalassionema frauenfeldii* | 12.14 |
| 2 | 39 | 5 | 4953 | *Thalassionema frauenfeldii* | 36.74 |
| | | 20 | 6354 | *Thalassionema frauenfeldii* | 19.99 |
| 3 | 63 | 5 | 3435 | *Thalassionema frauenfeldii* | 36.32 |
| | | 20 | 3606 | *Thalassionema frauenfeldii* | 42.29 |
| | | 40 | 4457 | *Thalassionema frauenfeldii* | 36.55 |
| | | 55 | 5445 | *Thalassionema frauenfeldii* | 21.64 |
| 4 | 67 | 5 | 4568 | *Thalassionema frauenfeldii* | 31.49 |
| | | 20 | 5859 | *Thalassionema frauenfeldii* | 33.42 |
| | | 40 | 2256 | *Oscillatoria erythraea* | 19.97 |
| | | 55 | 5844 | *Thalassionema frauenfeldii* | 23.13 |
| 5 | 52 | 5 | 5095 | *Thalassionema frauenfeldii* | 38.1 |
| | | 20 | 4421 | *Thalassionema frauenfeldii* | 30.58 |
| | | 40 | 10854 | *Thalassionema frauenfeldii* | 37.37 |
| 6 | 38 | 5 | 2243 | *Thalassionema frauenfeldii* | 26.27 |
| | | 20 | 3277 | *Thalassionema frauenfeldii* | 57.64 |
| | | 30 | 5773 | *Thalassionema frauenfeldii* | 23.41 |
| 7 | 34 | 5 | 3602 | *Oscillatoria erythraea* | 25.96 |
| | | 15 | 7557 | *Thalassionema frauenfeldii* | 41.05 |
| | | 30 | 12379 | *Thalassionema frauenfeldii* | 16.52 |
| 8 | 45 | 5 | 7473 | *Thalassionema frauenfeldii* | 27.13 |
| | | 20 | 11508 | *Thalassionema frauenfeldii* | 24.4 |
| | | 40 | 10612 | *Thalassionema frauenfeldii* | 20.91 |
| 9 | 60 | 5 | 8815 | *Thalassionema frauenfeldii* | 21.43 |
| | | 20 | 13003 | *Thalassionema frauenfeldii* | 24.53 |
| | | 40 | 9396 | *Thalassionema frauenfeldii* | 20.1 |
| | | 55 | 6901 | *Thalassionema frauenfeldii* | 34.65 |
| 10 | 69 | 5 | 7851 | *Thalassionema frauenfeldii* | 19.87 |
| | | 20 | 5775 | *Thalassionema frauenfeldii* | 29.51 |
| | | 40 | 5256 | *Oscillatoria erythraea* | 29.13 |
| | | 60 | 10402 | *Thalassionema frauenfeldii* | 19.83 |
| 11 | 69 | 5 | 4115 | *Oscillatoria erythraea* | 26.95 |
| | | 20 | 5096 | *Oscillatoria erythraea* | 22,78 |
| | | 40 | 5687 | *Oscillatoria erythraea* | 17.67 |
| | | 60 | 3834 | *Coscinodiscus radiatus* | 15.29 |

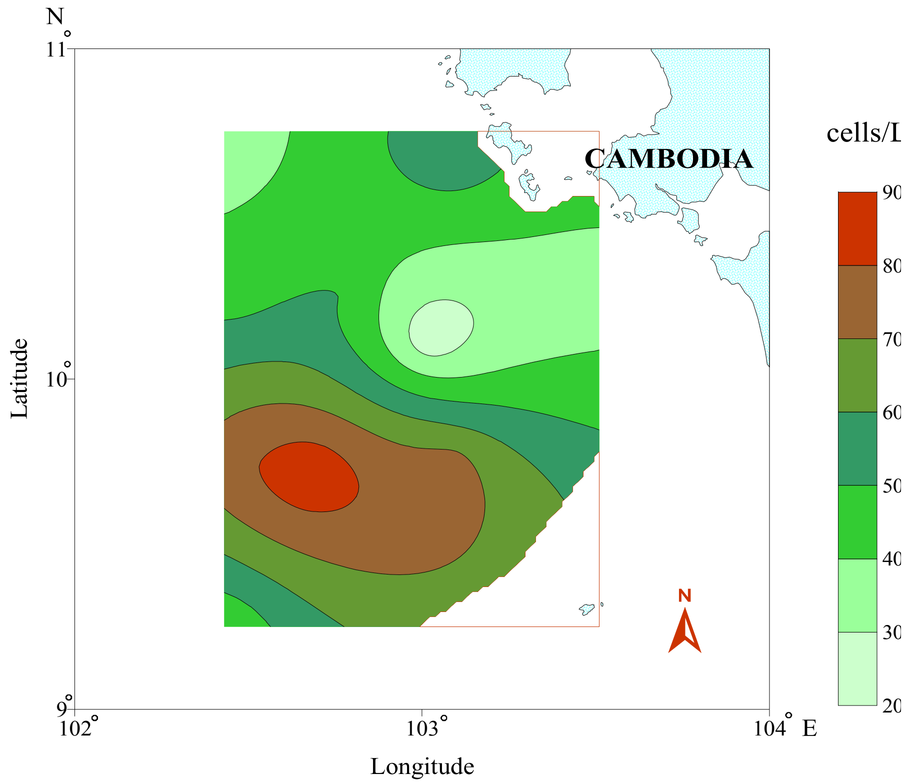


**Figure 2.** Distribution of phytoplankton in the surface layer

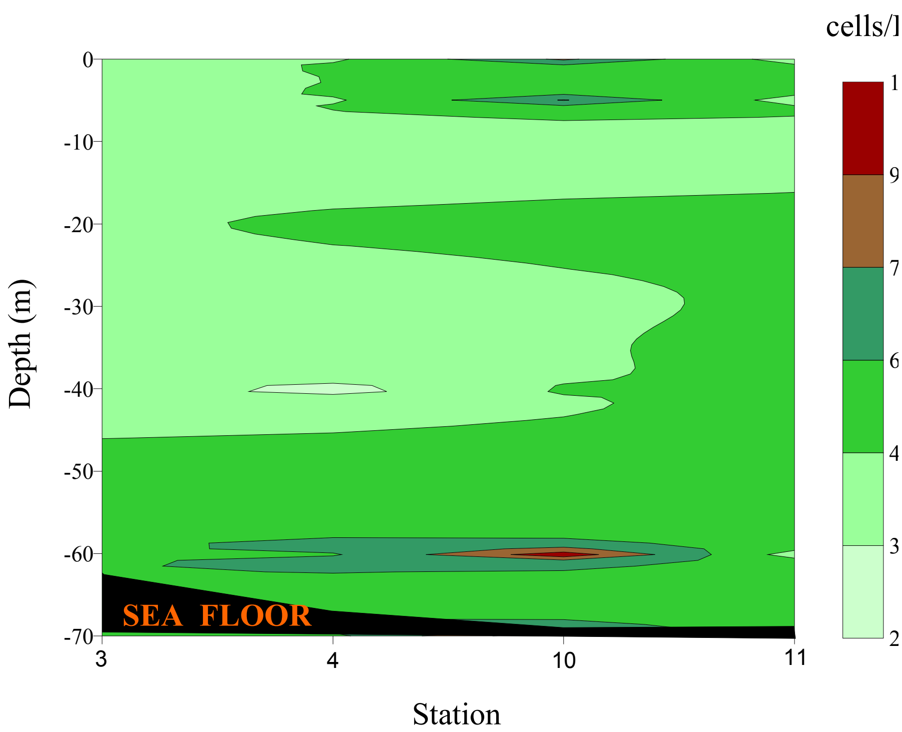


**Figure 3.** Vertical section of phytoplankton density along the transect of offshore stations (transect 1)

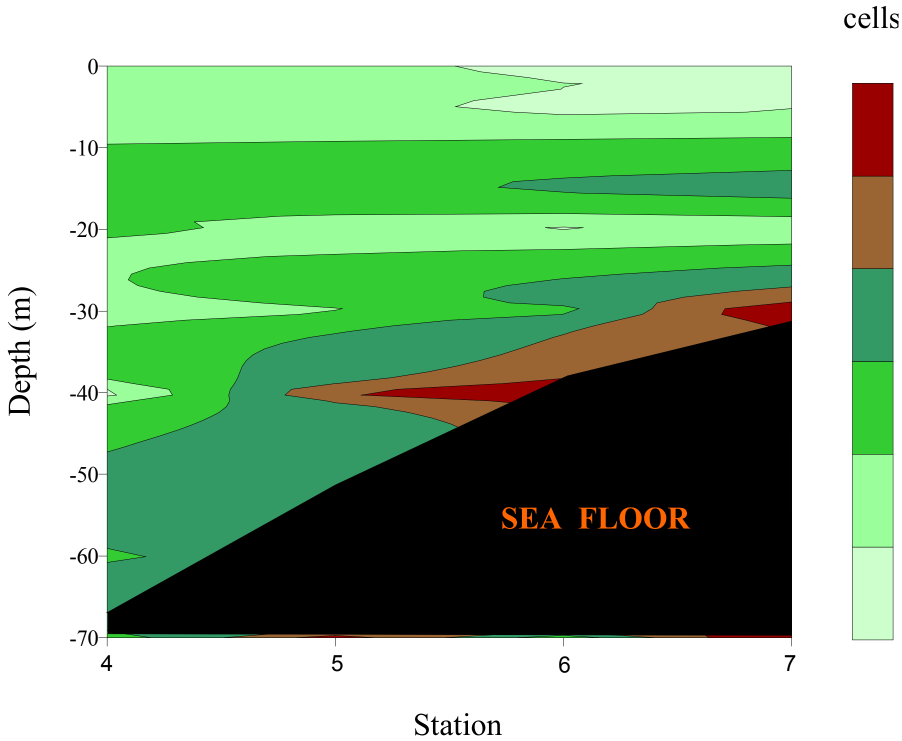


**Figure 4.** Vertical section of phytoplankton density along the transect from offshore to coastal stations (transect 2)

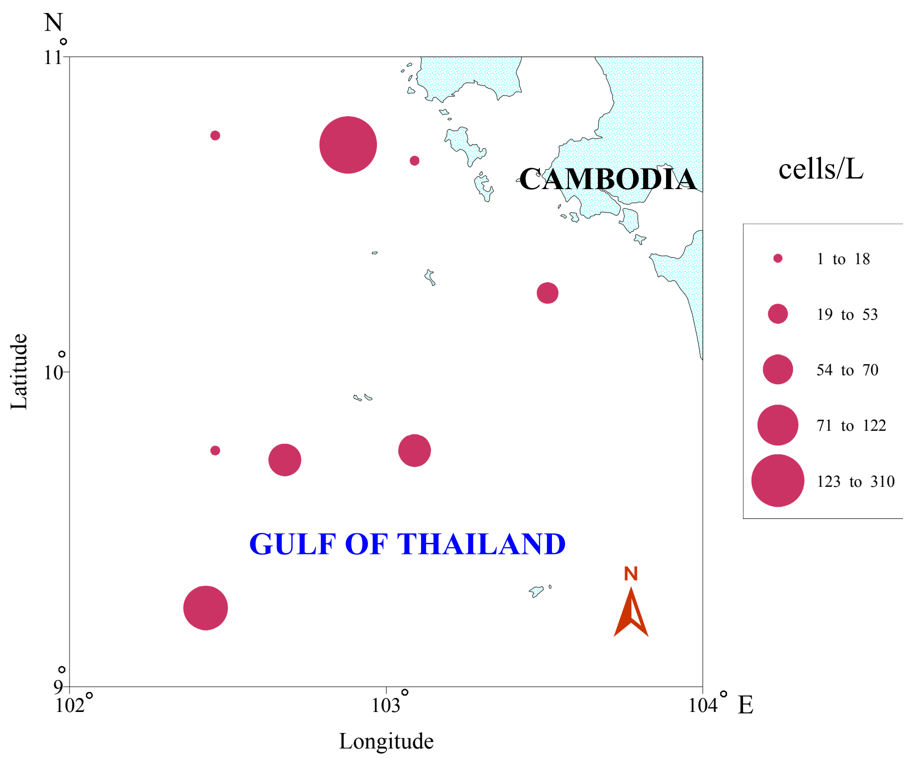


**Figure 5.** Distribution of *Alexandrium spp.*


SEAFDEC2

# WATER CHARACTERISTICS IN THE CAMBODIAN WATER

By

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Jitraporn Phaksopa

# WATER CHARACTERISTICS IN THE CAMBODIAN WATER

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## Abstract

The horizontal and vertical distributions of salinity, temperature, and density (sigma-t) were investigated at 11 stations, covering the area from 09°15 to 10°45 N and 102°27 to 103°30 E in Cambodian water during the period from 18 to 26 November, 2005. On board the ship M.V. SEAFDEC2 those parameters were measured using conductivity-temperature-depth sensor (CTD; SBE19). The results show that the 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, and it decreased again below this depth at all sampling stations, except at station 11 in the offshore area. The salinity and density profiles exhibited a similar pattern showing that both parameters were stable from surface to 15-20m depth with salinity around 30.1 psu and density at 18.3 kg/m$^3$. However, sudden changes in those parameters were observed in subsurface layer at 20 – 30 m depth, below which they became stable again with salinity at 33.7 - 33.8 psu and density 20.5 - 21.0 kg/m$^3$. At the near shore station, due to river discharge, the salinity (29.8 psu) and density (18.3 kg/m$^3$) were less than that at offshore station with salinity at 30.5 psu and density 18.75 kg/m$^3$. Additionally, it was also found that the density distribution was more closely related to salinity distribution than to temperature distribution. Therefore, it can be concluded that water density depends chiefly on salinity and less on temperature in Cambodian water.

**Key words:** salinity distribution, density distribution, temperature distribution, Cambodian water and weak upwelling

## Introduction

Most parts of Cambodian maritime territorial water (42000 km$^2$) 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 relating fish population to oceanographic environment. However, the only record available 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 document details in some characteristics of the seawater for future application.

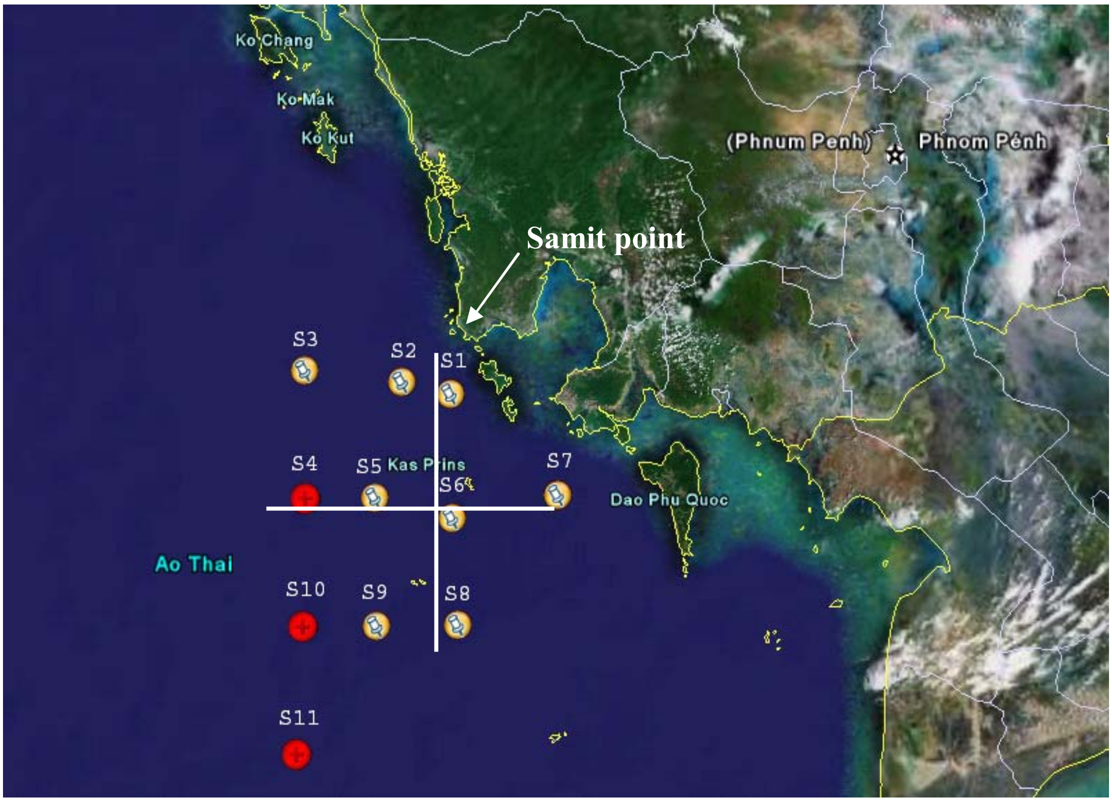


**Figure 1.** Positions of oceanographic survey in Cambodian water

## Materials and Methods

Field observations were made on-board ship M.V. SEAFDEC2 at 11 stations, covering the area from 09°15 to 10°45 N and 102°27 to 103°30 E in Cambodian territorial water **(Fig. 1)** during the period from 18 to 26 November, 2005. A CTD sensor 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 5m above the sea floor. The sensor was lowered and retrieved at a constant velocity of 0.5 m/s.

The data obtained from the survey were analyzed and used to construct vertical and horizontal distribution of each parameter. The first analysis was to plot vertical profiles of each parameter at each station; the second was 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 iso-value intervals were: temperature at 0.25 °C; salinity at 0.2 psu and density at 0.25 kg/m$^3$. Third, vertical sections were done with iso-value of temperature at 0.25 °C, salinity at 0.5 psu and density at 0.25 kg/m$^3$.

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

## Vertical profiles

The temperature profile at most stations was different from the normal pattern except St.11 with a common pattern. 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 curve indicated that the maximum temperature occurred at the depth of 20 - 30 m **(Fig. 2a)**.

The salinity and density profiles exhibited 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 18.3 kg/m$^3$, 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 20.5 - 21.0 kg/m$^3$ **(Fig. 2b)**.

## Horizontal distribution

The horizontal temperature distribution in surface and subsurface layers showed a similar pattern, but the surface temperature ranging from 29 to 29.5 C was slightly lower by approximately 0.25 C than the subsurface layer ranging from 29.25 to 29.75 C. The highest temperature was found near Samit point in northeast 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 **Fig. 3** and **Fig. 4**.

The surface salinity distribution showed a tongue-like pattern with salinity increasing from northeast to southwest. Salinity at inshore stations in the northeast was less than 29.8 psu and increased slightly in the central area to approximately 30.0 psu and to higher than 30.5 psu in the southwest area **(Fig. 5)**. But salinity distribution at 30-m depth showed a different pattern. It was found that the low saline water (< 32 psu) entered from the east and southeast of the survey area, and encountered higher saline water (> 33 psu) at the center, station 6. The prevailing salinity in the survey area ranged between 32 and 33 psu (**Fig. 6)**.

The horizontal density distribution showed a similarly pattern as that of salinity distribution in both surface and subsurface layers. The density distribution in surface water in the northeast was less than 18 kg/m$^3$ and increased to higher than 18.75 kg/m$^3$ in the southwest. The distribution at 30-m depth showed that the low density water (< 19.75 kg/m$^3$) entered the survey area from east and southeast, and increased to high density (> 20.5 kg/m$^3$) at the center, station 6; while density in most survey area was between 19 and 20 kg/m$^3$. The horizontal distribution of water density is shown in **Fig. 7** and **Fig. 8**.

## Vertical distribution

The vertical distribution of water temperature was not much different throughout the water column which temperature was 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 observation 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 the 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 of high salinity (above 33.0 psu) was only found at depth greater than 30 m.

Vertical distribution of water density is illustrated in two layers with low (<18 kg/m$^3$), and high (>21 kg/m$^3$) densities. Water of low density (<18 kg/m$^3$) was found at the near shore station in northern end of Transect 2. Water of high density (>21 kg/m$^3$) was found in deep-water area. The vertical distribution of water temperature, salinity and density in transects 1 and 2 are shown in **Fig. 9** and **Fig. 10**

## Discussion

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.

The NAGA's expedition (1960) 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, (1984) reported that mean salinity in sea surface was maximal in winter season (33.36 ppt) and minimal in autumn 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 characteristic of Cambodian water was composed of both diluted water and non-diluted water.

The diluted water covered from the surface to the depth at 20-25 m with strong dilution near the Samit point. This was probably due to the influence of river runoff by Klong Klum river and Stoeng Keb river. A similar discussion was reported by Yanangi *et. al.* (2001), who concluded 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 salinity and density in surface water to the depth of 20-25 m.

The non-diluted water occurred in subsurface layer approximately below 25 m, but it is interesting to note that the water from the east to southeast was slightly less saline **(Fig. 3, 4 and 6)**. This phenomenon was possible due to intrusion of water mass with lower salinity and temperature into Cambodian water from the South China Sea. This intrusion was also observed by other researchers who explained that in autumn 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, 1984). This fact coincides with the STATISTICS OF OCEAN CURRENT in JODC data, which shows that the currents moved from the South China Sea into the Gulf of Thailand via Cambodia during the northeast monsoon **(Fig 11)**. Rojana-anawat, (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 the South China Sea due to the high volume of inflow of river runoff and it was kept near shore by the northeast wind (Pinyoporn, 1986).

As a result of weak upwelling at station 6, the surface-water temperature was slightly lower than the subsurface layer **(Fig. 9 and 10)**. The horizontal plots of temperature and salinity indicate the occurrence of the weak upwelling caused lower temperature and higher salinity than the nearby area **(Fig. 3 and Fig. 6)**. This weak upwelling carried low temperature water to surface **(Fig. 9)** and raised the salinity (> 32.5 psu) **(Fig. 10)**.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 (Naga expedition, 1960).

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.

## Acknowledgment

I'm especially grateful to Dr. Somboon Siriraksophon and Mr. Pratakphol Prajakjitt for giving me an opportunity to work on this project. I would also, like to thank all research division staffs of SEAFDEC and crew of the M.V. SEAFDEC 2 for their assistance and support to this research survey. Lastly, I would like to thank Miss Penchan Raongmanee and Dr.Chang-Kwei Lin for useful suggestions and edition of the paper.

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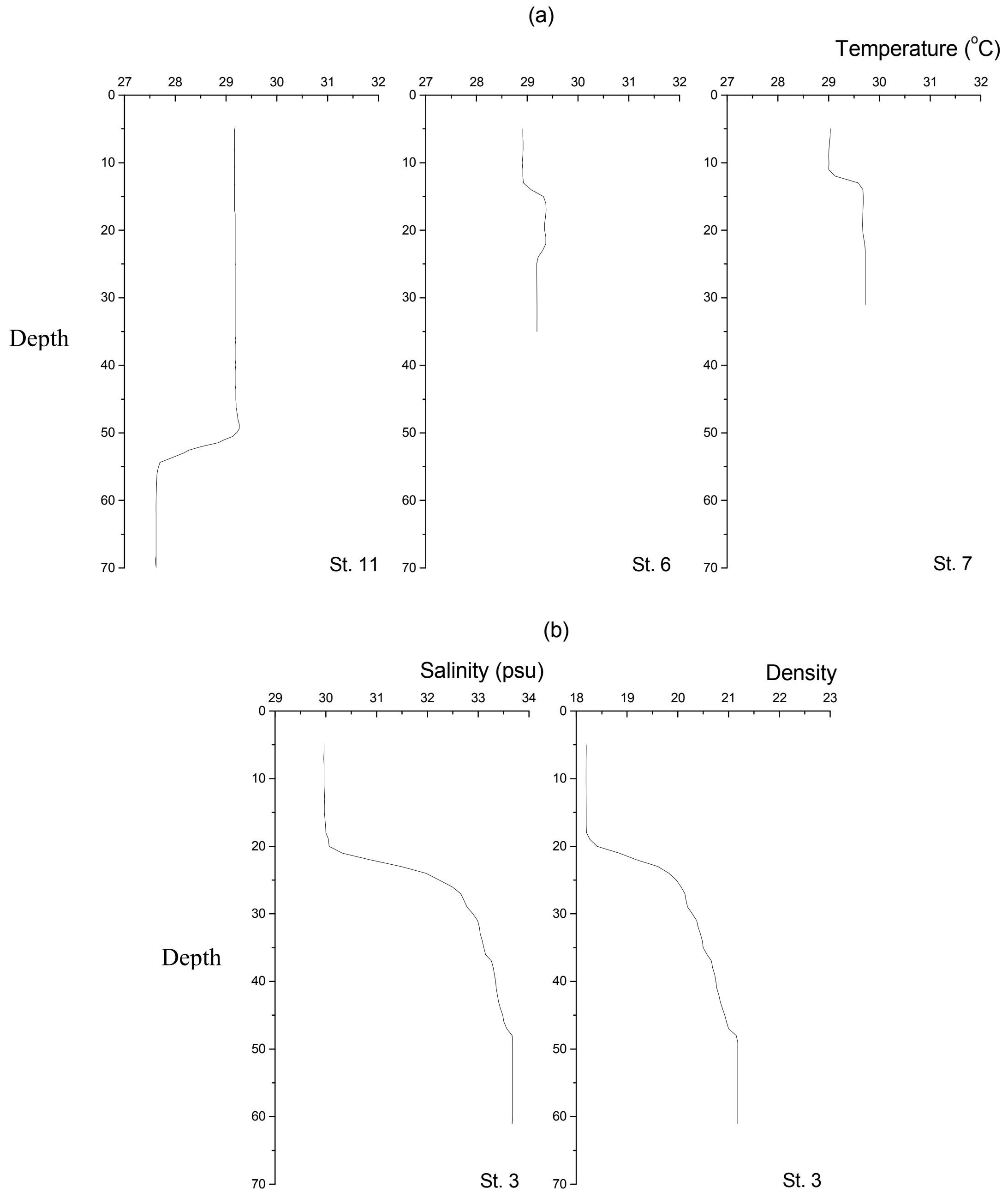



**Figure 2.** (a): Vertical profile of temperature at St. 11 (common pattern in temperature profile), St.6 and St. 7 (irregular pattern temperature profile)
(b): Vertical profile of salinity and density at St. 3

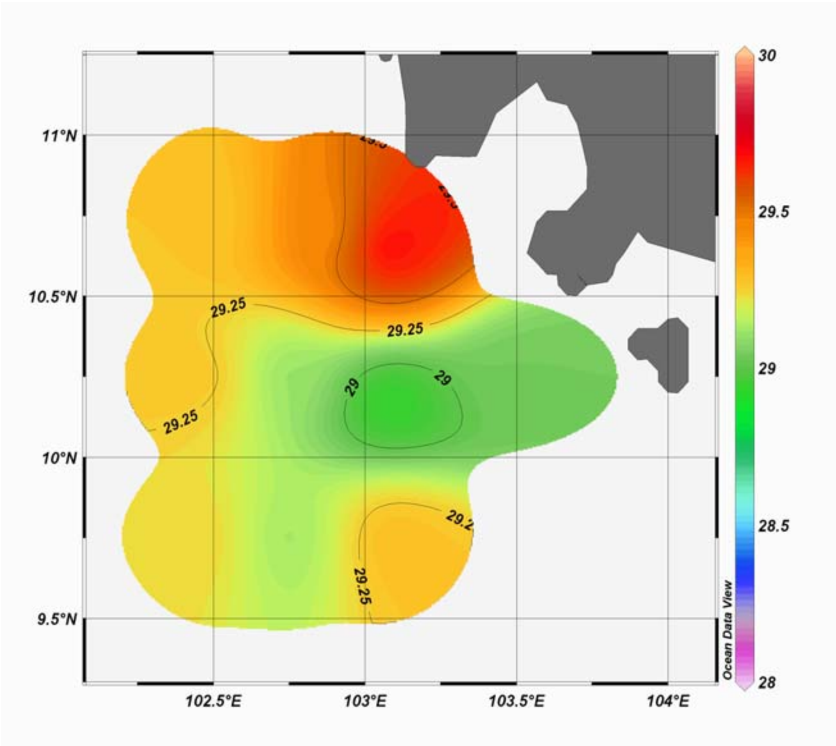



**Figure 3.** Horizontal temperature distribution at 5-m depth

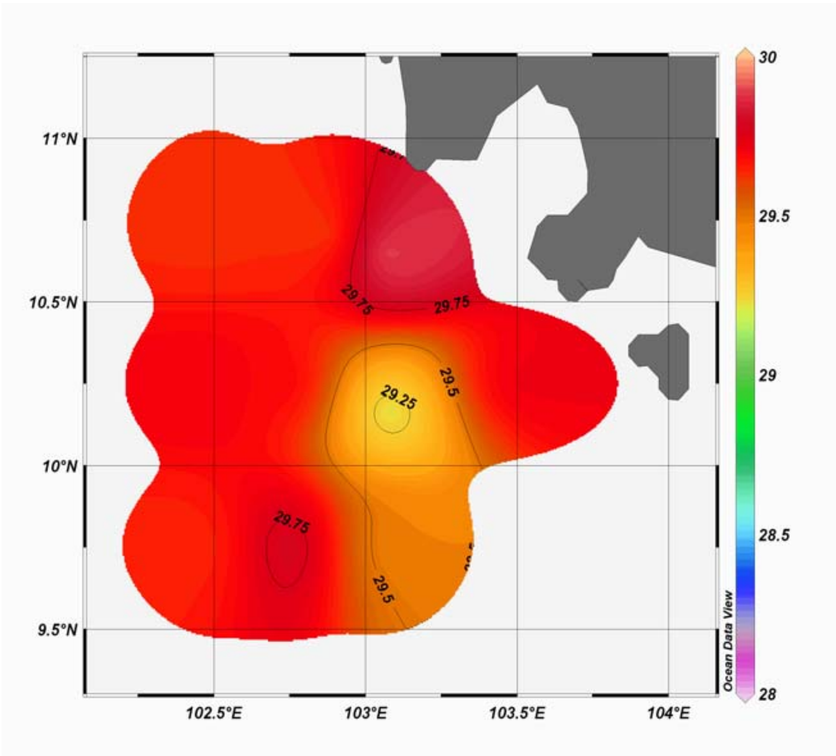



**Figure 4.** Horizontal temperature distribution at 30-m depth

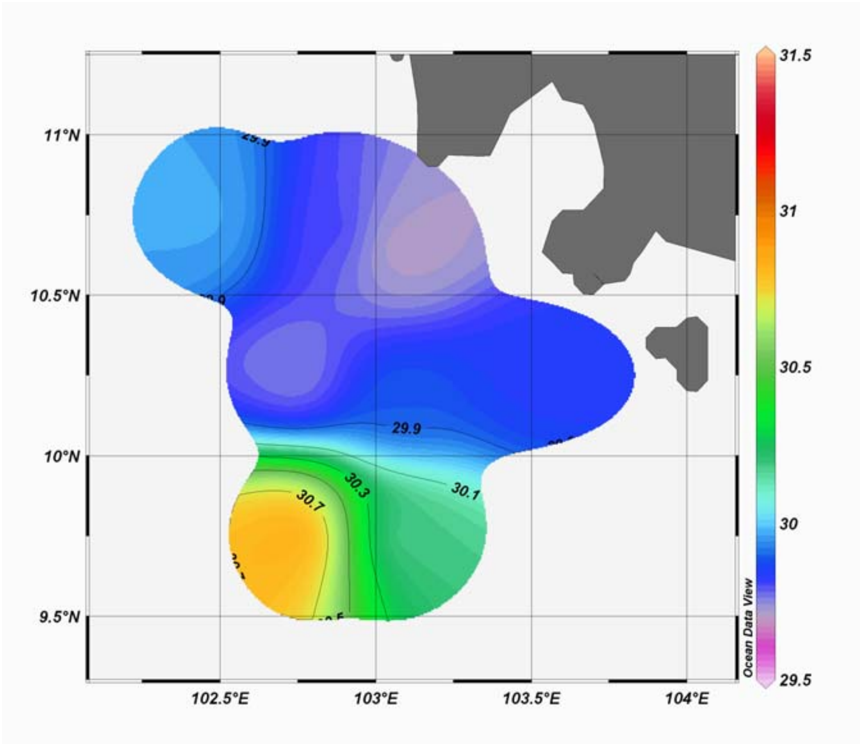



**Figure 5**. Horizontal salinity distribution at 5-m depth

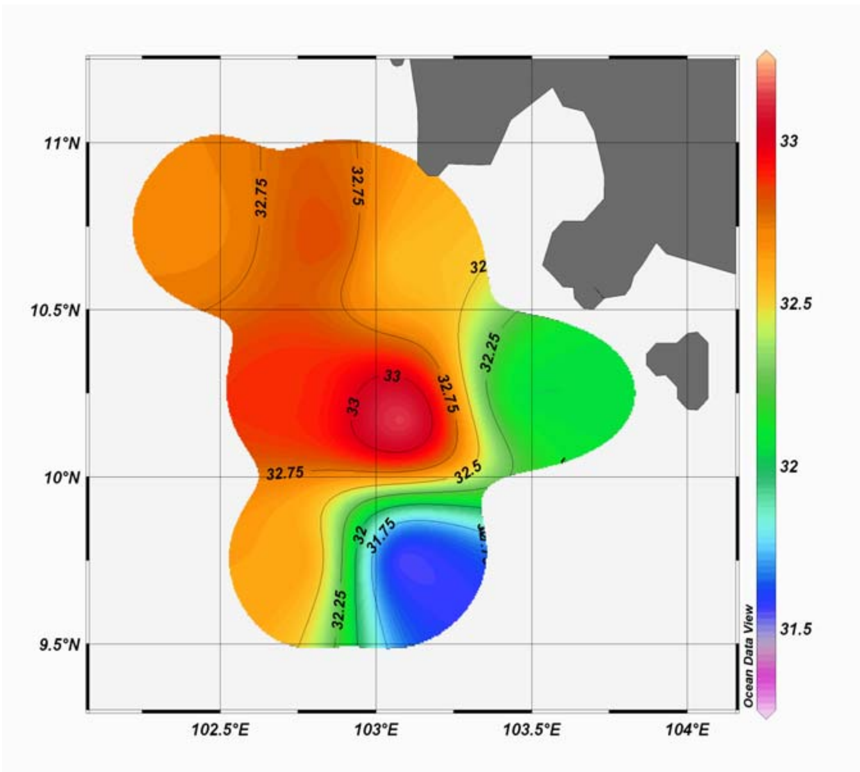



**Figure 6.** Horizontal salinity at 30 m

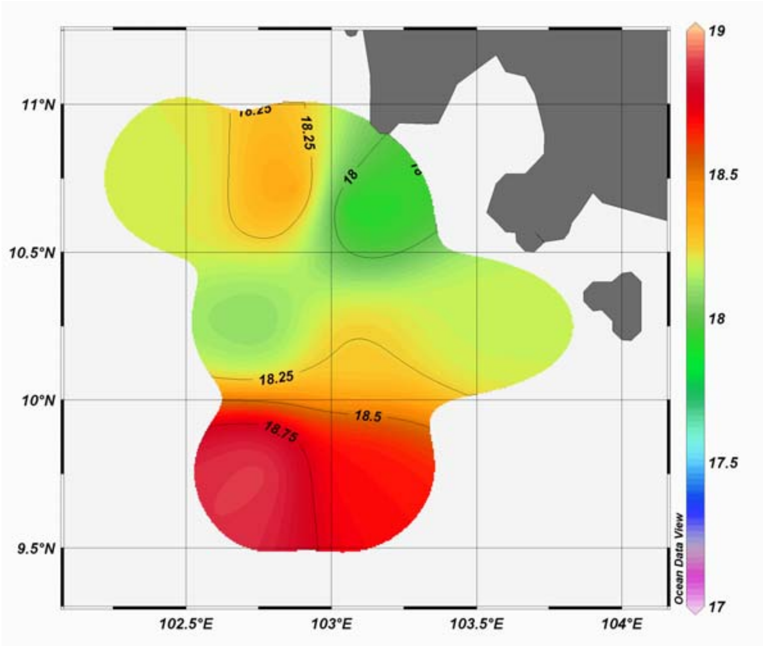



**Figure 7.** The horizontal density distribution at 5-m depth

**Figure 8.** Horizontal density distribution at 30-m depth

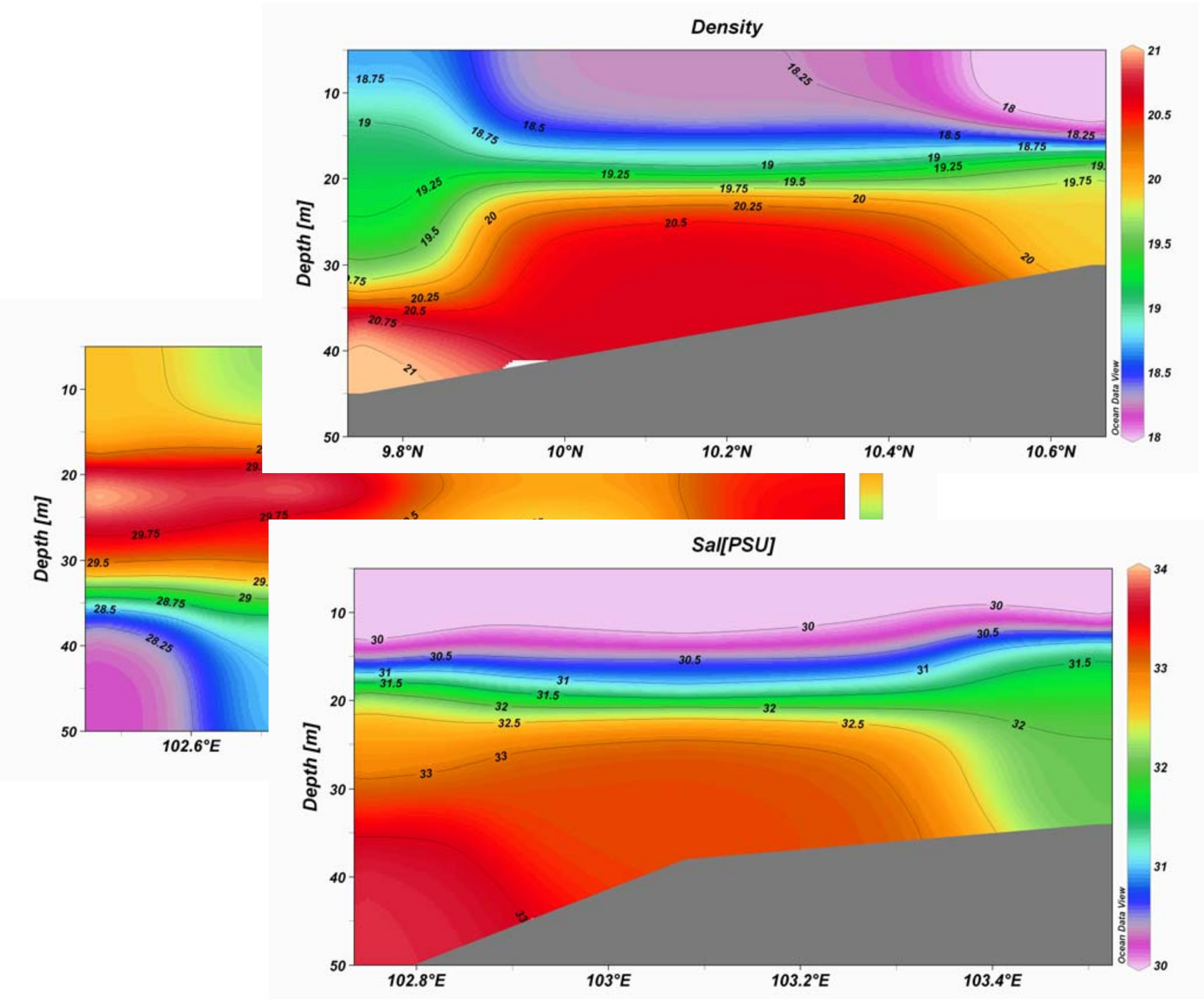



**Figure 9.** The vertical distribution of temperature, salinity and density in transact 1

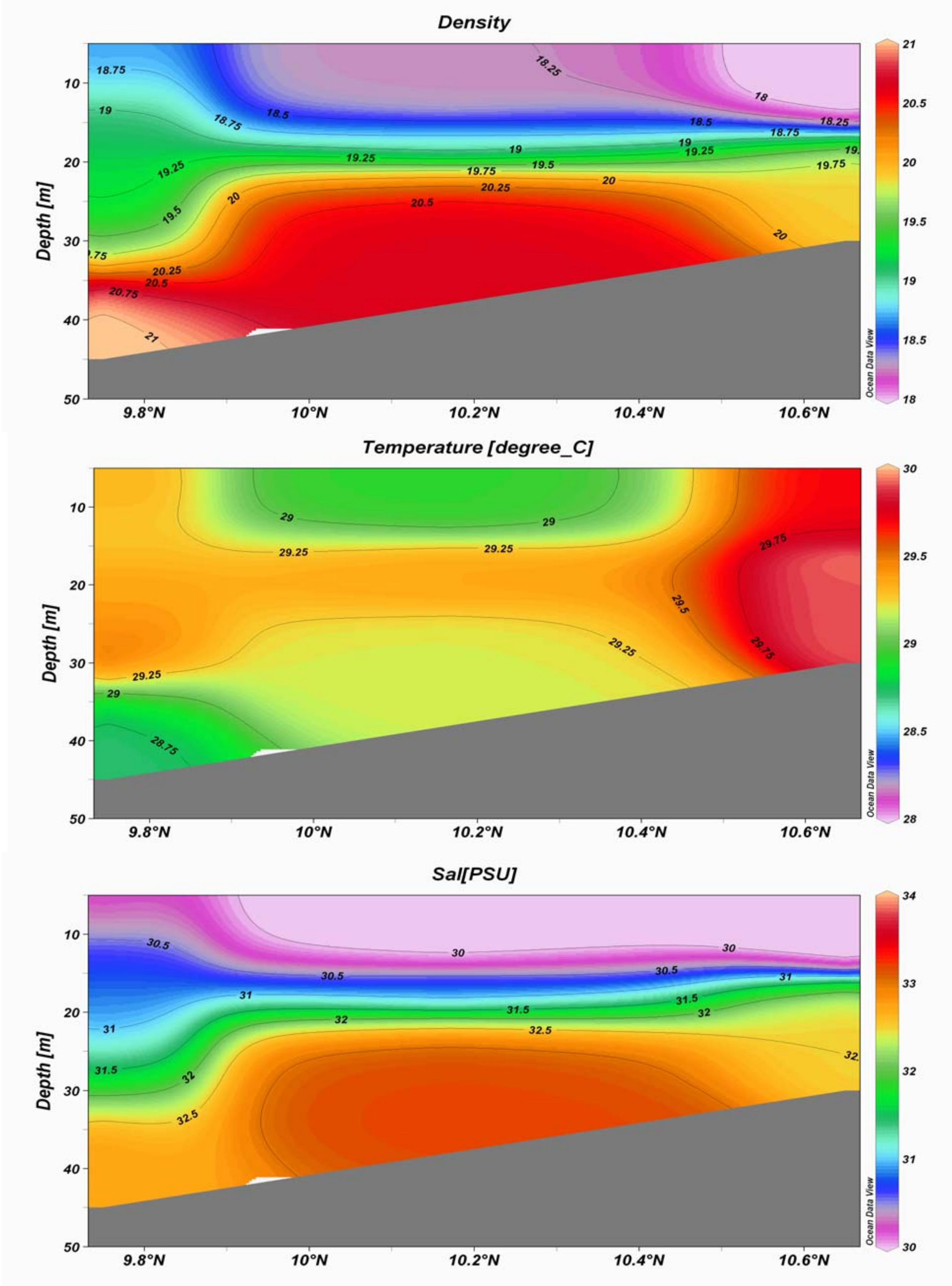



**Figure 10.** The vertical distribution of temperature, salinity and density in transact 2

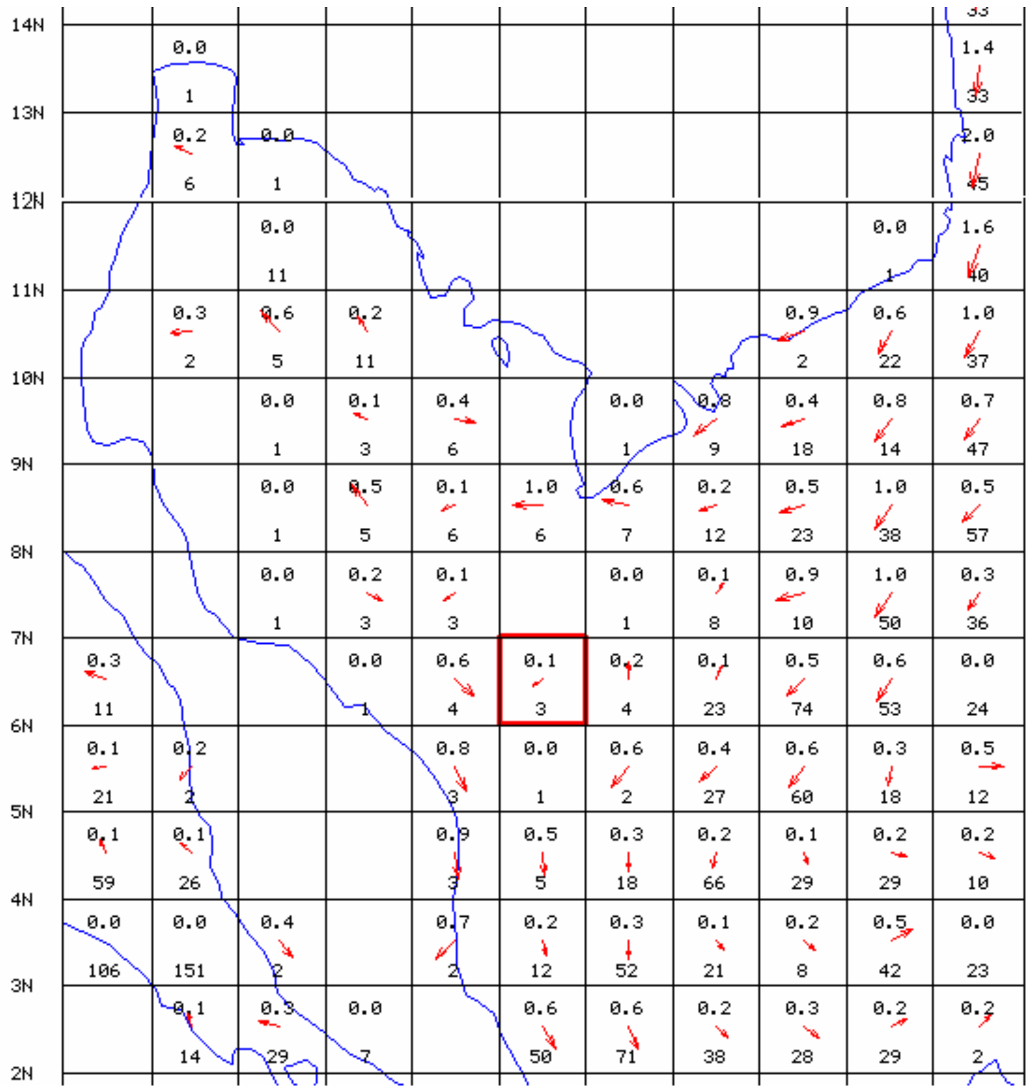
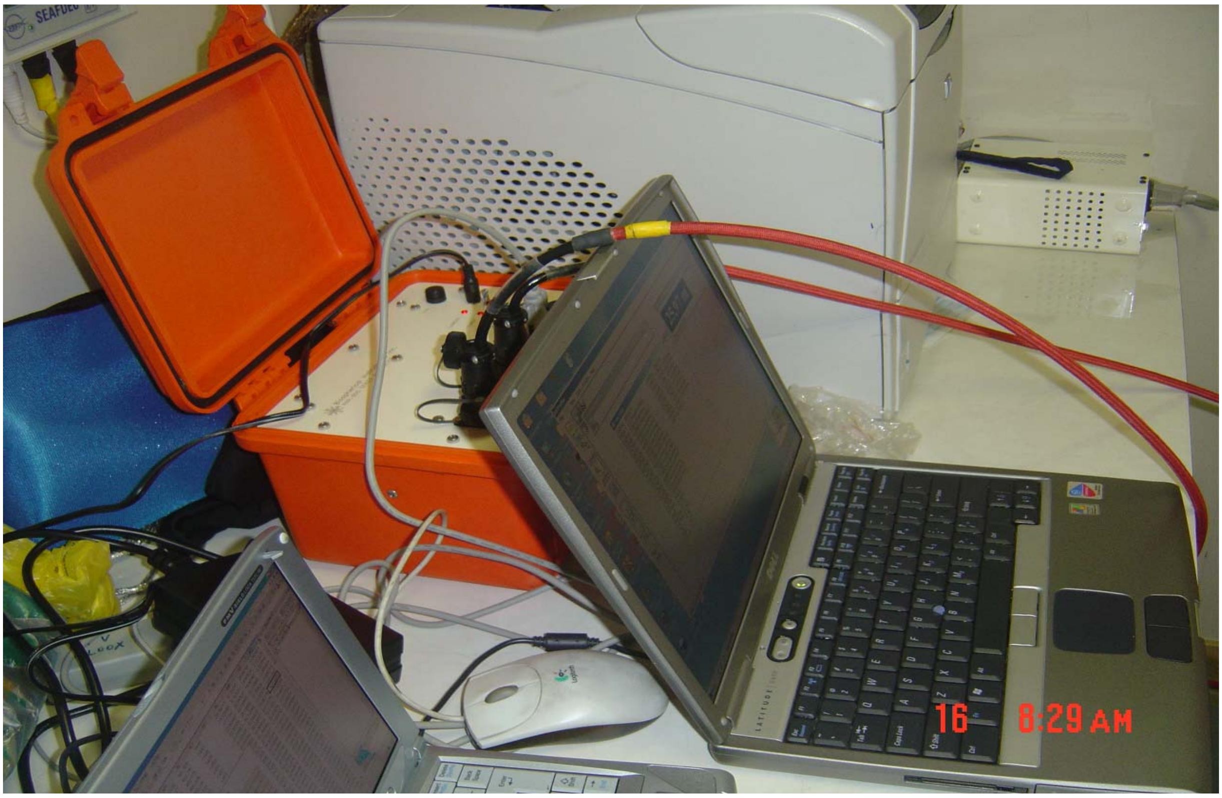



**Figure 11.** The prevailing current direction and velocity in November as shown in the JODC data (From: http://www.jodc.go.jp/)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# SPATIAL DISTRIBUTION OF NUTRIENTS IN THE CAMBODIAN WATER

BY

**Sukanya Obromwan**

# SPATIAL DISTRIBUTION OF NUTRIENTS IN THECAMBODIAN WATER

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## Abstract

The distribution of nutrients (nitrite, nitrate, silicate and phosphate) was investigated in the Cambodian water during 20-23 November, 2005. The samples taken from 11 stations were collected on board of the ship MV SEAFDEC 2 and analyzed with an auto analyzer (The Integral Futura Continuous Flow Automated Analysis of Seawater Nutrients). The average concentration of nitrite, silicate and phosphate in surface water at 5-m depth was 0.223 M, 3.921 M and 0.173 M, while at 30-m layer was 0.438 M, 4.993 M and 0.221 M, respectively. The vertical distribution of nutrient concentration increased with depth at some stations, while was uniform throughout the water column at others. Furthermore, the nutrient values were higher at the near-shore stations than those at off-shore ones. The nitrate concentration was not determined because of mal-functioned Analyzer.

**Key words :** nutrients, distribution, Cambodian water

## Introduction

The inorganic nitrogen (nitrite and nitrate), silicate and phosphate are important nutrients in marine environment as they are essential for the growth of phytoplankton and other algae. Those primary producers form the base of marine food chain. Biological processes dominate the inter-conversion of various forms of nutrient in the sea. The dissolved inorganic nutrients are taken up and incorporated by photosynthetic organisms into organic forms. When phytoplankton or higher organisms die, they are decomposed by marine bacteria and fungi, converting the particulate form of nutrients to dissolved forms that can be used by phytoplankton again.

The distribution of nutrient concentration in the sea is affected not only by the growth and death processes of phytoplankton, but also by the physical factors and human activity. Combined inorganic and organic nitrogen compounds enter the sea from terrestrial drainages. Similarly, the amounts of silicate and phosphate in seawater originate mostly from weathering of mineral rocks and erosion of soils on land, and enter the sea from river discharges. Wastes caused by human activities in agriculture and industry enhance the nutrient inputs to coastal waters.

The study on nutrient distribution in Cambodian waters in the South China Sea is not only to determine the distribution of nutrient, but more importantly to understand the potential of primary production in this area.

# Materials and Methods

## Study location

The study area is located in Cambodian waters from 09°.15 to 10°.45 N and from 102°.25 to 103°.30 E (Figure1). The water samples were taken from 11 stations during 20-23 November, 2005. The sampling sites are listed in **Table1.**

| Station | Date | Time | Latitude | Longitude | Bottom Depth (m) |
|---|---|---|---|---|---|
| 1 | 20-Nov-05 | 13:20 | 10° 39' 2 N | 103° 04' 3 E | 30 |
| 2 | 20-Nov-05 | 17:55 | 10° 42' 8 N | 102° 52' 4 E | 39 |
| 3 | 21-Nov-05 | 05:27 | 10° 44' 9 N | 102° 27' 9 E | 63 |
| 4 | 21-Nov-05 | 13:39 | 10° 15' 0 N | 102° 27' 5 E | 67 |
| 5 | 21-Nov-05 | 18:40 | 10° 14' 7 N | 102° 44' 5 E | 53 |
| 6 | 22-Nov-05 | 05:27 | 10° 10' 1 N | 103° 05' 0 E | 38 |
| 7 | 22-Nov-05 | 11:50 | 10° 15' 2 N | 103° 30' 5 E | 34 |
| 8 | 22-Nov-05 | 19:00 | 09° 44' 7 N | 103° 05' 1 E | 45 |
| 9 | 23-Nov-05 | 05:30 | 09° 44' 9 N | 102° 45' 3 E | 55 |
| 10 | 23-Nov-05 | 11:21 | 09° 45' 1 N | 102° 27' 7 E | 60 |
| 11 | 23-Nov-05 | 17:57 | 09° 15' 0 N | 102° 26' 0 E | 69 |

**Table 1** : The sampling sites in the Cambodian water.

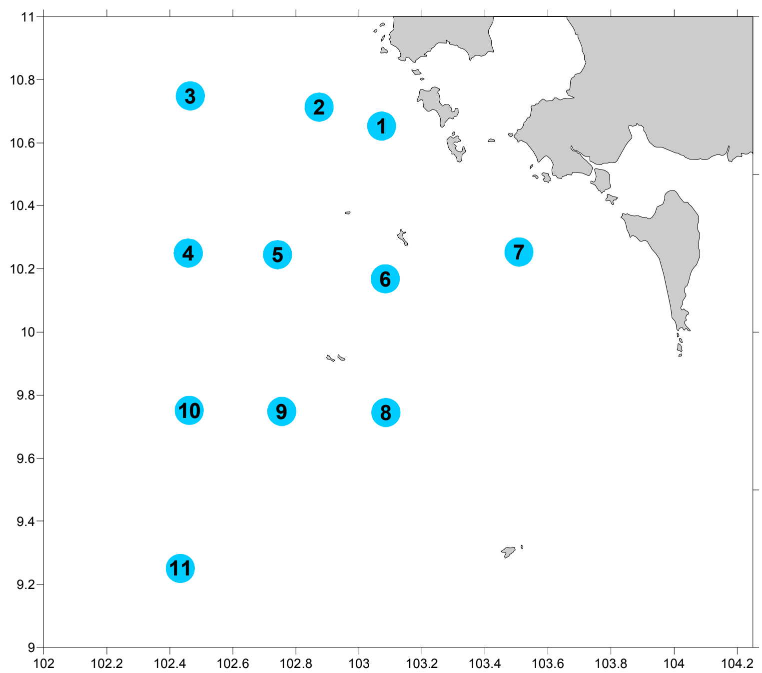



**Figure 1** : Map of the Cambodian water showing the location of sampling sites.

**Sampling and Analytical Methods**

Water samples were collected at various depths using 2.5-liter Niskin water samplers on broad the MV SEAFDEC 2. In case of moderate sea condition at stations 4, 10 and 11 the Vandorn water samplers were used instead. For vertical distribution, the surface water samples were taken at 5-m depth; all other sampling depths were set at 10-m intervals until 10-15 m above sea bottom. Approximately 60 ml water sample was filtered through a Whatman GF/C filter paper (1.2 m pore size filters) to remove the particulates. Each filtered sample was collected in a 60-ml polypropylene bottle, which was rinsed with the sample water, and froze at -40 °C. All samples were analyzed at SEAFDEC/TD laboratory with The Integral Futura Continuous Flow Automated Analysis of Seawater Nutrients.

Procedure of a Continuous Flow Analyzer (CFA) involved the use of a multi-channel peristaltic pump to mix samples and chemical reagents which continuously flowed to automate colorimetric analyzer. The reagent preparation and analytical procedures for each nutrient followed the method detailed by Gordon *et al*. (1993).

Nitrate and nitrite were analyzed according to the method of Armstrong *et al*. (1967). While the nitrate was analyzed in nitrite form after reduction the concentration includes both nitrate and nitrite in the sample; the nitrite was measured directly without reduction (Gordon *et al*, 1993)

The method for phosphate analysis was modified from the procedure of Bernhardt and Wilhelms (1967). Molybdic acid was added to the seawater sample to form phosphomolybdic acid which was in turn reduced to phosphomolybdous acid using hydrazine as reductant. The sample was heated with steam to speed up the rate of color development (Gordon *et al*, 1993).

The silicate was analyzed following the procedure of Armstrong *et al*. (1967). The silicic acid in the sample formed -silicomolybdic acid by adding molybdic acid; then the silicomolybdic acid was reduced by adding stannous chloride to silicomolybdous acid, or “molybdenum blue” (Gordon *et al*, 1993).

## Results

The nutrient concentration of analyzed parameters (nitrite, silicate and phosphate) in the surface water at 5-m depth and subsurface at 30 m are presented in Table 2. Because of mal-function of the Continuous Flow Analyzer the nitrate concentration was not determined.

Table 2 shows the nitrite concentration at surface and 30-m layers. The average concentration of nitrite at the surface layer was 0.223 M. The minimum value of 0.156 M was found at station 1 and the maximum value of 0.446 M at station 7. In this layer, the nitrite concentration at off-shore stations was lower than that at inshore waters (Figure 2). At 30-m layer the nitrite concentration was relatively uniform among all stations with a mean of 0.438 M; the highest nitrite concentration was 0.816 M at station 1, and the lowest 0.276 M at station 6 (Figure 3). Generally, the samples taken from deeper water had higher concentration than that in surface samples, but in some stations the concentration was uniform at all depths. Variation of nitrite concentration among sampling stations is presented in Figures 8-9.

The silicate concentration in surface water was also lower than that at 30-m layer (Table 2). The average value at surface layer was 3.921 M with the highest concentration of 9.739 M at station 7 and undetectable at station 11. Thus, water samples taken from off-shore stations contained little silicate compto near-shore coastal stations (Figure 4). At 30-m layer, the concentration of silicate increased slightly with a mean of 4.993 M. The maximum value of 13.072 M was found at the near-shore station 1 and the minimum 0.752 M at station 10; while the concentration was undetectable at offshore stations 9 and 11 (Figure 5). However, the silicate concentration appeared to increase with depth. The variation of silicate concentration at all stations is shown in Figures 10-11.

| Station | Nitrite (μM) | | Silicate (μM) | | Phosphate (μM) | |
|---|---|---|---|---|---|---|
| | Surface | 30 m. | Surface | 30 m. | Surface | 30 m. |
| 1 | 0.156 | 0.816 | 1.725 | 13.072 | 0.201 | 0.232 |
| 2 | 0.216 | 0.567 | 2.126 | 11.107 | 0.160 | 0.283 |
| 3 | 0.218 | 0.380 | 3.239 | 2.478 | 0.147 | 0.246 |
| 4 | 0.276 | 0.469 | 1.997 | 0.807 | 0.168 | 0.197 |
| 5 | 0.181 | 0.406 | 4.671 | 2.706 | 0.143 | 0.253 |
| 6 | 0.204 | 0.276 | 3.973 | 11.223 | 0.155 | 0.224 |
| 7 | 0.446 | 0.487 | 9.737 | 8.766 | 0.209 | 0.209 |
| 8 | 0.165 | 0.541 | 6.841 | 4.009 | 0.153 | 0.234 |
| 9 | 0.211 | 0.310 | 5.790 | 0.000 | 0.214 | 0.236 |
| 10 | 0.098 | 0.287 | 3.035 | 0.752 | 0.206 | 0.181 |
| 11 | 0.285 | 0.283 | 0.000 | 0.000 | 0.149 | 0.144 |

**Table 2** : The nutrient concentrations of measured parameters in water column from the surface to 30 m deep.

Table 2, shows that the average value of phosphate at surface layer was 0.173 M; the highest concentration at 0.214 M was found at station 9; the lowest 0.147 M at station 3 (Figure 6). Little variation was observed between two depth layers. At 30-m layer, the horizontal distribution of mean phosphate concentration was 0.221 M, with the maximum value 0.283 M found at station 2 and the minimum value 0.181 M at station 10 (Figure 7). The vertical profiles of phosphate concentration are presented in Figures 12-13; at some stations the concentration was mostly uniform throughout the water column, or slightly increased with depth.

## Conclusions

The results of this study show that the distribution of all nutrients (nitrite, silicate and phosphate) increased with depth, i.e. higher nutrient concentrations were found in deeper layer than those in the surface layer. Unfortunately, the concentration of nitrate at all stations was unable to determine because of mal-functioned Continuous Flow Analyzer.

Generally, all nutrient contents in the surface water were nearly undetectable perhaps due to phytoplankton up-take. In comparison, the nutrient concentration increased in water column below the photic zone where the phytoplankton uptake was limited. Meanwhile, the nutrient regeneration through decomposition of organic matter released inorganic nutrients back to the deep water column.

Furthermore, the major sources of most nutrients to the sea are usually drained from terrestrial environment as products of rock weathering, decay of organic material, together with man-made contaminants (Spencer,1975) Therefore, nutrient concentrations in near-shore water are much higher than those in the off-shore.

For further understanding of nutrient distribution in this area, more information on the other oceanographic parameters are needed.

## Acknowledgments

I wish to express my sincerely thank to Research Division Head, Dr. Somboon Siriraksophon and Fishing Ground Section Head, Mr. Pratakphol Prajakjitt for giving me the opportunity to work on this project and for their useful suggestions. I also thank all of research division staffs and the crew of the MV SEAFDEC 2 for their assistance and support to carry out this research survey.

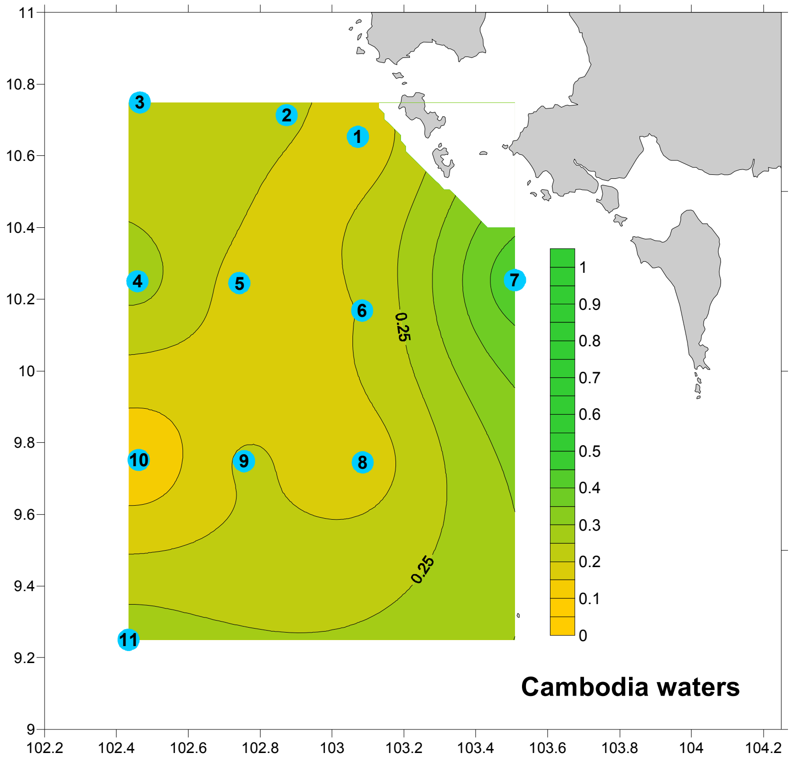



**Figure 2**. The horizontal distribution of nitrite concentration( M) in surface water. The minimum value 0.156 M was found at station 1 and the maximum value of 0.446 M at station 7.

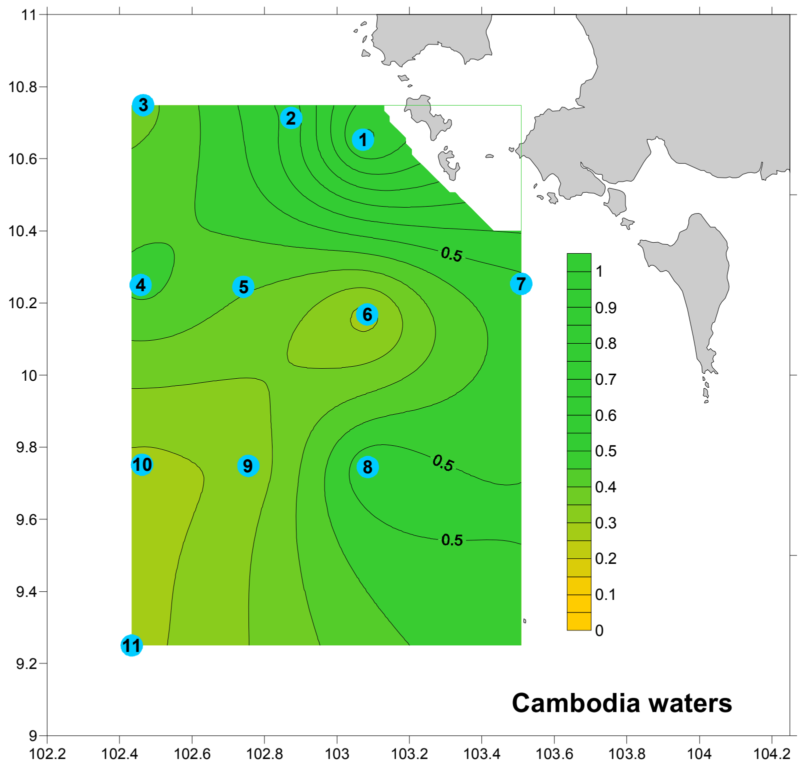



**Figure 3**. The horizontal distribution of nitrite concentration ( M ) in water at the 30-m depth. The minimum value 0.276 M was found at station 6 and the maximum value of 0.816 M at station 1.

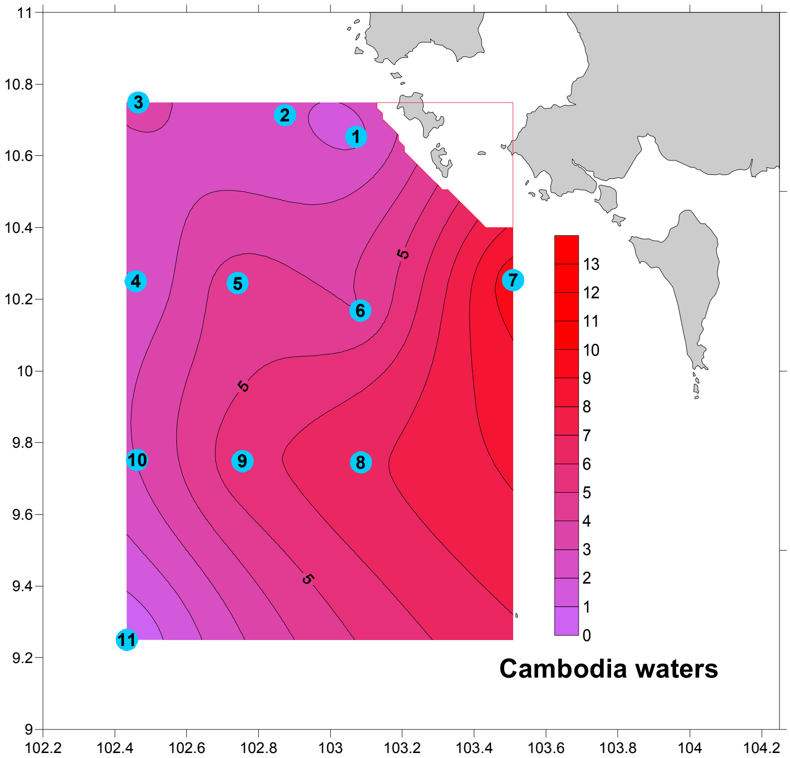



**Figure 4**. The horizontal distribution of silicate concentration ( M ) in surface water. The highest concentration of silicate was 9.739 M at station 7 and undetectable at station 11.

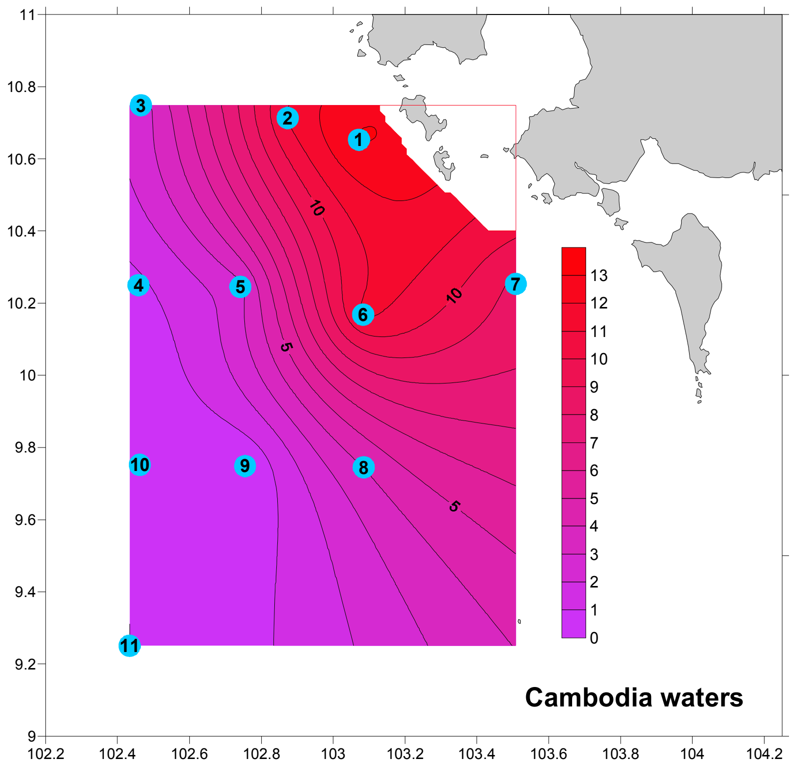



**Figure 5.** The horizontal distribution of silicate concentration ( M ) in water at 30-m depth. The maximum value 13.072 M was found at station 1 and the minimum value 0.752 M was found at station 10.

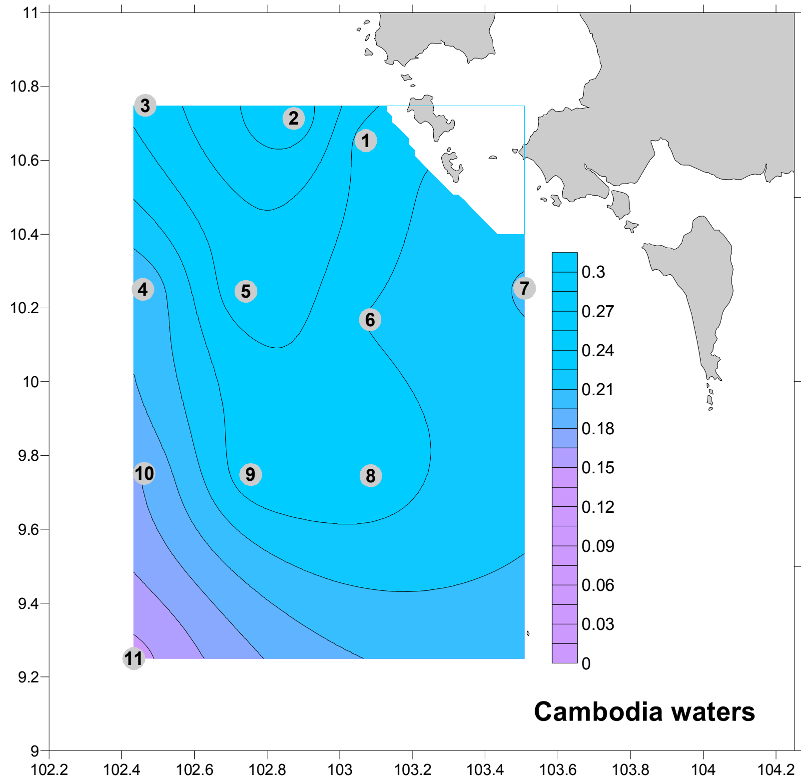



**Figure 6.** The horizontal distribution of phosphate concentration (  M) in surface water. The maximum value 0.214  M was found at station 9 and the minimum value 0.147  M was found at station 3.

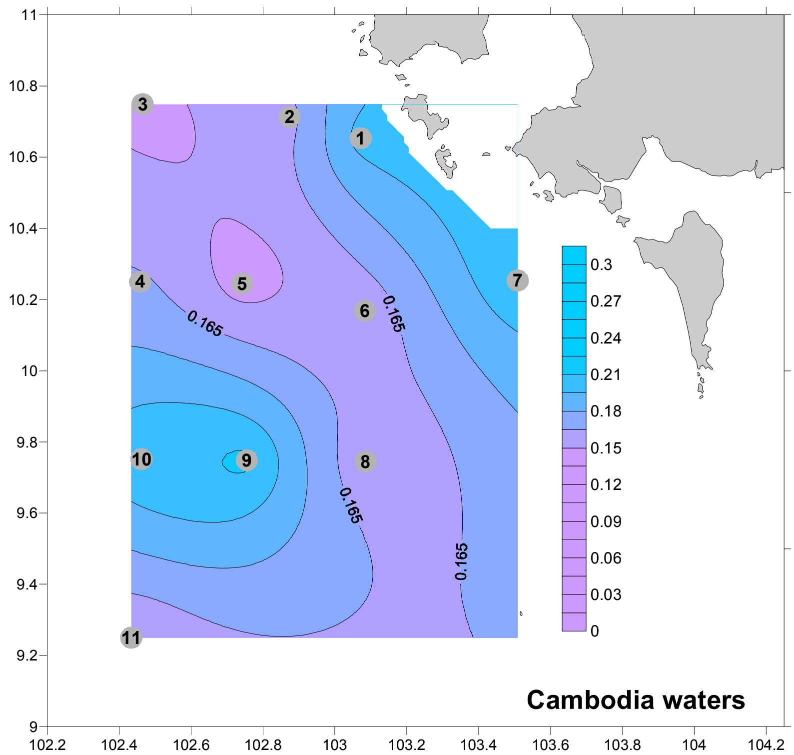



**Figure 7.** The horizontal distribution of phosphate concentration (  M) in water at 30-m layer. The maximum value 0.283  M was found at station 2 and minimum value 0.181  M was found at station 10.

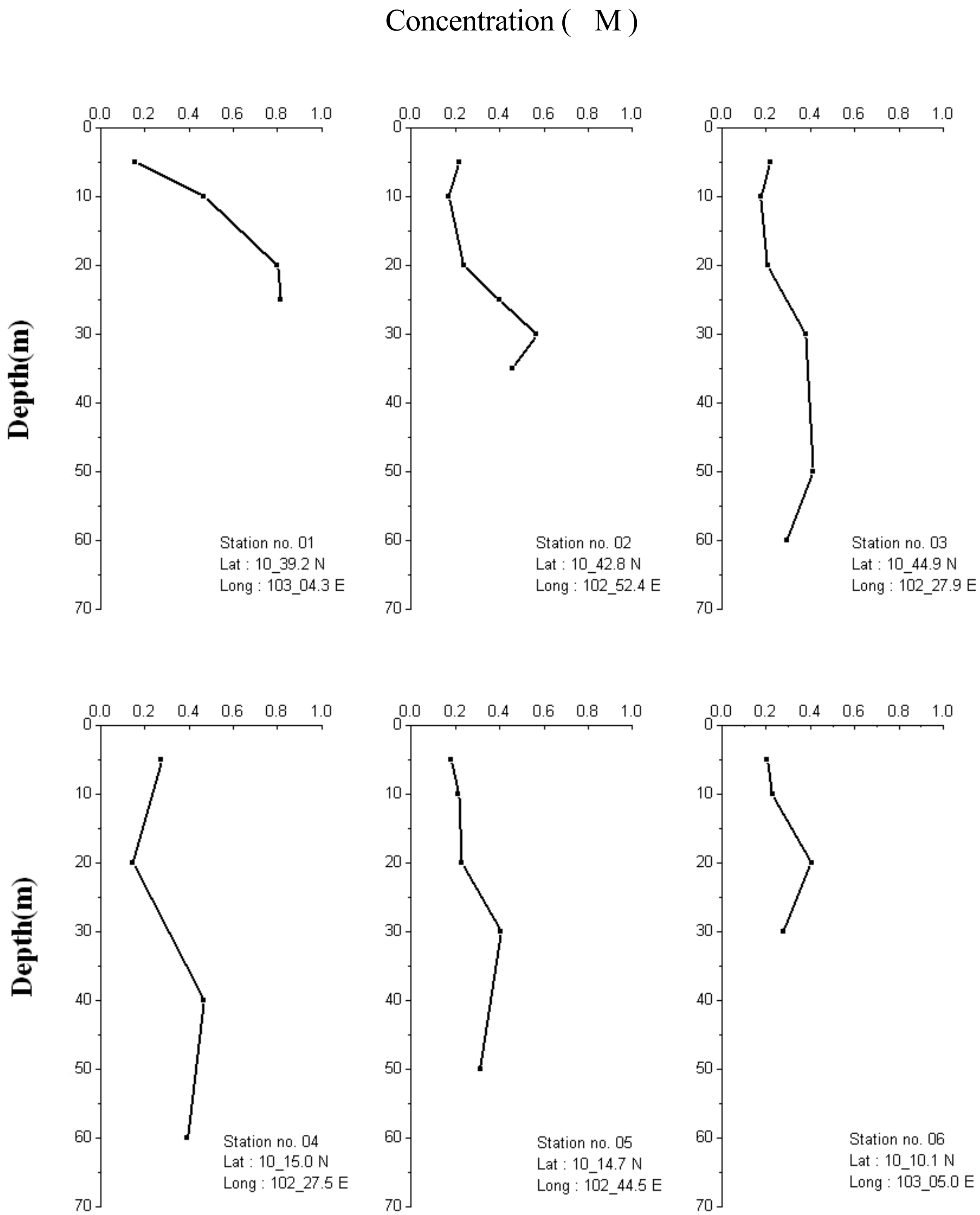



**Figure 8.** The profile of vertical distribution of nitrite concentration at stations 1 - 6.

Concentration ( M )

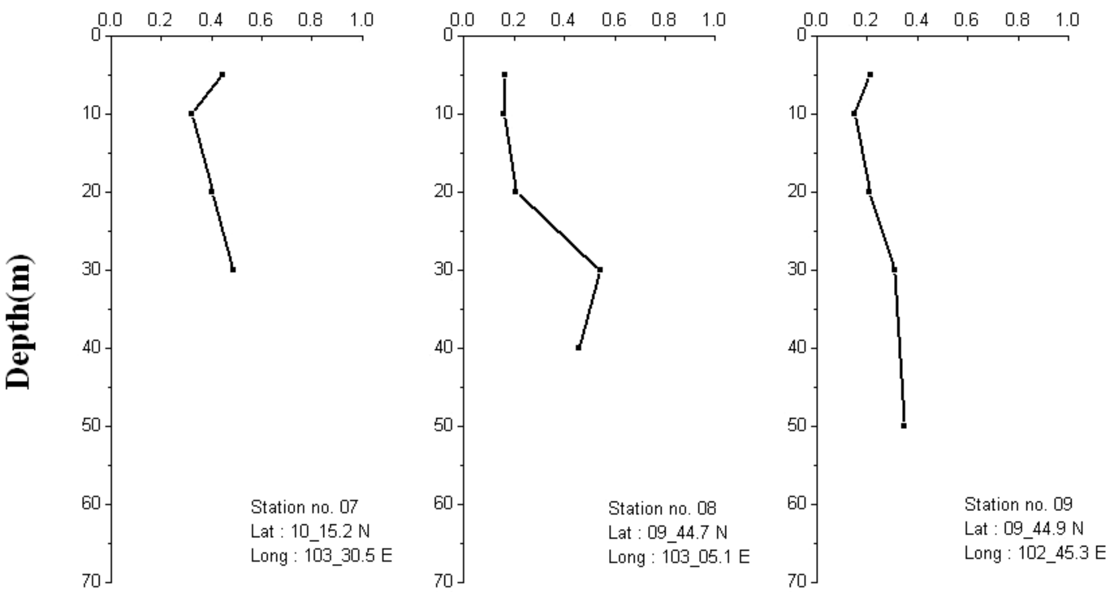
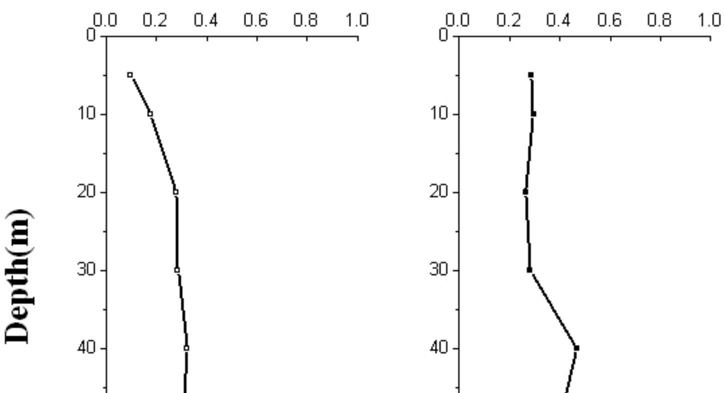



**Figure 9.** The profile of vertical distribution of nitrite concentration at station at stations 7 - 11.



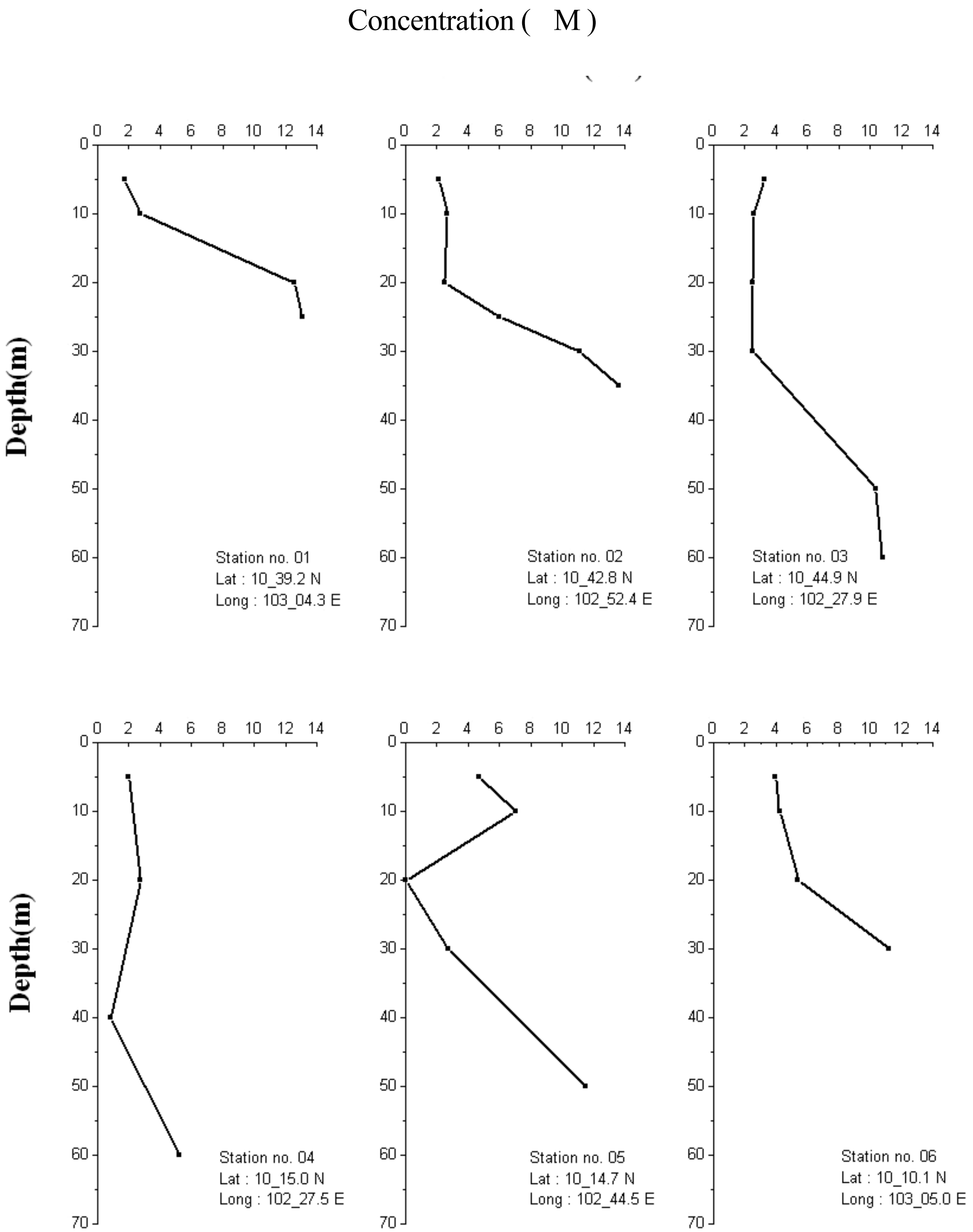



**Figure 10.** The profile of vertical distribution of silicate concentration at stations 1 - 6.

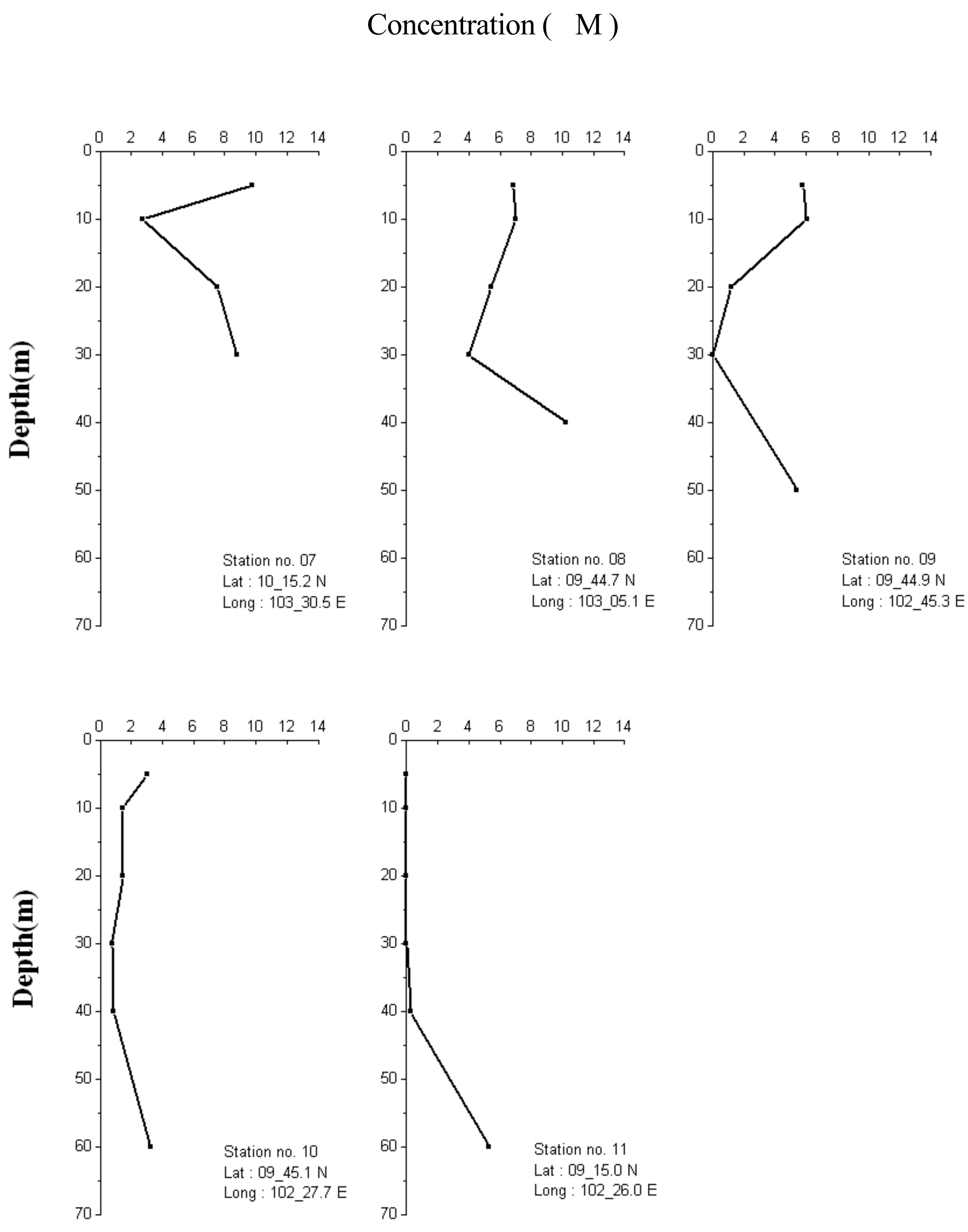



**Figure 11.** The profile of vertical distribution of silicate concentration at stations 7 -11.

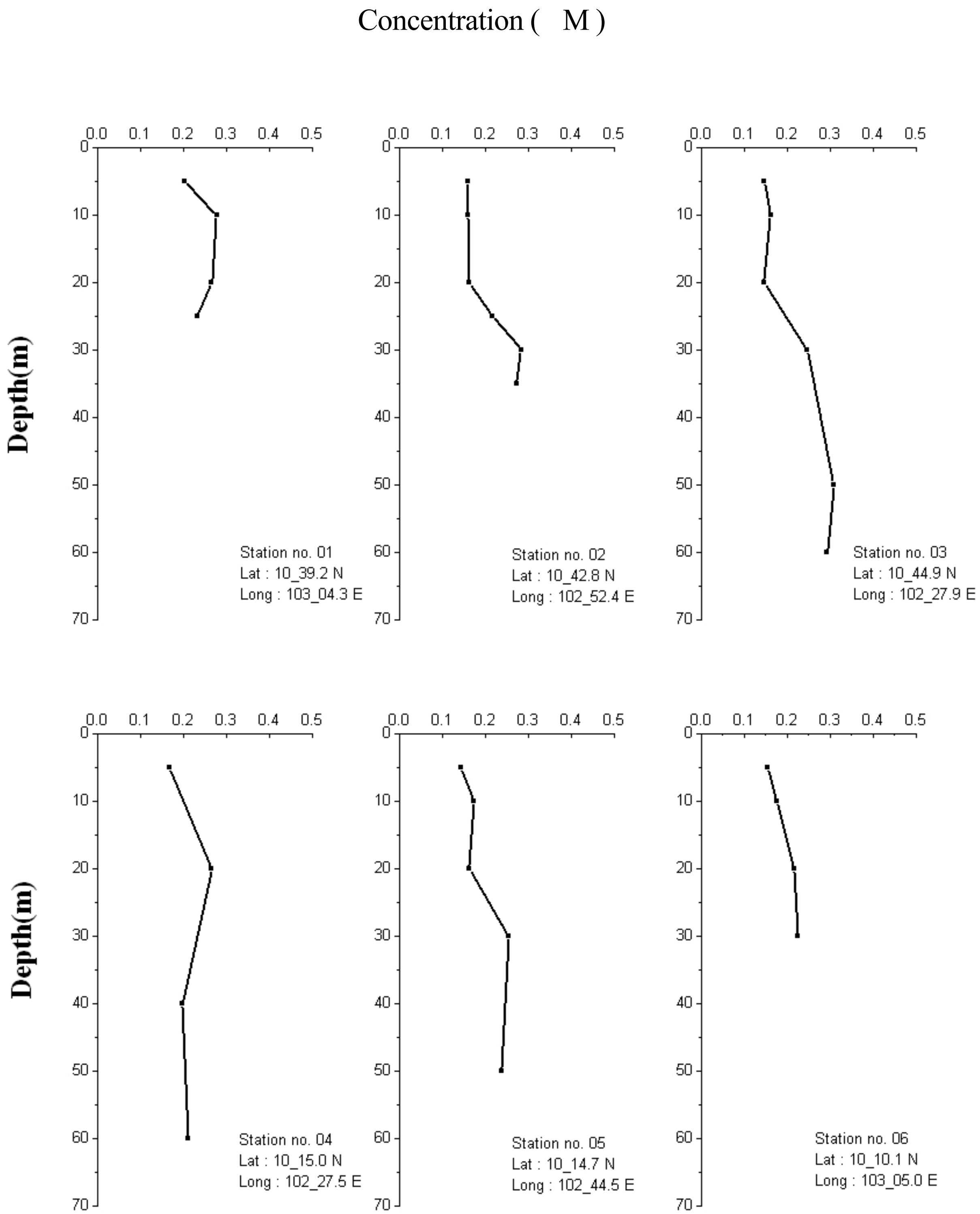



**Figure 12.** The profile of vertical distribution of phosphate concentration at stations 1 - 6.

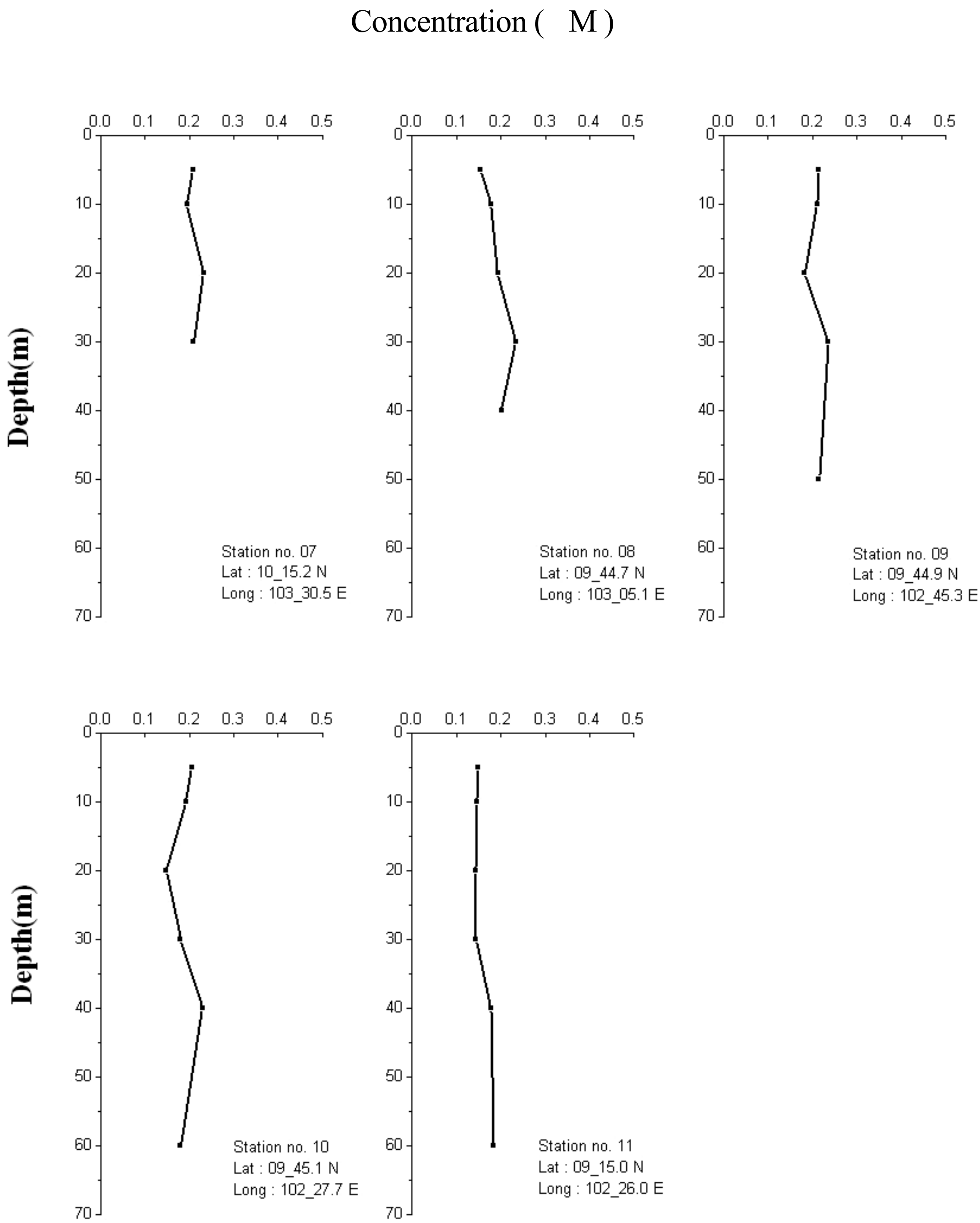



**Figure 13.** The profile of vertical distribution of phosphate concentration at stations 7 - 11.

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# OPTICAL CHARACTERISTICS IN THE CAMBODIAN WATER

**BY**

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# OPTICAL CHARACTERISTICS IN THE CAMBODIAN WATER

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## Abstract

A study was conducted with the aim to understand the optical characteristics of Cambodian water. The optical measurement was made on board the research vessel MV SEAFDEC2 at 7 stations in Cambodian water during $20^{th}$ - $23^{rd}$ November, 2005. In principle, there are three in-water optically active constituents affecting the optical characteristics which are chlorophyll-a, total suspended solids, and colored dissolved organic matter. The distribution of each optically active constituent does not exhibit conservative properties related to the salinity distribution. Patterns of remote sensing reflectance exhibit distinct characterization of two different optical groups. The first group shows large absorption in short wavelengths and large reflectance in long wavelengths coinciding with those stations situated in the northwestern corner of the survey area, where relatively high concentrations of chlorophyll and suspended solids were observed. Another group showed relatively small absorption in short wavelengths and relatively small reflectance in long wavelengths coinciding with those stations located in the southeastern corner where relatively high CDOM absorption was observed. The optical properties of the water are apparently influenced by terrestrial discharges, material transports form remote areas, re-suspension of bottom sediment, as well as sediment composition. In addition, the state of system changes with weather and season. Therefore, the optical characteristics can change dramatically over the distance and vary greatly over time. However, it is still far from understanding all of these interdependencies.

**Key words:** optical characteristics, optically active constituents, Cambodian water.

## Introduction

The color of the sea is influenced by the processes of absorption, scattering and, in some case, fluorescence. The ocean color examines, in principle, how the quantitative information on seawater and its content can be recovered from measurement of the light leaving the sea. From the pioneering observation and theoretical foundation in the mid-twentieth century (Jerlov, 1968, 1976), the discipline of optical oceanography has now matured into the science of ocean optics (Spinrad *et al.*, 1994; Robinson, 2004). It is now applied in a wide range of oceanographic studies as diverse as photochemistry, mixed layer dynamics, biogeochemical cycles, primary production, marine pollution and fisheries oceanography (IOCCG, 1998, 1999, 2000, 2004).

The propagation of light in the ocean-atmosphere system is governed by the integral differential equation of radiative transfer (Gordon, 1994), containing absorption and scattering parameters that are characteristics of a particular water body being studied. To consider underwater optical process, scattering and absorption deal with a variety of optically active constituents found in the sea. If a photon interacts with something that causes it to scatter before it is absorbed, there is a chance that it will be scattered back out of the sea and be seen by remote sensing. The other possible source of underwater light is from fluorescence, in which pigments such as chlorophyll, stimulated by absorption of a high energy photon, emit a photon at a longer wavelength.

A bipartite classification scheme of the world ocean waters was introduced according to which all natural waters are partitioned into Case 1 and Case 2 waters (Morel and Prieur, 1977). Unlike Case 1 waters, the optical properties of Case 2 waters are influenced not only by phytoplankton pigments, but also by organic and inorganic, suspended and dissolved materials.

Case 1 waters are basically characterized by a strong correlation between scattering and absorbing substance concentrations and the chlorophyll-*a* concentration (Robinson, 2004). The open ocean surface water is typical Case 1 water. The strong correlation is due to the fact that all the substances originate in biological processes. A primary source of the substances is photosynthesis of marine phytoplankton together with accompanying and co-varying products of their life cycles. Hence, Case 1 waters can be characterized by a single parameter—chlorophyll concentration.

Case 2 waters are characterized by a lack of any correlation between scattering and absorbing substance concentration and chlorophyll-*a* concentration (Robinson, 2004). Accordingly, Coastal waters are often referred to as Case 2 waters. Phytoplankton is not the dominant optically active constituent. Suspended sediment and colored dissolved organic matter, which do not always co-vary with chlorophyll-*a*, also affect seawater optical properties. Therefore, Case 2 water can be referred to as multi-parameter water; its optical properties are described by a set of parameters.

However, It must be acknowledged that this classification concept is somewhat idealized because, in reality, all natural water belongs to an intermediate case (Robinson, 2004).

Flux passing down into the lower part of the water column is described as the downwelling irradiance (Ed), whilst that being backscattered from below traveling towards the surface is the upwelling irradiance (Eu). Basically, there are three ways in which the sea surface itself affects the light that leaves the surface in the direction of the sensor. First, the surface directly reflects sunlight and skylight. Second, there may be colored material present at the surface which reflects the light. Third, the air-water interface refracts the light emerging from beneath the sea surface. Intrinsic color of the ocean is defined by spectral variations in reflectance. Sea surface reflectance (R) at any depth z is defined as:

$$R(\lambda, z) = \frac{E_u(\lambda, z)}{E_d(\lambda, z)} \qquad (1)$$

where Eu( , z) is the irradiance (flux per unit surface area) in all the upward directions, or upwelling irradiance, at wavelength and depth z; and Ed( , z) is the irradiance in all the downward directions, or downwelling irradiance, at the same wavelength and depth.

In the remote sensing context, it deals with remote sensing reflectance (Rrs), which is closely related to the sea-surface reflectance R, but makes use of upwelling radiance rather than irradiance. It is a measure of how much of the downwelling light that is incident onto the sea surface. Rrs therefore provides the connection between the known input to the water body and its output which is the water-leaving radiance (L). It is defined as:

$$R_{RS}\ (\theta, \phi, \lambda, 0) = \frac{L(\theta, \phi, \lambda, 0)}{E_d(\lambda, 0)} \qquad (2)$$

The arguments and $\phi$ on the radiance indicate that the water-leaving radiance can vary with the viewing angle(at surface $z_0$). Remote sensing reflectance has dimension of [$sr^{-1}$].

Ocean color information has become an important remotely sensed parameter. In general, there are at least three in-water constituents that affect the optical properties of coastal waters. These are phytoplankton pigments which are indexed by chlorophyll-a concentration (CHA), total suspended sediments (TSS), and colored dissolved organic matter (CDOM) which is indexed by its absorption at a reference wavelength. The goal of ocean color remote sensing is to derive quantitative information on the types of substances present in the seawater and on their concentrations from variations in the spectral form and magnitude of the ocean color signal.

The optical characteristics of Cambodian water are much complex due to variable proportion of materials from terrestrial discharges. With regard to the better understanding on marine optical environment which affects living resources together with water quality characteristics, this study attempts to provide additional information on optical oceanography in the Cambodian water.

## Materials and Methods

### Field Observation

Sea truth observation was made at 11 stations in Cambodian water during 20th - 23rd Nov, 2005 onboard the research vessel MV SEAFDEC II which belongs to the Training Department, Southeast Asian Fisheries Development Center (TD/SEAFDEC, Thailand). Due to unsuitable weather and light conditions, the optical survey was then limited and adjusted to only 7 stations as shown in Table 1 and Figure 1.

At each station, seawater samples were obtained at some reference depths using Vandorn Samplers, then they were filtered through glass fiber filter paper to determine concentrations of three optically active constituents: chlorophyll-a, total suspended sediment and colored dissolved organic matter. In addition, ancillary measurements for other oceanographic parameters such as nutrients, salinity, temperature, density, dissolved oxygen, transparency depth and water color level were obtained using basic onboard oceanographic instruments. (manufacturer, brand name and model)

| Station | Latitude (N) | Longitude (E) | Depth (m) |
|---|---|---|---|
| 1 | 10° 39' 2 N | 103° 04' 3 E | 30 |
| 3 | 10° 44' 9 N | 102° 27' 9 E | 63 |
| 4 | 10° 15' 0 N | 102° 27' 5 E | 67 |
| 6 | 10° 10' 1 N | 103° 05' 0 E | 38 |
| 7 | 10° 15' 2 N | 103° 30' 5 E | 34 |
| 9 | 09° 44' 9 N | 102° 45' 3 E | 55 |
| 10 | 09° 45' 1 N | 102° 27' 7 E | 60 |

**Table 1**. Locations of optical sampling stations in the Cambodian water

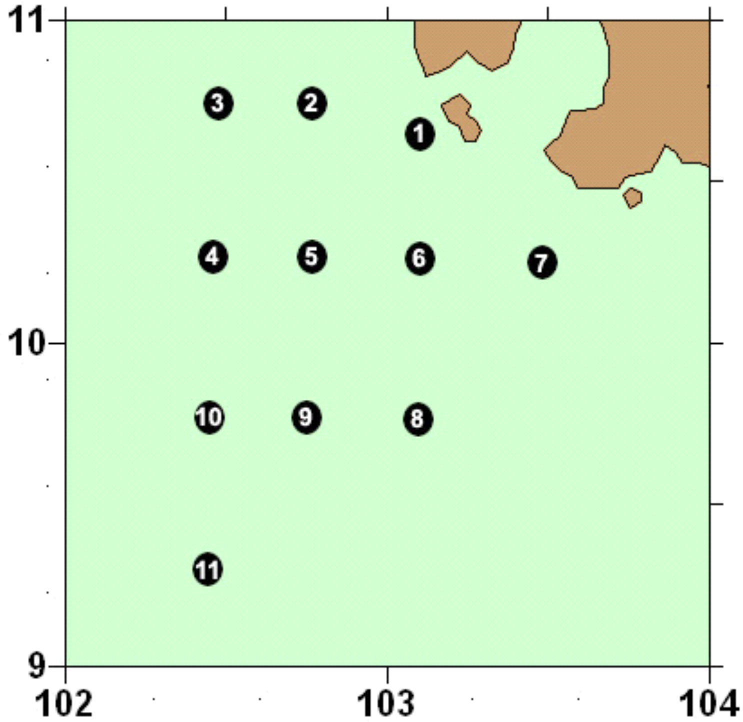



**Figure 1.** Positions of optical sampling stations in Cambodian water

| **Parameters** | **Channel** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Downwelling Irradiance | 412 | 443 | 490 | 510 | 555 | 625 | 665 | PAR |
| Upwelling Radiance | 412 | 443 | 490 | 510 | 555 | 625 | 665 | PAR |

**Table 2** Sensor channels and light profile parameters of profiling reflectance radiometer

With regard to the optical survey, the underwater light was characterized using the Profiling Reflectance Radiometer (PRR), that provides instantaneous profiles of the downwelling irradiance (Ed) and the upwelling radiance (Lu) at wavelengths coinciding with the sensor channels as listed in Table 2. The irradiance measurement at a given depth was normalized to the surface incident irradiance measured by a deck-based irradiance sensor, thus eliminating errors due to variability of surface light condition.

**Laboratory Techniques**

1. Phytoplankton pigments

Chlorophyll-*a* concentration was measured fluorometrically following the procedures of Strickland and Parsons (1972). Water samples were filtered through GF/F Whatman glass microfibre filters (47 mm diameter, 0.7 µm pore size) under low vacuum then subsequently extracted in 90% acetone at room temperature.

2. Total suspended sediment

Total suspended solids were measured gravimetrically as outlined in Strickland and Parsons (1972). The water samples were filtered through GF/C Whatman glass microfibre filters (47 mm diameter, 1.2 μm pore size) onboard then dried at 70 °C in an oven for a few hours and left in a dessiccators overnight. This process was repeated until a constant weight reading is achieved.

3 Colored dissolved organic matter

The concentration of colored dissolved organic matter was measured spectrophotometrically (Kirk, 1980). The water samples were firstly filtered through GF/F Whatman glass microfibre filters followed by filtering through nucleopore membrane filters (47 mm diameter, 0.2 μm pore size) for scanning light absorption ranging from 300 to 800 nanometer.

**Data Analysis**

The optical data obtained from the profiling reflectance radiometer for each station were analyzed and processed according to the reference wavelengths at reference depths. First, the downwelling irradiance (Ed) and the upwelling radiance (Lu) were normalized by the surface incident irradiance (Es); second, the diffuse attenuation coefficient for downwelling irradiance (Kd) was obtained. Then, the remote sensing reflectance (Rrs) was calculated from the ratio of the upwelling radiance to the downwelling irradiance.

All stations were subsequently categorized according to patterns of remote sensing reflectance. This method of classification is based on the relationships between the typical reflectance and the concentrations of products of interests present in the sea. Such classification assists in identification of relationship between each constituent and typical changes in spectral reflectance. To be clear, the patterns of remote sensing reflectance were then described according to the concentrations of three optically active constituents present.

In addition, all optically active constituents were plotted and interpolated to contour maps throughout the study area using Kriging method (Software Surfer 8.04). Kriging is a geostatistical gridding method that attempts to express trends suggested from data. Furthermore, Kriging can be either an exact or a smoothing interpolator depending on the specified parameters. It incorporates anisotropy and underlying trends in an efficient and natural manner. Consequently, their distribution patterns were basically compared with such environmental factors as salinity and nutrients. Eventually, optical characteristics of Cambodian water were described and discussed.

## Results

Sea truth data on three optically active constituent concentrations were plotted and interpolated over the area. Consequently, their distributions were compared with such environmental oceanographic factors as salinity and nutrients as illustrated in Figures 2 - 3. Distribution of each optically active constituent did not exhibit conservative properties according to the salinity distribution. Chlorophyll-*a* distribution was relatively higher in the vicinity of coastline. CDOM distribution apparently showed a similar pattern to those of nutrients. Contrary to total suspended solids, its distribution was likely to exhibit an inverse pattern to those of nutrients. It was due to the fact that water circulation in the Gulf of Thailand turns clockwise in northeast monsoon. Accordingly, the suspended solids were apparently transported from the inner gulf to this area.

Patterns of remote sensing reflectance exhibit distinct characterization of two different optical groups as shown in Figures 4 - 5. The first group shows large absorption in short wavelengths (blue wavebands) and large reflectance in long wavelengths (green wavebands) which coincided with those stations situated in the northwest corner where relatively high chlorophyll-*a* concentration and suspended solids were observed. Another group showed relatively small absorption in short wavelengths and relatively small reflectance in long wavelengths which coincided with those stations located in the southeast corner where relatively higher CDOM absorption was observed.

## Discussion

Coastal waters by nature are in highly dynamic environments with a variety of processes which alter their optical characteristics. As mentioned previously, the optical characteristics of Cambodian water are quite complex due to variable proportions of materials discharged from land. Therefore, all optically active constituents can vary independently in the coastal zone as a result of terrestrial discharges and bottom resuspension (Bhatrasataponkul, 2005). As a result, higher concentrations of chlorophyll, suspended solids and dissolved organic matter were associated with the distance from coastline. When transported into the estuary those constituents in the riverine discharge acts as filters and those materials are influenced by factors from varying physicochemical constraints. These physicochemical parameters including pH, redox potential, salinity, concentrations of nutrients and complexing ligands can undergo major variations in estuary. Accordingly, the dissolved and particulate transformations are driven by estuarine stress status, for example, flocculation-aggregation, absorption-desorption at surfaces of suspended solids and uptake via biological processes. Obviously, exchange processes between the three fractions (dissolved, colloidal, particulate) are more complex than sometimes supposed and the disappearance of colloids can enrich particulate matter or return to dissolved phase.

In marine environment, shift in the phytoplankton species and pigment composition may affect the characteristic optical properties. Differences in pigment composition among algal taxa are well-known. Species composition is of great importance in biological and ecological studies and there is certainly some interests in developing potential techniques in remote sensing to distinguish various types of phytoplankton (IOCCG, 2000, 2004). However, this task is likely to be even more difficult in coastal waters like coastal water in Cambodian as its optical characteristics can change dramatically over the distance and vary greatly over time.

## Conclusions

The optical characteristics of Cambodian water are apparently influenced by freshwater inflows, material transports form remote areas, bottom sediment resuspension, as well as composition of sediment characteristics. In addition, the state of system changes with weather and seasons. However, the optical properties of the Cambodian water are too complex to understand interdependence of all these variables.

The difficulty in optical studies is that the relationship between ocean color and constituents of the water vary specially or seasonally according to the species composition and size distribution of phytoplankton cells, mineral composition of the inorganic particles in suspension or chemical composition of dissolved organic substances. Therefore, further studies are needed to elucidate the optical complexity.

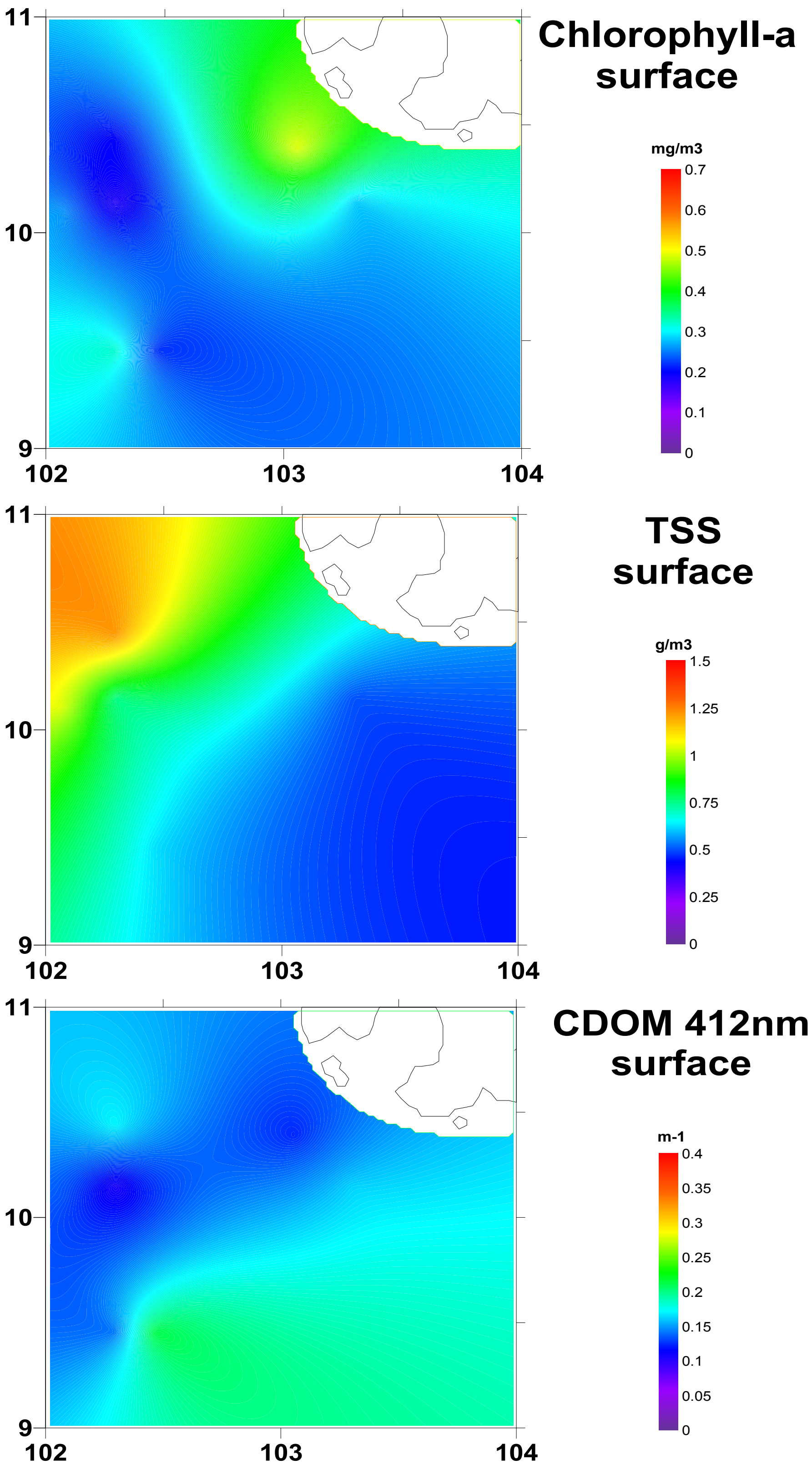



**Figure 2.** Distributions of optically active constituents in Cambodian water

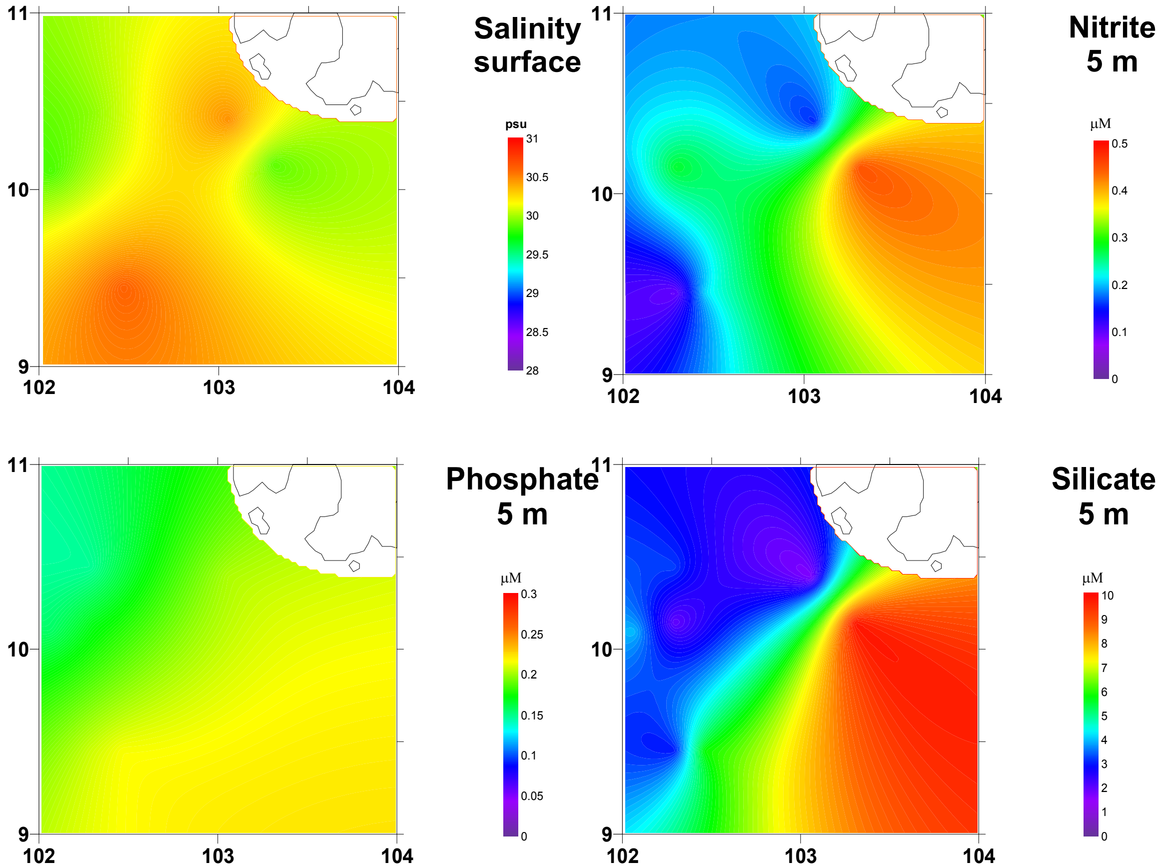



**Figure 3.** Distributions of salinity and nutrient concentrations in Cambodian water

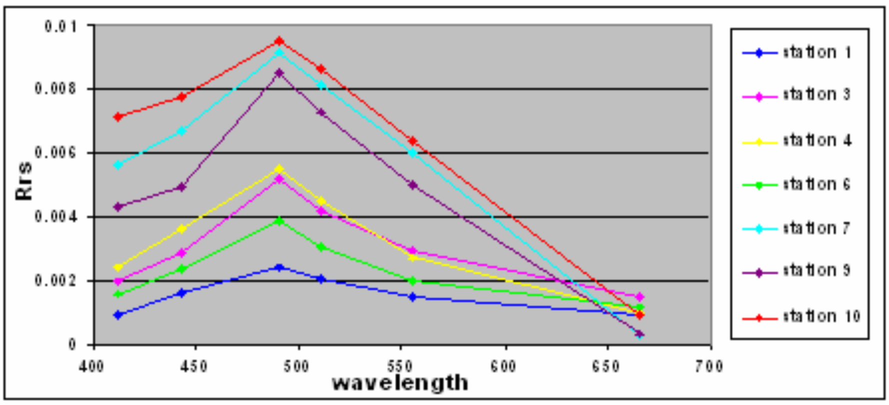
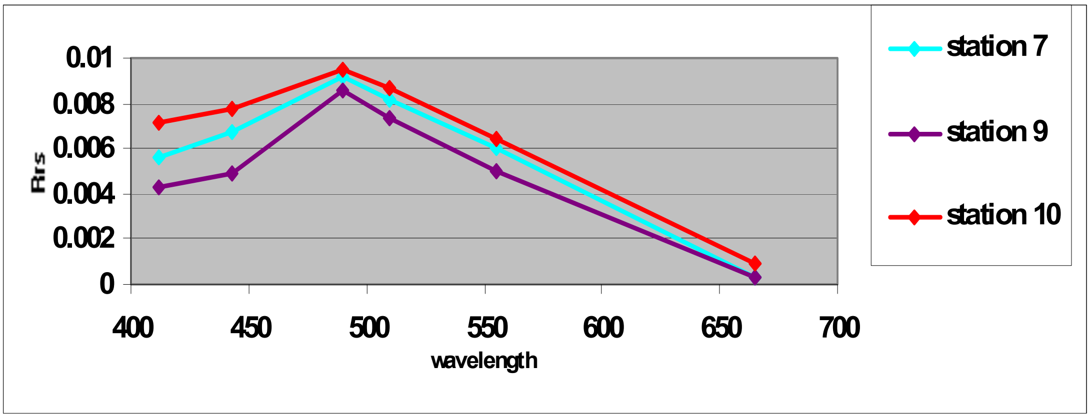
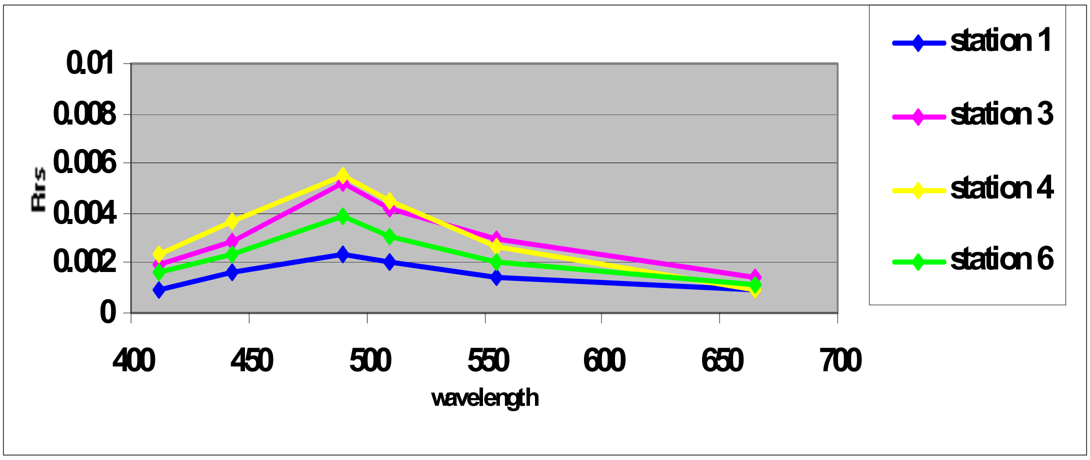



**Figure 4.** Remote sensing reflectance




(a)




(b)

**Figure 5**. Patterns of remote sensing reflectance

## Acknowledgement

Many thanks go to all MV SEAFDEC2 cruise members for their specific help.

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# ABUNDANCE, SPECIES COMPOSITION AND DISTRIBUTION OF MARINE FISHERIES RESOURCES IN THE CAMBODIAN WATER

BY

**Kanit Cheuapun**

**Isara chanrachkij**

# ABUNDANCE, SPECIES COMPOSITION AND DISTRIBUTION OF MARINE FISHERIES RESOURCES IN THE CAMBODIAN WATER

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## Abstract

This paper present species composition and distribution and estimate abundant if marine resources sampling bottom trawl in the Gulf of Thailand, Cambodian Water. The resources survey had implemented in northeast monsoon season. The result from 10 sampling station indicates that the CPUE is 15.37 kg/hr and individual catch range is from 8.16-27.13 kg/hr. Total Biomass Estimation of the resources survey by using bottom trawl in Cambodian Water during northeast monsoon period is 4209.57 mt. Group of Demersal fish appears the most dominant with 90.75 kg (60.54% of total catch) Ten most dominant species is No.1 Bigeye (*Priacanthus taeneatus*) 15.9 kg (10.60% of total catch), No.2 Goat fish (*Upeneus luzonius*)12.61 kg (8.41% of total catch), No.3 squid, *Photololigo Duvaucelli*, 12.36 kg (8.41% of total catch), No.4 Pomfret (*Pampus chinensis*) 10.49 kg (7.0% of total catch), No.5 Leather jacket (*Altura monoceros*) 9.39 kg (6.26% of total catch), No.6 Lizard fish (*Saurida undosquamis*) 9.24 kg (6.16% of total catch), No.7 Pony fish (*Leiognathus bindus*) 8.13 kg (5.4% of total catch), No.8 Red sea bream (*Nemipterus nematophorus*) 5.51 kg (3.68% of total catch), No.9 Monocle bream (*Scolopsis taenniopterus*) 4.82 kg (3.21% of total catch) and No.10 Emperor snapper (*Lethrinus lentjan*) 3.82 kg (2.55% of total catch). Average catch from the depth range of 30-40 m, 40-50 m have not shown significant different, as 17.65 kg/hr, 17.69 kg/hr respectively. The depth range of 50-60 m is slightly less than shallower ranges as 16.581 kg/hr but depth range at 60-70 m is found much lowest with 11.39 kg/hr.

**Key word:** Catch, distribution, abundance, composition, northeast monsoon, Cambodian Water

## Introduction

Cambodia is one of country in the Southeast Asia Region. Cambodian water is a part of South China Sea, located a part of Gulf of Thailand. The national maritime claim as 443 km with the approximated Exclusive Economic Zone (EEZ) EEZ area is 64,687 Sq km. EEZ is declare with 200 nautical miles (nm) from shore line. During the last decades, marine capture production of Cambodian fisheries had raised up continuously from 95,018 mt in year1994 and highest capture 428,200 in year 2002. The marine capture has obviously declined to 364,357 mt in year 2004. Because of the depletion of marine resources in the Gulf of Thailand, Cambodian Waters is a part of Thailand presumes that is collaterally affected from the heavy fishing activities in The Gulf of Thailand by neighbor countries. Since the few decades, Cambodian Waters has not been conducted the marine resource research survey because lack to personal and research vessel. In order to develop the marine fisheries sector and promote responsible fishing and practices, Cambodia fisheries department as one of Eligible Committee of utilization of M.V. SEAFDEC2 has submitted a year 2005 plan of marine research survey in the Cambodia waters since November 2004, during the meeting of Eligible Committee and Operational Committee in Pattaya, Thailand. The survey is planned to estimate the latest resources abundant and investigate the species composition and distribution of demersal resources sampling by bottom trawl of M.V. SEAFDEC2.

This paper attempts to present preliminary result of the distribution, abundant, species composition and diversity of catch in marine species following the one week marine resource research survey by using M.V.SEAFDEC2 in the Gulf of Thailand, Cambodia Waters on northeast monsoon season.

## Material and Method

### Survey Area and positions

11 survey stations in EEZ of Cambodia have been marked within Latitude 09 15 .0N to 10 45 .0N and Longitude 102 15 .0E to 103 45 .0E. Every survey stations are covered within standard grid 30 sq nm. The depth of survey has ranged from 22-70 m. Because the station survey No.3 is intruded into Thai Waters, sampling station is shifted about 3 nm into Cambodia Waters.

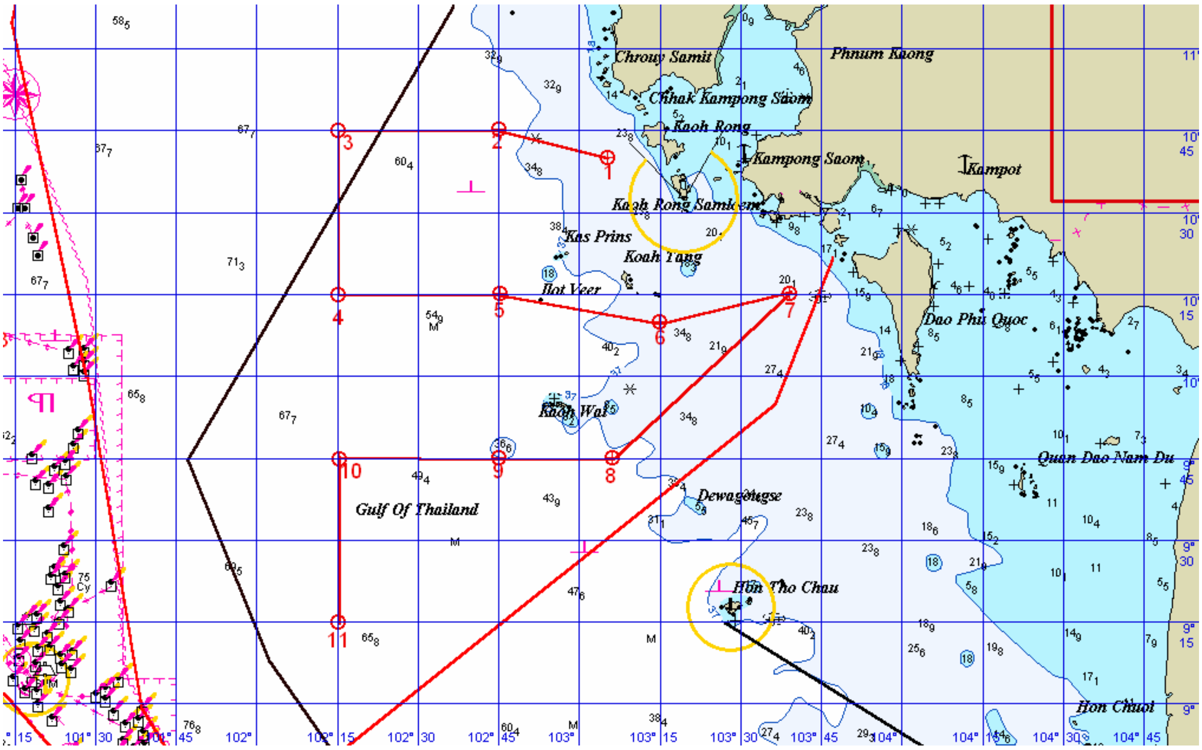



**Figure 1**. Survey area and position

### Research vessel and Fishing gear specification

M.V.SEAFDEC2 is a research vessel under the managing by SEAFDEC/TD. She was constructed from Niigata Dockyard, Japan in 2004. M.V. SEAFDEC2 has been equipped with various oceanographic instruments e.g., Integrated Conductivity Temperature and Depth with the 12 Carousel bottles, Thermosalinograph and Fluorometer, Plankton net, etc. Fishing gears e.g., Bottom trawl, Mid-water trawl, Drifting Gillnet bottom vertical longline, and etc. Vessel's particular details have been appeared below;

**Vessel name:** M.V.SEAFDEC2
**Port of Registry:** Bangkok, Thailand
**Length overall (LOA):** 32.50 m.
**Breath:** 7.20 m.
**Gross tonnage:** 210 tons (international)
**Main Engine:** 1 Yanmar 736 kW
**Service speed:** 12 knots
**Fish hold:** 20 Cu.m.
**Fuel oil tank:** 55 Cu.m.
**Complement:** 37 persons

**Trawl net and Design**

One set of 4 seams bottom trawl has selected to install onboard M.V.SEAFDEC2. The net is 34 meters ground rope length and 31.6 head rope length. Total length of net body is 42.55 m and 36.55 m. without cod end part. Knotted nets of polyethylene PE 360 denier are used to be majority webbing material. Wing net is composed by 2 mesh sizes i.e., 240 mm and 150 mm. net body is composed by 3 mesh size, i.e. 150 mm, 120 mm and 80 mm. cod end part is knotless net, mesh size 25 mm.

The head-rope and ground rope is made from combination rope, diameter 18 mm. Length of head rope is 35 m and length of ground rope is 39 m. The ground rope is weighted with some special cylindrical iron weight, or with lead sinkers.

Otter-boards are rectangular type and curve, made of iron, 140 cm wide and 220 cm long, with a bridle chain and a back strap.

Sweep lines or hand-ropes are 38 m long, 18 mm in diameter, made of Steel wire, type 6 24, Joint with upper pendant wire and lower pendant wire. The upper pendent wires are 48 m long, 14 mm in diameter, made of Steel wire, type 6 24. The lower pendent wires are same length as upper pendant wires, 16 mm in diameter, made of steel wire, type 6 24.

The warps, stored in the trawl winches, are 20 mm in diameter, also made steel wire, type 6 24. Trawl winches are used for paying and hauling warps. And trawl net is stored int0 the net drum.

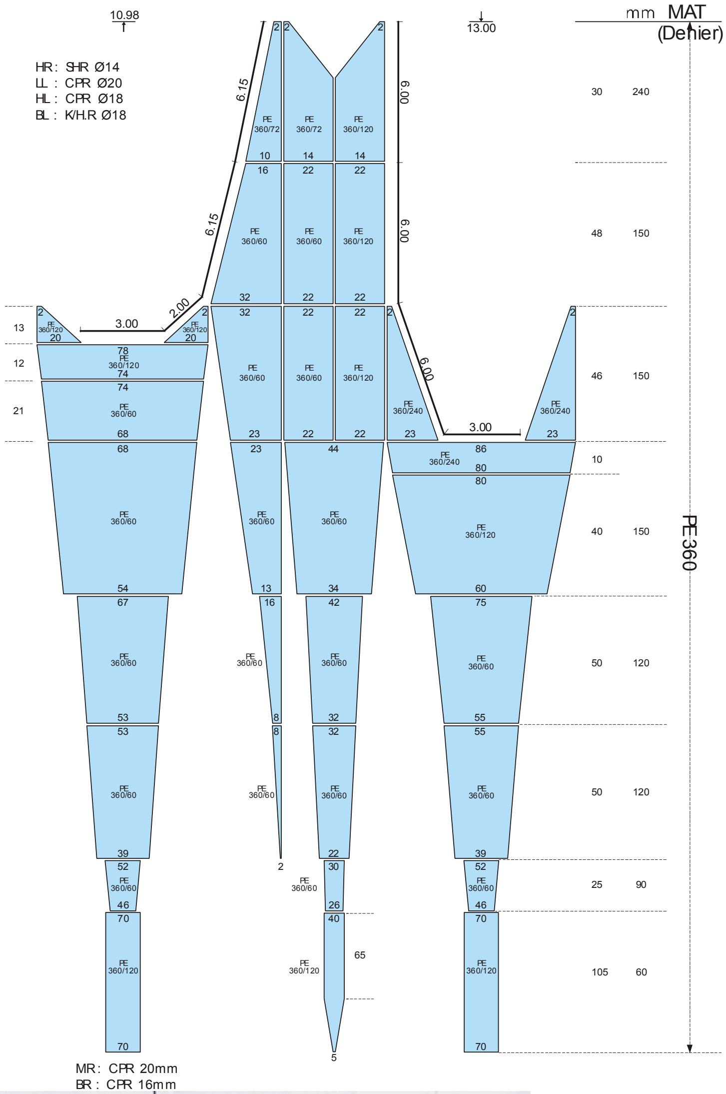
Setting operation: When the gear is to be prepared, the boat streams along the desired course, into wind if desirable. The codend is thrown out and the working ropes retied in their correct positions on head line and wings and the net streamed out astern, the sweep lines run out. The otter boards are connected to the warps and unhooked from the gallows, all is ready for setting.

This may be accomplished by releasing the winch brakes simultaneously so allowing the otter boards to drop into the water and spread while “on the run” or alternatively the warps may first be eased out until the otter boards are just below the surface and seem to be spreading satisfactorily before the warps are released.

All is now ready to set the otter boards and run out the warps to their required extent.

With towing speed 3-4 knot, the wing of trawl net was spread about 17-20 m and 3-4 m height. The ground gear is usable on both hard bottom and flat bottom sea beds. Under the safety of gear and vessel the operation was limited shallower than 400 m. That mean trawl net of M.V. SEAFDEC2 is able to operate from coastal to deep sea. Trawl accessories is full equipped with SCANMAR , distance sensor and trawl-eyed sensor. Trawl net can be monitored the net opening and net spread in order to find out the sweep area for calculating the fish abundant. The standard of Towing speed will be set at 3.5-4.0 knots regarding to the operation circumstance with 1 hour towing time.

Hauling: When hauling, the otter boards are hove up to the gallows by trawl winch. Otter boards are lift and hang by the warps, winch breaks are engaged and safety warps is hooked if necessary to prevent slamming. The sweep lines and pendant lines were wound by net drum winch to the ground rope. Then the ground ropes, wings, bellies and codend of the trawl also are hauled up to the stern emptying.



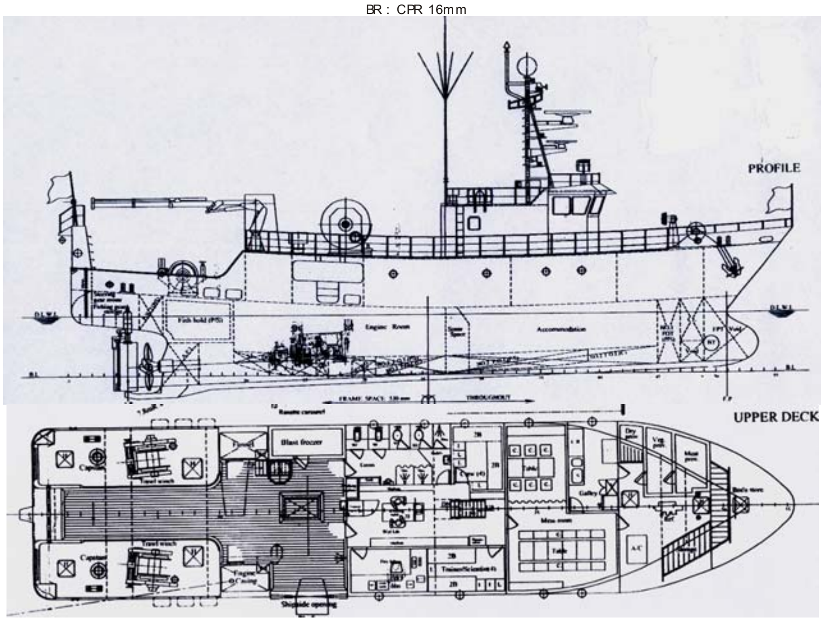




**Figure 2.** Trawl net and Design

**Standard Trawl sampling**

Standard Trawl sampling is referred to the standard operation procedure of FAO as below;

**Step1** Remove all sea snakes and other venomous or otherwise dangerous animals Also remove turtles and if alive, return these to sea. Record number and kind of animals removed.

**Step 2** Remove inorganic debris and plant material Record type of material removed

**Step 3** Remove the larger fish that are readily visible and place them in a box

**Step 4** Wash the remainder of catch (Small fish) if necessary, and mix with shovel

**Step 5** Put the mix catch in boxes while continuing to remove larger fish and putting them into the box mentioned in step 3. The box should be filled simultaneously, not one after the other, and it should be made certain that all boxes contain approximately the same weight of fish.

**Step 6** Count the number of boxes with small fish and record.

**Step 7** A rule of thumb, is to take one box out of every five at random for sub-sampling. Record number of boxes taken to sub-sampling as B1, B2, B3… etc.

**Step 8** The boxes talking for sub-sampling is (are) then treated as follow: Weight total catch in B1 and record. Place fish of B1 on sorting table and sort to species level as far as food fish and valuable crustacean (e.g. shrimps) are concern and taxonomic groupings as well defined as possible (e.g. genus , family, etc.) for other group (the non-edible fish and miscellaneous crustacean) Repeat procedure if appropriate for the other boxes, B2, B3,… etc.

**Step 9** If more than one box was sorted, compute, for each species (or higher taxonomy group) the total weight and number in all sorted boxes.

**Step 10** Multiply the number and weight of fish and invertebrate by species or higher taxonomic group) by the ratio of the number of unsorted to sorted boxes

**Step 11** Weigh and count the larger fish mention in step 3 and 5 by species (Very large fish should be weighed individually and measure.

**Step 12** Add, when there is an overlap (when the fish of a certain species occurred both in the sorted boxes of small fish in the large fish box) The weights and number obtained in step 11 to weights and number in step 10

**Step 13 Step 12** (as well as **step 11** when there is no overlap) provided estimates of total catch, both in weight and number, by species and higher taxonomic groups. Record the total, both in weight and numbers in to the appropriate the fishing log and convert to catch per unit if fishing time is less or more than an hour. During surveys, this step must be complete after each haul or every evening at the latest to preclude loss of information.

# Result

## Overall Catch

Table1 shows overall technical operational details by individual station. Altogether 10 bottom trawl sampling operations were successfully sampled with one haul per operation per survey station. Only station No.11 was cancelled because survey period was not sufficient for conducting sampling operation. The survey was remarked that station No.4 has not been complete operation with one hour trawling time. The trawling time at of station No.4 has been conducted within 32 minutes, because bottom topography is rough and unsuitable for bottom trawl sampling method. Almost of the operations were conducted in the daytime except 3 stations, No.2, No.5, and No.8, were operated when the nighttime because the vessel could not reached survey stations within daytime. The nighttime operation has strongly effected with the catch composition and it can not be compared with the other daytime bottom trawl sampling operation. Daytime and nighttime is different in term of species composition, e.g. shrimp, squid, and etc. However this paper is preliminary bottom survey in Cambodia waters. The variety of different operational periods has to look over and the result is focused on the overview catch of trawl survey in Cambodian water.

**Table 1** Trawl sampling operation by individual station

| Station No. | Date (dd:mm:yy | Start trawling | | | Finish trawling | | | Trawling | |
|---|---|---|---|---|---|---|---|---|---|
| | | Position | | Time | Position | | Time | Distance | Time |
| | | Latitude | (hh:mm) | (hh:mm) | Latitude | Longitude | (hh:mm) | nmi | (hh:mm) |
| 1 | 20/11/05 | 10°34.4N | 103°04.7 | 14:32 | 10°42.1 N | 103°03.8 | 15:32 | 3.05 | 1:00 |
| 2 | 20/11/05 | 10°41.8N | 102°51.2 | 18:37 | 10°40.2 N | 102°48.6 | 19:37 | 3.1 | 1:00 |
| 3 | 21/11/05 | 10°46.2N | 102°27.1 | 6:47 | 10°49.0 N | 102°27.3 | 7:47 | 3.08 | 1:00 |
| 4 | 21/11/05 | 10°13.9N | 102°25.2 | 14:38 | 10°13.4 N | 102°23.9 | 15:10 | 1.73 | 0:32 |
| 5 | 21/11/05 | 10°13.9N | 102°43.5 | 19:15 | 10°13.5 N | 102°40.2 | 20:15 | 3.2 | 1:00 |
| 6 | 22/11/05 | 10°09.9N | 103°03.7 | 6:27 | 10°06.5 N | 103°01.6 | 7:27 | 3.15 | 1:00 |
| 7 | 22/11/05 | 10°14.5N | 103°31.7 | 12:48 | 10°13.3 N | 103°34.9 | 13:48 | 3.3 | 1:00 |
| 8 | 22/11/05 | 09°44.0N | 103°04.5 | 19:33 | 09°42.1 N | 103°02.2 | 20:33 | 3 | 1:00 |
| 9 | 23/11/05 | 09°44.7N | 102°44.1 | 6:14 | 09°43.2 N | 102°41.2 | 7:15 | 3.05 | 1:01 |
| 10 | 23/11/05 | 09°44.2N | 102°25.5 | 12:40 | 09°43.2 N | 102°22.5 | 13:40 | 3.15 | 1:00 |

*Nmi: Nautical mile = 1852 meter*

Table 2 shows overall catch rate of various by individual station. The total catch 149.89 kg, average catch of 10 stations is 14.89 kg. Ranged from individual station is from vary from 5.3 to 27.13 kg. The operation No.7 is shown highest catch with 27.13 kg, and followed by station No.8 with 23.66kg. Catch result show very low quantity at Station No.4, is 5.38 kg but the towing time at station No.4 is 32 minute towing time so that the corrected calculation as 10.09 kg/hour. Therefore catch result from station No.1 is become the lowest as 8.16 kg/hr. The actual total catch of bottom survey from the survey in Cambodia waters is 149.89 kg, with the trawling time 9:33 hours. CPUE calculated by this research survey is 15.70 kg/hr.

Average catch from the depth range of 30-40 m, 40-50 m have not shown significant different between each other, as 17.65 kg/hr, 17.69 kg/hr respectively. The depth range of 50-60 m is slightly lower than previously referred range as 16.581 kg/hr but range of the depth 60-70 m is found much lowest with 11.39 kg/hr. Table 3 shows overall catch in different range of sea depth.

**Table 2**. Depth and Catch by Individual Station

| Station No. | Date (dd:mm:yy) | Start trawling Position | | Finish trawling Position | | Depth (m) | Weight (Kg) |
|---|---|---|---|---|---|---|---|
| | | Latitude | Longitude | Latitude | Longitude | | |
| 1 | 20/11/05 | 10°34.4N | 103°04.7 E | 10°42.1 N | 103°03.8 E | 30-36 | 8.16 |
| 2 | 20/11/05 | 10°41.8N | 102°51.2 E | 10°40.2 N | 102°48.6 E | 39-47 | 17.46 |
| 3 | 21/11/05 | 10°46.2N | 102°27.1 E | 10°49.0 N | 102°27.3 E | 62-63 | 13.86 |
| 4 | 21/11/05 | 10°13.9N | 102°25.2 E | 10°13.4 N | 102°23.9 E | 63-67 | 5.38 |
| 5 | 21/11/05 | 10°13.9N | 102°43.5 E | 10°13.5 N | 102°40.2 E | 53-59 | 16.57 |
| 6 | 22/11/05 | 10°09.9N | 103°03.7 E | 10°06.5 N | 103°01.6 E | 39 | 17.91 |
| 7 | 22/11/05 | 10°14.5N | 103°31.7 E | 10°13.3 N | 103°34.9 E | 33 | 27.14 |
| 8 | 22/11/05 | 09°44.0N | 103°04.5 E | 09°42.1 N | 103°02.2 E | 50-58 | 23.66 |
| 9 | 23/11/05 | 09°44.7N | 102°44.1 E | 09°43.2 N | 102°41.2 E | 55-60 | 9.5 |
| 10 | 23/11/05 | 09°44.2N | 102°25.5 E | 09°43.2 N | 102°22.5 E | 68-71 | 10.24 |
| | | | | | Total weight : 149.89 kg | | |

**Table 3**. Catch rate by Range of Captured Depth

| Range of Depth (m) | Station No. | Catch (kg/hr) | Average Catch (kg/hr) | Remark |
|---|---|---|---|---|
| 30-40 | 1 | 8.16 | 17.65 | |
| | 7 | 17.46 | | |
| 40-50 | 2 | 13.86 | 17.69 | |
| | 6 | 5.38 | | |
| 50-60 | 5 | 16.57 | 16.58 | |
| | 8 | 17.91 | | |
| | 9 | 27.14 | | |
| 60-70 | 3 | 23.66 | 11.39 | |
| | 4* | 10.09 | | *Catch after adjusting |
| | 10 | 10.24 | | |

**Abundance**

In order to seek for information of the abundant of biomass, estimated calculation methodology described into the FAO manual, *Introduction to tropical stock assessment*, is introduced to refer in this paper. Important information such swept area, size of the area under investigation and etc, have to collect and calculate.

Swept area or effective parh swept, has been calculated and present by meter$^2$ from the equation;

$$a = D \times hr \times X_2 \text{ or } a = D \times W$$
$$(\text{While; } D = V \times t)$$

Where; **a** is swept area or effective path swept (Unit is nautical mile)
**D** is towing distance (Unit is nautical mile)
**hr** is the length of the head-rope,
**V** is velocity of the trawl over the ground when trawling (Unit is knot),
**T** is towing time (Unit is hour)
**$X_2$** is that fraction of the head-rope length, hr, which is equal to the width of the path swept by the trawl
**W** is wing spread, recorded by Hydro-acoustic distance sensor (*SCANMAR* )).
The record is the real-time (Unit is nautical mile)

From the Total No.1, trawling time of 10 fishing operations are 9:33 hours. By the swept area equation, total sweep area of 10 sampling operations by bottom trawl in Cambodia Waters is 0.29243 nm$^2$ that represented the total research survey area, 8212.5 nm$^2$.

Demersal Biomass Estimation (B) is estimated by using the equation *THE SWEPT AREA METHOD*

$$B = [(Cw/a) \quad A] / X1$$

Where; Cw is the catch in weight of a hau
a is the area swept
A is the total
X1 is the fraction of the biomass is the effective path swept by the trawl which is actually retained in the gear. Refer to Department of Fisheries, Thailand, demersal biomass is obtained by using X1 = 1.0

By the calculation, Total Biomass Estimation of the resources survey by using bottom trawl in Cambodia Waters during northeast monsoon period is 4,209,572.08 kg (4209.57 mt). That included pelagic fishes caught by bottom trawl. In the other way, Demersal Biomass Estimation, that excluded the pelagic resources sampling, by bottom trawl is 4090138.48 kg (4090.13 mt) and individual group of Cephalopod Estimation Biomass is 809,011.38 kg (809.01 mt)

**Table 4**. Catch comparison in group of catch by survey stations

| Group | Station No. | | | | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Weight (kg) | % |
| Cephalopod | 2.13 | 1.26 | 2.49 | 1.16 | 1.32 | 7.19 | 7.01 | 2.18 | 2.34 | 1.73 | 28.81 | 19.22 |
| Crab | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.35 | 0.75 | 0.00 | 0.00 | 1.1 | 0.73 |
| Demersal | 3.16 | 13.16 | 9.8 | 3.81 | 13.07 | 4.71 | 14.92 | 14.99 | 5.29 | 7.84 | 90.75 | 60.54 |
| Other | 0.17 | 0.13 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.46 | 0.31 |
| Pelagic | 0.8 | 0.13 | 0.51 | 0.18 | 0.14 | 2.18 | 0.56 | 1.01 | 0.87 | 0.00 | 6.38 | 4.26 |
| Shrimp | 0.00 | 0.95 | 0.00 | 0.00 | 0.46 | 0.00 | 0.00 | 0.6 | 0.00 | 0.00 | 2.01 | 1.34 |
| Trash | 1.9 | 1.83 | 1.09 | 0.24 | 1.49 | 3.83 | 4.3 | 4.06 | 1.01 | 0.66 | 20.38 | 13.6 |
| **Grand Total** | **8.165** | **17.462** | **13.86** | **5.39** | **16.57** | **17.91** | **27.14** | **23.67** | **9.5** | **10.24** | **149.89** | **100** |

**Table 5**. Swept area of bottom trawl catch by survey stations.

| Station No. | Date (dd:mm) | Start trawling | | Finish trawling | | Time (hh:mm) | Distance nmi | Net spread m | Sweep Area $nmi^2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | Position | | Position | | | | | |
| | | Latitude | Longitude | Latitude | Longitude | | | | |
| 1 | 20/11 | 10°34.4N | 103°04.7 E | 10°42.1 N | 103°03.8 E | 1:00 | 3.05 | 17 | 0.028 |
| 2 | 20/11 | 10°41.8N | 102°51.2 E | 10°40.2 N | 102°48.6 E | 1:00 | 3.1 | 19 | 0.032 |
| 3 | 21/11 | 10°46.2N | 102°27.1 E | 10°49.0 N | 102°27.3 E | 1:00 | 3.05 | 20.4 | 0.034 |
| 4 | 21/11 | 10°13.9N | 102°25.2 E | 10°13.4 N | 102°23.9 E | 0:32 | 1.73 | 18.75 | 0.018 |
| 5 | 21/11 | 10°13.9N | 102°43.5 E | 10°13.5 N | 102°40.2 E | 1:00 | 3.2 | 18 | 0.031 |
| 6 | 22/11 | 10°09.9N | 103°03.7 E | 10°06.5 N | 103°01.6 E | 1:00 | 3.15 | 17.45 | 0.03 |
| 7 | 22/11 | 10°14.5N | 103°31.7 E | 10°13.3 N | 103°34.9 E | 1:00 | 3.3 | 16.5 | 0.029 |
| 8 | 22/11 | 09°44.0N | 103°04.5 E | 09°42.1 N | 103°02.2 E | 1:00 | 3 | 18 | 0.029 |
| 9 | 23/11 | 09°44.7N | 102°44.1 E | 09°43.2 N | 102°41.2 E | 1:01 | 3.05 | 17.5 | 0.029 |
| 10 | 23/11 | 09°44.2N | 102°25.5 E | 09°43.2 N | 102°22.5 E | 1:00 | 3.15 | 18.25 | 0.031 |

**Species Composition**

Catch total weight and percentage of each species and families caught during research cruise were shown by table 6. During the survey, demersal group is found dominant catch with 90.75 kg (60.54% of total catch), the second dominant group is cephalopod is 28.807 kg (19.22% of total catch) and followed by group of trash fish, 20.38 kg (13.60% of total catch). Because of the net height while towing underwater is about 2-3 m, it makes trawl net rarely to catch pelagic sample species. Pelagic species caught by 10 bottom trawl fishing operation is 6.382 kg (4.26% of total catch)

Bigeye (*Priacanthus taeneatus*) is appeared to be the most dominant fish species with 15.9 kg (10.60% of total catch). Bigeye (*Priacanthus taeneatus*) is the highest composition in term of the weight of station No.5 and No.8 with, 7.6 kg and 5.9 kg respectively. It is also shown 2$^{nd}$ major species of station No.2 with 1.2 kg. Mentioned from the item of overall catch that station No.2 No.5, No.8 was operated during the nighttime period. Bigeye (*Priacanthu spp*) is one of the species recognized that majority catch during the nighttime. The operation period of bottom should be taken into the consideration while planning the survey details. Otherwise the result may be inaccurate even though the researchers onboard strictly control other factors.

The second dominant species is Goat fish (*Upeneus luzonius*), 12.61 kg (8.41% of total catch). Goat fish is categorized within the group of trash fish, caught by bottom trawl. The highest catch is shown at station No.7 (8.4 kg).

The third dominant species is squid, *Photololigo Duvaucelli*, 12.36 kg (8.41% of total catch). Operation No.6 and No.7 is appeared the highest catch, 4.3 kg and 3.4 kg respectively. Squid, *Photololigo Duvaucelli*, is categorized within the group of cephalopod and this group shown second dominant group of total catch. Trawl operation at nighttime has not shown higher effective catch than daytime. Therefore it is possible to assume that abundant of squid catch by the bottom trawl fishing activity is depended on fishing ground more than period of operation. Squid,

The other seven most dominant species caught during the survey is No.4 Pomfret (*Pampus chinensis*) 10.49 kg (7.0% of total catch), No.5 Leather jacket (*Altura monoceros*) 9.39 kg (6.26% of total catch), No.6 Lizard fish (*Saurida undosquamis*) 9.24 kg (6.16% of total catch), No.7 Pony fish (*Leiognathus bindus*) 8.13 kg (5.4% of total catch), No.8 Red sea bream (*Nemipterus nematophorus*) 5.51 kg (3.68% of total catch), No.9 Monocle bream (*Scolopsis taenniopterus*) 4.82 kg (3.21% of total catch) and No.10 Emperor snapper (*Lethrinus lentjan*) 3.82 kg (2.55% of total catch)

Total weight of Cardinal fish is 5.03 kg (3.36% of total catch) however it has not been identified to species level so that Cardinal fish is not able to compare the dominant catch within the species level.

Classify into the level of family, Priacanthidae is appeared to be the most dominant family with 15.9 kg (10.60% of total catch). The second dominant family is Nemipteridae 15.6 kg (10.40% of total catch). The Third dominant species is cephalopod, family Loliginidae 15.11 kg (10.08% of total catch)

The other seven most dominant family caught during the survey is No.4 Mullidae 13.88 kg (9.26% of total catch), No.5 Synodontidae 11.77 kg (7.85% of total catch), No.6 Stromatidae 10.49 (7.0% of total catch), No.7 Leiognathidae 9.29 kg (6.20% of total catch), No.8 Apogonidae 5.03 kg (3.36% of total catch), No.9 Carangidae 5.02 kg (3.34% of total catch), and No.10 Lutjanidae 4.97 kg (3.32% of total catch).

Cephalopod is the most dominant group of invertebrate caught during the survey. The total weight of cephalopod is 16.84 kg (23.80% of total catch). Shrimp is the second dominant group of invertebrate with 2.01 kg (1.34% of total catch) and the third dominant group of invertebrate is crab with 1.83 kg (1.22% of total catch).

Squid, Photololigo Duvaucelli, is appeared to be the most dominant invertebrate species with 12.36 kg (8.41% of total catch and 38.72% of total invertebrate catch).

Trash fish share 13.60% of total catch (20.38 kg). Leiognathidae is dominant species of trash 20.38 kg kg (45.56 % of total trash catch) followed by Apogon with 5.03 kg (24.68% of total trash catch) and Tetrodontoidei 2.8 kg (13.73% of total trash catch).

Orangefin ponyfish, Leiognathus bindus is appeared the highest dominant trash with 8.13 kg (5.4% of total catch and 39.89% of total trash catch).

**Catch Diversity**

At least 13 orders, 40 families and 80 species of marine fish are found from the bottom survey. Because some species particularly on the trash fish have not been classified into species level diversity of fish sampled in Cambodia water is more than 80 species. At least 8 cephalopod species with 3 families, Loliginidae, Sepiidae and Octopodidae are found in sampling survey. Loliginidae and Sepiidae are classified to species level but octopodidae is classified to genus level. Only shrimp family is Peneus, with 3 genuses, *Peneus*, *Metapeneus* and *Trachypeneopsis* found in sampling survey. All of them are classified into species level. Most of shrimp are found at survey Station No.2 No.5 and No.8 when operated in the nighttime. It is recognized that shrimp trawling is suitable to operate during nighttime. Consideration on the shrimp distribution that effected from sampling period, Shrimp should not significant mention in this survey. The survey of shrimp resources in Canbodia water should particularly design only nighttime trawl sampling survey.

There are 3 species i.e. *Saurida undosquamis*, *Suarida isarakurai*, and *Upeneus benzazi*, found in most of sampling stations. There is two species, Leather jacket (Altura monoceros) and squid, *Photololigo Duvaucelli*, found from 9 sampling stations.

As the bottom survey has found that no any significant different in term of average total catch between range of depth 30-40 m and 40-50 m. But the range of depth 50-60 is slight lower than both 2 shallower ranges and range 60-70 m shows the lowest catch. Distribution of the target group consider with the depth range of capture, demersal group is appeared as highest catch in the range 50-60 m. Range 50-60 m is composed of 3 sampling stations, No.5, No.7, and No.9. Survey operation at station No.5 and No.7 was operated in nighttime that Bigeye (Priacnthidae) is dominant species. This paper can not ensure that depth range of 50-60 m is highest demersal catch according that the bias was happened by operational period.

Catch of cephalopod group has shown very close average catch at range 30-40 and 40-50 m with 4.6 kg and 4.2 kg respectively. Catch of trash fish group is slightly decreased average weight from shallow area to deep area.

## Discussion

The overall average catch rate from individual station is very low CPUE as 15.7 kg/hr. The highest catch is 27.14 kg/hr at station No.7 and the lower catch is 8.16 kg/hr. at station No.1. Because of the resources sampling was conducted by using bottom trawl so that dominant group of sample is demersal fish. However cephalopod is show very interesting resources with the third dominant species (19.22%). According to the nighttime operation, there are some bias on the catch appear in the catch result such as Bigeye (Priacanthidae) is very high catch on the nighttime operation opposite with squid that nearly disappear from the nighttime station or sample of shrimp appeared in nighttime station. For the next survey, the plan should specific for daytime or nighttime operation according the the target catch.

The numbers of sampling survey with in an area of grid survey are too less in numbers, only one operation in area of 30×30 nm (300 $nm^2$). In this survey, sweep area form 10 sampling station is 0.29243 $nm^2$ that represented total area, 8212.5 $nm^2$. That is very difficult to precisely estimate the marine biomass in Cambodia Waters. Adding the sampling operation in a grid survey or reduce the area of grid survey should be considered. Anyhow more station survey need higher budget.

Seasoning is also one of the important for the research survey. The research survey in the southwest monsoon should be implement however the plan must be carefully considered according to the sea condition during southwest monsoon is very rough and strong gale.

Human Resource Development to Marine Fisheries officers necessary to conduct as well as the resource survey. That is very important to Marine fisheries of Cambodia to develop the officer for the resource survey activity and fish landing inspectors in order to collect accurate information in standard of fisheries data and statistic for predicting the stock of marine resources and provide the proper fisheries measurement.

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**Table 6.** Catch pecentage by weight of each species and families caught during research cruise

| NO. | ORDER/FAMILY / SPECIES | | STATION 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | WEIGHT TOTAL | AVERAGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Kg | Kg | Kg | Kg | Kg | Kg | Kg | Kg | Kg | Kg | (Kg) | (Kg) |
| 1 | **ORECTOLOBIFORMES** | | | | | | | | | | | | | |
| | **Hemiscylidae** | *Chiloscyllium punctatum* | | | | | | 0.36 | | | | | **0.36** | **0.036** |
| | | *Chiloscyllium griseum* | | 1.8 | | | | | | | | | **1.8** | **0.18** |
| 2 | **MYLIOBACTIFORMES** | | | | | | | | | | | | | |
| | **Dasyatidae** | *Dasyatis kuhlii* | | 0.6 | | | | | | | | | **0.6** | **0.06** |
| | | *Dasyatis zugei* | | | | | 0.95 | | | 0.7 | | | **1.65** | **0.165** |
| 3 | **ANGUILLIFORMES** | | | | | | | | | | | | | |
| | **Muraenisocidae** | *Muraenesox sp.* | | | | | | | | 0.55 | | | **0.55** | **0.055** |
| 4 | **CLUPEIFORMES** | | | | | | | | | | | | | |
| | **Engraulidae** | *Encrasicholina punctifer* | | 0.13 | | | | | | | | | **0.13** | **0.013** |
| | | *Stolephorus indicus* | | | | | 0.06 | | | | | | **0.06** | **0.006** |
| 5 | **AULOPIFORMES** | | | | | | | | | | | | | |
| | **Synodontidae** | *Saurida elongata* | | 0.21 | | | 0.28 | | | | 0.28 | | **0.77** | **0.077** |
| | | *Saurida isarankurai* | 0.03 | 0.08 | 0.3 | 0.06 | 0.15 | 0.11 | 0.26 | 0.02 | 0.3 | 0.45 | **1.76** | **0.176** |
| | | *Saurida undosquamis* | 0.33 | 0.36 | 0.66 | 0.34 | 0.7 | 1.7 | 1 | 1.05 | 0.3 | 2.8 | **9.24** | **0.924** |
| 6 | **OPHIDIIFORMES** | | | | | | | | | | | | | |
| | ***Ophiidae*** | *Sirembo jerdoni* | | | | | 0.18 | | | | | | **0.18** | **0.018** |
| 7 | **SILURIFORMES** | | | | | | | | | | | | | |
| | **Plotosidae** | *Plotossus lineatus* | | | | | | | | 0.4 | | | **0.4** | **0.04** |
| 8 | **BARYCIFORMES** | | | | | | | | | | | | | |
| | **Holocentridae** | *Sargocentron rubrum* | | | | 0.22 | | | | | | | **0.22** | **0.022** |
| 9 | **GASTEROSTEIFORMES** | | | | | | | | | | | | | |
| | **Centriscidae** | *Aeoliscus strigatus* | | | | | | | | | 0.01 | | **0.01** | **0.001** |
| | **Fistularidae** | *Fistularia commersoni* | | 0.05 | 0.12 | | 0.4 | 0.09 | | 0.01 | 0.25 | | **0.92** | **0.092** |
| 10 | **SCORPHAENIFORMES** | | | | | | | | | | | | | |
| | **Scorpaenidae** | *Scorpaenodes sp.* | | | | | 0.03 | | | | | | **0.03** | **0.003** |
| | | *Inimiscus sinensis* | | 0.06 | | | | | | | | | **0.06** | **0.006** |
| | | *Pterios russelli* | | | | | | | | | 0.23 | | **0.23** | **0.023** |
| | | *Pterios sp.* | | | | | 0.06 | | | | | | **0.06** | **0.006** |
| | **Platycephalidae** | *Platycepharus sp.* | | | | 0.08 | 0.3 | | | | | | **0.38** | **0.038** |
| | | *Elates ransonnetii* | | 0.01 | | | 0.02 | | | 0.06 | | | **0.09** | **0.009** |
| | | *Thrysanophrys arenicola* | | 0.19 | 0.08 | | | | | 0.18 | | | **0.45** | **0.045** |

**Table 12.** Continue

| 11 | PERCIFORMES | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Priacanthidae** | *Priacanthus tayenus* | | 1.2 | 0.23 | | 7.6 | 0.4 | 0.05 | 5.9 | 0.53 | | **15.9** | **1.59** |
| | **Serranidae** | *Epinephelus sexfasciatus* | | 0.08 | 0.48 | | | 0.4 | | 0.05 | 0.34 | | **1.35** | **0.135** |
| | | *Epinephelus areolatus* | | 0.24 | 0.46 | 0.5 | 0.06 | | 0.24 | 1 | 0.2 | | **2.7** | **0.27** |
| | **Apogonidae** | *Apogon spp.* | 0.19 | 1.1 | 0.1 | | 0.22 | | | 3.3 | 0.12 | | **5.03** | **0.503** |
| | **Carangidae** | *Alepes melanophtera* | 0.52 | | | | | | | | | | **0.52** | **0.052** |
| | | *Atule mate* | 0.04 | | | | 0.08 | | | | 0.06 | | **0.18** | **0.018** |
| | | *Carangoides uii* | | | 0.05 | | | | | | | | **0.05** | **0.005** |
| | | *Carangoides malabaricus* | | | | 0.18 | | 0.19 | | 0.19 | | | **0.56** | **0.056** |
| | | *Caranx sexfasciatus* | | | | | | 0.28 | | | | | **0.28** | **0.028** |
| | | *Selaroides leptolepis* | | | | | | | | | 0.6 | | **0.6** | **0.06** |
| | | *Uraspis uraspis* | | | 0.46 | | | 0.75 | | | | | **1.21** | **0.121** |
| | | *Decapterus maruadsi* | | | | | | | | 0.19 | | | **0.19** | **0.019** |
| | | *Parastromateus niger* | | | | | | 0.96 | 0.28 | | | | **1.24** | **0.124** |
| | | *Seriolina nigrofasciata* | 0.06 | | | | | | | 0.13 | | | **0.19** | **0.019** |
| | **Menidae** | *Mene maculata* | | | 0.12 | | | | 0.09 | | | | **0.21** | **0.021** |
| | **Gerreidae** | *Gerres oyena* | | 0.16 | | 0.34 | | 0.01 | 0.03 | 0.15 | 0.08 | | **0.77** | **0.077** |
| | ***Leiognathidae*** | *Leiognathus bindus* | 0.96 | | 0.28 | 0.14 | | 3 | 3.2 | 0.01 | 0.35 | 0.19 | **8.13** | **0.813** |
| | | *Leiognathus elongatus* | | 0.04 | | | | 0.01 | | 0.06 | | | **0.11** | **0.011** |
| | | *Leiognathus leuciscus* | | 0.3 | 0.06 | 0.07 | 0.06 | | | 0.01 | 0.01 | | **0.51** | **0.051** |
| | | *Leiognathus smithursti* | | | 0.22 | | | | | | | | **0.22** | **0.022** |
| | | *Secutor insidiater* | 0.15 | 0.03 | | 0.01 | | | 0.01 | 0.12 | | 0.01 | **0.33** | **0.033** |
| | ***Lutjanidae*** | *Lutjanus russelli* | | 0.25 | | | | | | | | | **0.25** | **0.025** |
| | | *Lutjanus lineolatus* | 0.7 | 1.2 | | | 0.05 | | 0.3 | 0.44 | | | **2.69** | **0.269** |
| | | *Lutjanus vitta* | | 1.8 | 0.24 | | | | | | | | **2.04** | **0.204** |
| | **Caesionidae** | *Ptercaesio digramma* | | 0.02 | | | | | | 0.1 | | | **0.12** | **0.012** |
| | ***Haemulidae*** | *Plectorhinchus pitcus* | 0.19 | 0.01 | | | | | 0.19 | | | | **0.39** | **0.039** |
| | **Lethrinidae** | *Lethrinus lentjan* | | 3.3 | | | | | | 0.52 | | | **3.82** | **0.382** |
| | ***Nemipteridae*** | *Nemipterus mesoprion* | | 0.6 | 0.08 | | 0.38 | | | 0.57 | 0.21 | 0.1 | **1.94** | **0.194** |
| | | *Nemipterus nematophorus* | | | 2.4 | 0.56 | 0.35 | | | | | 2.2 | **5.51** | **0.551** |
| | | *Nemipterus Nemurus* | | 0.25 | | | 0.2 | | | 0.08 | | 0.35 | **0.88** | **0.088** |
| | | *Nemipterus peronii* | | 0.12 | | | | | | 0.38 | | | **0.5** | **0.05** |
| | | *Nemipterus tambuloides* | | | | 0.5 | | | | | 0.9 | 0.55 | **1.95** | **0.195** |
| | | *Scolopsis taeniopterus* | 0.25 | 0.15 | 0.18 | | 0.42 | 0.33 | 3.2 | 0.29 | | | **4.82** | **0.482** |

**Table 12.** Continue

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | ***Mullidae*** | *Upeneus luzonius* | 0.46 | 0.55 | 0.12 | 0.23 | 0.4 | 0.4 | 8.4 | 0.5 | 0.6 | 0.95 | **12.61** | **1.261** |
| | | *Upeneus molucensis* | | | | | | | | 0.11 | | | **0.11** | **0.011** |
| | | *Upeneus sulphureus* | | | 0.43 | 0.15 | 0.12 | | | 0.46 | | | **1.16** | **0.116** |
| | **Theraponidae** | *Theraponidae* | | | | | | | | | 0.21 | | **0.21** | **0.021** |
| | | *Therapon theraps* | | | 0.04 | | | | | 0.52 | | | **0.56** | **0.056** |
| | **Ephippidae** | *Platex boersi* | | | | | | | 0.25 | | | | **0.25** | **0.025** |
| | **Pomacentridae** | *Chromis sp.* | | | | | | 0.02 | | | | | **0.02** | **0.002** |
| | **Chaetodontidae** | *Chaetodon sp.* | 0.12 | | | | | | | | | | **0.12** | **0.012** |
| | **Siganidae** | *Siganus oramin* | | | | | 0.22 | | | 0.22 | | | **0.44** | **0.044** |
| | ***Scombridae*** | *Rastrelliger kanagurta* | | | | | | | | | 0.21 | | **0.21** | **0.021** |
| | | *Rastrelliger brachysoma* | 0.18 | | | | | | | 0.2 | | | **0.38** | **0.038** |
| | | *Scomberomorus commerson* | | | | | | | 0.28 | 0.3 | | | **0.58** | **0.058** |
| | **Trichiuridae** | *Trichiurus haumela* | 0.7 | | 0.18 | 0.21 | | 0.31 | | | 0.14 | | **1.54** | **0.154** |
| | **Stromatidae** | *Pampus chinensis* | 1.6 | | 0.5 | 0.54 | | 2.3 | 2.1 | 1.5 | 0.95 | 1 | **10.49** | **1.049** |
| | ***Sphyraenidae*** | *Sphyraena jello* | 0.08 | | 0.42 | | | 0.19 | | | | | **0.69** | **0.069** |
| | **Gobiidae** | Unidentified Gobiid | | | | | | 0.04 | | | | | **#REF!** | **#REF!** |
| **12** | **PLEUNECTIFORMES** | | | | | | | | | | | | | |
| | **Pleuronectidae** | *Unidentified Pleuronectidae* | | 0.02 | 0 | 0.02 | 0.04 | | | | 0.04 | 0.03 | **0.15** | **0.015** |
| **13** | **TETRADONTIFORMES** | | | | | | | | | | | | | |
| | **Monacanthidae** | *Alutera monoceros* | 0.43 | | 3.5 | 0.62 | 0.9 | 0.5 | 1 | 0.8 | 1.2 | 0.44 | **9.39** | **0.94** |
| | **Balistidae** | *Unidentified Balistoidei* | | 0.04 | | | | 0.01 | 0.7 | | | | **0.75** | **0.075** |
| | **Diodontidae** | *Diodon hystrix* | | | | | 0.13 | | | | | | **0.13** | **0.013** |
| | **Lagocephalidae** | *Lagocephalus lunaris* | 0.48 | | 0.15 | | 0.23 | 0.48 | 0.3 | 0.5 | | 0.44 | **2.58** | **0.258** |
| | | *Lagocephalus sceleratus* | | | | | | 0.09 | | | | | **0.09** | **0.009** |
| **33** | **OTHER** | | | | | | | | | | | | | |
| | | Unidentified | | 0.14 | | | | | | | | | **0.14** | **0.014** |
| | | *Batrachus grunniens* | | | | | 0.03 | | | | | | **0.03** | **0.003** |
| | | *Bregmaceros rarisquamosus* | | | | | 0.11 | | | | | | **0.11** | **0.011** |
| **34** | **SQUIDS** | | | | | | | | | | | | | |
| | **Loliginidae** | *Photololigo duvaucelii* | | 0.84 | 1.5 | 0.4 | 1 | 4.3 | 3.4 | 0.3 | 0.41 | 0.21 | **12.36** | **1.236** |
| | | *Nipponololigo sumatrensis* | 0.19 | | 0.42 | 0.18 | 0.06 | 0.3 | 0.24 | | 0.9 | 0.46 | **2.75** | **0.275** |
| | | *Sepiotheuthis lessoniana* | 0.34 | | | | | 0.29 | 1.1 | | | | **1.73** | **0.173** |
| **35** | **CUTTLES FISH** | | | | | | | | | | | | | |
| | **Sepiidae** | *Sepia aculeata* | | | | | | | 0.03 | | | | **0.03** | **0.003** |
| | | *Sepia pharaonis* | | | | | | | 0.14 | | | | **0.14** | **0.014** |
| | | *Sepia recurvirostra* | | | | | | | | | | 0.06 | **0.06** | **0.006** |
| | | *Sepia brevimana* | | | 0.01 | 0.04 | 0.27 | | | 0.3 | 0.08 | | **0.7** | **0.07** |

**Table 12.** Continue

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **36** | **OCTOPUS** | | | | | | | | | | | | | |
| | | *Octopus spp.* | | 0.42 | 0.06 | | | | | 0.08 | | | **0.56** | **0.056** |
| **37** | **SHRIMPS** | | | | | | | | | | | | | |
| | **P. semisulcatus** | *Peneaus semisulcatus* | | 0.21 | | | | | | | | | **0.21** | **0.021** |
| | | *Metapenaeus stridulans* | | 0.04 | | | 0.07 | | | | | | **0.11** | **0.011** |
| | | *Trachypenaeus fulvus* | | 0.7 | | | 0.4 | | | 0.6 | | | **1.7** | **0.17** |
| **38** | **CRABS** | | | | | | | | | | | | | |
| | | *Charybdis cruciata* | | | | | | | 0.35 | 0.75 | | | **1.1** | **0.11** |
| | | *Crabs (trash)* | | 0.04 | | | | 0.09 | | | | | **0.13** | **0.013** |
| **39** | **OTHER CRUSATACEANS** | | | | | | | | | | | | | |
| | ***Amoecium*** | Unidentified | 0.17 | | | | 0.08 | | | | | | **0.25** | **0.025** |
| | ***Squillidae*** | *Mantis shrimps* | | 0.13 | | | | | | 0.08 | | | **0.21** | **0.021** |
| | | | | | | | | | | | | | | **0** |
| | | **TOTAL CATCH RATE** | **8.17** | **17.46** | **13.86** | **5.39** | **16.57** | **17.91** | **27.14** | **23.67** | **9.5** | **10.24** | **149.89** | **14.989** |


SAFETY FIRST

# COMPOSITION, ABUNDANCE AND DISTRIBUTION OF ZOOPLANKTON IN THE CAMBODIAN WATER

BY

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# COMPOSITION, ABUNDANCE AND DISTRIBUTION OF ZOOPLANKTON IN THE CAMBODIAN WATER

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## Abstract

The zooplankton samples were collected from 10 stations in the Cambodian water during 20-23 November 2005. The bongo net was used for the oblique sampling. The zooplankton samples were identified representing to 8 Phylum comprise of Cnidaria, Annelida, Mollusca, Arthopoda, Chaetognatha, Chordata and the meroplanktonic Echinodermata and Brachiopoda. The average abundance of zooplankton and larva zooplankton were 69.48 and 43.13 individuals/m$^3$ respectively. Copepods consistently occurred at all stations and were the most dominant group in terms of abundance and distribution in the study areas. For larva zooplankton, meroplanktonic Echinodermata were the most dominant group in the study areas, especially in the coastal stations. The present results of zooplankton in the Cambodia waters did not clearly show that the differences of environment factor could contribute to the difference in abundance, distribution and composition of zooplankton. They only showed that zooplankton abundance and distribution according to the depth, the coastal shallow areas tending to be higher density of zooplankton.

**Keywords**: Zooplankton, Cambodian water, composition, abundance, distribution

## Introduction

Zooplankton occupy a key role in pelagic ecosystems as they control phytoplankton both biomass and diversity, their also important source of food for many marine nektons. The zooplanktons are an important part of the food web by transfer energy to higher tropic levels. They contribute to export organic matter through their grazing activity to the deep sea and the benthos, by faecal pellets production and vertical migration, thus exerting a control on biogeochemical cycles. The study of abundance and diversity of zooplankton largely determine the diversity, abundance and recruitment of pelagic fisheries resources such as fish and squid etc. In addition to their significant role in pelagic food chains, some groups of zooplankton such as chaetognathas are well-known biological indicators of distinctive types of surface ocean water.

Although Cambodia has 435 kilometers of shoreline and a corresponding exclusive economic zone (EEZ) extending more than 55,600 square kilometers, its marine fishery is small compared to the inland fishery. Freshwater fisheries playing an important role in the daily food production and contributing to the national economy, they are one of the most productive in the world due to the presence of large floodplains around the Great Lake and along the Tonle Sap and the Mekong River. So there were very few marine researches in Cambodia waters especially in marine zooplankton. There were many worked on marine zooplankton (diversity, abundance and distribution) in the South China Seas such as Gulf of Thailand, Malaysia, Philippines and Viet Nam. Whereas many papers concerned the marine zooplankton in the Cambodia waters were based on the results of NAGA Expedition during 1965-1951.

The proposal of this investigation is to identify the composition of zooplankton, and determine the numerical abundance and distribution of zooplankton in Cambodian water, this information may used to formulate appropriate fisheries management strategic plans.

## Methods

The zooplankton samples were collected from 10 stations (Table 1, Fig 1.) between 9° 15' 0 N to 10° 44' 9 N and 102° 26' 0 E to 103° 30' 5 E in the Cambodia waters. The bongo net with 60 cm. in diameter and 330 m mesh size was used for the oblique sampling. The water volume passed into the nets was estimated by flow meters that attached at 1/3 of the mouthpart of each net. The zooplankton samples were immediately fixed with 10 % formaldehyde solution in seawater and kept to be analyzed in laboratory at Faculty of Fisheries, Kasetsart University. The abundance of zooplankton was estimated in term of number of individuals per cubic meters.

**Table 1.** The sampling sites in the Cambodian water

| Station | Date / Time | Latitude | Longitude | (m) |
|---|---|---|---|---|
| 2 | 20-Nov-05 / 17:55 | 10° 42' 8 N | 102° 52' 4 E | 39 |
| 3 | 21-Nov-05 / 05:27 | 10° 44' 9 N | 102° 27' 9 E | 63 |
| 4 | 21-Nov-05 / 13:39 | 10° 15' 0 N | 102° 27' 5 E | 67 |
| 5 | 21-Nov-05 / 18:40 | 10° 14' 7 N | 102° 44' 5 E | 53 |
| 6 | 22-Nov-05 / 05:27 | 10° 10' 1 N | 103° 05' 0 E | 38 |
| 7 | 22-Nov-05 / 11:50 | 10° 15' 2 N | 103° 30' 5 E | 34 |
| 8 | 22-Nov-05 / 19:00 | 09° 44' 7 N | 103° 05' 1 E | 45 |
| 9 | 23-Nov-05 / 05:30 | 09° 44' 9 N | 102° 45' 3 E | 55 |
| 10 | 23-Nov-05 / 11:21 | 09° 45' 1 N | 102° 27' 7 E | 60 |
| 11 | 23-Nov-05 / 17:57 | 09° 15' 0 N | 102° 26' 0 E | 69 |

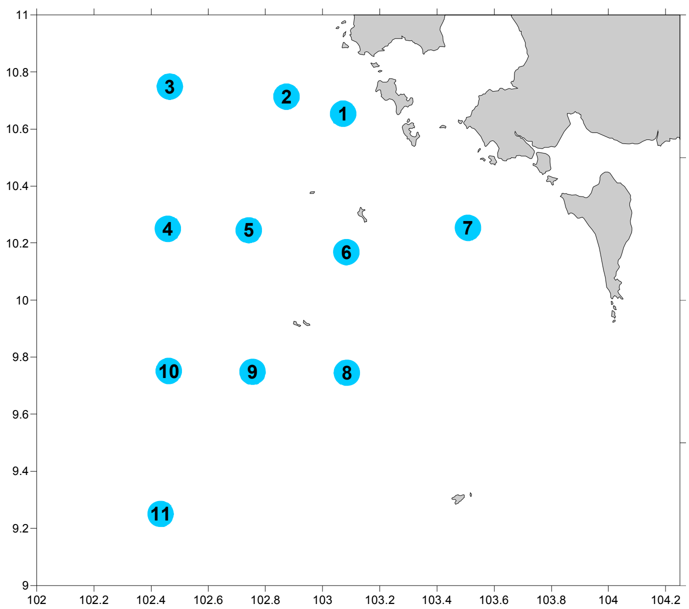


**Figure 1.** The sampling station in the Cambodia water

# Result

**Abundance of total Zooplankton**

The abundance and distribution of zooplankton and larva zooplankton were collected from the sampling stations in Cambodia waters are shown in Table 2 and 3. The average abundance of zooplankton and larva zooplankton were 69.48 and 43.13 individuals/$m^3$ respectively. The highest zooplankton abundance was observed in station 8 with 168.78 individuals/$m^3$, followed by station 7 with 157.22 individuals/$m^3$. The lowest density was found in station 10 with 28.5 individuals/$m^3$ (Table 4). For the larva zooplankton (both holoplanktonic and meroplanktonic zooplankton), the highest abundance was observed in station 7 with 246.07 individuals/$m^3$, followed by station 2 with 72.4 individuals/$m^3$. The lowest density was found in station 10 with 2.19 individuals /$m^3$ (Table 5).

**Zooplankton composition, diversity and distribution**

**Total zooplankton**

Zooplankton samples were identified representing to 8 Phylum comprise of Cnidaria, Annelida, Mollusca, Arthopoda, Chaetognatha, Chordata and the mero- planktonic Echinodermata and Brachiopoda (Table 2 and 3). Phylum arthopoda consistently occurred at all stations and were the most dominant group in terms of abundance and composition in the study areas. The average abundance of arthropods was 36.08 individuals/$m^3$ and consisted 51.93 % of the total zooplankton population. Phylum chordata was ranked the second in percentage of occurrence with 25.02 % of the total zooplankton population, with 17.38 individuals/$m^3$ (Table 4 and 6).

For the larva zooplankton, meroplanktonic Echinodermata was the most dominant in terms of abundance and composition in the study areas, especially in the coastal areas (station 2 and 7). The average abundance of Echinodermata was 35.45 individuals/$m^3$ and consisted 82.20 % of the total larva zooplankton population, followed by the arthopods larva with 9.62 % of the total zooplankton population and 4.15 individuals/$m^3$ (Table 5 and 7).

**Individual zooplankton**

**Phylum Cnidaria**

The Cnidarians were found only the mature stage; this phylum includes Hydro-medusae and family Diphyidae (Order Siphonophora), comprising together about 12.09 % of the total zooplankton population, with 8.40 individuals/$m^3$ (Table 2 and 6). Cnidarians were a common group that found in every station. They were the third most abundant group of Zooplankton. Diphyidae are gelatinous zooplankton with streamlined bodies and a large nectosac, features related to their generally fast swimming speed. They feed on small crustaceans and fish larvae. The majorities are truly oceanic, but a few species are neritic, occurring in shallow inshore waters where the salinity is not greatly reduced.

**Phylum Annelida**

This phylum was found only Class Polychaeta that composed of polychaete larvae and mature planktonic polychaetes (Order Phyllodocida). Pelagic polychaetes were very rare in this study, mature polychaete was found only in station 4 and polychaete larva was only in station 7. They comprised of 0.04

and 0.51 % of the total mature zooplankton and larva zooplankton population, respectively (Table 6 and 7). They feed on small zooplankton, siphonophores, chaetognathas and appendicularian.

**Phylum Mollusca**

The mollusks were observed to be common and widely distribution in this study. This group was composed of planktonic mollusks and planktonic larval stages. Cavoliniidae was only one family of planktonic mollusk found in this investigation, forming 3.07 % of the total zooplankton population (Table 6). The Cavoliniidae comprised of *Cavolinia* and *Creseis*. *Cavolinia* has a globular, transparent shell with dorsal and ventral surfaces different and well separated, dorsal aperture border curved. *Creseis* have transparent, cross-section circular shell with rounded aperture and no longitudinal groove over dorsal side.

The meroplanktonic mollusks composed of gastropod and bivalve larvae were common in this study. They were the third most abundant consisted of 3.66 % of the total larva zooplankton population (Table 7).

**Phylum Arthropoda**

Arthropoda was very common and widely distribution in this study. They were the most abundance of zooplankton and the second most abundance of larva zooplankton in this investigation. The major group of arthopoda was calanoid copepod (Order Calanoida), with 7.42 – 47.63 individuals/$m^3$ (Table 2). The abundance of calanoid copepods was highest at 8 with 89.98 individuals/$m^3$, followed by station 7, with 89.98 and 70.52 individuals/$m^3$. Calonoida was one of the most numerous and diverse copepod orders, this is small crustaceans usually between 0.2-12 mm. in length. They are neritic to oceanic, epipelagic to abyssal depths. They are important link in marine food web, that are recognized as in discriminate or selective suspension or particle feeders and they may be herbivorous, predatory feeders (carnivorous), or omnivorous also saphroplages or coprophages, some copepods are switch from one feeding mode to another according to circumstances. Arthropoda larvae were also widely distribution, found in every station. The highest abundance was 14.70 individuals/$m^3$ at station 8, followed by station 7 with 7.35 individuals/$m^3$ (Table 5).

**Phylum Chaetognatha**

Chaetognatha were the fourth most abundant group of zooplankton. They were very common and widely distribution in this study. Chaetognatha are important, common active predators, with a set of long, brown, grasping hooks on each side of the head for capturing prey. The diet of pelagic chaetognathas includes a wide range of organisms; copepods, small crustaceans and fish larvae. They play an important role in food chains and their biomass in the pelagic world ocean is 30% of that of copepods. *Sagitta* was only chaetognathas found in this study, they consisted 7.85 % of the total zooplankton population, with 5.46 individuals/$m^3$ (Table 4 and 6).

**Phylum Echinodermata**

The larvae of echinodermata found in this study were consisted of ophiopluteus and echinopluteus larvae. They were observed to be very common and widely distribution in this study. They were the most abundance of larva zooplankton with 82.20 % of the total zooplankton population (Table 3 and 7). They were higher abundance at near shore than offshore station. The highest abundance of echinodermata larvae was 225.53 individuals/$m^3$ at station 8, followed by station 2 with 68.03 individuals/$m^3$ (Table 5).

**Phylum Chordata.**

This phylum comprised of fish larvae and a large group of gelatinous zooplankton, Urochordata included classes Appendicularia and Thaliacea (Table 2). Urochordata were very common and widely distribution, they were the second most abundant group of zooplankton forming 25.02 % of the total zooplankton population, with 17.38 individuals/$m^3$ (Table 4 and 6). Urochordata comprised of Okipleuridae, Doliolidae and Salpidae. Appendicularians found in this study was only in Family Oikopleuridae, is planktonic tunicates that recognized by the persistence of the notochord in the adult and the lack of a peribranchial cavity and cloaca. Thaliaceans found in this study comprised of Family Doliolidae and Salpidae, they are planktonic colonial tunicates and some groups are an alternation of generation between asexual (oozooids) and sexual (blastozooids) generation. They feed by filtering suspended particles from a stream of water through mucous area. The highest abundance of Urochordata was 49.45 individuals/$m^3$ at station 7, followed by station 8 and 11 with 37.05 and 36.94 individuals /$m^3$, respectively. Fish larvae or Ichthyoplankton are as an important element of the aquatic food web, they were the fourth most abundant group of larva zooplankton consisted 3.54 % of total zooplankton population with 1.52 individuals/$m^3$ (Table 4 and 6).

**Table 2.** Total abundance of zooplankton from the study area in Cambodia water during 20-23 November 2005. (Individuals/m$^3$)

| Taxa | Station | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Phylum Cnidaria | | | | | | | | | | |
| Hydromedusae | | 0.18 | | 0.41 | 0.28 | 5.14 | 1.76 | 0.25 | 0.60 | |
| Family Diphyidae | 5.54 | 4.00 | 6.13 | 1.85 | 5.12 | 15.43 | 26.46 | 5.93 | 3.59 | 1.34 |
| Phylum Annelida | | | | | | | | | | |
| Order Phyllodocida | | | | | | | | | | |
| Polycheates | | | 0.28 | | | | | | | |
| Phylum Mollusca | | | | | | | | | | |
| Family Cavoliniidae | | | | | | | | | | |
| *Cavolinia* spp. | 2.37 | 1.27 | 0.00 | 0.82 | 0.85 | 5.88 | 5.88 | 1.73 | | |
| *Creseis* spp. | 0.40 | 0.55 | 0.56 | | | | 0.59 | 0.25 | 0.20 | |
| Phylum Arthropoda | | | | | | | | | | |
| Order Onychopoda | | | | | | | | | | |
| Family Podonidae | | | | | | | | | | |
| *Pseudevadne terges-tina* (Claus, 1877) | 0.40 | | | | | 0.73 | 3.53 | | | |
| Order Ctenopoda | | | | | | | | | | |
| Family Sididae | | | | | | | | | | |
| *Penilia avirostris* Dana, 1852 | | | | | 0.57 | 5.88 | 1.76 | | | |
| Order Myodocopida | | | | | | | | | | |
| Ostracods | 6.72 | 17.82 | 7.25 | 4.12 | 9.10 | 8.82 | 22.94 | 7.16 | | |
| Order Calanoida | | | | | | | | | | |
| Calanoid copepods | 22.15 | 18.73 | 20.62 | 7.42 | 11.95 | 42.61 | 47.63 | 23.45 | 8.57 | 9.35 |
| Order Cyclopoida | | | | | | | | | | |
| Family Oithonidae | | | | | | | | | | |
| *Oithona* spp. | | 0.73 | 0.28 | 0.21 | | 2.20 | | 0.25 | | |
| Order Poecilostomatoida | | | | | | | | | | |
| Family Sapphirinidae | | | | | | | | | | |
| *Copilia* spp. | 0.40 | 1.09 | 3.62 | 1.03 | 0.85 | 5.88 | 3.53 | 1.23 | 2.39 | 0.89 |
| *Sapphririna* spp. | | 0.36 | 0.28 | 0.21 | 0.28 | 1.47 | 0.59 | 0.74 | 0.40 | 1.78 |
| Family Corycaeidae | | | | | | | | | | |
| *Corycaeus* spp. | | | | | 0.28 | 1.47 | 0.59 | 0.25 | | 0.45 |
| Order Mysidacea | | | | | | | | | | |
| Mysids | | 0.91 | | 0.41 | | | 4.12 | 0.74 | | |
| Order Amphipoda | | | | | | | | | | |
| Amphipods | | | 0.28 | | 0.28 | | 2.35 | 0.74 | | |
| Order Decapoda | | | | | | | | | | |
| Family Luciferidae | | | | | | | | | | |
| *Lucifer* sp. | 0.40 | 0.73 | | 1.24 | | 1.47 | 2.94 | 0.74 | | 0.45 |
| Phylum Chaetognatha | | | | | | | | | | |
| Family Sagittidae | | | | | | | | | | |
| *Sagitta* spp. | 6.72 | 2.73 | 6.69 | 5.56 | 6.54 | 10.28 | 7.06 | 3.46 | 4.18 | 1.34 |
| Phylum Chordata | | | | | | | | | | |
| Family Oikopleuridae | 3.16 | 0.73 | 0.56 | | 0.85 | 2.94 | 0.59 | 0.99 | 1.00 | |
| Family Doliolidae | | 0.73 | 0.28 | 1.03 | 0.00 | 2.94 | 0.59 | 0.99 | 1.99 | 2.23 |
| Family Salpidae | 1.58 | 0.73 | 2.79 | 7.01 | 12.23 | 44.08 | 35.87 | 7.65 | 5.58 | 34.72 |
| Total | 49.84 | 51.29 | 49.62 | 31.32 | 49.18 | 157.22 | 168.78 | 56.55 | 28.5 | 52.55 |

**Table 3.** Total abundance of larva zooplankton from the study area in Cambodia waters during 20-23 November 2005. (Individuals/$m^3$)

**Table 4.** Zooplankton composition (Phylum level) from the study area in Cambodia waters during 20-23 November 2005. (Individuals/$m^3$)

**Table 5.** Larva zooplankton composition (Phylum level) from the study area in Cambodia waters during 20-23 November 2005. (Individuals/m$^3$)

| Taxa | Station | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Average |
| ylum Annelida | | | | | | 2.20 | | | | | 0.22 |
| ylum Mollusca | | 0.91 | 3.07 | 1.24 | 0.57 | 2.20 | 2.94 | 3.95 | | 0.89 | 1.58 |
| ylum Arthropoda | 3.56 | 1.09 | 2.51 | 3.50 | 3.98 | 7.35 | 14.70 | 1.23 | 1.79 | 1.78 | 4.15 |
| ylum inodermata | 68.03 | 1.45 | 7.80 | 13.81 | 29.86 | 225.53 | 1.18 | 4.44 | 0.20 | 2.23 | 35.45 |
| ylum chiopoda | 0.79 | | | | 0.57 | 0.73 | | | | | 0.21 |
| ylum Chordata | | 1.45 | 0.56 | 1.24 | 0.28 | 8.08 | 2.94 | 0.49 | 0.20 | | 1.52 |
| Total | 72.38 | 4.91 | 13.93 | 19.78 | 35.27 | 246.10 | 21.76 | 10.12 | 2.19 | 4.90 | 43.13 |

**Table 6.** Zooplankton composition relative abundance (%) from the study area in Cambodia waters during 20-23 November 2005.

| Taxa | Station | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Average |
| hylum Cnidaria | 11.11 | 8.16 | 12.36 | 7.24 | 10.98 | 13.08 | 16.72 | 10.92 | 14.68 | 2.54 | 12.09 |
| hylum Annelida | | | 0.56 | | | | | | | | 0.04 |
| hylum Mollusca | 5.56 | 3.55 | 1.12 | 2.63 | 1.73 | 3.74 | 3.83 | 3.49 | 0.70 | | 3.07 |
| hylum Arthropoda | 60.31 | 78.73 | 65.17 | 46.71 | 47.40 | 44.86 | 53.31 | 62.44 | 39.85 | 24.58 | 51.93 |
| hylum Chaetognatha | 13.49 | 5.32 | 13.48 | 17.76 | 13.30 | 6.54 | 4.18 | 6.11 | 14.68 | 2.54 | 7.85 |
| hylum Chordata | 9.52 | 4.26 | 7.30 | 25.66 | 26.59 | 31.78 | 21.95 | 17.03 | 30.07 | 70.34 | 25.02 |

**Table 7.** Larva zooplankton composition relative abundance (%) from the study area in Cambodia waters during 20-23 November 2005.

| Taxa | Station | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Average |
| ylum Annelida | | | | | | 0.90 | | | | | 0.51 |
| ylum Mollusca | | 18.52 | 22.01 | 6.25 | 1.61 | 0.90 | 13.51 | 39.03 | | 18.17 | 3.66 |
| ylum Arthropoda | 4.92 | 22.22 | 18.00 | 17.71 | 11.29 | 2.99 | 67.57 | 12.20 | 81.86 | 36.33 | 9.62 |
| ylum inodermata | 93.99 | 29.63 | 56.01 | 69.79 | 84.67 | 91.64 | 5.41 | 43.91 | 9.10 | 45.42 | 82.20 |
| ylum chiopoda | 1.09 | | | | 1.61 | 0.30 | | | | | 0.49 |
| ylum Chordata | | 29.63 | 4.00 | 6.25 | 0.81 | 3.28 | 13.51 | 4.88 | 9.10 | | 3.54 |

## Discussions

There were very few studies on in Cambodia waters, many papers concerned the zooplankton in this area were based on the results of NAGA Expedition during 1965-1951. Although the result of this study indicates that the Cambodia waters were observed to be very low in term of diversity (found only 8 Phylum) and abundance was lower than in the Gulf of Thailand and East Coast of Peninsular Malaysia (Jiwaluk, 1999 a), West Coast of Sabah, Sarawak and Brunei Darussalam (Jiwaluk, 1999 b), but the abundance of zooplankton in Cambodia waters found to be higher than in the Andaman Sea (Jitchum *et al*, 2006).

The composition and diversity of zooplankton in this study agrees with various researches that copepod was the most dominants in term of abundance, composition and widely distributed of the zooplankton population in the South China Sea especially Gulf of Thailand, Malaysia, Sarawak, Sabah and Brunei areas (Jiwaluk, 1999 a and b; Jitchum *et al*, 2006; Sribyatta, 1996; Suwanrumpa, 1980, 1983 a and b)

The present results of zooplankton in the Cambodia waters did not clearly show that the differences of environment factor could contribute to the difference in abundance, distribution and composition of the zooplankton. They only showed that zooplankton abundance according to the depth, the coastal shallow areas tending to be higher density of zooplankton.

The distribution pattern of several zooplanktons showed no distinct distribution pattern. They were common and widely distributed, this group included Phylum Cnidaria, Mollusca (both planktonic mollusca and meroplanktonic mollusca), Arthopoda, Chaetognatha and Chordata (fish larvae and Urochordata). The other group, mero-planktonic Echinodermata showed coastal pattern, they were also widely distributed but high number in coastal shallow stations. Final group, found in a few station *e.g.* planktonic polychaetes in Order Phyllodocida found only in station 4 and polychaete larvae only in station 7, Brachiopod larva found only in coastal shallow areas (station 2, 6 and 7).

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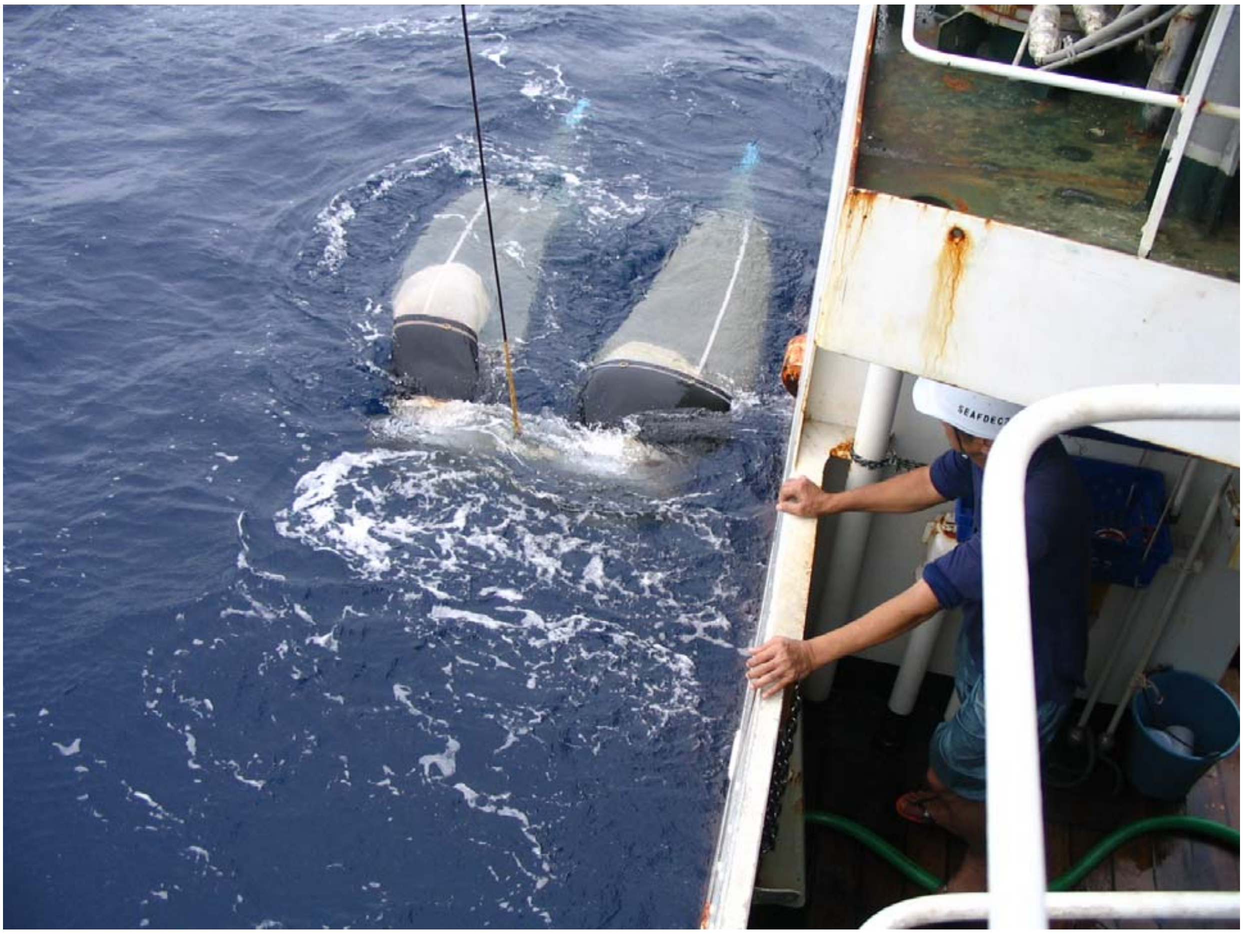
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# A REPORT OF PRELIMINARY STUDY ON DISTRIBUTION OF DINOFLAGELLATE CYSTS IN THE CAMBODIAN WATER

BY

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**Dusit Srivilai**

# A REPORT OF PRELIMINARY STUDY ON DISTRIBUTION OF DINOFLAGELLATE CYSTS IN THE CAMBODIAN WATER

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The preliminary study on dinoflagellate cyst distribution was conducted in Cambodian water during the period of November 18-26, 2005. The surface sediment samples of 11 sampling stations were collected by gravity corer. All samples were prepared for cyst identification by the method of Matsuoka and Fukuyo (2000). A total of 13 species of dinoflagellates cysts were found in this preliminary study. As showed in table.1 and 2, cyst density was quite low at all stations and no any cysts were found at stations 3-4 and 10-11.

**Table 1.** Dinoflagellate cyst assemblage and density in Cambodian water St. 1- St. 6

| **Station** | | **St.1** | **St.2** | **St.3** | **St.4** | **St.5** | **St.6** |
|---|---|---|---|---|---|---|---|
| Wet weight for observation (g) | | 2.37 | 2.87 | - | - | 2.31 | 1.93 |
| Water content rate of this sample (%) | | 72.77 | 81.42 | - | - | 79.96 | 77.43 |
| Total observed volume in 10 ml (ml) | | 5 | 5 | - | - | 5 | 5 |
| **Biological cyst name** | **Paleontological cyst name** | **Cysts/gram dry weight sediment** | | | | | |
| Autotrophic species | Autotrophic species | | | | | | |
| Gonyautacales | Gonyaulacales | | | | | | |
| *Gonyaulax scrippsae* | *Spinifera bulloidesu* | 3.1 | 3.75 | - | - | 4.32 | 9.18 |
| *Gonyaulax spinifera* | *Spinifera mirabilis, S. ramosus* | 6.2 | 3.75 | - | - | 4.32 | 4.59 |
| *Gonyaulax sp.* | *Spinifera hyperacanthus* | - | - | - | - | 4.32 | 4.59 |
| *Lingulodinium polyedrum* | *Lingulodinium machaerophorum* | 3.1 | 3.75 | - | - | 8.64 | - |
| *Protoceratium reticulatum* | *Operculodinium centrocarpum* | 3.1 | - | - | - | - | 9.18 |
| *Pyrophacus steinii* | *Tuberculodinium vancampoae* | 6.2 | 3.7 | - | - | - | |
| Heterotrophic species | Heterotrophic species | | | | | | |
| Gy monodiniales | Gymnodiniales | | | | | | |
| *Palykrikos schwartzii* | *Polykrikos schwartzii* | - | - | - | - | - | 4.59 |
| Peridiniales | Peridiniales | | | | | | . |
| *Protoperidinium oblongum* | *Votadinum calvum* | 6.2 | - | - | - | 4.32 | 4.59 |
| *Protoperidinium conicum* | *Selenopemphix quanta* | - | 3.75 | - | - | - | - |
| *Protoperidinium pentagonum* | *Trinovantedinium capitatum* | - | - | - | - | 4.32 | 4.59 |
| *Protoperidinium sp.* | *Brigantedinium sp. Cf. B. cariacoense* | 12.4 | 7.5 | - | - | 4.32 | 9.18 |
| *Protoperidinium sp.* | *Brigantedinium sp. Cf. B. simplex* | - | - | - | - | 4.32 | - |
| **Total** | | **40.3** | **26.2** | | | **38.88** | **50.49** |

**Table 1.** Dinoflagellate cyst assemblage and density in Cambodian water St. 7- St. 11

| **Station** | | **St.7** | **St.8** | **St.9** | **St.10** | **St.11** |
|---|---|---|---|---|---|---|
| Wet weight for observation (g) | | 2.24 | 1.72 | 1.33 | - | - |
| Water content rate of this sample (%) | | 81.76 | 77.74 | 78.88 | - | - |
| Total observed volume in 10 ml (ml) | | 5 | 5 | 5 | - | - |
| **Biological cyst name** | **Paleontological cyst name** | | | | | |
| Autotrophic species | Autotrophic species | | | | | |
| Gonyautacales | Gonyaulacales | | | | | |
| *Gonyaulax scrippsae* | *Spinifera bulloidesu* | 4.89 | - | 14.24 | - | - |
| *Gonyaulax spinifera* | *Spinifera mirabilis, S. ramosus* | 4.89 | 5.22 | - | - | - |
| *Gonyaulax spinifera* | *Spinifera hyperacanthus* | - | - | 7.12 | - | - |
| *Lingulodinium polyedrum* | *Lingulodinium machaerophorum* | 9.79 | 5.22 | - | - | - |
| *Pyrophacus steinii* | *Tuberculodinium vancampoae* | 4.89 | 10.44 | - | - | - |
| Heterotrophic species | Heterotrophic species | | | | | |
| Gy monodiniales | Gymnodiniales | | | | | |
| *Palykrikos schwartzii* | *Polykrikos schwartzii* | 4.89 | - | - | - | - |
| Peridiniales | Peridiniales | | | | | |
| *Protoperidinium oblongum* | *Votadinum calvum* | 4.89 | 5.22 | - | - | - |
| *Protoperidinium conicum* | *Selenopemphix quanta* | 4.89 | - | - | - | - |
| *Protoperidinium leonis* | *Quinquecuspis concreta* | - | - | - | | |
| *Protoperidinium pentagonum* | *Trinovantedinium capitatum* | 4.89 | - | - | - | - |
| *Protoperidinium sp.* | *Brigantedinium sp. Cf. B. cariacoense* | 9.79 | 10.44 | - | - | - |
| *Protoperidinium sp.* | *Brigantedinium sp. Cf. B. simplex* | - | - | 7.12 | - | - |
| **Total** | | **53.81** | **36.54** | **28.48** | **-** | **-** |