

Exploration of Oceanic Squid, *Sthenoteuthis oualaniensis* Resources in the South China Sea, Vietnamese Waters

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ABSTRACT

Results from 10 sampling stations show that only one species of the purpleback flying squid, *Sthenoteuthis oualaniensis* (Lesson, 1930) were caught by automatic squid jigging gear. The distribution and abundance of the purpleback flying squid in term of the CPUE (number of squid per line hour) are presented. Over the entire survey area, the CPUEs of the squid were ranged between 0.25-9.11 squids per line hour. Drop-off rates for jigs fished on the jigging machines were averaged 3 squid/line hour. Angling depth where the squid were abundant ranged between 50 and 100m.

A total of 1,439 squids were measured and mantle length ranged from 90 to 240 mm. Female dominated the catch, accounting for 80% of the all squid sexed. Males were generally smaller than females. The mantle length composition for males was single peak mode at between 120 and 130 mm. Females also had one peak between 120 and 130 mm mantle length with means of 150.5 mm. A similar length-weight relationship coefficients between male and female was found. The main prey of the squid were crustaceans, fishes (mainly flying fish) and squid.

The squid were found in a warm water mass where the sea temperature ranged from 18°C to 30°C at the depth from 125m up to sea surface at night. Good fishing ground of the squid was at 14°N latitude and 112°E longitude (9.11 squids/line hour) nearby the existing upwelling at 111°E longitude.

Keywords: purpleback flying squid, *Sthenoteuthis oualaniensis*,
Vietnamese waters, South China Sea, upwelling,

Introduction

The flying squids (Roper *et al.* 1984) of the family Ommastrephidae (Suborder Oegopsida) account for about 65% percent of the world's commercial cephalopods (Brunetti 1990), which totalled about 2.6 million in 1991 (FAO 1993). The purpleback flying squid, *Sthenoteuthis oualaniensis* (Lesson) and flying squid, *Ommastrephes bratamii* are the oceanic squid species of this family which their geographical distribution are found from the Indo-Pacific to Indian Ocean. Voss (1973) speculates a potential of the purpleback flying squid of at least 100,000 metric tons in the Central eastern Pacific. It is on record that the purpleback flying squid are caught commercially in the eastern and southern East China Sea, Taiwan to Okinawa by hook and line with light at night (Tung 1981, Yoshikawa 1978, Okutani and Tung 1978, Okutani 1980). In addition the most promising evidence were for the exploitation of this squid in the eastern Arabian and in the western Pacific Ocean to the eastward of the Philippines and Indonesia

(JAMARC 1977). The studies of this species in the Vietnamese waters were reported in 1998 under the study on Marine Resources in Vietnam by Fuyo Ocean Development & Engineering Co., Ltd. (FODECO, 1998).

In the Southeast Asian region due to the extreme over-exploitation of both demersal and pelagic resources raises suspicion, the “oceanic squid” should be a sustainable catch that might have been taken. It is premature to say much about the feasibility of commercial fishing for these oceanic squid at this stage with the exception of the existing fisheries in the region as found in the Philippines and Vietnam. The availability of these species in terms of likely catch rates for local fisheries is still unknown even though the potential yield is believed to be large. Oceanographic and environmental condition also are need to be examined in connection with the ecological/biological requirements of the squid. In an attempt to come up with this initial jigging fishery on oceanic squid therefore, SEAFDEC has planed to conduct a comparative study on the squid in the region covered the South China Seas and Andaman Sea since 1998 under the SEAFDEC Collaborative Research Program in the South China Sea. The survey will determine distribution and abundance of the oceanic squid in relation to oceanographic conditions and examine the feasibility of harvesting squid with jig gear. This paper reports the experimental fishing on the automatic squid jigging gear which was carried out in the Exclusive Economic Zone of Vietnamese waters by M.V. SEAFDEC.

Materials and Methods

Survey Area

Experimental fishing and oceanographic conditions were conducted by M.V. SEAFDEC in the Exclusive Economic Zone of Vietnamese waters from 29 April to 30 May 1999. All 58 oceanographic survey stations and 10 experimental fishing stations were designed covered from 7° to 21° N Latitude and from 103° to 112° E longitude as shown in **Figure 1**.

Fishing Gear

Squid sampling were collected by four automatic squid jigging machines model: **SE-88**, Sanmei, Co. Ltd. that were installed at port side consisting of eight main lines. Each main line was attached to a series of 25 typical japanese squid jigs spaced approximately 1m apart by nylon mono-filament leaders (30 to 50 lb test) as show in **Figure 2**. The jig was lowered to the desired depth and the line moved up and down approximately 1 m in a slow jigging motion until a squid was hooked. Attractive lights were suspended approximately 1 m inboard and 5 m above the machine. Bulbs were 500 W and were spaced 70-80 cm apart down the length of the port side of the vessel where the machines were set. 54 lights or a total of 27kW were used. No sea anchor was used during the fishing operation.

Data Collection

Catch and data effort data were collected at each fishing station. Target species caught were counted and if not all weighted, a sub-sample was weighted and counted to extrapolate the total catch weight at each station. Effort was recorded in line hours, which were calculated by multiplying the number of lines actively fishing by the length of time finished. The number of squid lost due to drop-off for a given period of time was also observed.

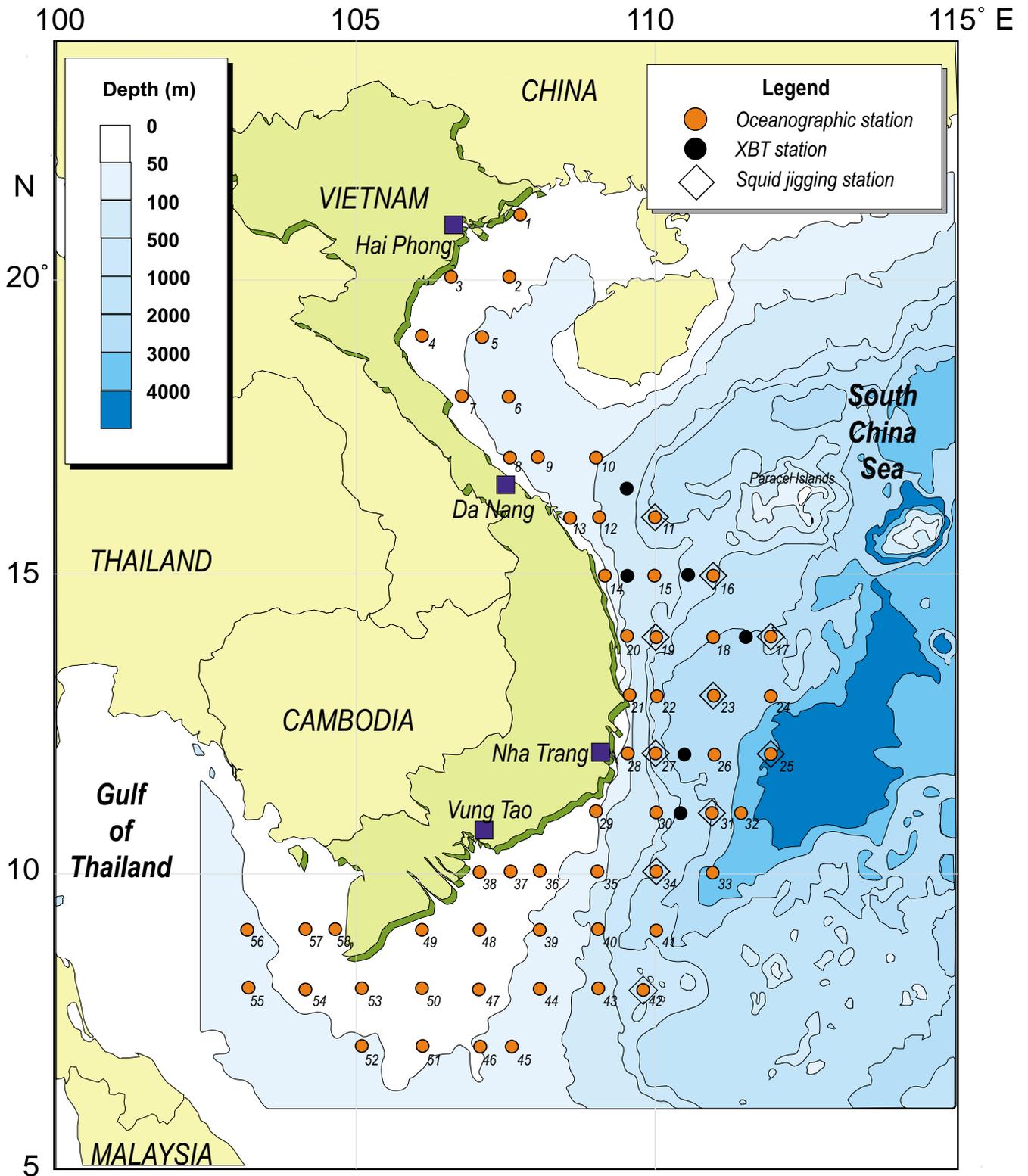
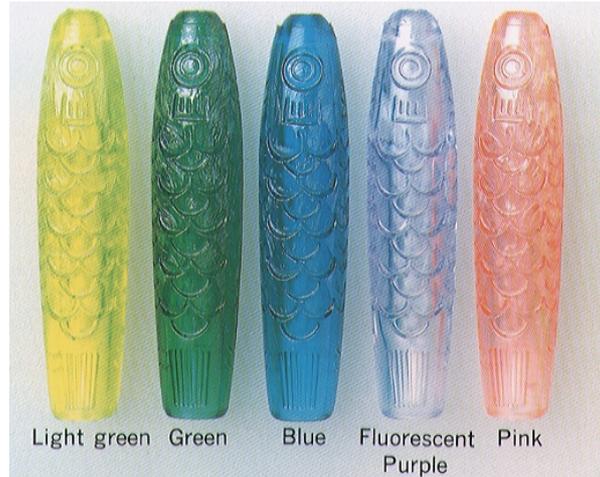
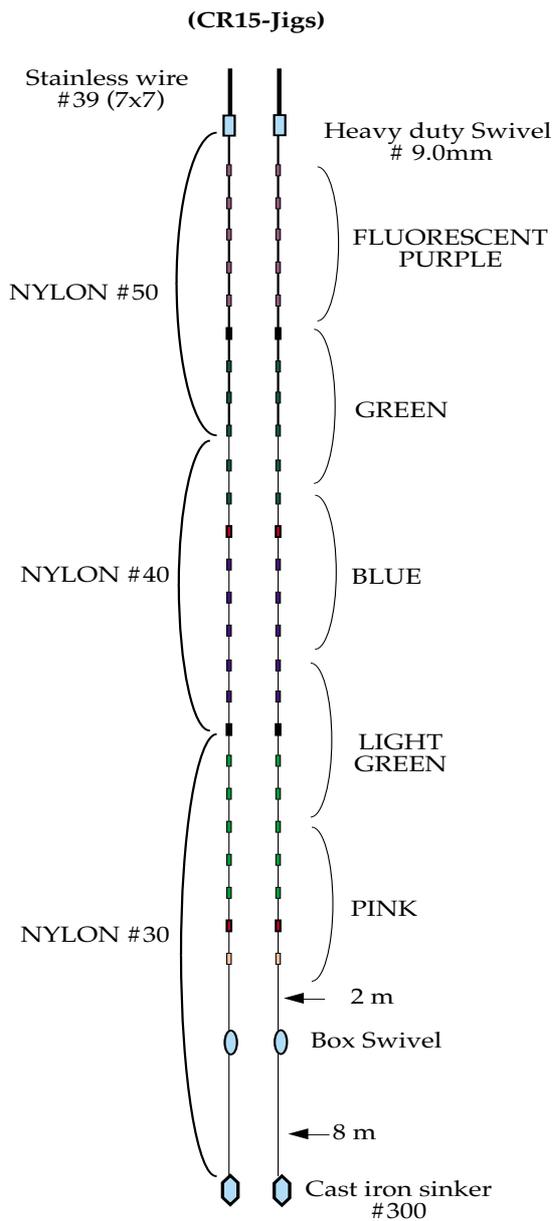
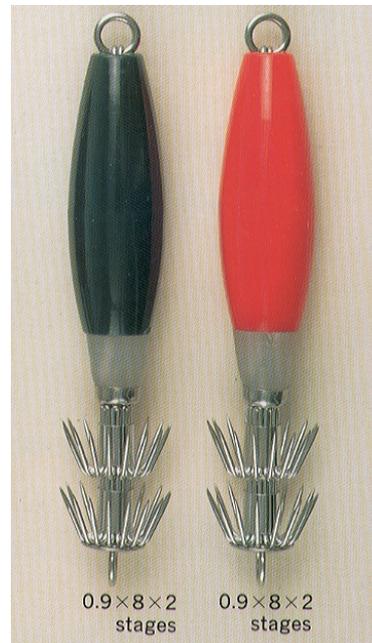


Fig. 1. Fish sampling and oceanographic survey stations in the South China sea, Vietnamese waters during 29 April - 30 May 1999.



CR15 New Kaio Hook



CR20 Bakelite Cased Hook

Fig. 2. Arrangement of squid jig line and types of squid jig used in the experiment.

Biological feature information was collected from target species. Length frequencies (mantle length) were recorded in millimetres and weight in grams, Length and weight data were transformed with a log transformation and length-weight relationships calculated using a least squares regression method.

Oceanographic characteristics observations were conducted to clarify the oceanographic features in the Vietnamese waters. The physical oceanographic parameters were measured by the Falmouth Scientific Integrated CTD unit [ICTD], using the sampling rate of 25 Hz. Temperature was corrected to ITS 90 standard. Salinity was calculated by the PSS 78 scale. Dynamic depth relative to the surface was calculated by the EG & G CTD Post-acquisitive Analysis Software at every dbar pressure interval. Continuous oxygen profiles at each station were obtained using the Beckman Polarographic electrode connected to the ICTD unit and the

raw data was averaged at every dbar pressure level (The data was calibrated at some stations by the Winkler titration method).

Environmental factors such as wind, current, moon age and other navigational data were observed.

Data Analysis

The vertical profiles of physical oceanographic parameter were prepared along longitude of each Line-1 to 2 for the north-south direction and along latitude of each Line-A to D for the west-east direction as shown in **Figure 3**. Horizontal distribution of each oceanographic parameter are based on the measurements at the 10m depth layer, not the values at the sea surface in order to avoid meteorological disturbance. All vertical profiles and horizontal distribution were analysis and plotted from a data processing application “Transform version 3.4” (Fortner software).

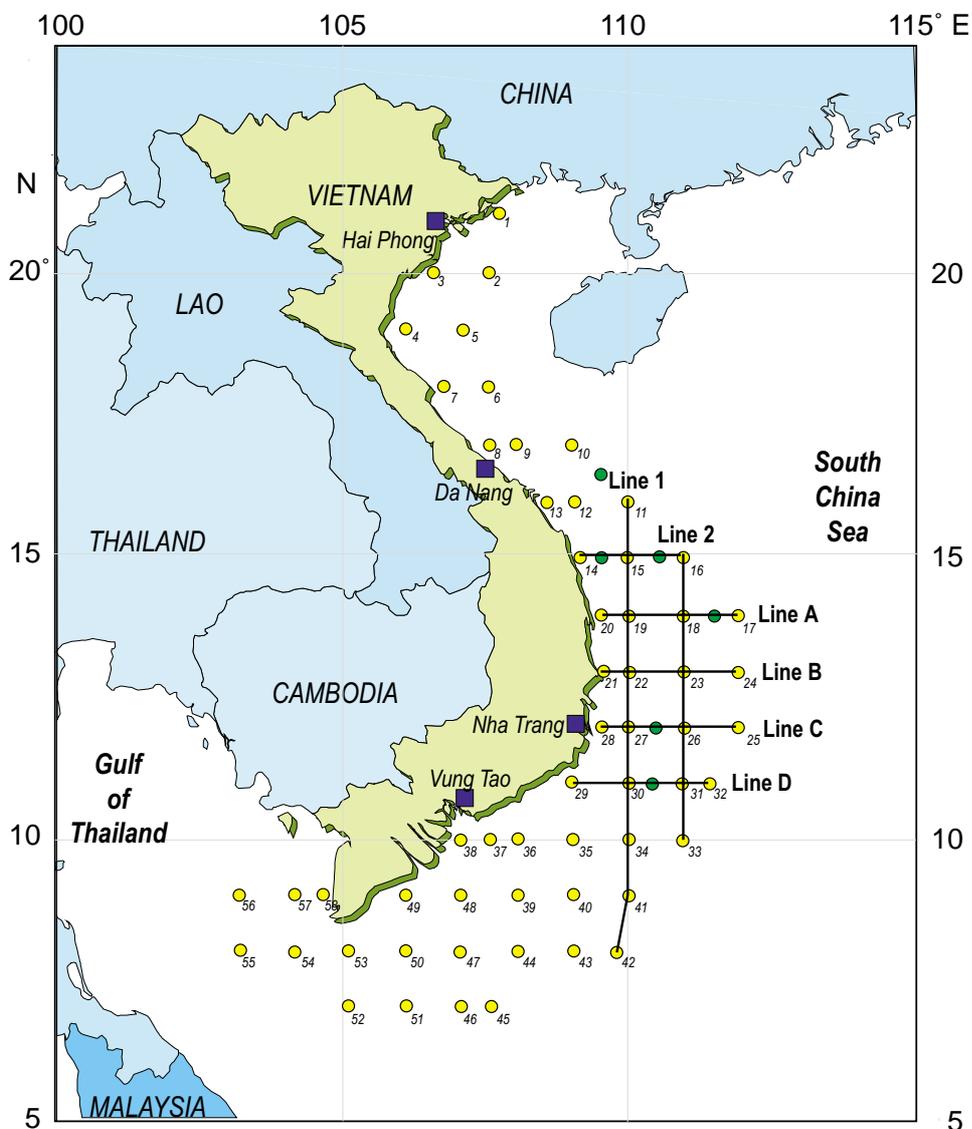


Fig. 3. Lines of cross section

Results and Discussion

Catch

Results from 10 sampling stations of the survey area show that only purpleback flying squid, *Sthenoteuthis oualaniensis* (Lesson, 1930) were caught by the automatic squid jigging gear. This target species was confirmed by *Anuwat et al.* 2000. **Table 1** shows the information of sampling stations and catch results of the purpleback flying squid in term of the catch-per-unit-effort (CPUE, number of squid per line hour). Over the entire survey area, CPUE of the squid averaged 3.08 squids/line hour. Minimum and maximum of the CPUE of the squid were 0.25 and 9.11 squids/line hour, respectively.

Figure 4 shows the CPUEs distribution of the purpleback flying squid in the overall survey area. It is found that high CPUE areas where the squid were caught more than 5 squids per line hour were found at St.#16 and St.#17. Drop-off rates for jigs fished on the jigging machines averaged 3.0 squid/line hour.

Biological characteristics

Sex ratio

Sex ratio of the catch in the Vietnamese waters varied between 68 - 91% by females. The sex ratio observed in the Vietnamese waters and in the western Philippines are close to 80% by females but vary slightly between areas. The sex ratio of catch in the Vietnamese waters and western Philippines were averaged to be 75% and 81% by females, respectively.

Length distribution

Figure 5 shows the length frequency distribution for the purpleback flying squid from each fishing stations. Two sizes of specimens, small and large were found in the survey area. At

Table 1. Information of sampling stations and catch results of the purpleback flying squid in the Vietnamese Waters during May 1999.

Opt. No.	St. No.	Date (d-m)	Location		Sounding Depth (m)	No. of line	No. of jig	Effort (h)	Total Catch		CPUE (ind./line hour)
			Lat. (N)	Long. (E)					Weight (kg)	Number (ind.)	
1	11	3-May	16° 01.4'	109° 58.0'	847	8	200	5.00	12.61	73	1.83
2	16	7-May	15° 02.5'	110° 58.8'	1,230	8	200	6.75	52.59	492	9.11
3	17	8-May	14° 06.5'	111° 56.5'	2,100	8	200	6.50	36.72	262	5.04
4	19	9-May	14° 10.7'	109° 58.9'	653	8	200	4.50	44.48	174	4.83
5	23	11-May	12° 55.3'	111° 00.3'	2,703	8	200	6.00	13.43	87	1.81
6	25	12-May	12° 00.1'	111° 59.5'	4,117	8	200	5.50	20.08	135	3.07
7	27	14-May	11° 46.2'	109° 56.1'	1,734	8	200	4.00	8.37	83	2.59
8	31	18-May	10° 59.7'	111° 01.0'	2,940	8	200	4.50	1.47	9	0.25
9	34	21-May	09° 59.9'	110° 00.3'	1,614	8	200	5.50	8.98	72	1.64
10	42	26-May	08° 01.2'	109° 49.9'	628	8	200	5.00	4.74	25	0.63

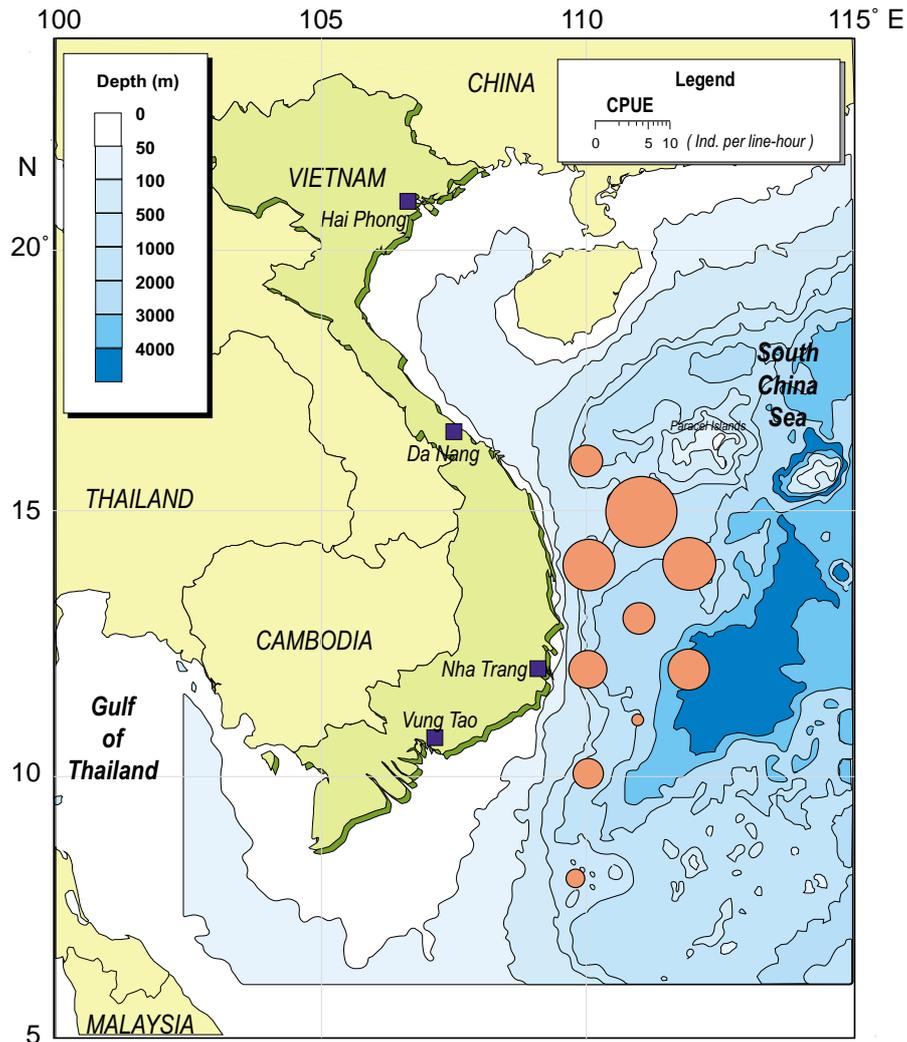


Fig. 4. CPUEs distribution of the purpleback flying squid in the South China sea, Vietnamese waters during 29 April - 30 May 1999.

abundant areas of squid, St.# 16 and St.#17, about 80% of the female specimens were small size squid with the mantle length ranged between 110 and 150mm. About 40% of large squid with the length ranged between 190 and 240mm were found at St.#19. Mantle length size of males were smaller than females.

Figure 6 show the overall mantle length distribution of the squid, a total of 1,439 specimens indicates that their mantle length ranged between 90 and 240mm with a mean length of 147mm and an averaged weight of 170g. Modal length of the squid for both females and males was 130mm with means of 150.5 and 127.5mm, respectively.

Length-weight relationships

Length-weight relationship coefficients for male, female of the purpleback flying squid are presented in **Figure 7**. The coefficients of both male and female squid were about 3.2 and it can be concluded that there are no difference in length-weight relation between them. In the western Philippines waters, the coefficients of both male and female are smaller especially for male is less than 3.

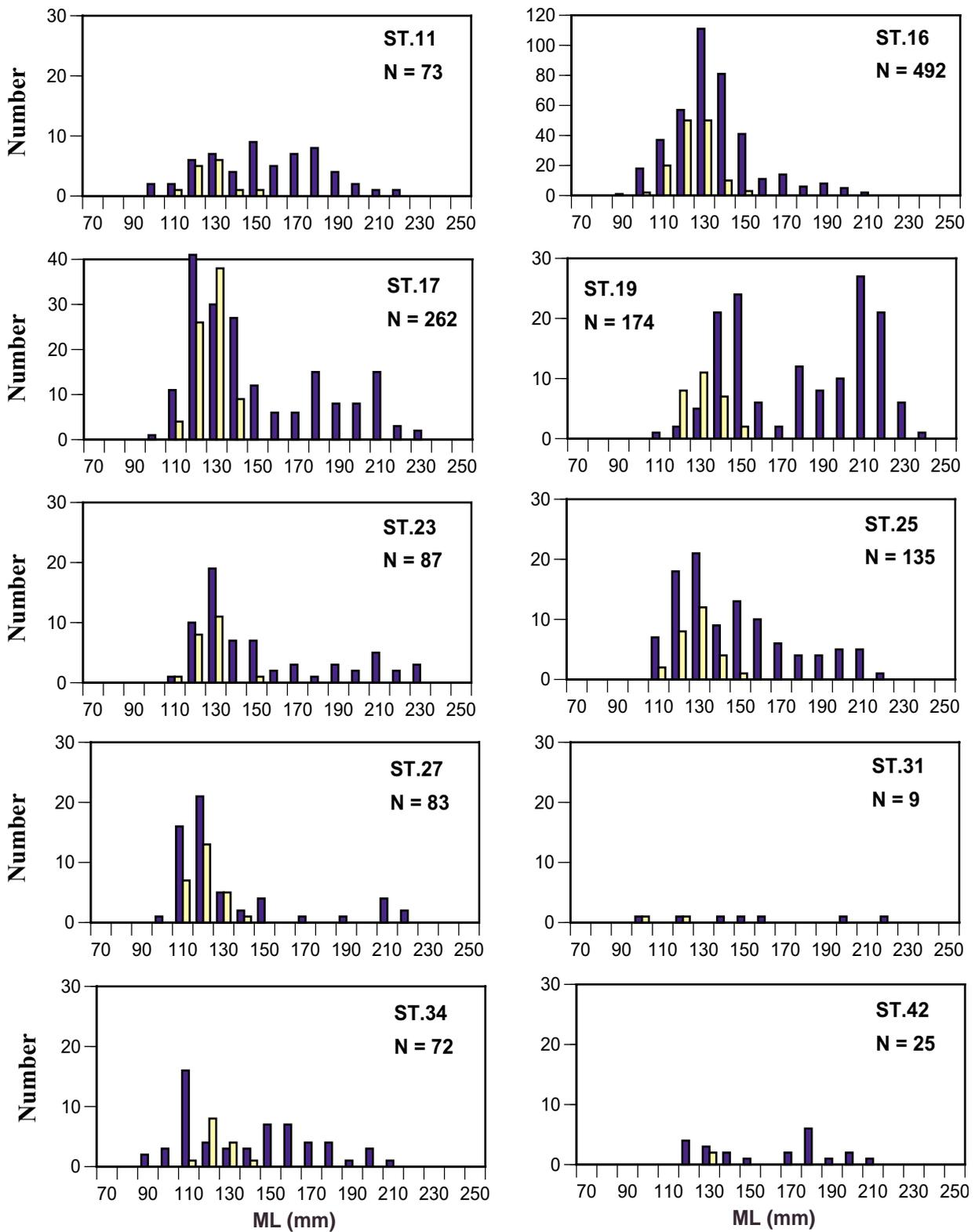


Fig. 5. Mantle length distributions of the males and females purpleback flying squid in each fishing station during May 1999 in the Vietnamese Waters.

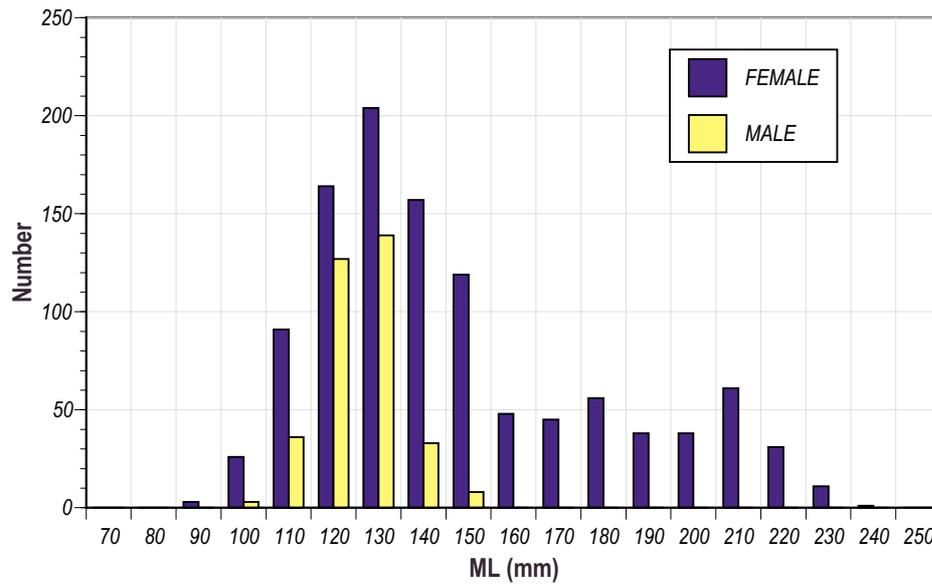


Fig. 6. Overall mantle length distributions of the males and females purpleback flying squid during May 1999 in the Vietnamese Waters.

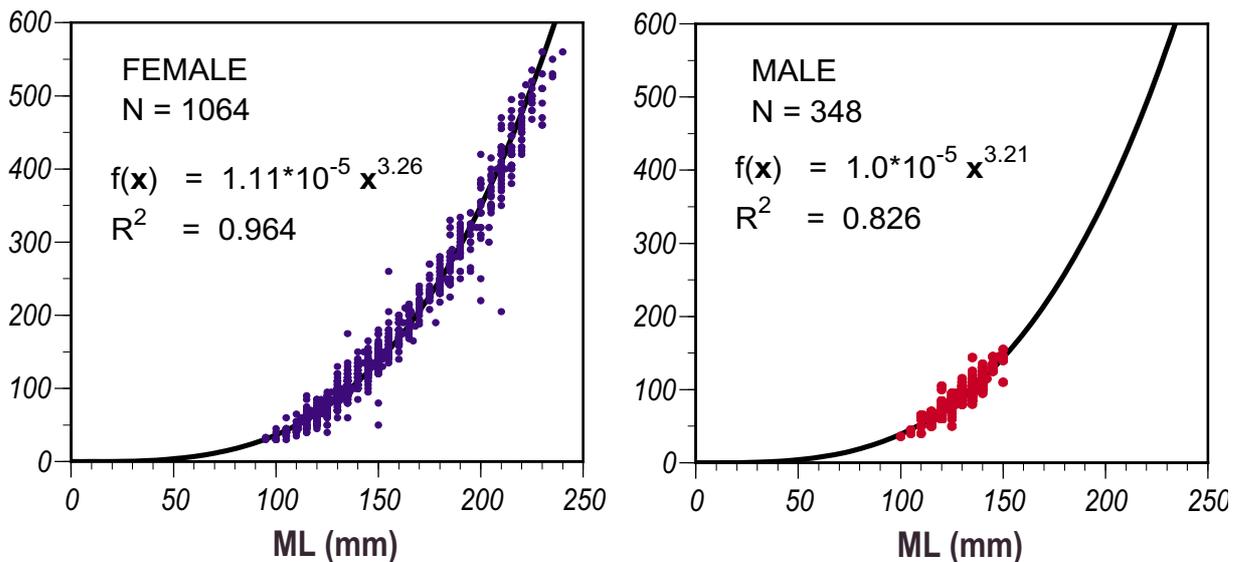


Fig. 7. Length-weight relationships of the males and females purpleback flying squid during May 1999 in the Vietnamese Waters.

Diet and Feeding

The diet and feeding habits of the *S. oualaniensis* are found that the main prey of the squid were crustaceans, fishes (mainly flying fish) and squid (including *S. oualaniensis*). It was observed by sight and echo sounder that the squid have a diet vertical migration, it was found that they migrate upwards to the surface for feeding at dusk and night and downwards to the deep layer before dawn and day time.

Oceanographic conditions

Horizontal distribution of temperature, salinity and fluorescence

Figure 8 show the horizontal profile of temperature at sea surface layer (a) and 100m (b) in the survey area. The water temperature were between 24.04 and 30.15°C at the surface layer (10m) and between 17.15° and 23.15°C at 100m deep. The figure clearly shows the water temperature was low ranging between 24 and 27°C in the north and about 30°C in the south at the surface layer. In the central part of Vietnamese waters where squid samplings were carried out, the waters temperature at surface layer was between 28° and 30°c.

At 14°N and 111°E, the cold water of 18°C was found at 100m deep, while the surrounding temperature were between 20 and 22°C. This cold waters was 14°C at 200m deep and 22.9°C at 50m. It is likely that up-welling existed in this location during the survey period of May or southwestern monsoon season. Fuyo Ocean Development and Engineering (1998) has reported existence of the upwelling in the same area and season.

Figure 9 show the horizontal profiles of salinity (a) and fluorescences (b) at the surface layer. The salinity showed remarkable variation in the sea surface. Low salinity was observed in the north at Station # 1-4 and in the south particularly at the river mouth appeared lowest value of about 31.6 PSS. In the low saline water, it was found that the water temperature was almost homogeneous at around 30°C in the South and about 25°C in the north. These indicate the existence of mixing layer. At the central area from Danang to NhaTrang, the salinity of sea surface water were high at about 33.4 PSS. The water temperature variation were observed in the range between 26 and 29°C.

For the fluorescence values in the sea surface were high and varied between 1.6 and 3.2 V at the station near by shore speciality at the river mouth off Haiphong, VungToa and Danang. In the central area where the squid were caught found that the fluorescence at sea surface was low at about 0.4-0.6 V. It is indicated that the fluorescence at sea surface has no relation to the fishing ground

By the results of water temperature and salinity distribution, it is clearly show that the water of high salinity was transported along the coast of Vietnam to the south due to the northeast monsoon, so that the low saline water from Mekong discharge was rapidly carried away by the strong currents off the coast.

Horizontal distribution of transparency depth and water colour

Figure 10 shows a horizontal profile of sea colour (a) water transparency depth (b) of the survey area. The clear water with water transparency depth values more than 41m were found at Station no.24 off NhaTrang and no.40 off Vuntao. The water transparency depth in the Central area where fishing activities were carried out were ranged between 30 and 38m. Comparisons with the catch results indicate that at the good fishing ground at Station #17 the transparency depth value was deep upto 38m.

Vertical profiles of water temperature and salinity

Figure 11 show the vertical profiles of salinity and temperature varied by depth upto 900m at each fishing stations. In these areas, it clearly show that the mixed layer were very

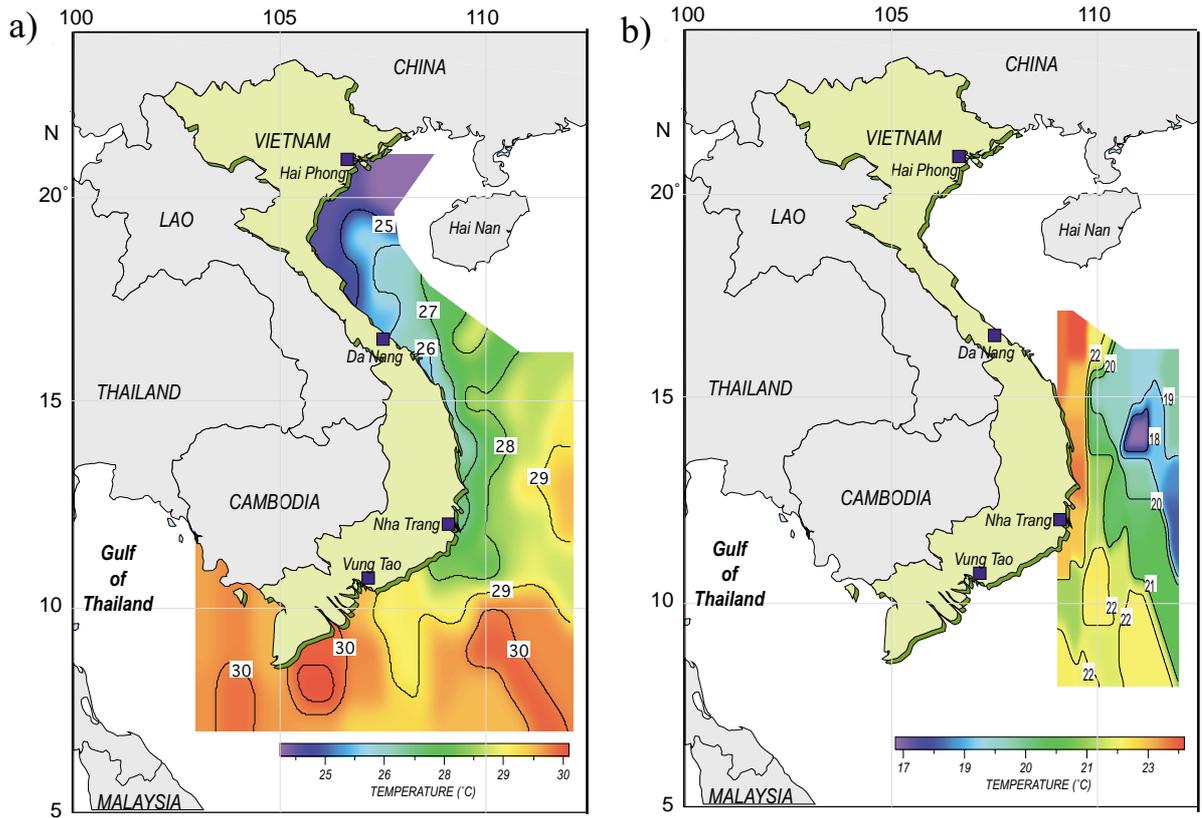


Fig. 8. 30 days synoptic chart of the sea surface temperature (a) and 100m deep (b) of the South China Sea: Vietnamese waters during 30 April - 29 May 1999.

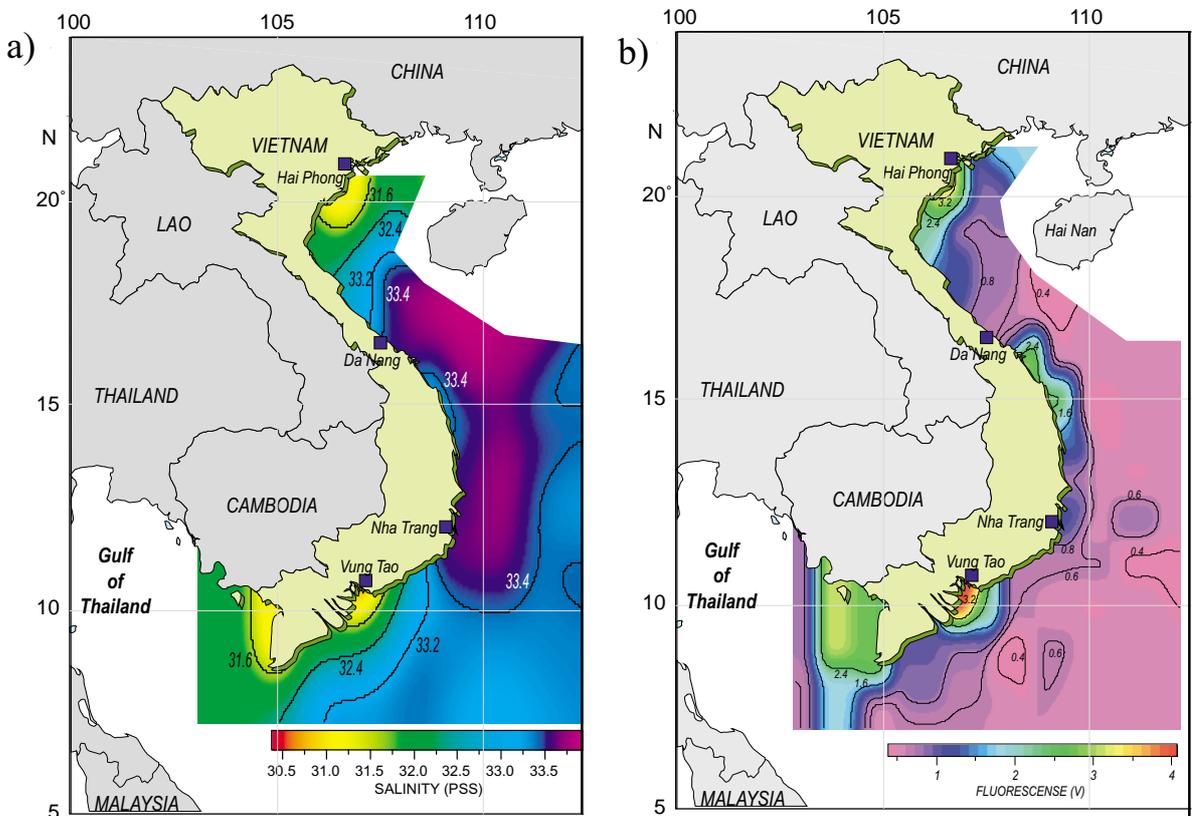


Fig. 9. 30 days synoptic chart of the salinity (a) and fluorescence (b) at the sea surface in the South China Sea: Vietnamese waters during 30 April - 29 May 1999.

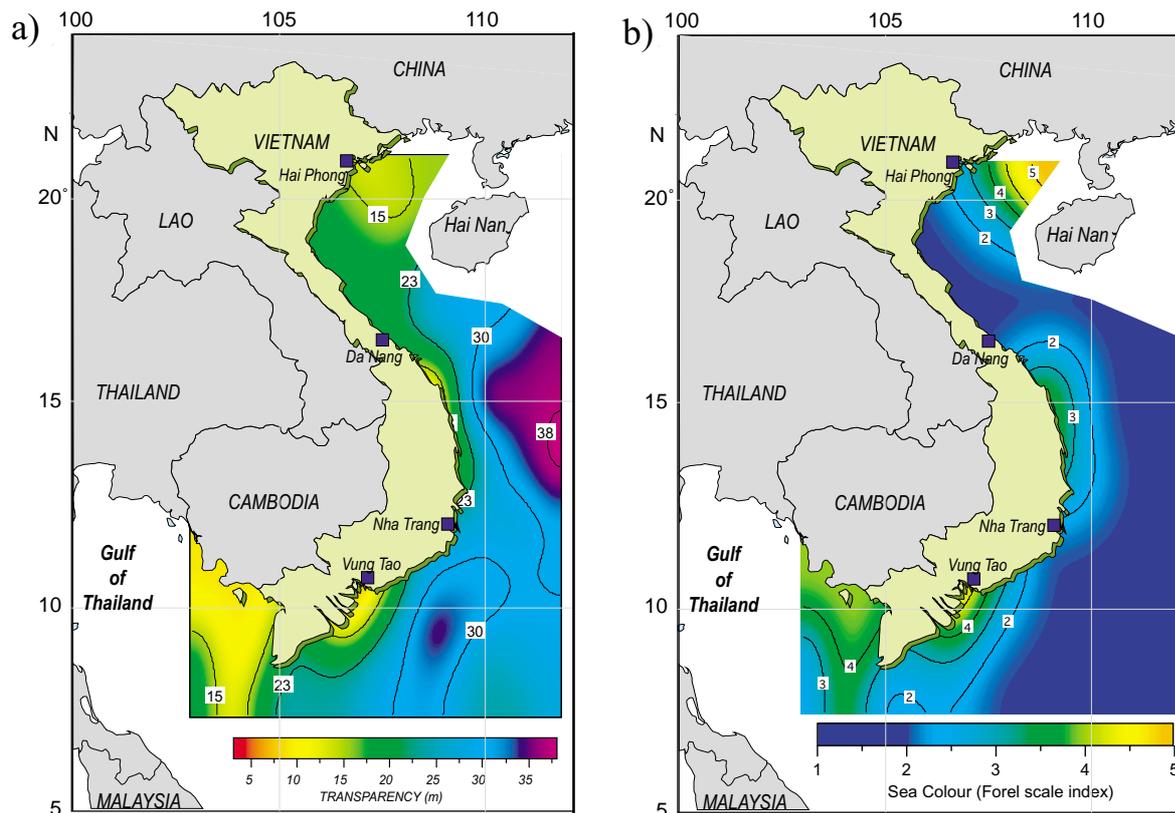


Fig. 10. 30 days synoptic chart of the transparency depth (a) and water color (b) of the South China Sea: Vietnamese waters during 30 April - 29 May 1999.

narrow and shallow ranged from the sea surface down to about 15m. Permanent thermocline generally appeared at about 15m deep from the surface where sea temperature was about 28°C in the north and 29.5°C in the south down to 1,500m deep where sea temperature was about 2.9°C. Salinity from depth between sea surface to 110m deep irregularly changed from 33.31 to 34.69 PSS, the salinity at deeper than 110m slightly reduce upto 34.47 PSS at the depth of about 300-500m deep, and then increase to be constant about 34.6 PSS.

Figure 12 shows the vertical profile of water temperature at LINE 1 and LINE 2 along longitude 110° and 111°E. The vertical profiles along the LINE 1 and LINE 2 indicate that the mixing layer was not much change, it was in a range from 15 to 45m for LINE 1 and 15m for LINE 2. Along LINE 1, the thermocline represented by 27°C was located at a depth of about 40m in the north from latitude 12° to 15°, while at depth of about 25m, shallower by 15m, at latitude 11°N. Along LINE 2, the thermocline represented by 28°C was located at a depth of about 15m in the north to south of latitude 15°-11°N, while at 10°N, was at 35m.

Salinity showed remarkable variation in near by sea surface. The results of salinity profile showed a remarkable relation to the water temperature. It was found that the upper layer surface (0-15m) where the water temperature was higher than 27°C the salinity was lower than 33.8 PSS. For the 24°C and 20°C water masses, the salinity were about 34.1 and 34.4 PSS, respectively.

Figure 13 shows the vertical profile of temperature at LINE A, B, C and LINE D. Along all LINE, the position of thermocline represented by 27°C and the thickness of mixing layer showed significant west-east variation. Low temperature at 27°C at sea surface was found in the coastal area and off shore by 29°C.

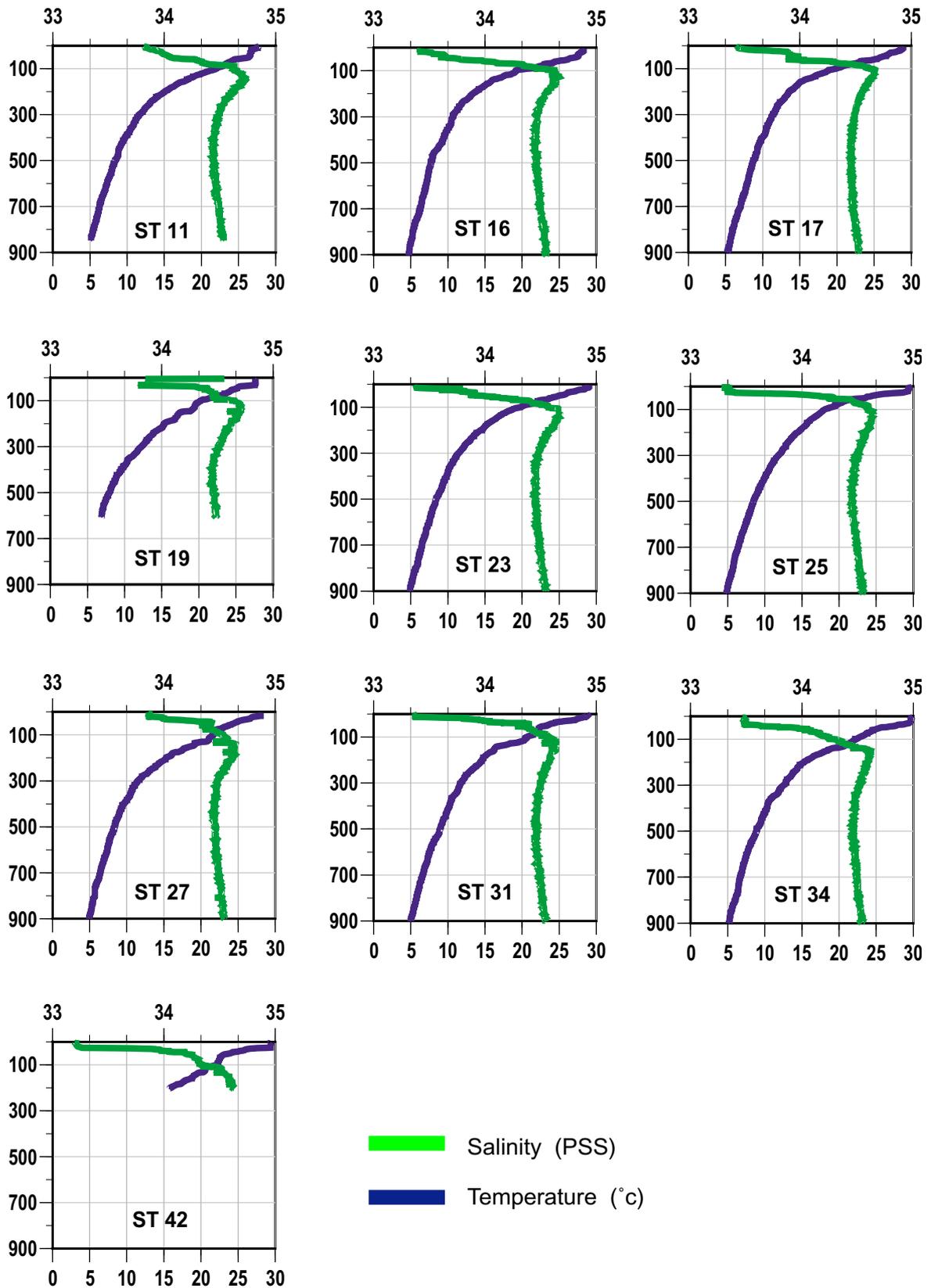


Fig. 11. Vertical profiles of the Salinity and Temperature of each fishing station in the Vietnamese Waters during May 1999.

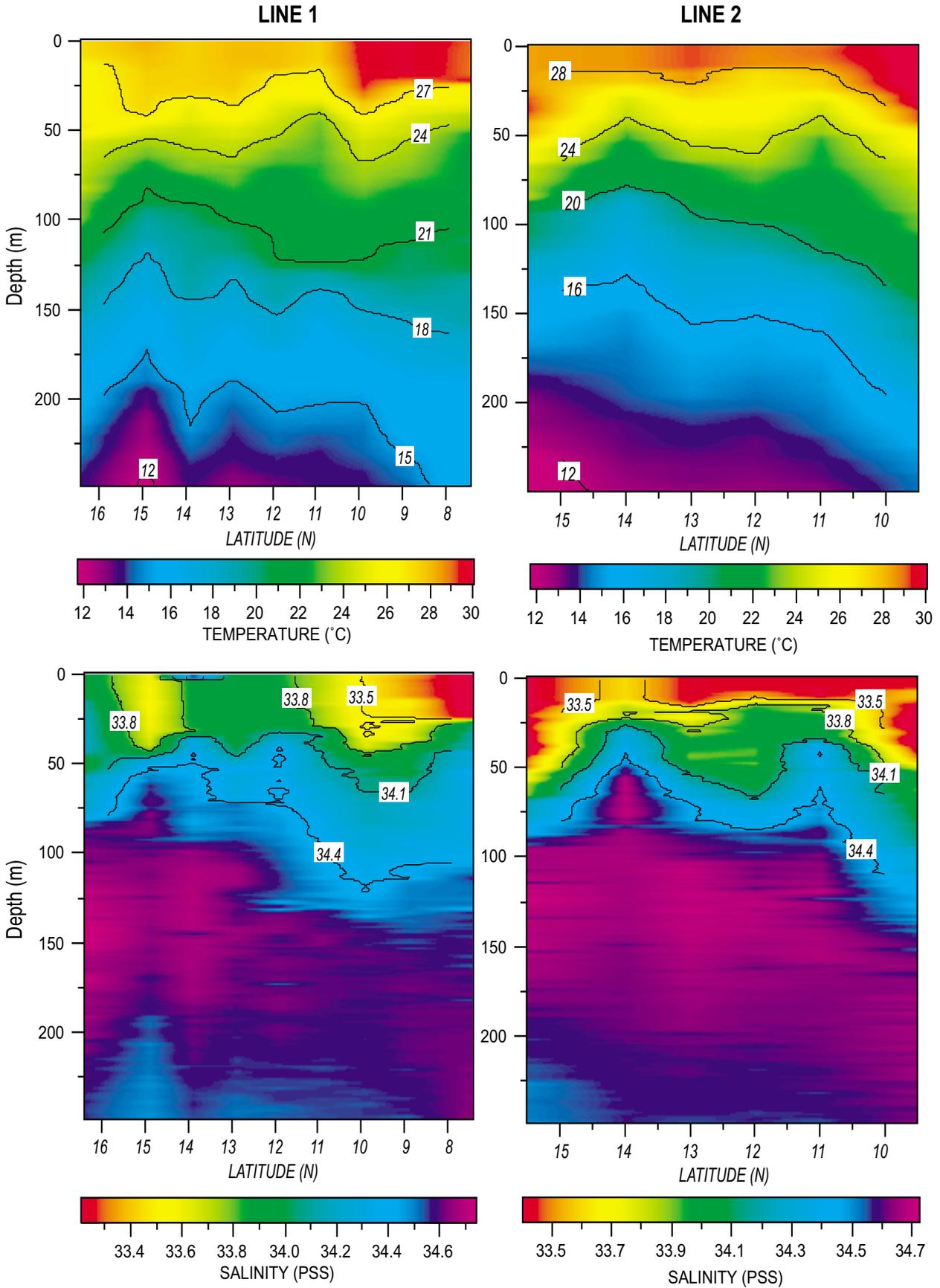


Fig. 12. Vertical profiles of water temperature and salinity at the cross section of LINE 1 and LINE 2 in the South China Sea: Vietnamese waters during May 1999.

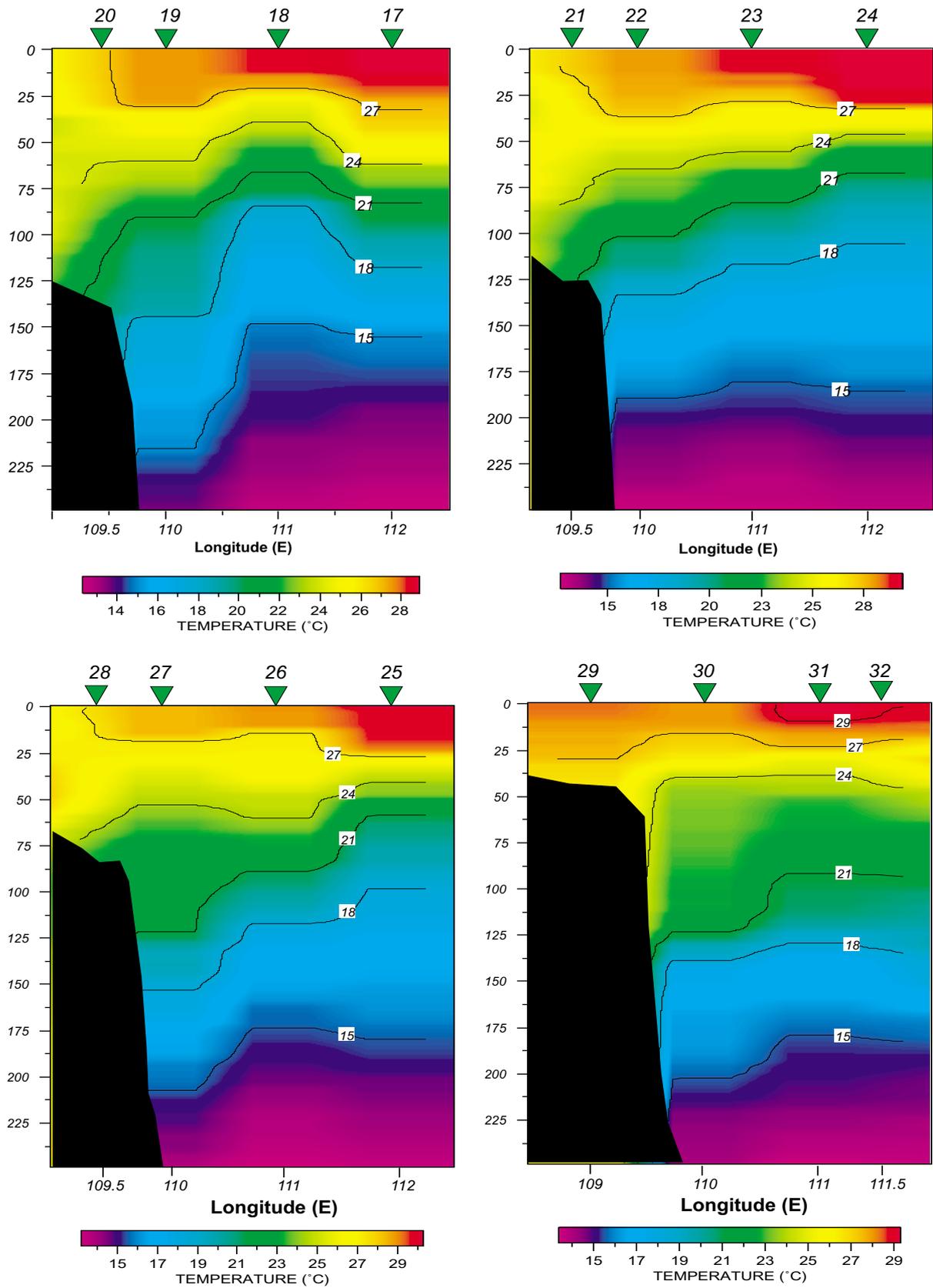


Fig. 13. Vertical profile of temperature (3°C interval) at the cross section of LINE A, LINE B, LINE C and LINE D in the South China Sea: Vietnamese waters during May 1999.

It is noted that the vertical profile of temperature along LINE 1, the upwelling of 18°C cold water move upwards to 80m deep in longitude 111°E at Station #18. Due to this appearances, many squid were caught near by the upwelling front/border in longitude 117°E at Station#17.

Angling Depth

By sight observation found that the squid behave aggregating nature and positive phototaxis, they swim on the surface of the sea at night. The results showed that purpleback flying squid scattered covering the entire area and generally caught at the depth ranged from sea surface down to 150m deep at night. The abundant depth was ranged from 50m to 100m.

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