Ecological Aspects of Oceanic Squid, *Sthenoteuthis oualaniensis* (Lesson) in the South China Sea, Area III: Western Philippines

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ABSTRACT

In an attempt to come up with initial jigging fishery on oceanic squid in the Southeast Asian Region SEAFDEC conducted a comparative study on the squid in the Philippines Exclusive Economic Zone off the coast of Western Philippines from 17 April to 9 May 1998. The survey objectives are to determine the distribution and abundance of the oceanic squid in relation to oceanographic conditions and to examine the feasibility of harvesting squid with jig gear.

Results from 11 sampling stations show that only one species of the purpleback flying squid, *Sthenoteuthis oualaniensis* (Lesson, 1930) were caught by autometic squid jigging gear. The distribution and abundance of the purpleback flying squid in term of the catch-per-unit-effort (CPUE, number of squid per line hour) are presented. Over the entire survey area, the CPUE of the squid averaged 5.7 squids/line hour. Drop-off rates for jigs fished on the jigging machines ranged from 0 to 0.33 squid/line hour. Angling depth where the squid were abundant ranged from 50 m to 100 m.

The squid had a mean overall mantle length of 147 mm and an averaged weight of 0.17 kg. A total of 2,592 squid were measured and mantle length ranged from 90 to 250 mm. Female dominated the catch, accounting for 1,380 squid or 81% of the 1,701 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 140 and 150 mm mantle length. A similar length-weight relationship coefficients between male and female was found.

The squid were found in a warm water mass where the sea temperature ranged from 14˚c to 31˚c at the depth from 150m up to sea surface at night. Good fishing grounds of the squid were at 18˚N latitue (18.5 squids/line hour) and at 19˚ N lattitude (11.6 squids/line hour) off the San Fernando and Currimao coasts, respectively where the upwelling occurred. Dissolved oxygen where squid abundant was ranged from 3.27 to 4.4 ml/l. Downwelling was found at 16˚N along the 118˚E where less potential of the squid, the water transparency depth in this area was deep of about 44 m. A period of 6 days before and after full moon day was good fishing day, while the percent illumination of the moon was less than 30%

Keywords: purpleback flying squid, *Sthenoteuthis oualaniensis,*
fishing ground, south china sea

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 totaled 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).

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 Resources Survey Program. 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 first experimental fishing which was carried out in the Philippines Exclusive Economic Zone off the coast of Western Philippines by M.V. SEAFDEC from 17 April to 9 May 1998.

Materials and Methods

Survey Area

Experimental fishing and oceanographic conditions were conducted by M.V.SEAFDEC in the Philippines Exclusive Economic Zone off the coast of Western Philippines from 17 April to 9 May 1998. All 31 oceanographic survey stations and 11 experimental fishing stations were designed covered from 11˚ to 20˚ N Latitude and from 117˚ to 121˚ E longitude as shown in **Figure 1**.

Fishing Gear

Squid sampling were collected by four automatic squid jigging machines: **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 18 to 30 typical japanese squid jigs spaced approximately 1m apart by nylon mono-filament leaders (30 to 50 lb test) as shown in **Figure 2a-b**. 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

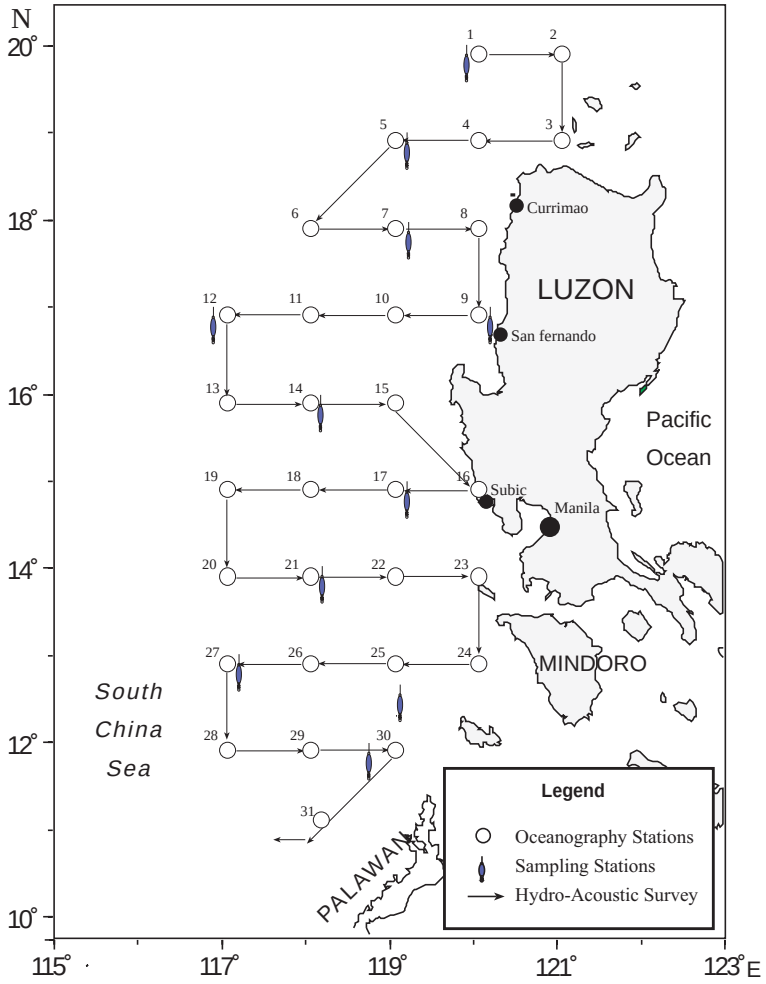


Fig. 1. Locations of fish sampling and oceanography stations in the survey area, off west coast of Luzon Islands

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.

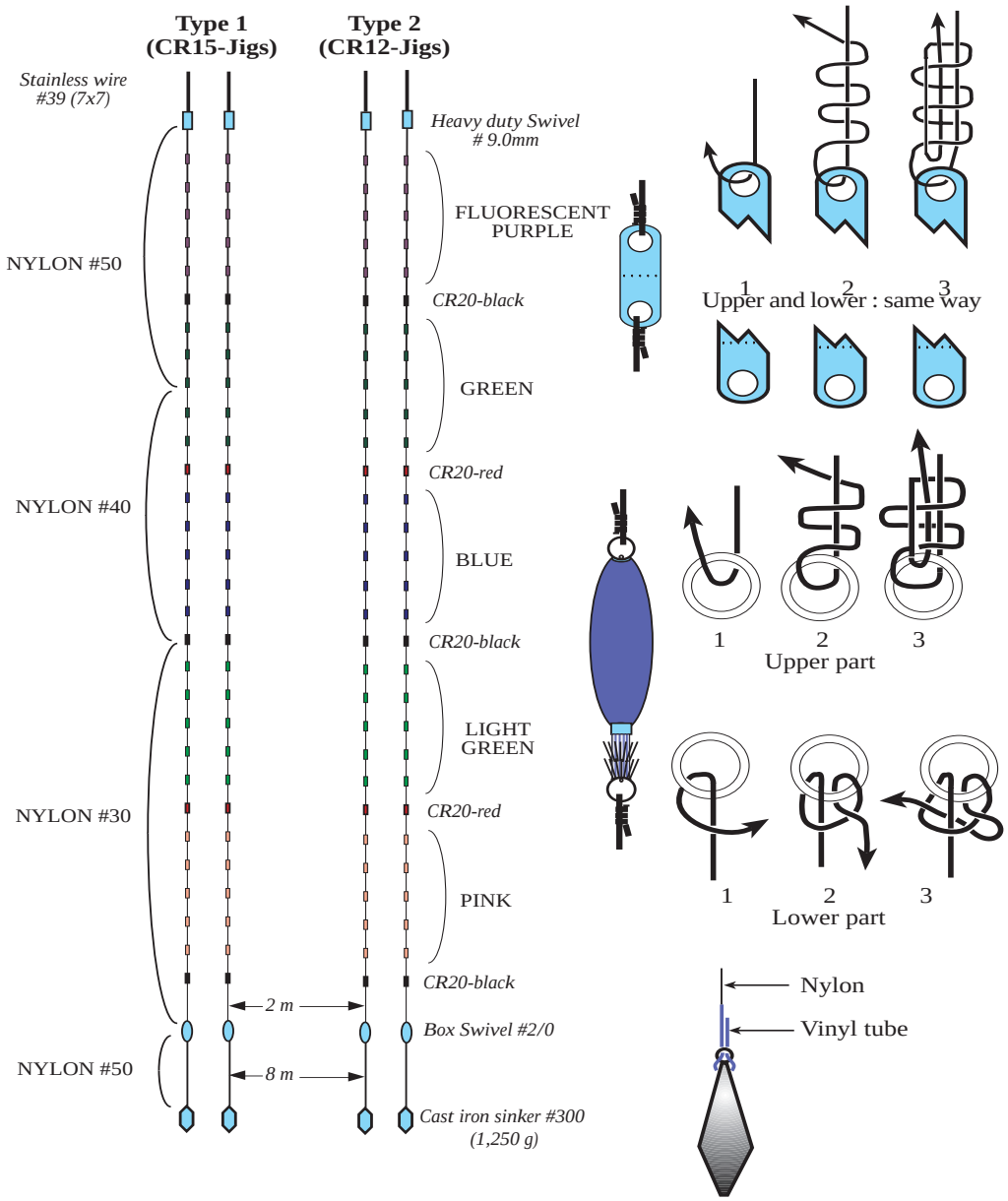
Data Collection

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.

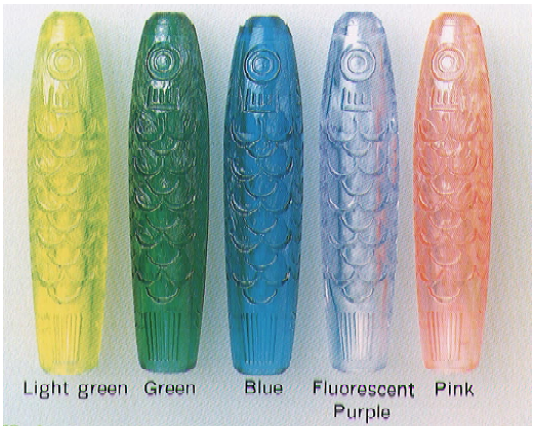
Biological feature information was collected from target species. Length frequencies (mantle length) were recorded in millimeters and weight in grams, Length and weight data were transformed with a log transformation and length-weight relationships calculated using a least squares regression method.

Oceanographic characteristics observations were conducted to clarify the oceanographic features in the west coast of the Philippines. 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.

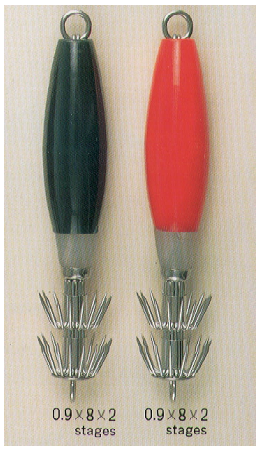
a)



b)



CR15 New Kaio Hook



CR20 Bakelite Cased Hook

Fig. 2. Arrangement of squid jig line(a) and types of squid jig (b) used in the experiment.

Dynamic depth relative to the surface was calculated by the EG & G CTD Post-acquisitive Analysis Software at every dbar pressure interval. Density figures were derived from temperature and salinity data using sigma-t computation tables. The dissolved carbonate system in seawater was calculated from total alkalinity and pH was measured using the in situ sensor attached to the ICTD [It was later measured on board using the Fisher Scientific model 1002 pH meter, when the pH sensor malfunctioned]. Total alkalinity was measured as the capacity of seawater to neutralize Hydrochloric acid and the saturation level of seawater was calculated from the ratio between actual carbonate concentration and its concentration at equilibrium. 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).

Light intensity in the water column was measured by Quantum Light Sensor for underwater

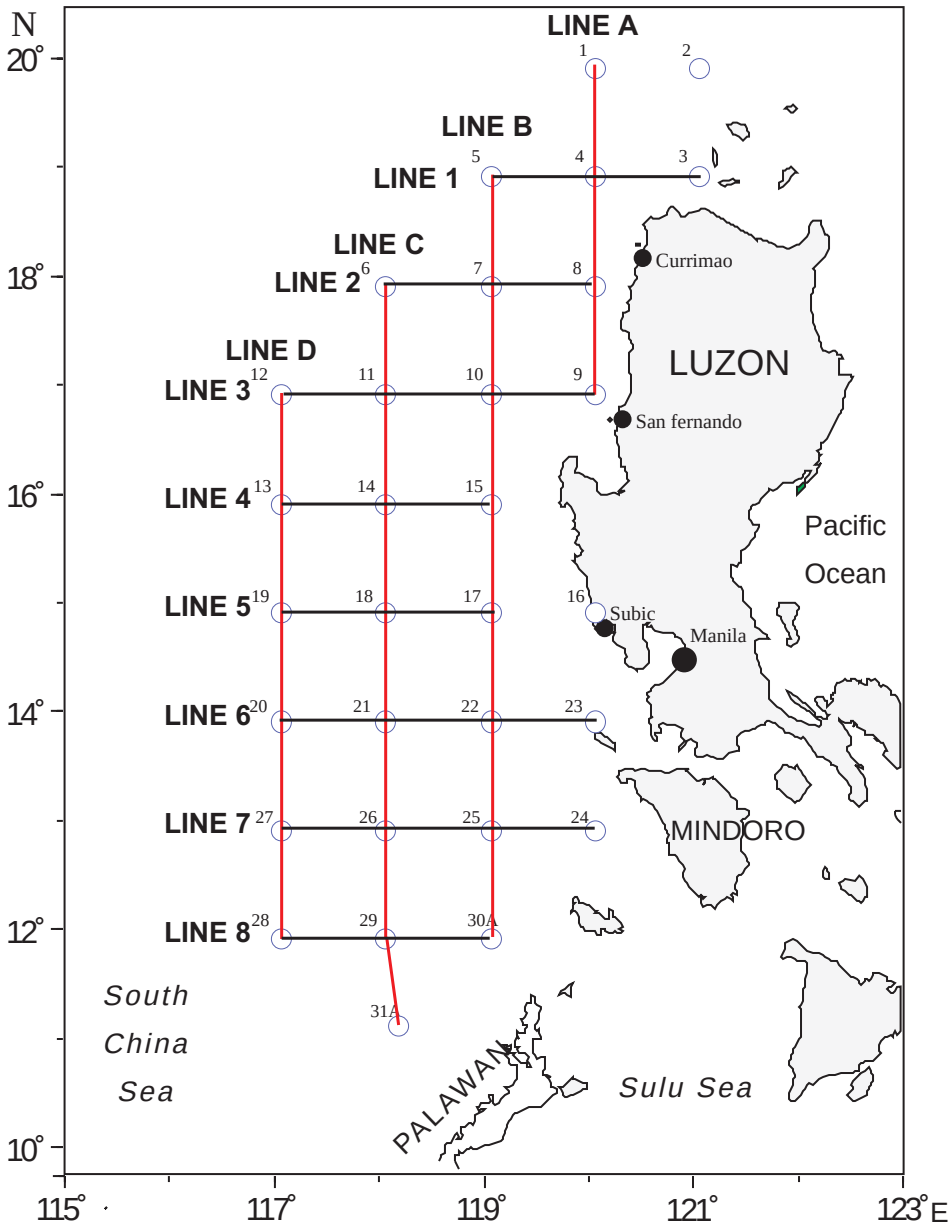


Fig. 3. Lines of cross section

and in air. These data were recorded on Data Logger IL1000 at the day-time stations. Water transparency was measured by Sechi disc in unit of meter at day-time stations. The average light intensity near sea surface (I_0) was used to estimate light intensity at a desired depth (I_z), from the following equation (Jerlov 1976):

$$I_z = I_0 \exp(-kz)$$

where k is the attenuation coefficient (m^{-1})

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-A to D for the north-south direction and along latitude of each Line-1 to 8 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 version3.4" (Fortner software).

Results and Discussion

Catch

Results from 11 sampling stations of the survey area show that only one species of the purpleback flying squid, *Sthenoteuthis oualaniensis* (Lesson, 1930) were caught by the automatic squid jigging gear. This was confirmed by Anuwat *et al*. 1999. **Table 1** shows the information of

Table 1. Information of sampling stations and catch results of the purpleback flying squid in the South China Sea, Area III: Western Philippines during April-May 1998.

No.	St. No.	Date	Position		Number of lines	Number of Jig	Time (h:min)	Total Catch Data		CPUE Ind./line hour
			Lat. (N)	Long.(E)				Weight (kg)	Number (ind)	
1	1	17-Apr	20° 02.30'	119° 56.70'	8	240	5	25.920	116	2.900
2	5	19-Apr	18° 59.18'	118° 59.68'	8	128	2	5.760	29	1.813
3	7	21-Apr	18° 00.40'	119° 00.28'	8	156	4.55	71.505	422	11.593
4	9	22-Apr	16° 59.90'	120° 01.70'	8	156	4	5.109	50	1.563
5	12	25-Apr	16° 59.64'	117° 04.77'	8	178	5	100.299	739	18.475
6	14	27-Apr	15° 59.50'	118° 00.60'	8	176	4.5	23.014	141	3.917
7	17	29-Apr	15° 00.64'	118° 59.52'	8	176	5	23.485	131	3.275
8	21	30-Apr	14° 00.50'	117° 59.90'	8	176	6	39.635	267	5.563
9	27	5-May	13° 00.40'	117° 06.41'	8	176	8	16.506	138	2.156
10	30a	8-May	11° 59.80'	118° 45.30'	8	153	6.5	25.728	159	3.058
11	31a	9-May	12° 47.60'	119° 09.00'	6	176	8	62.190	400	8.333

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 5.7 squids/line hour. The minimum and maximum of CPUE of the squid were 1.6 and 18.5 squids/line hour, respectively. The CPUE more than 11 squids per line hour were found at St.#7 and St.#12. Drop-off rates for jigs fished on the jigging machines ranged from 0 to 0.33 squid/line hour.

Biological features

A total of 2,592 purpleback flying squid were measured and their mantle length ranged from 90 to 250 mm. The squid had a mean overall mantle length of 147 mm and an averaged weight of 170 g. **Figure 4** shows the sex composition and the CPUE distribution of the squid

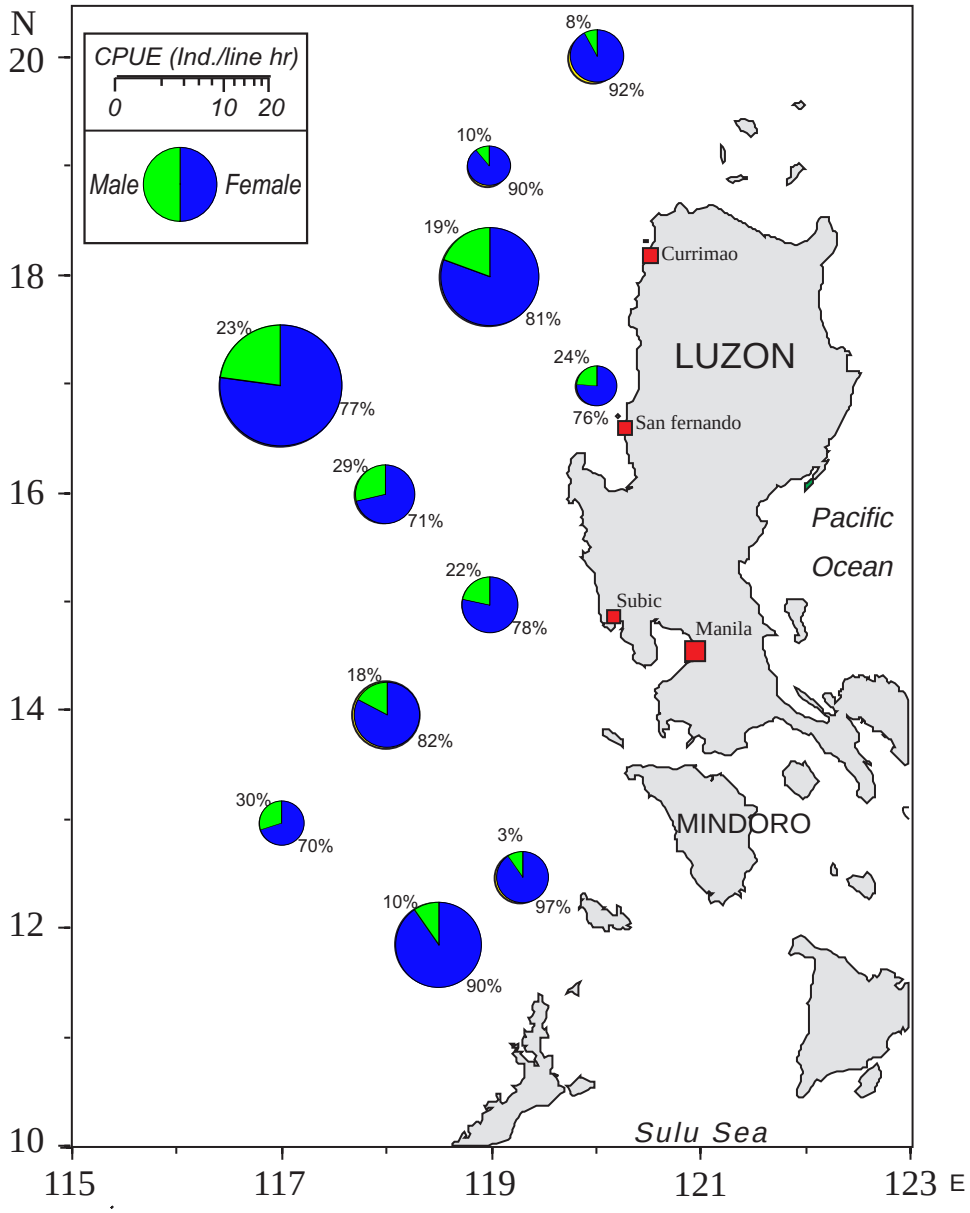


Fig. 4. Sex composition and CPUE distribution of purpleback flying squid caught in the South China Sea: Western Philippines during April-May 1998.

Fig. 5. Purpleback flying squid (male) caught in the South China Sea: Western Philippines during April-May 1998.

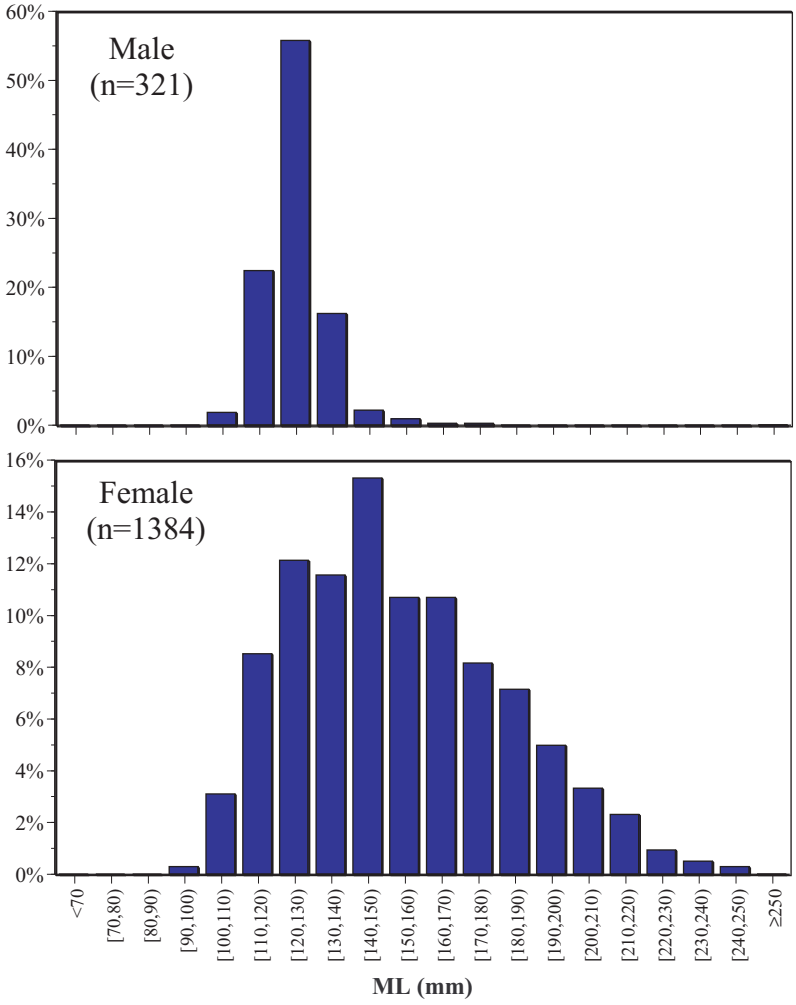


Fig. 6. Mantle length composition of purpleback flying squid caught in the South China Sea: Western Philippines during April-May 1998.

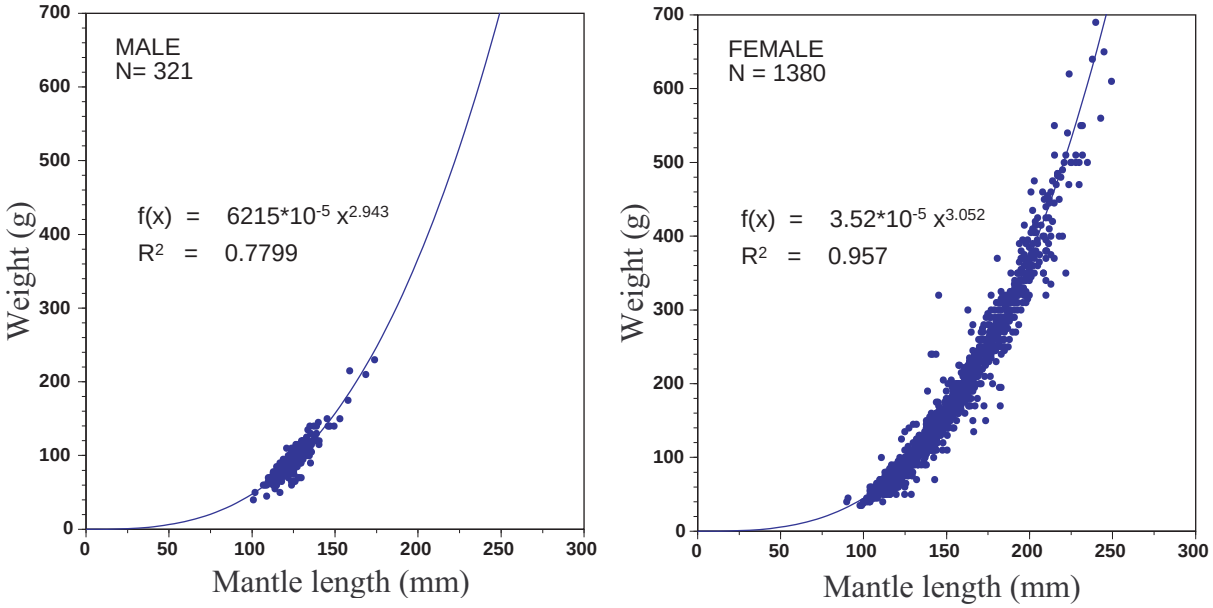


Fig. 7. Length-weight relationship of purpleback flying squid caught in the South China Sea: Western Philippines during April-May 1998.

caught in each sampling station. It is clearly shows that female dominated the catch, accounting for 1,380 squid or 81% of the 1,701 squid sexed. Males were generally smaller than females as shown in **Figure 5**. **Figure 6** show the mantle length composition of the squid caught in the survey area. Both of male and female, their mantle length composition have a single peak mode at between 120 and 130 mm (a) and at between 140 and 150 mm mantle length, respectively. Length-weight relationship coefficients for male, female of the purpleback flying squid are presented in **Figure 7**. It can be concluded that there are no difference in length-weight relation between male and female.

Fishing Ground Environment

Figure 8 shows the vertical profile of CTD and dissolved oxygen parameters varied by depth at all sampling stations. In the survey area, the mixed layer depth was clearly showed at all stations at the depth observed from 12 m to 71 m. Permanent thermocline generally appeared at about 50m deep from the surface where sea temperature was about 28˚c down to 1500 m deep where sea temperature was about 2.7˚c. Salinity from depth between sea surface to 150 m deep irregularly changed from 33.7 to 34.6 PSS, the salinity at deeper than 150m was almost constant about 34. 5 PSS. For dissolved oxygen at nearby sea surface down to 150m deep performed irregular change within between 4.4 ml/l and 3.1 ml/l, respectively and guadully decreased to a constant value of about 2.0 ml/l at deeper than 400m.

Figure 9 shows the horizontal profile of temperature at sea surface layer (a) and 100m (b) in the survey area. Most of the temperature ranged from 28˚ to 30.7˚c at sea surface and from 18˚ to 23.5˚c at 100m deep. The figure clearly shows a cold water flowed from the Pacific Ocean into the South China Sea in the northern Luzon. At 18˚N the sea temperature at 100m deep was low about 18˚c compared with the surrounded area where temperature was about 23˚c, this cold water appeared up to the surface where the sea temperature was found to be about 28˚c. Anond (1999) reported a cyclonic eddy was found in this area and its occurrence was due to wind turbulence in the South China Sea Area.

Figure 10 shows a horizontal profile of water transparency (m) of the survey area. The sea water was very clear which the transparency depth was about 44m, this location was between north latitude of 17 and 18˚ along 118˚ east longitude. Anond 1999 indicate this area as downwelling so that the catch results were very poor. However it is indicated that the good fishing at st.#7 and st.#12 located at the boundaries area where water transparency was in a range from 27 m to 33 m.

Figure 11 shows the vertical profile of temperature at LINE A, LINE B, LINE C and LINE D. The vertical profiles along the LINE A and LINE C indicate that the mixing layer was not much change, it was about 40-50 m for LINE A and 50-60 m for LINE C. Along LINE B, the thermocline represented by 27˚c is located at a depth of about 22 m in the north at st.#5 and 7,

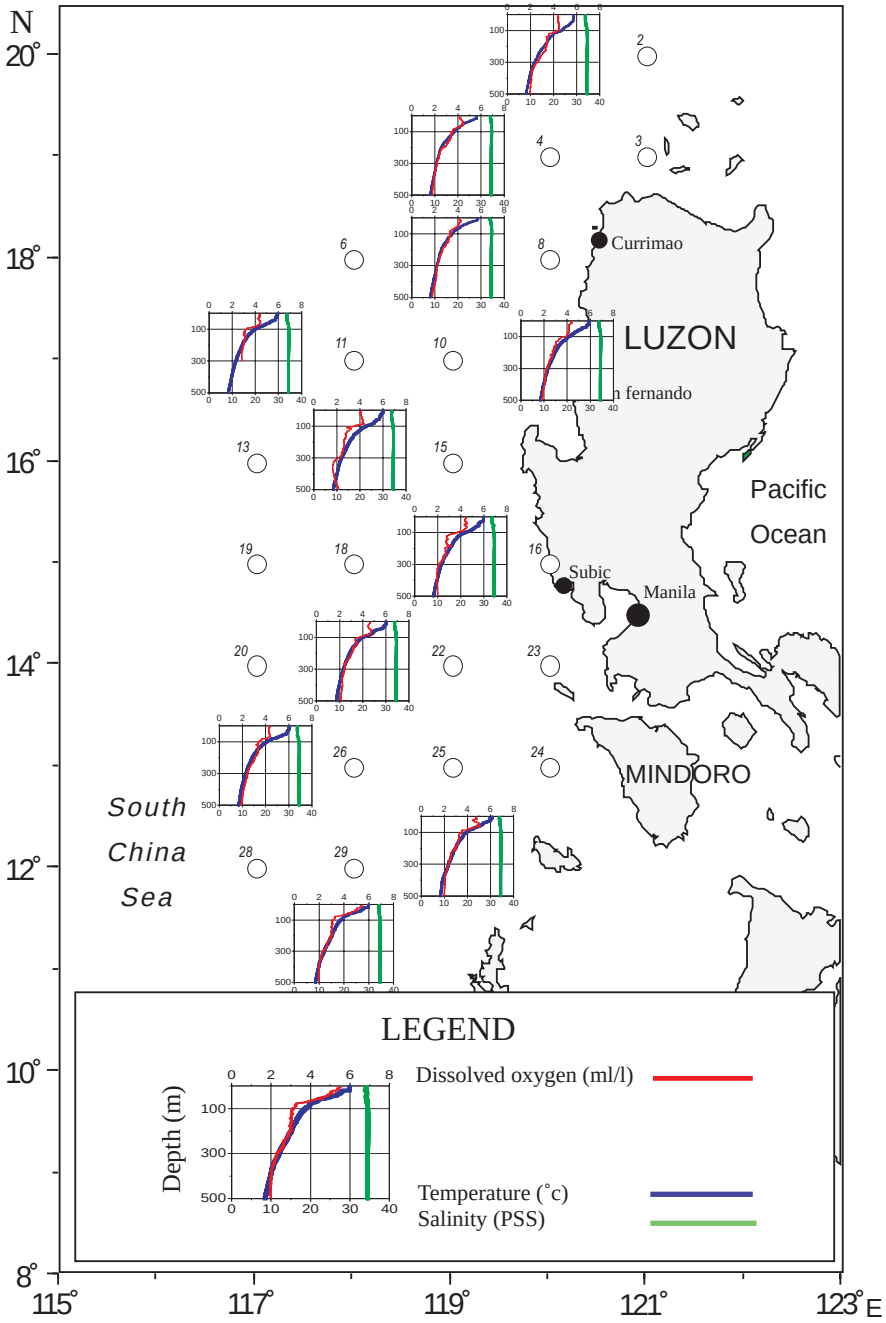


Fig. 8. CTD and dissolved profiles at squid sampling stations during April-May 1998.

while at depth of about 70 m, deeper by 48 m, in south. The upwelling was found at the st.# 7. A similar north-south change of thermocline was found along LINE D between st.#12 and st.#19.

Figure 12 shows the vertical profile of temperature at LINE 1 to LINE 8. West-east variation of thermocline was found not to be remarkable in the waters south of LINE 2, but significant along the LINE 1. Along LINE 1, the position of thermocline represented by 28˚c and the thickness of mixing layer showed significant west-east variation. It is noted that the vertical profile of temperature along west-east section showed no thermal gradient.

Angling Depth

By sight observation found that the squid behave aggregative nature and positive phototaxis, they swim on the surface of the sea at night. From the experimental results found that purpleback flying squid scattered covering the entire area and generally caught at the depth ranged from sea surface down to 200 m deep at night. The abundant depth was ranged from 50 m to 100 m as shown in **Figure 13** because some of the squid were caught and identified as purpleback flying squid. During fishing the quantum light intensity at 50 m deep was measured to be about 0.048µEm^{-2}s^{-1}. From the equation 1) the light intensity at sea surface (I_0) was observed more than 200µEm^{-2}s^{-1} in day time, in which I_z was 0.048µEm^{-2}s^{-1} as the optimum light intensity of

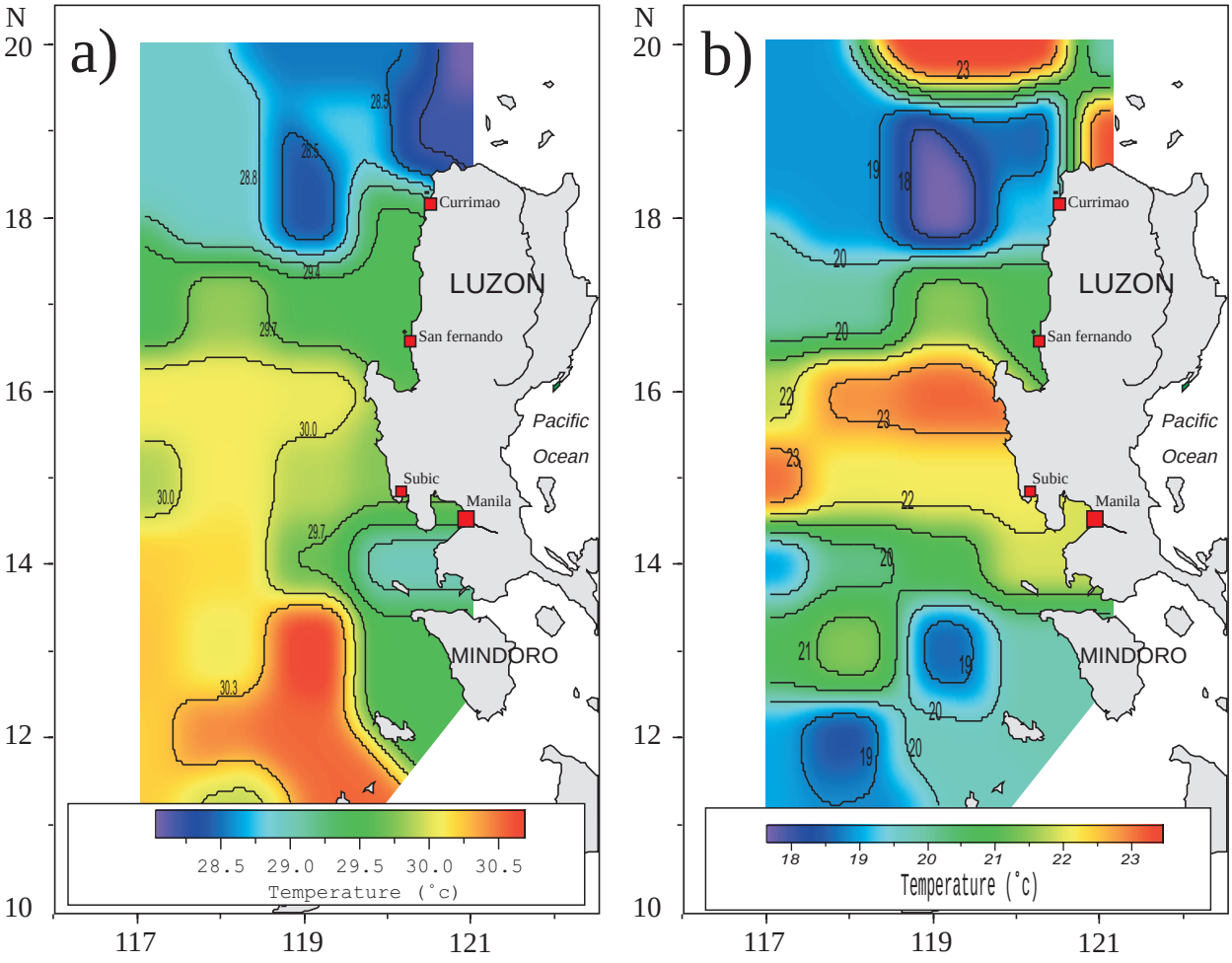


Fig. 9. 23 day synoptic chart of the sea surface temperature (a) and 100m deep (b) in the South China Sea: Western Philippines during 17 April- 9 May 1998.

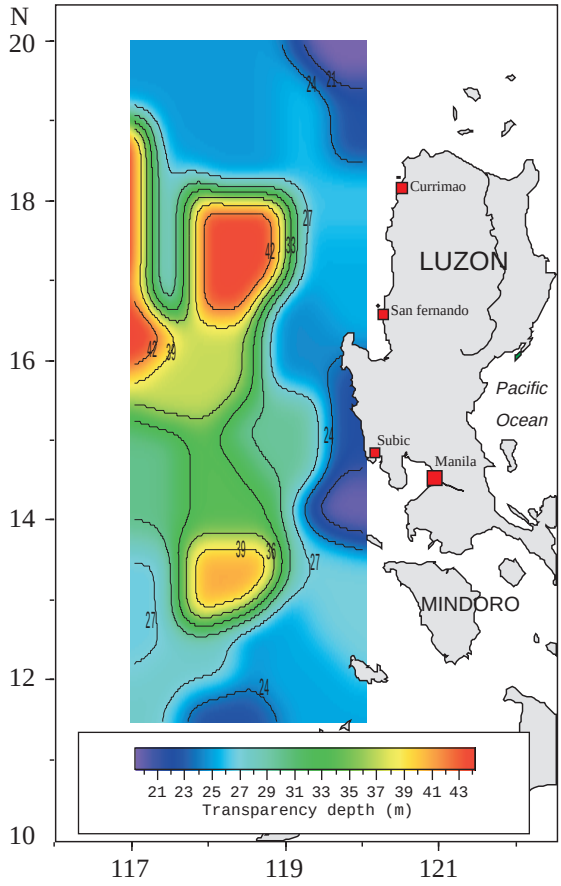


Fig. 10. 23 day synoptic chart of the water transparency depth (m) in the South China Sea: Western Philippines during 17 April- 9 May 1998.

the squid and ***k*** was 0.01m^{-1} obtained from the experiment, therefore the squid shall be living at deeper than 350m in the day. This is may be useful information for daytime operation.

Lunar Effects

Figure 14 shows the result of catch in CPUE related to percent of moon illumination. It was found that within the period before and after dark moon occurrence which the moon illumination is less than 30%, the catch of squid by jigging is high. A similar result was reported by Nakamura *et al.* showed that the oceanic squid species are generally active on feeding behaviour under dim light or less illumination from moon. How ever it will also depend upon the fishing ground conditions.

Acknowledgement

We wish to express our appreciation to the Captain and Crew of MV SEAFDEC for their kind cooperation during the survey.

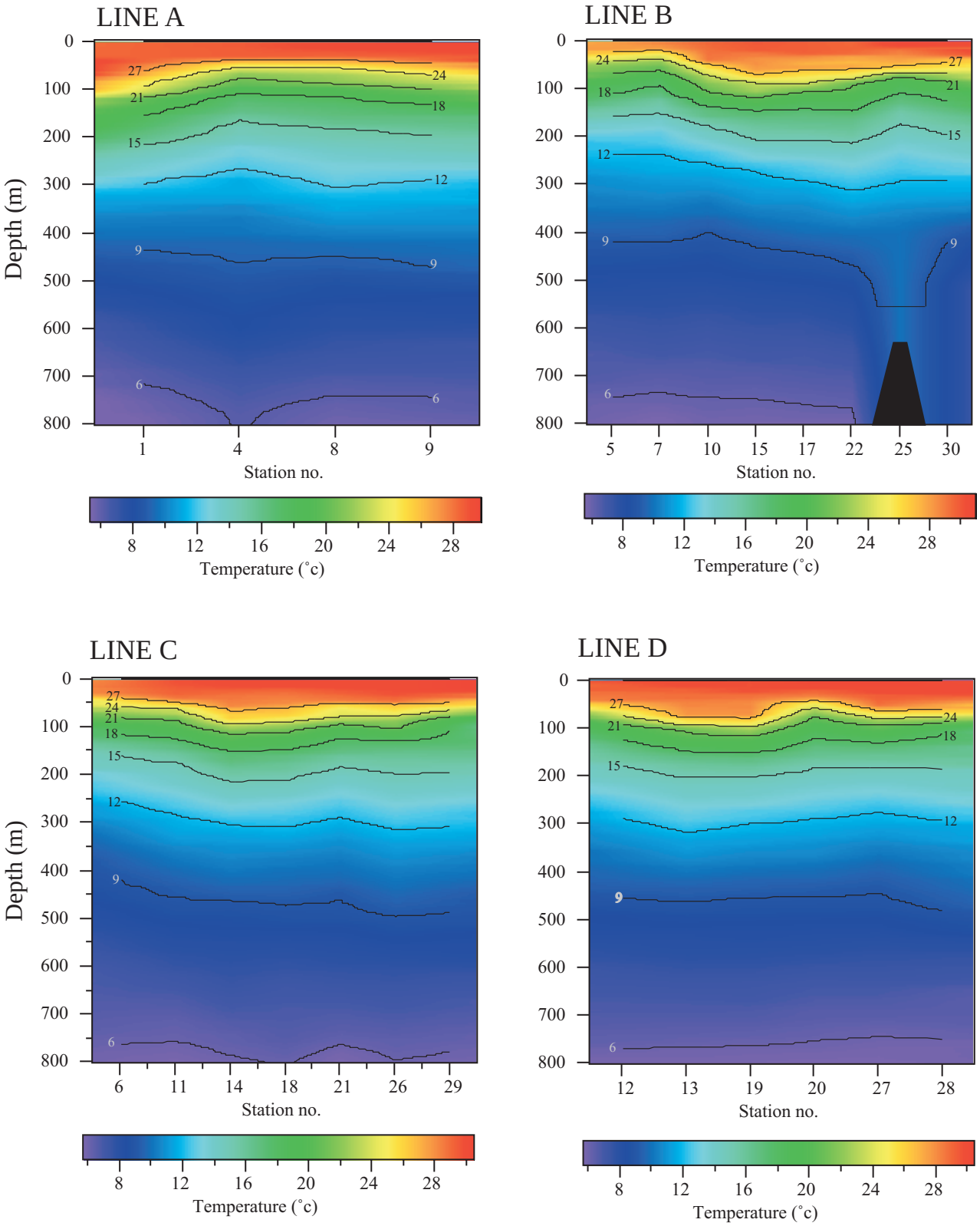


Fig. 11. Vertical profile of temperature (3˚c interval) at the cross section of LINE A , LINE B, LINE C and LINE D in the South China Sea: Western Philippines during April-May 1998.

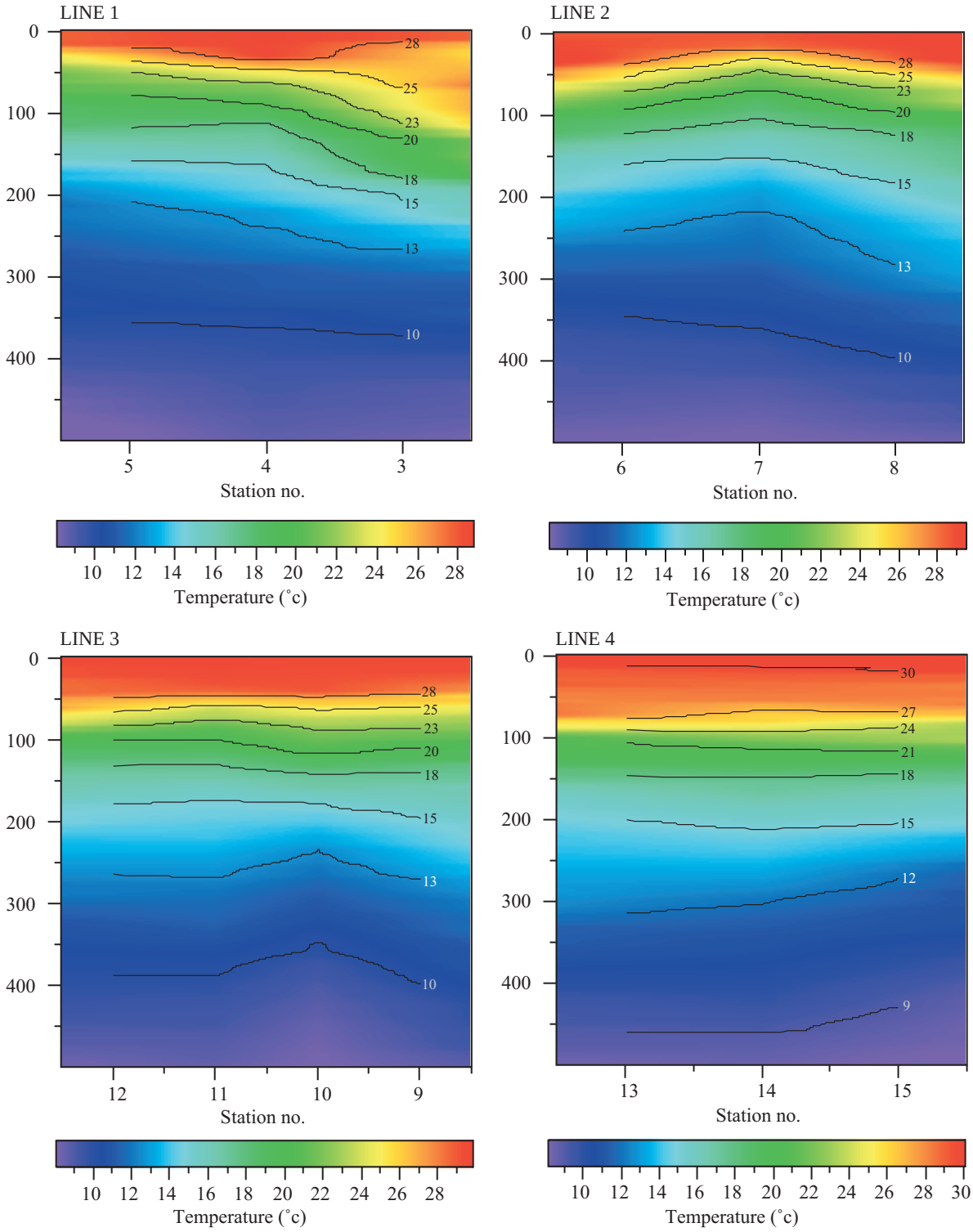


Fig. 12-1. Vertical profile of temperature (3˚c interval) at the cross section of LINE 1 , LINE 2, LINE 3 and LINE 4 in the South China Sea: Western Philippines during April-May 1998.

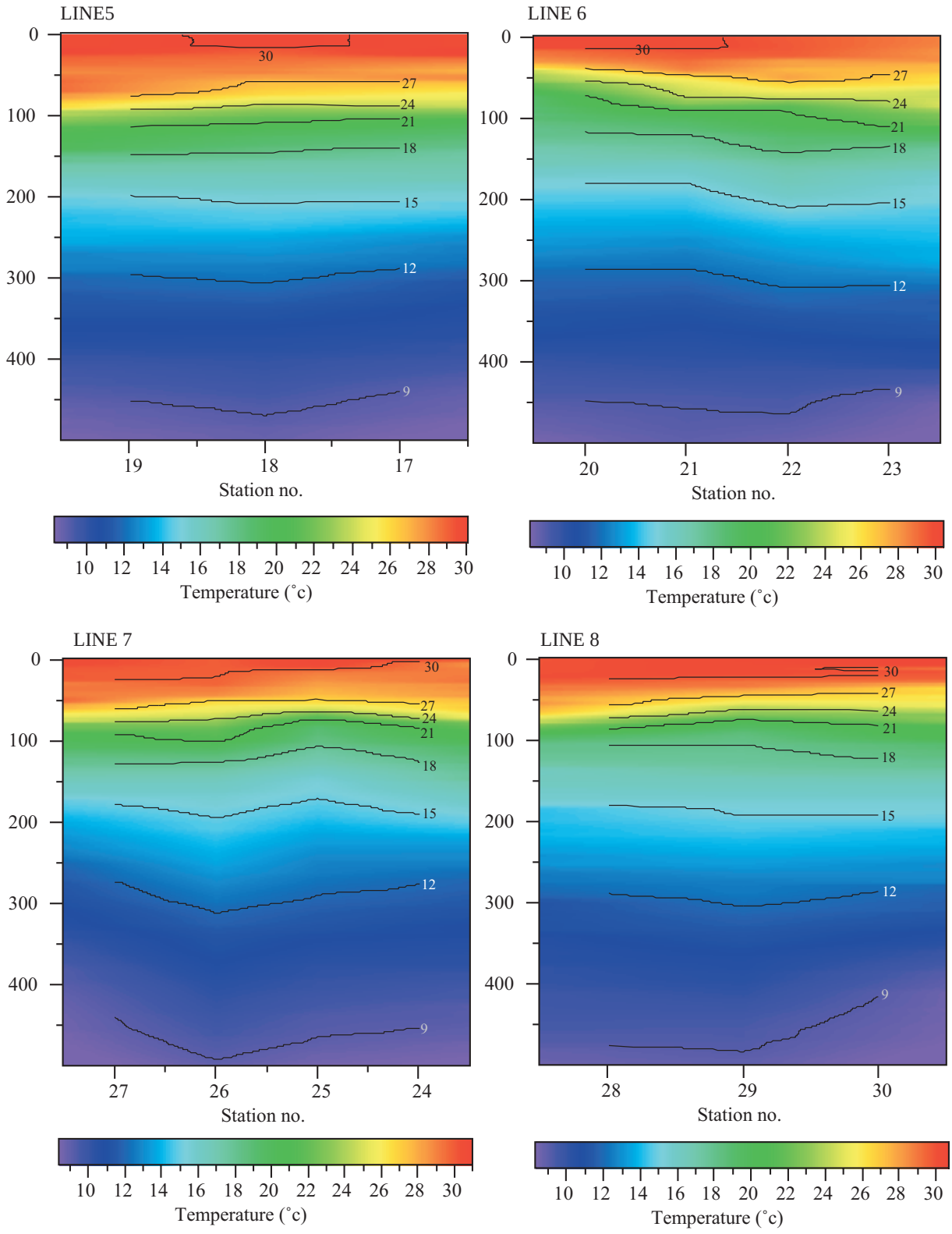


Fig. 12-2. Vertical profile of temperature (3˚c interval) at the cross section of LINE 5 , LINE 6, LINE 7 and LINE 8 in the South China Sea: Western Philippines during April-May 1998.

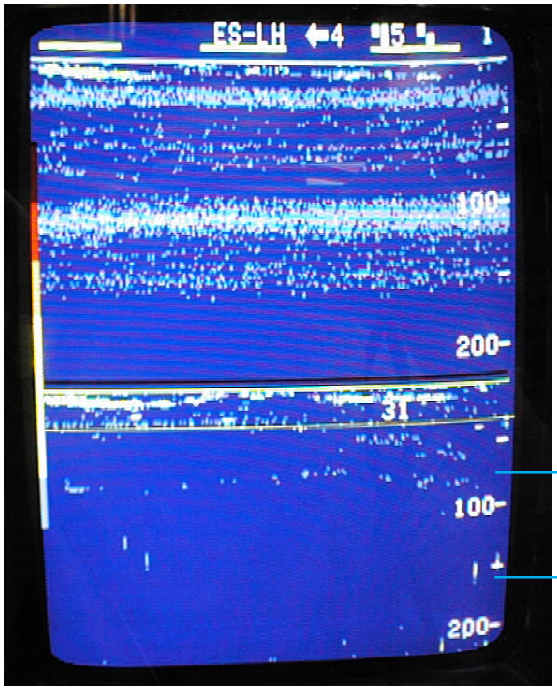


Fig. 13. Echo trace of the purpleback flying squid observed from colour echo sounder at 50 Hz and 200 Hz.

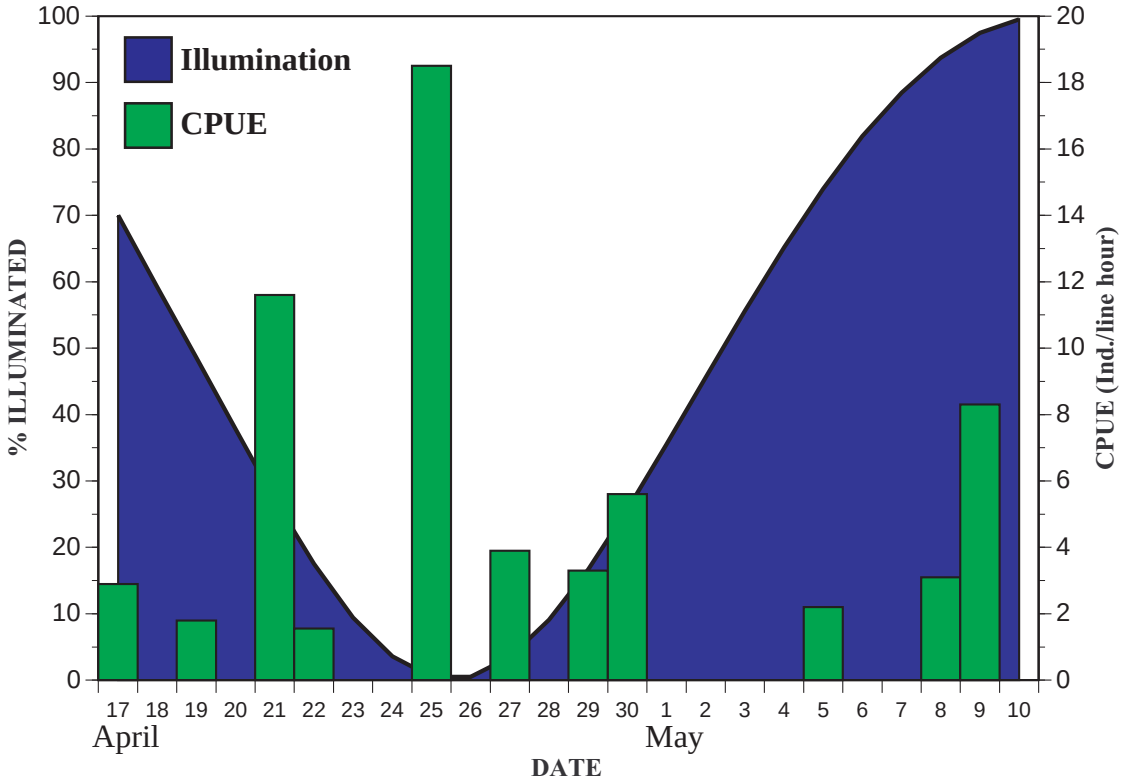


Fig. 14. Relationship between percent of illumination from the moon and result of catch in CPUE of the purpleback flying squid in the South China Sea: Western Philippines during April-May 1998.

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