Biological Feature of an Oceanic Squid, *Sthenoteuthis oualaniensis* in the South China Sea, Area III: Western Philippines.

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ABSTRACT

Several species of oceanic squids are believed to occur in the South China Sea, especially off the west coast of the Philippines. *Sthenoteuthis oualaniensis* was one of the species that dominated the catch during the research survey off western Philippines in April to May 1998. Preliminary study was carried out on some biological features of *Sthenoteuthis oualaniensis*, particularly on maturity pattern, sex ratio and stomach content. There was a similarity in maturity pattern throughout the study areas with the same proportion of mature and immature squids. In all stations, the female squids out numbered the male and the size of the female was general bigger then the male squids. ML50% of female was estimated to be at 175 mm while range of mature female was between 110 - 240 mm. Fish and cephalopods were the most frequently occurring prey taxa found in the diet of *Sthenoteuthis oualaniensis*, contributing between 37% - 46% and 30% - 43% respectively. Identification of prey taxa especially to species level was strictly limited, due to lack of proper references and understanding of the nature of fish species composition within the study areas. Results discussed in this paper may serve as early information for future biological study on *S. oualaniensis*.

Key words: *Sthenoteuthis oualaniensis,* maturity pattern, diet, stomach content, Philippines.

Introduction

Sthenoteuthis oualaniensis known as purpleback flying squid of Family Ommastrephidae is an oceanic squid widely distributed in the western Pacific and Indian Ocean. It covers throughout tropical and temperate waters of both the northern and southern hemispheres (Roper et al., 1984). It is known to carry out diurnal vertical migration between the surface at night to the deeper layers during the day. *Sthenoteuthis oualaniensis* in one of the oceanic squids occurring in the Philippine waters beside other common oceanic squid species such as *Nototodarus philippinensis and Todarodes pacificus*. Information on its biological features and ecological aspect such as stock structure, age span, spawning season and spawning grounds are still lacking compared to *Todarodes pacificus* which has been studied since late 1910s (Tioda, 1915). The fishery status of this species is also not known and not well documented, especially on monthly and annual landings and effort data. In the Philippines, oceanic squid fishery is practiced on a small scale and most of these squids are of relatively low market values.

The use of research cruise data to study the biology and the distribution of the squids have widely been used in other areas especially on *Loligo forbesi* (Holme, 1974; Collins et al., 1995). However, since most of the squids are mobile and migratory species, their abundance and distribution in certain areas will need survey data from several cruises. From survey data, analysis on stock assessment on squid fisheries can be used e.g. to provide recruitment indices, real time indices of adult abundance, or direct estimates of adult stock size (Lange and Sissenwide, 1983; Okutani and Watanabe, 1983). To date, no information on biology and abundance of the S. oulaniensis off the Western Philippines based on the survey data analysis is available.

The objective of this study was to preliminarily determine some basic biology of *Sthenoteuthis oualaniensis* based on the data collected from the research survey by the M.V. SEAFDEC. It included studies on sex ratio, length weight relationship, cohort and maturity patterns of the squids and the stomach contents, major prey composition by areas. Knowledge on the change in distributions of the oceanic squids with respect to time during the research survey was also very important in the study of their biology but this aspect was covered by another paper.

Materials and Methods

Samples of the squid were collected using the MV SEAFDEC along the west coast off Philippine waters, beginning at the first station in 120^0 00' E 20^0 00' N and finished at the last station in 119^0 09' E ,12^0 47.6' N. (Fig.1). The cruise took place from the beginning of April until the end of May 1998. The samples were caught using 4 automatic jigging, operating at difference depths ranging from 80 m to 120 m onboard the MV SEAFDEC.

The squids obtained from the sampling were sexed and measured their dorsal mantle length to the nearest millimeter. An initial body weight of individual squids were taken using spring balance to get an estimated body weight. For the maturity samples, after measuring the DML and body weight, the samples were kept in the ice room at -20°C for further analysis in the laboratory. Samples for stomach content study were taken onboard. The squids were immediately dissected after measurement of ML and body weight. The stomach contents were removed, their fullness (0-4) estimated, using subjective scale (O, empty; 1, one-quarter full, 2, half full; 3, three-quarter full, 4, full). The stomachs were then stored (-20°C) for further laboratory analysis.

In the laboratory, stomachs were thawed and washed in tap water over 0.35 mm sieve. Prey remains were then examined under a binocular microscope and presence and absence of major prey taxa were, noted. The remains for fish included bones, otoliths, scales, eye-lenses, skin and flesh while for cephalopods, the remains were beaks, arm suckers, gladius, flesh, skin and eye-lenses. For crustaceans, the remains usually consisted of fragments of exoskeleton, and pinkish eyes. Fish otoliths, selective fish bones, pieces of crustacean exoskeleton and sucker rings of cephalopods were removed and kept in dry bottle for further identification. Fish species identification through otoliths was limited as source of reference for fish species from the otoliths was unavailable unlike in cases such as those from the North Sea fish species (Harkonen, 1986), fish jaws and vertebrae (Watt et al., 1994) and for cephalopod beaks (Clarke, 1986).

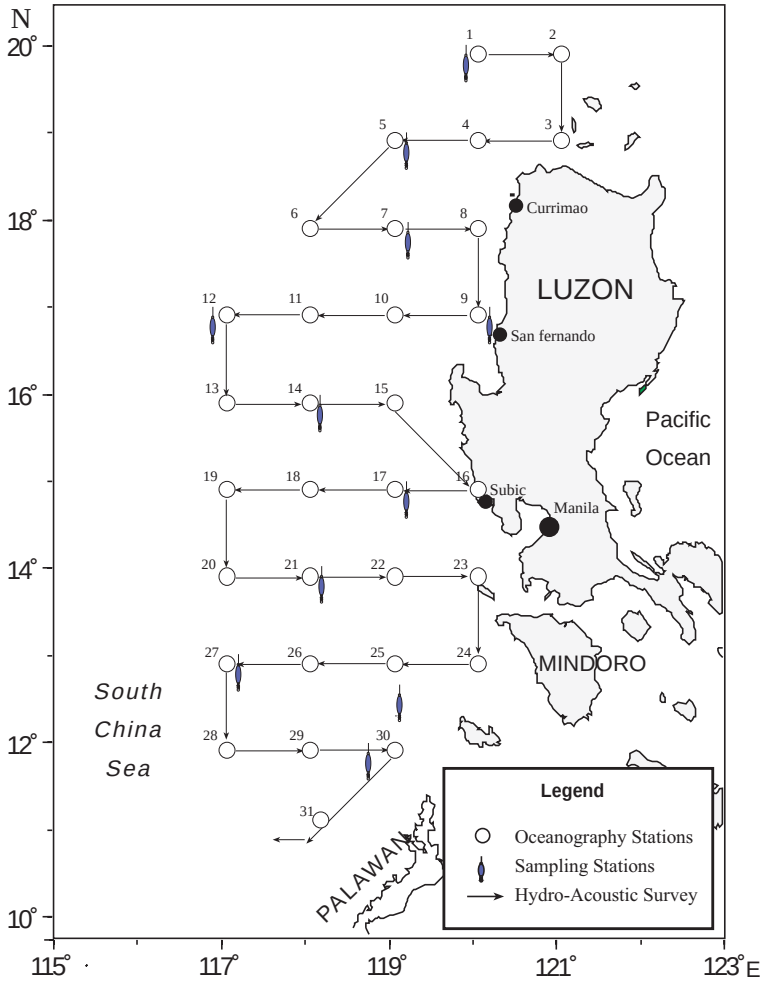

Fig. 1. Sampling stations on the South China Sea : off Western Philippines.

The maturity stages of male and females were assessed using a maturity scale of five stages (Boyle and Ngoile, 1993a) and maturity indices calculated as follows; for female maturity index, ML = NGL / ML where NGL is nidamental gland length (Durwad et al., 1979). The NGL/ML ratio was recommended as the best index of maturation for population studied because it is easily determined, continuously variable (and can therefore be easily and meaningfully averaged) and well correlated with other development events. For male, MI = HL / ML where HL is the proportion of arm length hectocotylized (Schuldt, 1979) is recommended instead of spermatophore length which tends to increase with squid length. Gonadosomatic index GSI was also calculated as GSI = GW / BW x 100 where GW is gonad weight (Guerra et. Al., 1992).

Results

Sex ratio

Fig. 2 shows the sex composition of *Sthenoteuthis oualaniensis* caught in the waters off western Philippines. The number of females outnumbers the males in most of the stations. The variation in number caught between both sexes were so significant that in certain stations less than 10 males out of the total number were caught. The whole population seemed to be dominated by females, which have has much longer mantle length than male showing a natural sexual dimorphism of this species.

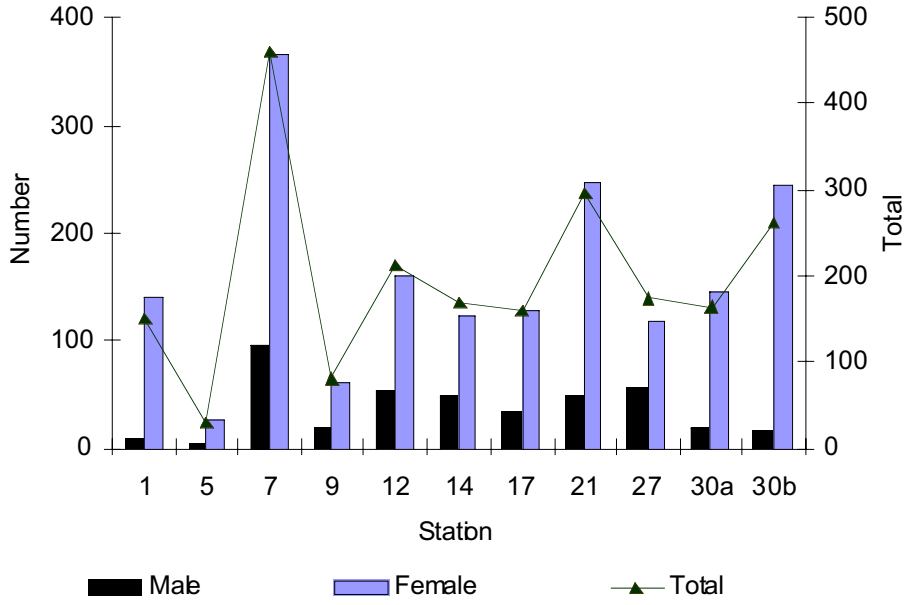

Fig. 2. Difference in sex compositoion of S. oualaniensis caught during the survey in the waters off Western Philippines.

Length-weight relationship

Regression analyses were carried out on *Sthenoteuthis oualaniensis* on 1239 and 298 female and male samples respectively (Fig. 3). Regression on both male and female were significant ($P < 0.001$) and the coefficient of determination of female was higher that male ($r^2 = 0.971$, female; $r^2 = 0.849$, male). The slope of female (3.1029) was slightly higher than male (3.04225) but did not show significant difference between sexes, indicating a similar increase in weight with increasing length.

Length frequency distribution

The smallest size of the squids caught by automatic jigging was 90 mm for female and 101 mm for male respective. These are the sizes being recruited and entering the fishery along the West Coast of Philippines waters. Fig. 4 shows length frequency distribution of male and female *S. oualaniensis* during the survey period. At all the stations, the female quite obviously showed the presence of more than one cohorts. However, in male it seemed to show only one cohort present in every station. The number of male samples was too small to show any obvious mode. The biggest male and female squid caught during the research survey in were 197 mm and 249.5 mm respectively. Overall mantle length average of the male and female *S. oualaniensis* were 126.17 mm and 154.17 mm respectively. It seemed that the length of the largest female was almost twice the size of male squid.

Maturation

Table 1 shows the maturation process in females which can easily be observed through morphological features, the nidamental gland to mantle length ratio (NGL/ML) and the ovary to body weight ratio (OW/BW). The NGL/ML ratio seemed to be more distinct to categorize the

Table 1: Characteristic of the maturation stages in female *Symplectoteuthis oualaniensis*

Maturation stages	Range of NGL/ML	Ranges of NGL (mm)	Ranges of OW/BW	Ranges of OW (g)
I	m<=0.1	9 - 12	m <=0.003	0.12 - 0.6
II	0.1 < m <=0.15	14 - 23	0.0015 < m <= 0.015	0.4 - 1.3
III	0.15 < m <= 0.25	22 - 40	0.006 < m= 0.04	0.8 - 7
IV	0.25 < m <= 0.4	30 - 80	0.01 < m <= 0.12	3 - 50
V	0.4 <= m	65 - 120	0.13 < m	20 - 66

maturity stages of the female squid. The mature squids were counted as those above stage 3 and evaluation was a combination between Maturity Indices and visual observation. Fig. 5 shows the maturity percentage of male and female squids along the West Coast of Philippine waters. In all the stations, except station 9, the mature and immature females were equal. However, in male the mature and immature seemed to vary significantly in many stations except for station 14. Since the number of male samples was small, it was unable to note any distinction between different maturity stages.

ML of mature females was range from 110 - 240 mm and the female reached the mean size of maturity (50% ML) at 180 mm (Fig. 6). A single mode in the length frequency distribution of the mature female suggests that the spawning of the female only occurred from single cohort and single rate. Although there were small mature females, the mode was not obvious.

Stomach contents

Table 2 shows the percentage of stomach fullness in *Sthenoteuthis oualaniensis* from three different stations. It seemed that the percentage of squids having empty stomach were relatively higher in station 27 and 30B and only single squid in station 30A. The percentage of full stomach

Table 2. Percentage of squids at different stomach fullness and relation to mantle length range.

Stomach fullness	Station 27 %	ML range (mm)	30A %	ML range (mm)	30B %	ML range (mm)
0	14.81	117 - 212	1.96	175	17.39	120 - 186
1	5.56	117 - 173	37.25	110 - 210	28.26	116 - 188
2	16.67	113 - 179	31.37	116 - 192	32.61	124 - 182
3	31.48	113 - 185	19.6	120 - 210	15.22	120 - 200
4	31.48	115 - 224	9.8	158 - 220	6.5	164 - 178
n	54		51		46	

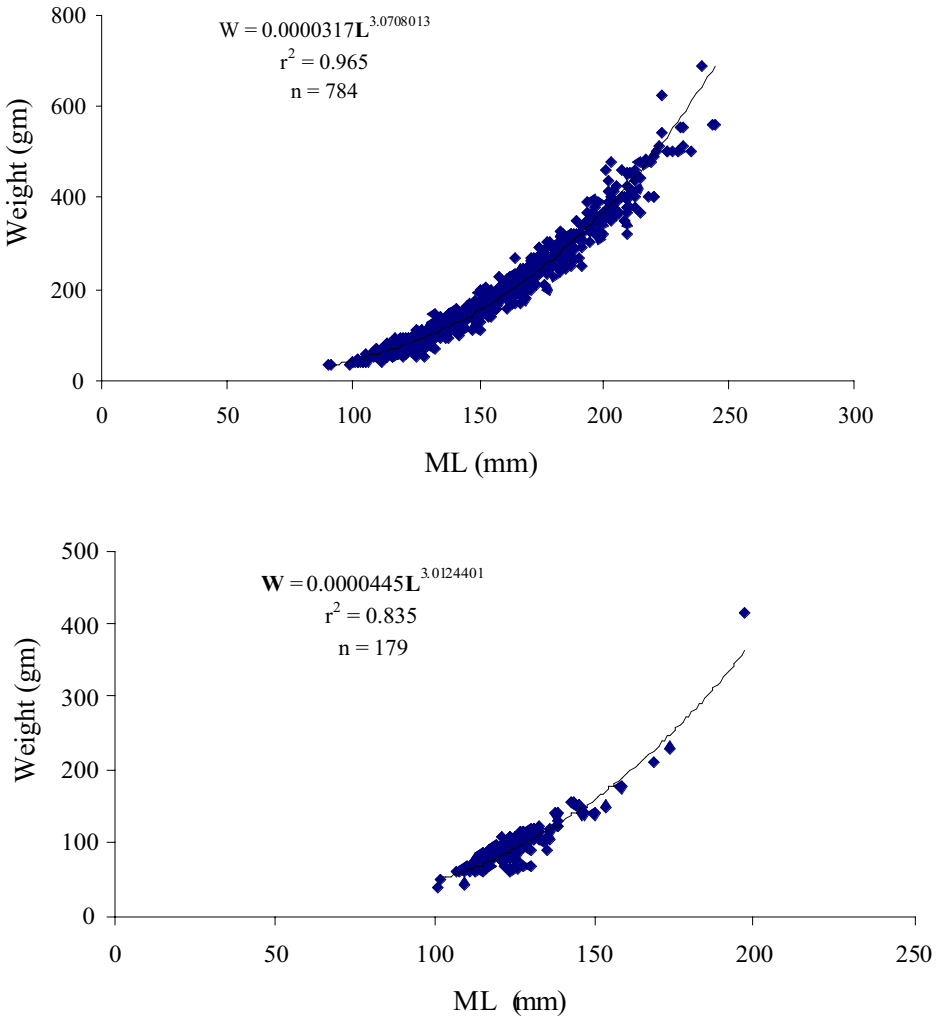

Fig. 3. Length-weight relationship for male and female *S. oualaniensis.*

were very low in stations 30A and 30B but higher in station 27. Size ranges and stomach fullness relationship seemed not to show any pattern. This shows that feeding intensity is not influenced by the size of the squids, an indications that size is not an important factor.

The major prey groups found in the *Sthenoteuthis oualaniensis* diet were fish, cephalopods, crustacea and others. Fig 7 shows the occurrence percentage of these major preys in the diet of *Sthenoteuthis oualaniensis*. Generally, in all the stations, fish and cephalopods were the major components of the preys. Many of the stomach contents consisted of mixture of fish and cephalopod, thus giving high percentage of their occurrence in the diet. Otoliths, eye-lenses, vertebrae and bones of fish, fragments of exoskeleton and appendages of crustaceans, cephalopod beaks, lenses, gladii were found.

Identification of preys to the lowest taxa using otoliths for fish and beaks for cephalopod was quite limited. Many of the references are related to the North Sea and temperate species such as otoliths guide (Harkonen, 1986), identification of cephalopods through beaks and statoliths (Clark, 1986) and crustacean through main exoskeleton fragments such as telson, rostrum and spination (Lagardere, 1971: Smaldon, 1979). Therefore understanding the nature of species composition of fish, cephalopods and crustacean found in the study areas will help to identify preys to the lowest taxa.

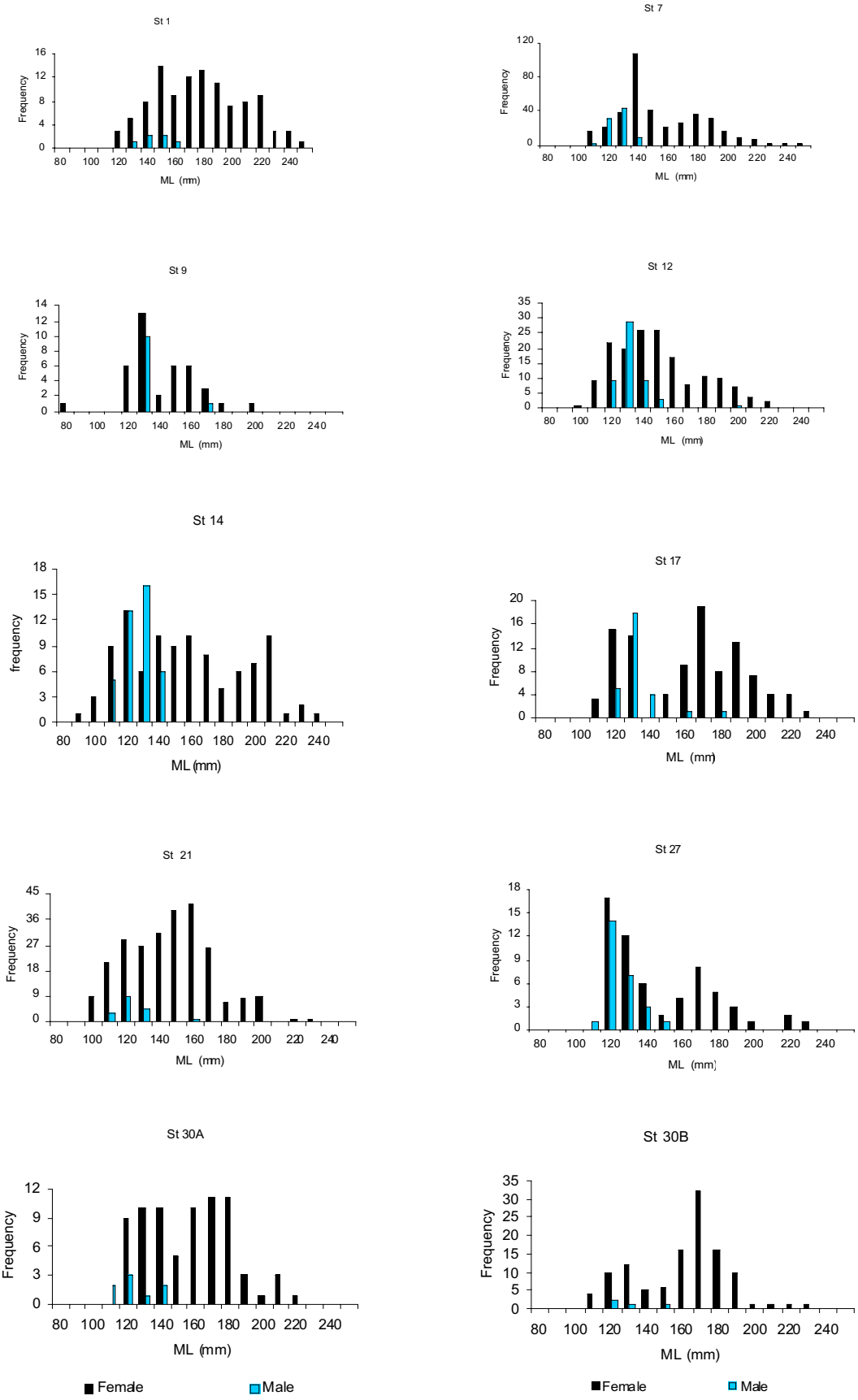

Fig. 4. Length frequency distribution of male and female S. oualaniensis caught in the South China Sea off Western Philippines.

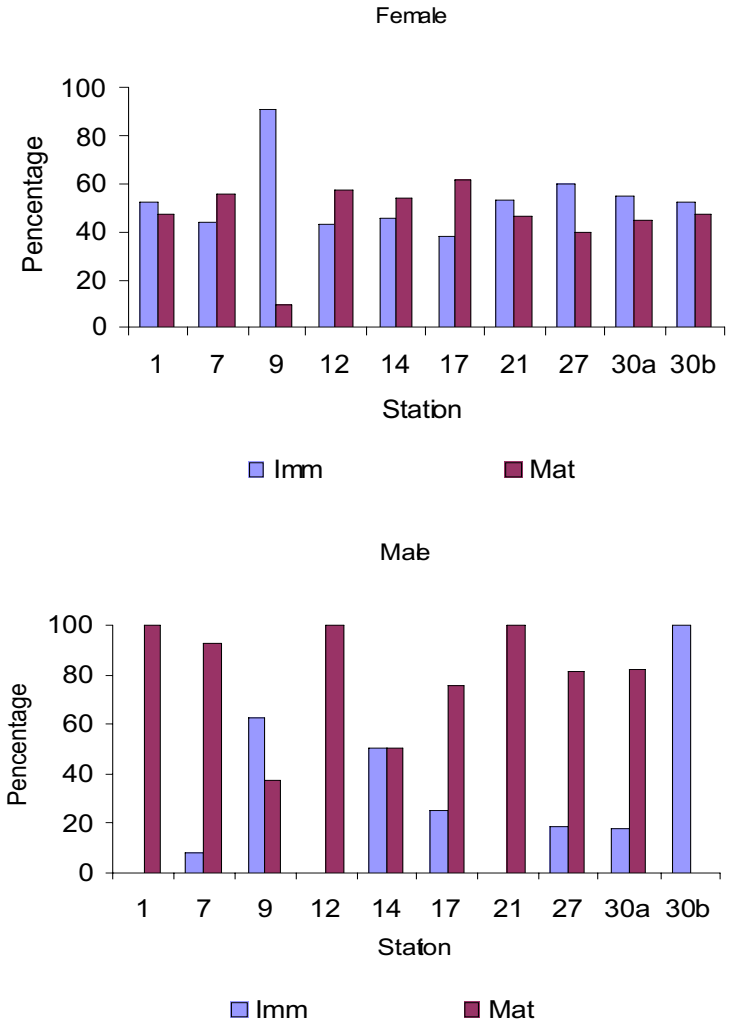

Fig. 5. Percentage of mature and immature squids by stations

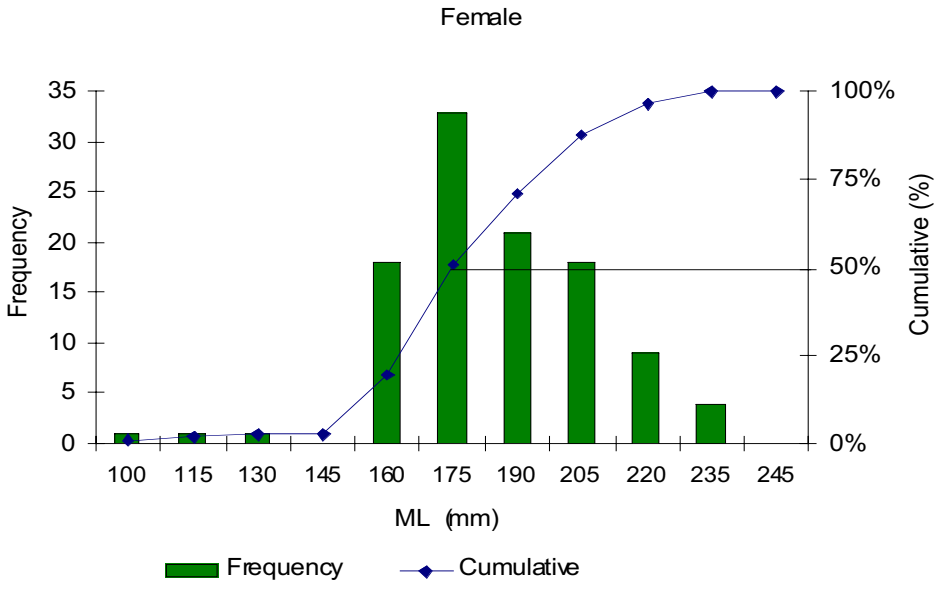

Fig. 6. Frequency distribution of ML of female squid.

Table 3 shows the frequency occurrence of the preys found in *Sthenoteuthis oualaniensis stomach contents.* Certain fish species such as *Trichiurus sp* could be identified through its silvery content of the stomach. Number of otoliths in the stomachs helped in the estimation of the number of fish preys. The highest number of otoliths found with different sizes was 18. Eye-lenses of fish and beaks were also commonly found. Fish lenses are normally round compared to squid lenses which are hemispherical semi-circular. Identification of cephalopods species was mostly through sucker rings. If the stomach contents only consisted of gladii or beaks they would therefor be referred to as other possible cephalopod species, especially ommastrepids (*Nototodarus philippinensis and Todarodes pacificus*) that were found in those areas. The presence of copepods in some specimens was high. And the common species were *Calanus and Labidocera* spp. A number of gastropods and bivalves were also found in the stomachs.

Table 3. Frequency occurrence of the preys found in the stomach contents

Taxon	Frequency accurrence Station		
	27	30A	30B
Fish (Total)	27	37	33
Trichiurus sp		1	2
Gobidae	3		
Clupeidae	6	3	5
Carangids		2	3
Unidentified	18	31	23
Cephalopoda (Total)	31	27	25
Sepia sp	3	4	1
S. oualaniensis	15	10	11
Ommastrephids	3	4	5
Unidentified	10	9	8
Crustacean (Total)	9	13	15
Decapoda	3	3	4
Isopoda	1	2	1
Euphausiidae	2	4	2
Calanus sp	1		2
Labiddocera sp		2	2
Oncaea venusta	1		
Unidentified	1	2	4
Other Mollusc (Total)	5	2	9
Gastopod	3	1	6
Bivalves	2	1	3

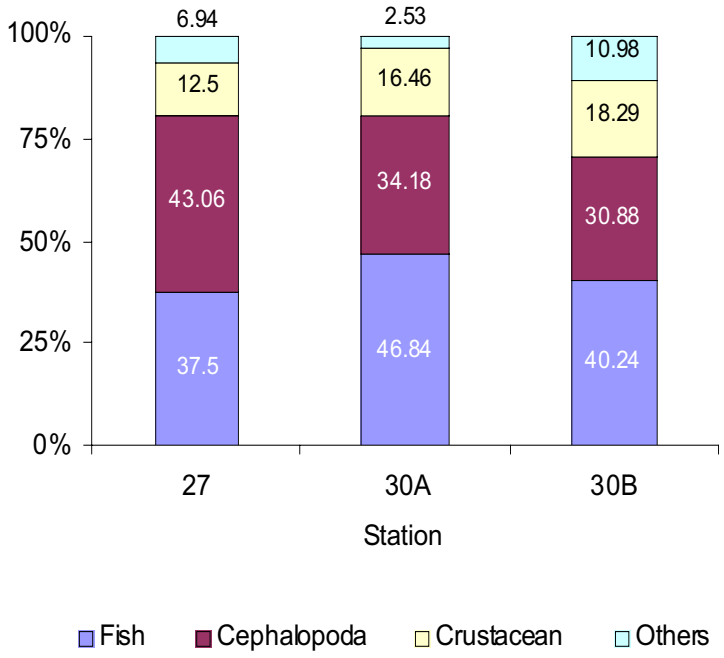

Fig. 7. Occurance percentage of the different prey groups in the diet of S. oualaniensis caught in the South China Sea : Off Western Philippines.

Discussion

Equal percentage of mature and immature squids that were caught from all sampling areas may indicate that the month of April to May was not peak spawning period. There may be an indication of constant recruitment of mature squids. It also explains the extended reproductive season where the presence of mature-maturing squids occur over a long period. It could be similar to myosip species such as *Loligo forbesi* which has a prolonged spawning season and with less clear peaks (Lum-Kong et. al., 1992; Collin et. al., 1993a). But small number of samples used in the maturation study may not end in sound conclusion. However, time series sampling on land based study may assist in precise determination of the spawning period and pattern of the species. Similar maturity pattern that had been shown throughout the study areas suggested that possible population migration to search for particular areas for spawning purpose is not happening in this species. Since the species is known as diurnal vertical migration species, it may be possible that spawning activity occurred within their population areas.

Small number of males does not effect the spawning process. A fully matured male will mate with several females (O'Dor, R.K., 1978). Thus, it is tentatively concluded that males both recruit to the fished population and disappear from the fished population earlier than females. Cannibalism could serve as another factor as to the low number for male squids. Smaller mantle sized males than female squids tent to make smaller males as the likely victims. Amaratunga (1980b) found out that in *Illex illecebrosus,* cannibalism appears to be an important element in the life cycle of the species. In nature it increases as total feeding decreases, and the largest squids are the most cannibalistic. Starvation about three days are needed to induce cannibalism and single victim may be divided between several cannibals (O'Dor et. al., 1980a).

Evaluating and identifying the diet composition of the stomach contents always face various difficulties (Hyslop, 1980; Pierce and Boyle, 1991). In cephalopods, the difficulty includes partial ingestion, fragmentation and rapid digestion of preys. Identification of fish preys in always associated with otoliths, vertebrae, bones and scales and this has enabled for more precise and quick detection of the main groups of fish eater. Identification of otoliths and bones from very small fish is particularly difficult due to different morphological appearance of small fish compared to a fully formed fish.

Fish and cephalopods were the two most frequently occurring prey taxa in the *Sthenoteuthis oualaniensis* diet. This happened at all the sampling stations and had further verified possible higher cannibalism happening among the *S. oualaniensis* population. In term of species composition of the diets apparently, there were no distinct variation between these three sampling areas except at station 27 where the occurrence percentage of cephalopods exceeded the fish species.

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References

Amaratunga, T. 1980. Preliminary estimates of predation by the short-finned squid (*Illex illecebrosus*) on the Scotian Shelf. NAFO SCR, Doc. No. 80/11/31 Ser. No. 63, 13 pp.

Amaratunga, T. 1983. The role of cephalopods in the marine ecosystem. In Advances in assessment of world cephalopod resources, pp. 379-415. Ed. By J. Caddy. *FAO Fisheries Technical Paper* 231, 452p.

Berg, J. 1979. Discussion of methods of investigating the food of fishes, with reference to a preliminary study of the prey of *Gobiusculus flavescens* (Gobidae). *Mar. Biol.*, 50: 263-273.

Boucher-Rodoni, R., E. Bouchanud-Camou and K. Mangold. 1987. Feeding and digestion. *In* Cephalopod life cycles, Vol. II. Comparative reviews, pp. 85-108. Ed. By P.R. Boyle. Academic Press, London. 441pp.

Boyle, P.R. and N.A.K. Ngoile. 1993. Assessment of maturity stages and seasonality of reproduction in *Loligo forbesi* (Cephalopoda : Loliginidae) from Scottish waters. *In* T.Okutani, R.K., O'Dor and T. Kubodera (Editors), Recent Advances in Fisheries Biology. Tokai University Press, Tokyo, : 37-48.

Caddy, J. F. 1983. The cephalopods: factors relevant to their population dynamics and to the assessment and management of stocks. *In* Advances in Assessment of World Cephalopod Resources. *FAO Fish Tech. Paper.*, 23:416-452.

Clark, M.R. (Ed.). 1986. A handbook for the identification of cephalopod beaks. Clarendon Press. Oxford. 273 pp.

Coelho, M. L., J. Quintela, V. Bettencourt, G. Olavo and H. Villa. 1994. Population structure, maturation patterns and fecundity of the squids *Loligo vulgaris* from Southern Portugal. *Fish. Res.*, 21(1-2):87-102.

Coelho, M. L., P. Domingues, E. Balgueriss, M. Fernandez and J. P. Andrade. 1997. A comparative study of the diet of *Loligo vulgaris* (Lamark, 1799) (Mollusca : Cephalopoda) from the south coast of Portugal and the Saharan Bank (Central-East Atlantic). *Fish. Res.*, 29:245-255.

Collins, M. A., G. M. Burnell and P. G. Rodhouse. 1993. Recruitment, maturation and spawning of the *Loligo forbesi* Steenstrup in the Irish and Celtic waters. International Council for the Exploration of the Sea (ICES), C.M. 1982/K:43, 11pp.

Collins, M. A., S. De Grave, C. Lordam, G. M. Bumell and P. G. Rodhouse. 1994. Diet of the squid *Loligo forbesi* Steenstrup (Cephalopods : Loliginidae) in Irish waters. *ICES J. Mar. Sci.*, 51:337-344.

Collins, M. A., G. M. Burnell and P. G. Rodhouse. 1995. Distribution and demography of *Loligo forbesi* in the Irish Sea. Biology and Environment. Proceedings of the Royal Irish Academic, 95B:49-57.

Durwad, R. D., T. Amaratunga and R. K. O'Dor. 1979. Maturation index and fecundity for female squid, *Illex illecebrosus*. (Lesueur, 1821). *ICNAF. Res. Bull.*,14: 67-72.

Fields, W. G. 1965. The structure, development, food relations, reproduction and life history of the squid *Loligo opalescens* Berry. California Department of Fish and Game, *Fish. Bull.,* 131:1-108.

Guerra, A., B. G. Castro and M. Nixon. 1991. Preliminary study of the feeding by *Loligo gahi* (Cephalopods : Loliginidae). *Bull. of Mar. Sci.*, 49:309-311.

Harkonen, T. 1986. Guide to the otoliths of the bony fishes of the Northeast Atlantic. Danbiu Aps. 256 pp.

Hyslop, E. J. 1980. Stomach contents analysis - a review methods and their application. *Journal of Fish Biology*, 17:411-429.

Lagaradere, J.P. 1971. Les erevettes des Cotes du Maroc. Travaux de I'Institut Scientifique et de la Faculte des Sciences. Serie Zoologie no. 36.

Lange, A. M. and M. P. Sissenwine. 1983. Squid resources of the Northwest Atlantic. *In* Advances in assessment of world cephalopod resources. pp. 21-54. Ed. by J. F. Caddy. *FAO Fisheries Technical Papers*, 231.

Lum-Kong, A., G. J. Pierce and C. Yau. 1992. Timing of spawning and recruitment in *Loligo forbesi* (Cephalopods : Loliginidae) in Scottish waters. *J. Mar. Biol. Assoc.* UK, 72(2):301-311.

Ngoile, M. A. K. 1987. Fishery biology of the squid Loligo Forbesi Steenstrup (Cephalopoda : Loliginidae) in Scottish waters. Unpublished Ph.D thesis. University of Aberdeen, Scotland.

O'Dor, R. K. 1978. Laboratory experiments with Illex illecebrosus, May, 1978. *Fish. Mar. Ser., Tech. Rep.* No. 833, pp. 1-18.

O'Dor, R. K., R. D. Durward, E. Vessey and T. Amaratunga. 1980. Feeding and growth in captive squid, *Illex illecebrosus*, and the influence of food availability on growth in the natural population. *ICNAF, Sel. Papers* No. 6, 15-21.

Okutani, T. and T. Watanabe. 1983. Stock assessment by larval surveys of the winter population of *Todarodes pacificus* Steenstrup (Cephalopods: Ommastrephidae), with a review of early works. *Biological Oceanography*, 2:433-456.

Pierce, G. J. and P. R. Boyle. 1991. A review of methods for diet analuysis in piscivorous marine mammals. *Oceanogr. Mar. Biol. Annu. Rev.*, 29: 409-486.

Porteiro, F., H. R. Martin and R. T. Hanlon. 1990. Some observations on the behavior of adult squids, *Loligo forbesi*, in captivity. *J. Mar. Biol. Assoc.* U.K., 70:459-472.

Roper, C.F.E., M.J. Sweeney and C.E. Nauen. 1984. FAO Species Catalogue. Vol. 3. Cephalopods of the World. An annotated and Illustrated Catalogue of Species of Interest to Fisheries. FAO Fish. Synop. 125, FAO, Rome, 227 pp.

Schuldt, M. 1979. Contribucion al Conocimiento del Ciclo reproductor *de Illex argentinus* (Cephalopoda: Ommastrephidae). Monografias 10, *Comision de investigaciones Cientificas*. Provincia de Buenos Aires, Argentina, 110pp.

Smaldon, G. 1979. British coastal shrimps and prawns. Academic Press. London.

Tioda, M., 1915. A contribution to the investigation of the surume fishery. *Niigata Pref. Fish. Rep*. For 1915, : 53-66 (JJ).

Watt, J., G.J. Pierce and P.R. Boyle. 1994. A guide to the identification of North sea fish using premaxillae and vertebrae. Coop. Res. Rep., International Council for the Exploration of the Sea, Copenhagen, in press.

Worms, J. 1983. *Loligo vulgaris*. *In* Cephalopod life cycles. Vol. I. Species account, pp. 143-157. Ed. P.R. Boyle. Academic Press, London. 475 pp.