J. Fish. Sci. Technol. 9(3), 129-133, 2006

JOURNAL OF
FISHERIES SCIENCE
AND TECHNOLOGY

Notes

Korean-Russian Surveys of Cephalopods in the East/Japan Sea in November and December 1993 and 1994

G.A. Shevtsov[1], N.M. Mokrin[1], Young Min Choi[2], Joo Il Kim[3], Kwang Ho Choi[4] and Jung Hwa Choi[4,*]

[1]*Pacific Scientific Research Fisheries Centre, TINRO-Centre, 4 Shevchenko Alley, Vladivostok 690950, Russia*
[2]*Jeju Fisheries Institute, NFRDI, Jeju 690-192, Korea*
[3]*South Sea Fisheries Research Institute, NFRDI, Yoesu 556-823, Korea*
[4]*Fisheries Resources Research Team, NFRDI, Busan 619-902, Korea*

We examined the distribution and biology of cephalopods collected during joint Korean-Russian surveys of the East/Japan Sea in 1993 and 1994. A total of six species of cephalopods belonging to five families were collected during the surveys: one sepiid squid, four teuthid squids, and one octopus.

Key words: Cephalopods, East/Japan Sea, Korean-Russian surveys

Introduction

There are a few endemic species in the East/Japan Sea; its fauna is derived from animal immigrants from the Pacific Ocean (Okiyama, 1993). The first preliminary lists of the cephalopods from the East/Japan Sea, including from Korean waters, were compiled by Sasaki (1920), Yamamoto (1942), and Nishimura (1968). More detailed lists of the cephalopod fauna from the East/Japan Sea were later compiled by Roper et al. (1984) and Nesis (1987), who summarized data on the distribution and zoogeography of cephalopods of the world. However, these records have little information on the biology of the various species.

Here, we summarize the distribution and biology of cephalopods collected during joint Korean-Russian surveys in 1993 and 1994.

Materials and methods

The samples were collected during cruises by the R/V "*Pusan 881*" from 23 November to 3 December 1993 and the R/V "*Kyung Buk 885*" from 15 to 25 November 1994. Surveys were conducted in the southern part of the East/Japan Sea, east of the Korean Peninsula (Fig. 1) by a joint scientific group of the National Fisheries Research and Development Institute (NFRDI, Korea) and the Pacific Scientific Research Fisheries Centre (TINRO-Centre, Russia). The surveys included oceanographic and acoustic observations, trawling, and ichthyoplankton sampling Catches were made only during the day, from 7:00 to 17:00. Twelve trawls were made in the epipelagic zone using a mid-water trawl in 1993 and eight trawls were made using a mid-water trawl in 1994. In 1993, the trawl mouth size was 6 m (vertical) × 8 m (horizontal), and in 1994 it was 10 m × 18 m. The trawls were pulled for 30 min at a speed of about 3.0 knots (=5.4 km/h). Plankton samples were collected using a plankton net (R-80). In 1993, 15-min surface trawls were conducted. In 1994 only verticals trawls were conducted, at horizons of 50-0 and 100-50 m and at a speed of 0.5 m/sec. Cephalopods were sorted from the catch, identified, counted, weighed, and measured after every positive trawl. The standard size of squids was measured as the length from the middle of the eyes to the end of the mantle (i.e., mantle length, ML). In octopods, the ML was measured from between the middle of the eyes to the end of the mantle. To determine sex and maturity, large specimens were dissected. In females, signs of mating were noted if present. Identification of cephalopods to the species level and biological analyses were conducted according to standard methods (Zuev et al.

*Corresponding author: choijh@momaf.go.kr

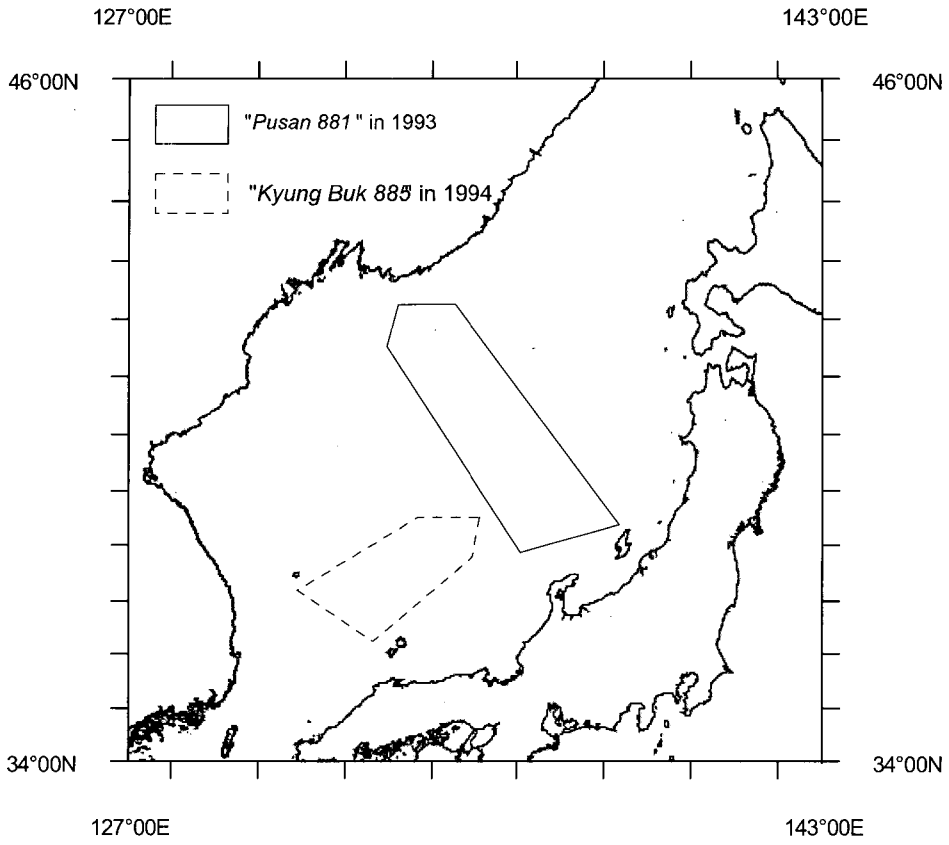

Fig. 1. Map showing the sampling area of the Joint Korean-Russian Survey for cephalopods in the East/Japan Sea.

Table 1. Date, vessels, and materials collected

Date	Vessel	Number of plankton samples	Number of trawls	Total cephalopod catch	Number of cephalopods measured
23 Nov.-3 Dec. 1993	*Pusan 881*	16	12	66	66
15-25 Nov. 1994	*Kyung Buk 885*	41	8	957	228

1985; Nesis, 1987). Plankton samples were fixed onboard. The final identification of sorted cephalopods from plankton catches was made at the NFRDI.

Results and Discussion

A total of 1023 cephalopod specimens were caught, of which 294 were measured (Table 1). Cephalopods were recorded from seven trawls (58.3% of the total) in 1993, and from six trawls (75%) and six plankton collections (14.6%) in 1994. A total of six species of cephalopod belonging to five families were collected during the cruises: one sepiid squid, four teuthid squids, and one octopus (Tables 2, 3).

Class Cephalopoda, Order Sepiida, Suborder Sepiina, Family Sepiolidae

There are three species of this family that are known to inhabit the East/Japan Sea. We collected only one of these species.

Sepiola birostrata Sasaki, 1918

Sepiola birostrata is a boreal species. This species was recorded from one mid-water trawl catch at 90-160 m in 1993, and once in a plankton sample at a depth of 100-50 m in 1994 (Tables 2, 3). Nine specimens were collected in 1993: two juveniles (ML 8 mm), three mature females (ML 20.0 mm), and four mature males (ML 16.0-18.0, mean 17.5 mm). In 1994, two paralarvae (ML 1.5 and 2.0 mm) were caught in a plankton net. The first records of *S. birostrata* in the East/Japan Sea are from Sasaki (1920) and Yamamoto (1942). Many paralarvae of

Table 2. Cephalopod occurrence, abundance, and average size from trawl catches

Species		1993					1994				
		n†	Oc	N	W	ML	n	Oc	N	W	ML
Sepiola birostrata	F	3	25	-	-	20.0	-	-	-	-	-
	M	4	33	-	-	17.5	-	-	-	-	-
	J	2	17	-	-	8.0	-	-	-	-	-
Sepioteuthis lessoniana	F	-	-	-	-	-	1	17	0.17	-	210.0
Abralia mulitihamata	F	2	17	0.29	-	21.5	-	-	-	-	-
	M	-	-	-	-	-	1	17	0.17	-	25.0
	J	-	-	-	-	-	24	50	4.33	-	9.3
Abralia andamanica	J	1	8	0.14	-	9.0	2	17	0.17	-	8.5
Todarodes pacificus	F	6	25	0.86	270	262.0	2	25	0.33	127	259.0
	M	7	25	1.00	300	240.0	2	25	0.33	105	236.0
	J	41	42	5.9	17	15.2	908	50	151.3	-	16.1
Argonauta hians	F	-	-	-	-	-	1	17	0.17	-	29.0

†n, total catch (number of individuals); Oc, occurrence (%); N, number of specimens (individuals/haul); W, weight (g/haul); ML, average mantle length (mm); F, female; M, male; J, juveniles and paralarvae. N and W were calculated for positive hauls.

Table 3. Occurrence (number of specimens) of cephalopod paralarvae collected in plankton nets by sampling station and horizontal towing depth (in meters)

Species	Station 2		Station 6		Station 7		Station 9		Station 16		Station 24	
	50-0	100-50	50-0	100-50	50-0	100-50	50-0	100-50	50–0	100-50	50-0	100-50
Todarodes pacificus	-	2	5	3	-	1	-	4	-	-	-	1
Sepiola birostrata	-	-	-	-	-	-	-	-	-	2	-	-

this species occur near Tsushima Island, in the southern part of the East/Japan Sea and in the northern part of the East China Sea (Tsuchiya et al., 1991). Spawning of *S. birostrata* probably takes place in the northern part of the East China Sea and the southern part of the East/Japan Sea, with paralarvae and juveniles dispersed in the shelf water of the East/Japan Sea up to Tatar Strait (Shevtsov and Mokrin, 1998).

Class Cephalopoda, Order Teuthida, Suborder Myopsida, Family Loliginidae

Eight species of this family are found in the East/Japan Sea (Sasaki, 1929; Okutani et al., 1987). However, we recorded only one species in our collections.

Sepioteuthis lessoniana Lesson, 1830

Sepioteuthis lessoniana is an Indo-Pacific neritic species and occurs from the Red Sea to the Hawaiian Islands and from southern Hokkaido to New Zealand (Roper et al., 1984; Okutani et al., 1987). A single immature female (ML 210 mm, weight 450 g) was caught in a mid-water trawl at a depth of 40-60 m in 1993 near Ulsan Inlet (35°27'N, 129°39'E). The presence of *S. lessoniana* in the East/Japan Sea was previously reported by Berry (1912), Sasaki (1929), and Yamamoto (1942). *Sepioteuthis lessoniana* inhabits mainly tropical and subtropical waters and migrates into the southern part of the East/Japan Sea through the Korean Strait. This species is of commercial value in Korea (Choe et al., 1999).

Class Cephalopoda, Order Teuthida, Suborder Oegopsina, Family Enoploteuthidae

We collected only two species from this family, although four species have been recorded in the East/Japan Sea (Okiyama, 1993; Tsuchiya, 1993).

Abralia multihamata Sasaki, 1929

Abralia multihamata is a subtropical species and mainly inhabits the shelf waters of the East China Sea, the southern part of the East/Japan Sea, and the Pacific waters off Honshu Island (Nesis, 1987; Tsuchiya et al., 1991; Okiyama, 1993; Tsuchiya, 1993). This species was recorded in both of our surveys. In 1993, we caught two females (ML 21 and 22 mm). In 1994, *A. multihamata* was one of the primary species recorded, occurring in 50% of samples. We collected 25 specimens at four sampling stations. Among these were one male (ML 25 mm) and many juveniles (ML 6-14 mm, mean 9.3 mm; Table 2). Taking into account a spent female collected in the center of the East China Sea (Tsuchiya, 1993), we propose that this species mainly spawns in the East China Sea, with juveniles carried into the East/Japan Sea by the Tsushima current.

Abralia andamanica Goodrich, 1896

Abralia andamanica is a common species in the shelf waters of the Indo-West Pacific, distributed from the Arabian Sea to southern Japan and eastern Australia (Nesis, 1987; Tsuchiya, 1993). Juveniles of this species were recorded on both cruises, with a single specimen (ML 9.0 mm) in 1993, and two specimens (ML 8.3 and 8.6 mm) in 1994 (Table 2). In the waters adjacent to Japan, *A. andamanica* occurs in the East/Japan Sea and in the Pacific Ocean (Sasaki, 1929; Kubota et al., 1982; Okiyama, 1993; Tsuchiya, 1993). In the East/Japan Sea only juveniles (our data) and paralarvae with MLs of 2.9-5.7 mm (Tsuchiya et al., 1991) have been recorded. It is likely that *A. andamanica* spawns in the East China Sea, after which paralarvae are carried by the Tsushima current into the East/Japan Sea, as in *A. mutihamata*.

Class Cephalopoda, Order Teuthida, Suborder Oegopsina, Family Enoploteuthidae

Five species from this family are found in the East/Japan Sea (Okiyama, 1993), but only one species was collected in this survey.

Todarodes pacificus Steenstrup, 1880

Todarodes pacificus is a southern boreal to subtropical and neritic to oceanic species (Nesis, 1985), occurring in the Northwest Pacific from 20° to 52°N (Roper et al., 1984; Filippova et al., 1997). *Todarodes pacificus* is one of the primary species in the East/Japan Sea. It was the most abundant species in both surveys, comprising 82% and 95% of the cephalopod catches in 1993 and 1994, respectively. In 1993, *T. pacificus* was recorded only in the trawl catches, at seven stations. A total of 54 specimens (6 females, 7 males, and 41 juveniles and larvae) were caught at horizons of 60-160 m. Young individuals were most common, found in 41% of samples, and abundant, at an average of 5.9 specimens per haul. Females ranged in size (ML) from 246 to 280 mm (mean 262 mm) and weighed between 280 and 500 g (mean 347 g). All females were at maturity stage IV (i.e., the ovary had mature oocytes, but did not connect to the oviduct), and showed signs of mating (i.e., implanted spermatophores on the buccal membrane). The average mid-mental gland length in females was 63.4 mm. Male ML ranged from 230 to 255 mm (mean 240 mm), and they weighed between 220 and 320 g (mean 270 g). All males were fully mature, at maturity stage V. The size (ML) of young immature specimens ranged from 6.0 to 40.0 mm, at 6.0 to 10.0 mm (mean 7.4 mm) in paralarvae (rhynhoteuthion) and 10.0 to 40.0 mm (mean 18.7 mm) in juveniles.

In 1994, *T. pacificus* was recorded both in trawl catches and in plankton samplings. A total of 912 squids were caught in a trawl near the surface at six stations: 2 females, 2 males, and 908 young specimens (Table 2). Young squids held the same position of abundance as in 1993, occurring in 50% of samples with an average of 151.3 specimens per haul. The MLs of early-maturing mated females (maturity stage IV) were 244 and 275 mm, and they weighed 340 and 420 g. The average mid-mental gland length of the females was 63 mm. The MLs of fully mature males (maturation stage V) were 225 and 247 mm, and they weighed 250 and 380 g. Of the young squids juveniles predominated (85.5%). They ranged in size from 6.0 to 29.0 mm, with MLs between 6.0 and 10.0 mm (mean 7.8 mm) in the rhynhoteuthion stage, and between 10.0 and 29.0 mm (mean 19.7 mm) in juveniles. Sixteen paralarvae in the rhynhoteuthion stage (ML 1.0-3.2 mm) were recorded in six plankton catches at five stations (Table 3). They were found mainly at depths of 50-100 m at a temperature range of 18.6-23.3°C.

Paralarvae hatch from egg masses 4-6 days after spawning occurs, and hatchling paralarvae are about 1 mm in length (Hamabe, 1961; Bower and Sakurai, 1996). Therefore, we have evidence that our surveys were conducted during the spawning season of *T. pacificus*. Yasui and Ishito (1955) suggested that the daily growth rate of *T. pacificus* paralarvae is 1.33 mm/day after hatching. Using this rate, we calculated that the largest juveniles (ML 40.0 mm) hatched in October. Consequently, the spawning of the autumn cohort takes place in the southern part of the East/Japan Sea from October to December. Adult squids, judging by maturation, belonged to the winter cohort.

Todarodes pacificus is one of the most important commercial species in Korea, where it is captured throughout the year. Annual catches have fluctuated widely, and in years with high stock, catches have been more than 200,000 mt.

Order Octopoda, Suborder Incirrata, Family Argonautidae

We found only one species from this family, although two species are known to inhabit the East/Japan Sea (Kubodera and Okutani, 1981).

Argonauta hians Solander, 1786

Argonauta hians is a tropical, cosmopolitan, oceanic, epipelagic species (Nesis, 1985). In 1994, a single immature female (ML 29.0 mm) was caught in a mid-water trawl in the southern section. In the East/Japan Sea, *A. hians* was previously recorded near southern Honshu (Nishimura, 1968), off the

coast of Niigata Prefecture (Honma et al., 1983), and near the southern coast of Korea (Yamamoto, 1942). This octopus probably migrates into the East/Japan Sea from the East China Sea (Nishimura, 1968; Okutani and Kawaguchi, 1983; Shojima, 1970).

In conclusion, our data show that epipelagic squids predominate in the waters off the Korean Peninsula. *Todarodes pacificus* is the most abundant and spawns mainly in autumn and winter. The high abundance of paralarvae and small juveniles is evidence that an autumn cohort of *T. pacificus* spawns in Korean waters from October to December.

References

Berry, S.S. 1912. A Catalogue of Japanese Cephalopoda. Proc. Acad. Nat. Sci. Philadelphia, 380-444.

Bower, J.R. and Y. Sakurai. 1996. Laboratory observations of *Todarodes pacificus* (Cephalopoda: Ommastrephidea) egg masses. Am. Malac. Bull., 13, 65-71.

Choe, B.L, M.S. Park, L.G. Jeon, S.R. Park and H.T. Kim. 1999. Commercial molluscs from the freshwater and continental shelf in Korea. Publ. Nat. Fish. Res. Dev. Inst., Korea, 1-197.

Filippova, J.A., D.O. Alekseev, V.A. Bizikov and D.N. Khromov. 1997. Commercial and Mass Cephalopods of the World Ocean: A Manual for Identification. TINRO Publishing, Moscow, 1-271.

Hamabe, M. 1961. Experimental studies on breeding habit and development of the squid. *Ommastrephes sloani pacificus* Steenstrup II. Spawning behavior. Zool. Mag., 70, 385-394.

Honma, Y., T. Kitami and R. Mizusawa. 1983. Records of Cephalopoda in the waters adjacent to Niigata and Sado Island in the Japan Sea, based partially on the pelagic squids stranded ashore. Bull. Biogeogr. Soc. Japan, 38, 23-29.

Kubodera, T. and T. Okutani. 1981. The systematics and identification of larval cephalopods from the North Pacific. Res. Inst. North Pac. Fish., Hokkaido Univ., Special Vol., 131-159.

Kubota, T., K. Iizuka and T. Okutani. 1982. Some biological aspects of *Abralia andamanica* from Sugara Bay, Japan (Cephalopoda: Enoploteuthidae). J. Fac. Mar. Sci. Technol., Tokai Univ., 15, 333-343.

Nesis, K.N. 1985. Oceanic Cephalopods: Distribution, Life Forms, Evolution. Nayka, Moscow, 1-287.

Nesis, K.N. 1987. Cephalopods of the World. T.F.H. Publications, Neptune City, 1-351.

Nishimura, S. 1968. A preliminary list of the pelagic Cephalopoda from the Japan Sea. Publ. Seto Mar. Biol. Lab., 16, 71-83.

Okiyama, M. 1993. Kinds, abundance and distribution of the oceanic squids in the Sea of Japan. In: Recent Advances in Fisheries Biology, Okutani, T., O'Dor, R.K. and Kubodera, T. eds. Tokai University Press, Tokyo, 403-415.

Okutani, T. and T. Kawaguchi. 1983. A mass occurrence of *Argonauta argo* (Cephalopoda, Octopoda) along the coast of Shimane Prefecture, western Japan Sea. Venus Jap. J. Malac., 41, 281-290.

Okutani, T., M. Tagawa and H. Horikawa. 1987. Cephalopods from the continental shelf and slope around Japan. Japan Fisheries Resource Conservation Association, Tokyo, 1-194.

Roper, C.F.E., M.Y. Sweeney and C.E. Nauen. 1984. Cephalopods of the World. FAO Fish. Synopsis No 125. Vol. 3, 1-277.

Sasaki, M. 1920. Report on cephalopods collected during 1906 by the United States Bureau of fisheries steamer "*Albatross*" in the Northwestern Pacific. Proc. U.S. Nat. Mus., 57, 163-203.

Sasaki, M. 1929. A monograph of the dibranchiate cephalopods of the Japanese and adjacent waters. J. Fac. Agr. Hokkaido Imp. Univ. Suppl., No 20, 1-351.

Shevtsov, G.A. and N.M. Mokrin. 1998. Cephalopods from the Japan Sea. Russian EEZ. In summer-fall. Izv. TINRO, 123, 191-206.

Shojima, Y. 1970. Cephalopod larvae and eggs taken at the surface in the northern South China Sea I. Bull. Sekai Reg. Fish. Res. Lab., 38, 61-77.

Tsuchiya, K. 1993. Distribution and zoogeography of the family Enoploteuthidae in the Northwest Pacific. Rec. Adv. Ceph. Fish. Biol., 571-585.

Tsuchiya, K., T. Nagasawa and S. Kasahara. 1991. Cephalopod paralarvae (excluding Ommastrephidae) collected from the western Japan Sea and northern sector of East China Sea during 1987-1988: preliminary classification and distribution. Bull. Jap. Sea Nat. Fish. Res. Inst., 14, 43-71.

Yamamoto, T. 1942. On the distribution of cephalopods in Korea. Venus. Malac. Soc. Jap., 11, 126-133.

Yasui, T. and Y. Ishito. 1955. A study on the growth rate and the spawning season of *Ommastrephes sloani pacificus* (Steenstrup). Bull. Tohoku Reg. Fish. Res. Lab., 4, 173-179.

Zuev, G.V., C.M. Nigmatullin and V.N. Nikolsky. 1985. Nektonic Oceanic Squids (Genus *Sthenoteuthis*). Agropromizdat, Moscow, 1-224.

(Received May 2006, Accepted September 2006)