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NOTES ON THE OCCURRENCE AND BIOLOGY OF THE OCEANIC SQUID, *THYSANOTEUTHIS RHOMBUS* TROSCHEL, IN JAPAN[1)]

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With 6 Text-figures

Though it is not so huge as *Architeuthis* or *Moroteuthis* nor so bizarre as *Chiroteuthis* or *Opisthoteuthis*, *Thysanoteuthis rhombus* TROSCHEL (Cephalopoda: Teuthoidea) is still one of the most remarkable members of the Japanese cephalopod fauna which comprises about one hundred and forty species. Its fully grown body will attain more than 80 cm in mantle length or more than 19 kg in weight and its robust body with the enormously developed fins makes it quite distinct from all other teuthoidean cephalopods; these features seem to deserve well of its being called a noticeable creature in the ocean.

This cephalopod is found rather frequently and in a moderate quantity in certain districts of Japan and well known to local fishermen by various Japanese names such as "*taru-ika*" (barrel squid), "*hako-ika*" (box squid), "*sode-ika*" (sleeved squid), "*kasa-ika*" (umbrella squid), "*aka-ika*" (red squid), etc. However, it is apparently very scarce in other parts of the world, being recorded outside the Japanese waters so far only from the Mediterranean (TROSCHEL 1857; JATTA 1896; NAEF 1921–28; etc.), the waters around Madeira (REES & MAUL 1956) and the Cape of Good Hope (BARNARD 1934), and almost nothing is known of its life history including migration, behavior, life span, etc.

In the Japanese waters, *Thysanoteuthis rhombus* is mostly found stranded after the rough weather in late autumn and winter and also it is caught by set net in a considerable number in certain districts (Fig. 1). In 1953 to 1963, while I was a member of the staff at the Japan Sea Regional Fisheries Research Laboratory in Niigata, I had several occasions to gain access to fresh specimens of this squid and sometimes even to observe some squids actually swimming around in the set net in which they were entrapped. These experiences stimulated my interest toward this noticeable cephalopod and I started to collect and examine any available informations of this animal, records of stranding, catch statistics by local commercial fisheries, and any

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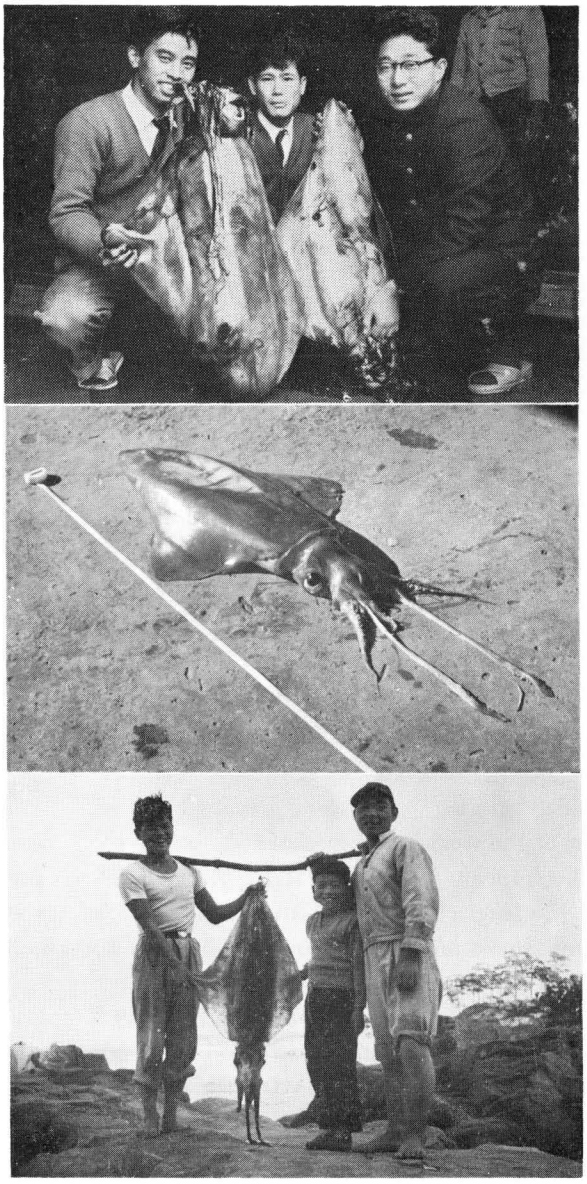

Fig. 1.

Above: *Thysanoteuthis rhombus* caught by set net at Washizaki, Sado Island, and landed at Niigata fish market in early November, 1959. The squids are mostly cooked into "*sashimi*" or sliced raw meat for Japanese dishes. (Courtesy of M. HIGUMA).

Middle: One of the specimens caught at the above-mentioned place on November 30, 1959. It measured 68.5 cm in dorsal mantle length and 123 cm in total length. The body is brick-red all over as in the Japanese common squid *Todarodes pacificus*, hence its local name "*aka-ika*" (red squid). Note the remarkable eye, which is as large as that of a bull. (Photo by S. NISHIMURA).

Below: The specimen caught off Obama, Masuda-shi, Shimane Prefecture in late October, 1960. The total length was about 100 cm. (Courtesy of T. KAMITA).

kind of informations pertinent to its biology.

In the present paper it is intended to give a summary of my studies on the occurrence of this squid in the Japanese waters and also that of my consideration on its migration pattern, together with some notes on its biological features.

In carrying out the present work, I am indebted to many persons and institutions; particularly I am grateful to Mr. K. NAKANO in Tamagawa-machi of Yamaguchi Prefecture for his invaluable informations, to Mr. I. OKACHI of the Japan Sea Regional Fisheries Research Laboratory for his generous permission to quote his unpublished data, to Mr. M. OKIYAMA of the same laboratory for his kind assistance, to Dr. Y. HIROSAKI of the Enoshima Aquarium and Mr. Y. KURATA of the Oshima Branch of the Tokyo Metropolitan Fisheries Experimental Station for informations of the records of this squid on the Pacific coast, to Dr. T. KAMITA of the Shimane University and Mr. M. HIGUMA of the Niigata Prefectural Fisheries Association for their permission to reproduce here photographs they took. The manuscript was read by Prof. H. UTINOMI and Dr. T. TOKIOKA of the Seto Marine Biological Laboratory, for whose kindness I wish to extend my sincere gratitude.

Records of Occurrence in the Japanese Waters

The records of stranding or catch by commercial fisheries of *Thysanoteuthis rhombus* are listed below in Table 1, and the localities concerned are plotted on the map in Fig. 2.

The records are considerably more frequent on the Japan Sea coast than on the Pacific coast. This trend may, on one hand, be accepted as true to some extent, as will be discussed later, though apparently it may partly be attributed to fewer available informations from the Pacific coast on the other hand.

So far as the Japan Sea coast is concerned, this squid is by no means rare. It is stranded or fished almost every year, especially frequently and abundantly on the middle and southern Honshu and northwestern Kyushu. The northernmost record is from the west coast of Hokkaido, where, of course, it is extremely rare (KINOSHITA 1939). Particularly interesting is that this squid appears quite regularly every year in the inshore waters of the above-mentioned areas in the season from late autumn to winter, though the quantity fluctuates from year to year. It is supposed that the squid, primarily an oceanic inhabitant in the southern warm seas, migrates regularly every year into the Japanese waters and availing the warm currents reaches as far north as the coast of northern Honshu, occasionally even up to west Hokkaido.

The majority of the stranded specimens were found still alive, though they were sluggish in most cases. Even the individuals found dead were fresh enough to be eaten; this seems to indicate that possibly they were stranded alive. Discussions will be made later as to the condition of the animals entrapped by set net (p. 344).

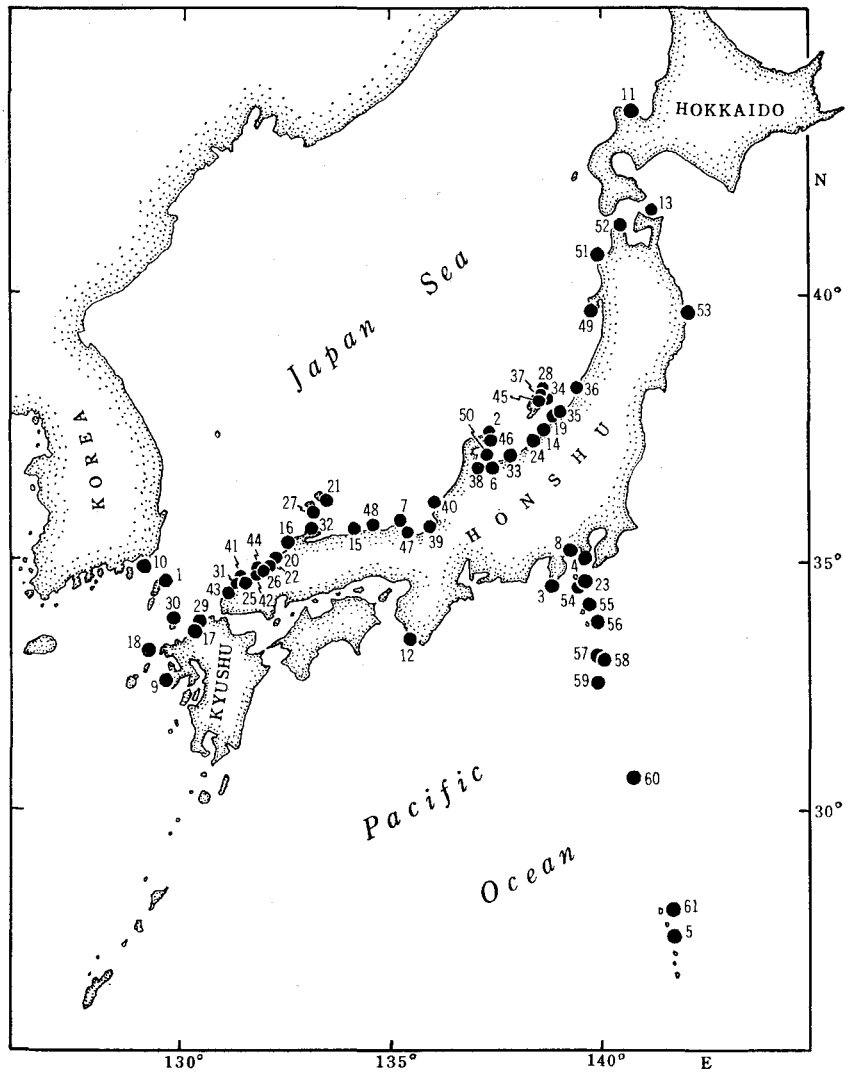

Fig. 2. Localities of stranding or catch of *Thysanoteuthis rhombus* in the Japanese waters. Solid circle shows the location of occurrence, but not necessarily the individual record. Records are seemingly less complete on the Pacific coast than on the Japan Sea coast, because of much fewer informations from the former. As to the number of localities, see Table 1.

Occurrence Patterns in the Commercial Catch on the West Honshu Coast

Through the courtesy of six local fisheries cooperations on the west coast of middle Honshu (Fig. 3), the catch statistics of *Thysanoteuthis rhombus* by set net in the 1958–59

Table 1. Records of *Thysanoteuthis rhombus* in the Japanese waters. Abbreviations: S—found stranded; N—caught in set nets; P—in purse seines; A—caught by angling; H—by hooks; ?—no data. ML—mantle length; BW—body weight.

Number shown in Fig. 2	Locality	Time of occurrence & remarks	Source
1.	Tsushima Islands (?)	Unknown	SASAKI 1927
2.	Noto Peninsula (?)	"	"
3.	Izu Peninsula (?)	"	"
4.	Miura Peninsula (?)	"	"
5.	Bonin Islands (?)	"	"
6.	Etchu Province (?)	"	SASAKI 1929a
7.	Tango Province (?)	"	"
8.	Sagami Bay (?)	"	"
9.	Near Nagasaki (?)	Unknown; commonly caught	ISHIKAWA 1933
10.	Near Pusan, Korea (?)	"	"
11.	Yoichi, Hokkaido (S)	Oct. 14, 1939. ML=62 cm	KINOSHITA 1939
12.	Sirahama, Wakayama Pref. (S)	May, 1953. Deposited in Sirahama Aquarium	Examined by the author
13.	Off Ohata-machi, Aomori Pref. (A)	Nov. 18, 1957. Deposited in Ohata Branch, Aomori Pref. Fish. Exp. Stat.	I. OKACHI (personal communication)
14.	Teradomari-machi, Niigata Pref. (S)	Almost every winter	Teradomari Fish. Coop. *in litt.*, 18 i 1958
15.	Karo-machi, Tottori Pref. (S)	"	Karo Fish. Coop. *in litt.*, 18 i 1958
16.	Nishihama, Koryo-mura, Shimane Pref. (S)	"	Nishihama Fish. Coop. *in litt.*, 18 i 1958
17.	Fukuma-machi, Fukuoka Pref. (?)	Sometimes in winter	Fukuma-machi Fish. Coop. *in litt.*, 24 i 1958
18.	Hirago, Ukyu-machi, Nagasaki Pref. (?)	"	Ukyu-machi Fish. Coop. *in litt.*, 27 i 1958
19.	Echizen-hama, Maki-machi, Niigata Pref. (S)	Oct. 26, 1958. ML=65 cm; BW=13.5 kg	NISHIMURA 1960
20.	Wae, Shizuma-machi, Shimane Pref. (S)	Dec. 10, 1958. ML=56 cm; BW=13.3 kg	KAMITA 1962
21.	Saigo, Oki Isls. (A)	Late Dec., 1958	"
22.	Uozu, Shizuma-machi, Shimane Pref. (S)	Jan. 7, 1959	"
23.	Izu-Oshima (?)	May 30, 1959. ML=80 cm; BW=19 kg	Y. HIROSAKI *in litt.*, 17 ii 1966
24.	Shimoara-hama, Naoetsu-shi, Niigata Pref. (S)	Nov. 19, 1959. BW=3.2 kg	NISHIMURA 1960
25.	Kushiro, Masuda-shi, Shimane Pref. (S)	Middle Nov., 1959. BW=13 kg	KAMITA 1962
26.	Hamada-shi, Shimane Pref. (S, P)	Almost every winter	S. IWATA in KAMITA 1962
27.	Urago, Oki Isls. (N)	"	"
28.	Washizaki, Sado Isl. (N)	"	NISHIMURA 1960
29.	Tsuyazaki-machi, Fukuoka Pref. (S)	Winter of 1959/60	S. MITO *in litt.*, 24 vi 1960

Table 1 (continued).

Number shown in Fig. 2	Locality	Time of occurrence & remarks	Source
30.	Iki Isl. (S)	Winter of 1959/60	S. MITO *in litt.*, 24 vi 1960
31.	Off Obama, Masuda-shi, Shimane Pref. (H)	Late Oct., 1960. BW=15 kg	KAMITA 1962
32.	Takobana, Shimane-mura, Shimane Pref. (A)	Nov. 13, 1960. BW=13.2 kg	"
33.	Oshiage, Itoigawa-shi, Niigata Pref. (S)	Oct. 15, 1961. BW=11.2 kg	*Niigata Nippo* (2nd ed.), 16 x 1961
34.	Ichiwagi, Ryotsu-shi, Sado Isl. (S)	Nov. 10, 1961. Two individuals; each BW=9.5 kg	*Asahi Shimbun* (5th ed.), 12 xi 1961
35.	Gakkocho-bama, Niigata-shi (S)	Nov. 4, 1962	*Niigata Nippo* (2B ed.), 5 xi 1962
36.	Kamibayashi-mura, Iwafune-gun, Niigata Pref. (S)	Nov. 9, 1962. BW=16.5 kg	*Asahi Shimbun* (5th ed.), 11 xi 1962
37.	Waki, Sado Isl. (N)	Nov. to Dec., 1962. Many specimens	Examined by the author
38.	Toyama Bay (observed)	Unknown. Two specimens	Y. MORITA (personal communication)
39.	Tsuruga-shi, Fukui Pref. (S)	Almost every winter	Information from Fukui Pref. Fish. Exp. Stat.
40.	Echizen-machi, Fukui Pref. (N, A, H, P, etc.)	Sept., to Dec., every year	SAMON 1964; I. OKACHI (personal communication)
41.	Off Cape Takayama, Yamaguchi Pref. (A, H)	Aug. to Nov., every year	K.NAKANO *in litt.*, 2 iii 1962
42.	Off Masuda-shi, Shimane Pref. (A, H)	"	"
43.	Hagi-shi, Yamaguchi Pref. (N)	Nov. to Jan., every year	"
44.	Hamada-shi, Shimane Pref. (N)	"	"
45.	Ryotsu Bay, Sado Isl. (N)	Nov. to Dec., almost every year	First record
46.	Usetsu, Ishikawa Pref. (N)	Oct. to Jan., every year	"
47.	Tai, Maizuru-shi, Kyoto Pref. (N)	Oct. to Dec., every year	"
48.	Kasumi, Hyogo Pref. (S)	Unknown	TSUTSUI et al. 1963
49.	Akita Pref. (S)	Sometimes in winter, especially in December	M. OKIYAMA *in litt.*, 22 ii 1966
50.	Toyama Bay (A)	Late Sept. to late Dec., 1964	Toyama Pref. Fish. Exp. Stat. 1965
51.	Fukaura, Aomori Pref. (S)	Winter, year unknown	M. TANABE *in litt.*, 26 ii 1966
52.	Horotsuki, Imabetsu-machi, Aomori Pref. (S)	Sometimes in winter	"
53.	Miyako-shi, Iwate Pref. (N)	Unknown. Deposited in Miyako Fish. High School	S. Fujita *in litt.*, 2 iii 1966
54.	Izu-Oshima (S)	Late Feb., 1966. ML=50 cm	Y. Kurata *in litt.*, 6 v 1966
55.	Niijima Isl. (S)	Sometimes in winter	"

Table 1 (continued).

Number shown in Fig. 2	Locality	Time of occurrence & remarks	Source
56.	Miyako Isl. (S)	Unknown	Y. Kurata *in litt.*, 6 v 1966
57.	Hachijo Isl. (S)	Spring of 1957	"
58.	Hachijo Isl. (S)	Winter of 1961. Two individuals	"
59.	Aogashima Isl. (H)	Mar. 29, 1954. One of the two individuals caught. BW=20 kg.	"
60.	Torishima Isl. (Hapooned)	Apr. 20, 1964. Two individuals	"
61.	Bonin Isls. (S)	Rather frequent; mostly in pairs	"

season are compiled here and in addition the statistics in the succeeding two seasons are also availed at Usetsu fishing ground in Toyama Bay (Table 2). Of these six set-net fishery grounds, Mitsu near Wakasa Bay is unique in that the net is set in the summer season while it is set in the season from autumn to next spring at all other places. Generally the set net is hauled in twice a day, in the morning and evening,

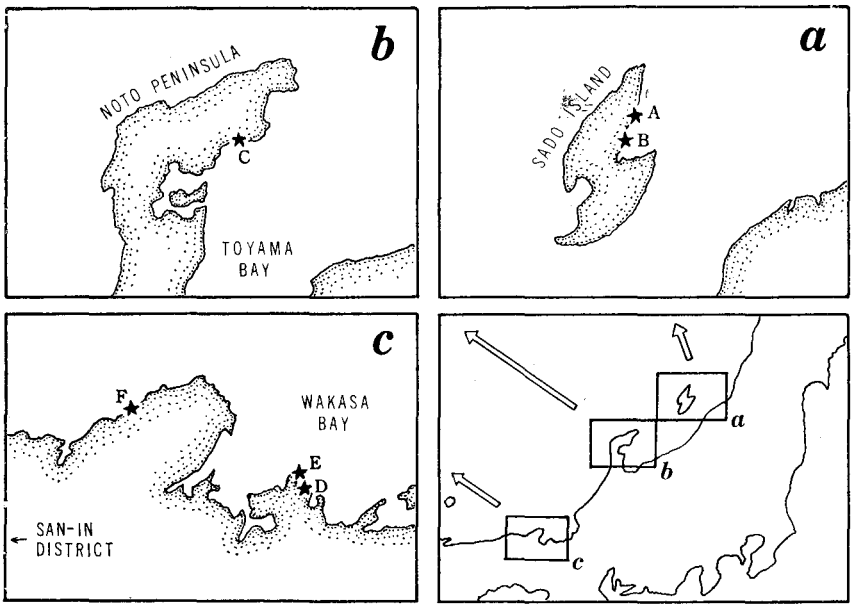

Fig. 3. Showing the location of six set-net grounds on the west coast of middle Honshu where catch statistics were available. A.-Waki, Sado Island, Niigata Prefecture; B.-Shirase, Sado Island, Niigata Prefecture; C.-Usetsu, Noto Peninsula, Ishikawa Prefecture; D.-Tai (Kyoto No. 2 Set Net), Maizuru-shi, Kyoto Prefecture; E.-Tai (Kyoto No. 7 Set Net), Maizuru-shi, Kyoto Prefecture; F.-Mitsu, Amino-machi, Kyoto Prefecture.

Table 2. Catches of *Thysanoteuthis rhombus* by set net at six spots on the Japan Sea coast of middle Honshu (see Fig. 3 for the location of respective spots) during the 1958–59 season, but at Usetsu, Ishikawa Prefecture, during the three successive seasons from 1958–59 to 1960–61.

The morning and evening catches are recorded separately. The month is indicated in the first column in Roman and the decades of a month in Arabic figures. The frequency of net-inhauling, the frequency of capture and the total number of the squid caught in each decade are respectively given in this order in italic Arabic in the second and last columns ; the figure parenthesized shows the number of individuals in respective inhauling.

A. WAKI, SADO ISLAND, NIIGATA PREFECTURE

1958–59 *season*

		Morning catch	Evening catch
XI	1	*5* ; *0* ; *0*	*3* ; *0* ; *0*
	2	*10* ; *0* ; *0*	*7* ; *0* ; *0*
	3	*10* ; *1* ; *2* (*2*)	*6* ; *0* ; *0*
XII	1	*10* ; *1* ; *2* (*2*)	*5* ; *0* ; *0*
	2	*10* ; *0* ; *0*	*8* ; *0* ; *0*
	3	*10* ; *0* ; *0*	*3* ; *0* ; *0*
I	1	*8* ; *0* ; *0*	*4* ; *0* ; *0*
	2	*8* ; *0* ; *0*	*1* ; *0* ; *0*
	3	*10* ; *0* ; *0*	*0* ; *0* ; *0*
II	1	*9* ; *0* ; *0*	*0* ; *0* ; *0*
	2	*8* ; *0* ; *0*	*0* ; *0* ; *0*
	3	*8* ; *0* ; *0*	*0* ; *0* ; *0*
III	1	*10* ; *0* ; *0*	*0* ; *0* ; *0*
	2	*10* ; *0* ; *0*	*0* ; *0* ; *0*
	3	*3* ; *0* ; *0*	*0* ; *0* ; *0*
IV	1	*8* ; *0* ; *0*	*0* ; *0* ; *0*
	2	*6* ; *0* ; *0*	*0* ; *0* ; *0*

B. SHIRASE, SADO ISLAND, NIIGATA PREFECTURE

1958–59 *season*

		Morning catch	Evening catch
X	3	*3* ; *0* ; *0*	*1* ; *0* ; *0*
XI	1	*10* ; *3* ; *8* (*2, 3, 3*)	*3* ; *1* ; *2* (*2*)
	2	*10* ; *2* ; *4* (*2, 2*)	*6* ; *1* ; *1* (*1*)
	3	*10* ; *0* ; *0*	*0* ; *0* ; *0*
XII	1	*10* ; *0* ; *0*	*0* ; *0* ; *0*
	2	*10* ; *0* ; *0*	*0* ; *0* ; *0*
	3	*11* ; *0* ; *0*	*0* ; *0* ; *0*
I	1	*10* ; *0* ; *0*	*0* ; *0* ; *0*
	2	*10* ; *0* ; *0*	*0* ; *0* ; *0*
	3	*10* ; *0* ; *0*	*0* ; *0* ; *0*
II	1	*10* ; *0* ; *0*	*0* ; *0* ; *0*
	2	*9* ; *0* ; *0*	*0* ; *0* ; *0*
	3	*8* ; *0* ; *0*	*0* ; *0* ; *0*

III	1	*9* ; *0* ; *0*	*0* ; *0* ; *0*
	2	*10* ; *0* ; *0*	*0* ; *0* ; *0*
	3	*9* ; *0* ; *0*	*1* ; *0* ; *0*
IV	1	*8* ; *0* ; *0*	*0* ; *0* ; *0*
	2	*9* ; *0* ; *0*	*1* ; *0* ; *0*
	3	*1* ; *0* ; *0*	*0* ; *0* ; *0*

C. Usetsu, Noto Peninsula, Ishikawa Prefecture

1958–59 *season*

		Morning catch	Evening catch
X	2	*7* ; *0* ; *0*	*2* ; *0* ; *0*
	3	*10* ; *0* ; *0*	*7* ; *0* ; *0*
XI	1	*10* ; *0* ; *0*	*7* ; *0* ; *0*
	2	*10* ; *1* ; *2* (*2*)	*9* ; *1* ; *1* (*1*)
	3	*10* ; *3* ; *6* (*2, 2, 2*)	*10* ; *0* ; *0*
XII	1	*10* ; *1* ; *1* (*1*)	*9* ; *0* ; *0*
	2	*10* ; *1* ; *1* (*1*)	*9* ; *0* ; *0*
	3	*10* ; *0* ; *0*	*10* ; *0* ; *0*
I	1	*9* ; *1* ; *1* (*1*)	*5* ; *0* ; *0*
	2	*8* ; *0* ; *0*	*3* ; *0* ; *0*
	3	*9* ; *0* ; *0*	*5* ; *0* ; *0*
II	1	*9* ; *0* ; *0*	*7* ; *0* ; *0*
	2	*10* ; *0* ; *0*	*3* ; *0* ; *0*
	3	*8* ; *0* ; *0*	*1* ; *0* ; *0*
III	1	*10* ; *0* ; *0*	*0* ; *0* ; *0*
	2	*9* ; *0* ; *0*	*5* ; *0* ; *0*
	3	*6* ; *0* ; *0*	*3* ; *0* ; *0*
IV	1	*8* ; *0* ; *0*	*3* ; *0* ; *0*
	2	*9* ; *0* ; *0*	*0* ; *0* ; *0*
	3	*9* ; *0* ; *0*	*1* ; *0* ; *0*
V	1	*8* ; *0* ; *0*	*1* ; *0* ; *0*
	2	*7* ; *0* ; *0*	*2* ; *0* ; *0*
	3	*11* ; *0* ; *0*	*5* ; *0* ; *0*
VI	1	*7* ; *0* ; *0*	*6* ; *0* ; *0*
	2	*6* ; *0* ; *0*	*3* ; *0* ; *0*
	3	*7* ; *0* ; *0*	*5* ; *0* ; *0*
VII	1	*6* ; *0* ; *0*	*0* ; *0* ; *0*

1959–60 *season*

		Morning catch	Evening catch
X	2	*2* ; *0* ; *0*	*1* ; *0* ; *0*
	3	*10* ; *0* ; *0*	*6* ; *0* ; *0*
XI	1	*9* ; *2* ; *6* (*2, 4*)	*9* ; *1* ; *2* (*2*)
	2	*10* ; *4* ; *11* (*2, 5, 2, 2*)	*10* ; *2* ; *6* (*4, 2*)
	3	*10* ; *4* ; *22* (*1, 2, 2, 17*)	*7* ; *2* ; *4* (*2, 2*)
XII	1	*10* ; *8* ; *24* (*6, 2, 4, 1, 2, 1, 6, 2*)	*8* ; *3* ; *6* (*2, 2, 2*)
	2	*10* ; *6* ; *28* (*3, 2, 7, 10, 2, 4*)	*9* ; *4* ; *8* (*3, 2, 1, 2*)
	3	*11* ; *1* ; *4* (*4*)	*9* ; *0* ; *0*

I	1	*8*; *1*; *2* (*2*)	*4*; *0*; *0*
	2	*8*; *2*; *3* (*2, 1*)	*5*; *0*; *0*
	3	*11*; *0*; *0*	*3*; *0*; *0*
II	1	*7*; *0*; *0*	*2*; *0*; *0*
	2	*8*; *0*; *0*	*0*; *0*; *0*
	3	*7*; *0*; *0*	*1*; *0*; *0*
III	1	*10*; *0*; *0*	*0*; *0*; *0*
	2	*10*; *0*; *0*	*0*; *0*; *0*
	3	*9*; *0*; *0*	*3*; *0*; *0*
IV	1	*8*; *0*; *0*	*2*; *0*; *0*
	2	*8*; *0*; *0*	*0*; *0*; *0*
	3	*9*; *0*; *0*	*0*; *0*; *0*
V	1	*10*; *0*; *0*	*0*; *0*; *0*
	2	*10*; *0*; *0*	*2*; *0*; *0*
	3	*9*; *0*; *0*	*9*; *0*; *0*
VI	1	*9*; *0*; *0*	*10*; *0*; *0*
	2	*7*; *0*; *0*	*7*; *0*; *0*
	3	*6*; *0*; *0*	*6*; *0*; *0*

1960–61 *season*

		Morning catch	Evening catch
X	2	*4*; *0*; *0*	*3*; *1*; *1* (*1*)
	3	*9*; *5*; *12* (*6, 1, 2, 1, 2*)	*10*; *2*; *3* (*2, 1*)
XI	1	*10*; *2*; *4* (*2, 2*)	*9*; *1*; *3* (*3*)
	2	*9*; *1*; *2* (*2*)	*10*; *1*; *2* (*2*)
	3	*8*; *1*; *2* (*2*)	*8*; *1*; *1* (*1*)
XII	1	*9*; *2*; *3* (*1, 2*)	*9*; *1*; *1* (*1*)
	2	*9*; *0*; *0*	*6*; *0*; *0*
	3	*10*; *2*; *2* (*1, 1*)	*5*; *1*; *1* (*1*)
I	1	*9*; *1*; *1* (*1*)	*3*; *0*; *0*
	2	*10*; *1*; *4* (*4*)	*5*; *1*; *1* (*1*)
	3	*9*; *0*; *0*	*1*; *0*; *0*
II	1	*8*; *0*; *0*	*1*; *0*; *0*
	2	*8*; *0*; *0*	*1*; *0*; *0*
	3	*8*; *0*; *0*	*1*; *0*; *0*
III	1	*10*; *0*; *0*	*0*; *0*; *0*
	2	*10*; *0*; *0*	*1*; *0*; *0*
	3	*11*; *0*; *0*	*0*; *0*; *0*
IV	1	*10*; *0*; *0*	*0*; *0*; *0*
	2	*8*; *0*; *0*	*1*; *0*; *0*
	3	*8*; *0*; *0*	*1*; *0*; *0*

D. TAI, MAIZURU-SHI, KYOTO PREFECTURE (KYOTO NO. 2 SET NET)

1958–59 *season*

		Morning catch	Evening catch
X	1	*7*; *0*; *0*	*0*; *0*; *0*
	2	*8*; *1*; *1* (*1*)	*0*; *0*; *0*
	3	*9*; *4*; *4* (*1, 1, 1, 1*)	*0*; *0*; *0*

XI	1	*10* ; *2* ; *3* (*1, 2*)	*0* ; *0* ; *0*
	2	*4* ; *2* ; *4* (*1, 3*)	*1* ; *0* ; *0*
	3	*10* ; *2* ; *3* (*1, 2*)	*0* ; *0* ; *0*
XII	1	*8* ; *4* ; *15* (*3, 8, 1, 3*)	*0* ; *0* ; *0*
	2	*9* ; *3* ; *5* (*2, 2, 1*)	*0* ; *0* ; *0*
	3	*8* ; *0* ; *0*	*0* ; *0* ; *0*
I	1	*4* ; *0* ; *0*	*0* ; *0* ; *0*
	2	*6* ; *0* ; *0*	*2* ; *0* ; *0*
	3	*7* ; *0* ; *0*	*1* ; *0* ; *0*
II	1	*3* ; *0* ; *0*	*0* ; *0* ; *0*

E. TAI, MAIZURU-SHI, KYOTO PREFECTURE (KYOTO NO. 7 SET NET)

1958–59 *season*

		Morning catch	Evening catch
X	2	*7* ; *0* ; *0*	*0* ; *0* ; *0*
	3	*6* ; *3* ; *6* (*3, 1, 2*)	*1* ; *0* ; *0*
XI	1	*5* ; *0* ; *0*	*0* ; *0* ; *0*
	2	*7* ; *1* ; *1* (*1*)	*1* ; *0* ; *0*
	3	*9* ; *1* ; *1* (*1*)	*1* ; *0* ; *0*
XII	1	*7* ; *1* ; *1* (*1*)	*2* ; *0* ; *0*
	2	*7* ; *1* ; *1* (*1*)	*1* ; *1* ; *2* (*2*)
	3	*4* ; *1* ; *2* (*2*)	*1* ; *0* ; *0*
I	1	*5* ; *0* ; *0*	*1* ; *0* ; *0*
	2	*8* ; *0* ; *0*	*0* ; *0* ; *0*
	3	*8* ; *0* ; *0*	*0* ; *0* ; *0*
II	1	*1* ; *0* ; *0*	*0* ; *0* ; *0*

F. MITSU, AMINO-MACHI, KYOTO PREFECTURE

1958 *season*

		Morning catch	Evening catch
IV	1	*3* ; *0* ; *0*	*3* ; *0* ; *0*
	2	*9* ; *0* ; *0*	*7* ; *0* ; *0*
	3	*7* ; *0* ; *0*	*7* ; *0* ; *0*
V	1	*9* ; *0* ; *0*	*6* ; *0* ; *0*
	2	*9* ; *0* ; *0*	*3* ; *0* ; *0*
	3	*9* ; *0* ; *0*	*4* ; *0* ; *0*
VI	1	*8* ; *0* ; *0*	*6* ; *0* ; *0*
	2	*7* ; *0* ; *0*	*4* ; *0* ; *0*
	3	*7* ; *0* ; *0*	*5* ; *0* ; *0*
VII	1	*9* ; *0* ; *0*	*6* ; *0* ; *0*
	2	*10* ; *0* ; *0*	*8* ; *0* ; *0*
	3	*6* ; *0* ; *0*	*5* ; *0* ; *0*
VIII	1	*7* ; *0* ; *0*	*7* ; *0* ; *0*
	2	*6* ; *0* ; *0*	*6* ; *0* ; *0*
	3	*2* ; *0* ; *0*	*0* ; *0* ; *0*

to collect the catch, and thus the record is made separately for the morning and evening catches. The morning catch comprises the fish caught at night after the previous evening updrawing, and the evening catch contains the fish caught in the daytime afte rthe morning updrawing on the same day, unless the weather and other conditions prevent the regular inhaul of the net.

As seen in the table, this squid is caught by set net during the period from middle October to middle January of the next year, though the exact period slightly differs with localities and years. It is noticeable that the animal is not caught after late January even during the season of set-net fishery and presumably never in the warm season, either, as the data obtained at Mitsu (F in Table 2) allude. A similar trend may be seen in the data concerning the stranding. The records of stranding with known date on the west coast of Honshu are confined to the term from middle October to early January (cf. Table 1).

At first sight, the above-mentioned occurrence pattern of *Thysanoteuthis* on the west coast of Honshu may appear rather unusual, since this squid is generally accepted as a warm-water surface animal. The temperature of the coastal surface water is highest in August, and then the period from October to January of the next year is the season when the water temperature drops rapidly (cf. NAGANUMA 1964). If the migration of this squid into the Japan Sea followed the season and the waters of the highest surface temperature, it should appear on the west coast of Honshu much earlier than it does actually.

Another noteworthy point deduced from the statistics of the set-net catch concerns the diel activity of the animal. In Table 3 is given the occurrence pattern of *Thy-*

Table 3. Occurrences of *Thysanoteuthis rhombus* in morning and evening catches at respective set-net grounds.
A.-Total number of net inhaulings made in the period indicated; B.-Frequency of occurrences of the squid in the same period; C.-Total number of the squid caught in the same period.

Place of set net (year)	Occurrence season of squid	Morning catch					Evening catch				
		A	B	C	B/A	C/B	A	B	C	B/A	C/B
Waki (1958–59)	XI_3–XII_1	20	2	4	0.10	2.0	11	0	0	0	—
Shirase (1958–59)	XI_1–XI_2	20	5	12	0.25	2.4	9	2	3	0.22	1.5
Usetsu (1958–59)	XI_2–I_1	59	7	11	0.12	1.6	52	1	1	0.02	1.0
Usetsu (1959–60)	XI_1–I_2	76	28	100	0.37	3.6	61	12	26	0.20	2.2
Usetsu (1960–61)	X_2–I_2	87	15	30	0.17	2.0	68	9	13	0.13	1.4
Kyoto No. 2 (1958–59)	X_2–XII_2	58	18	35	0.31	1.9	1	0	0	0	—
Kyoto No. 7 (1958–59)	X_3–XII_3	45	8	12	0.18	1.5	7	1	2	0.14	2.0

sanoteuthis in respective morning and evening catches by set net. The more frequent and abundant occurrences of the squid in the morning catch might be partly attributable to the situation that, in addition to those individuals caught at night, some individuals captured in the daytime of the previous day are included in the morning catch when the net was not drawn up in the previous evening, as actually the evening inhaulings are much less than the morning updrawings, but *vice versa* in a much smaller scale. Thus, there are some questions to accept as true the more frequent occurrence and greater number of this squid in the morning catch. In this respect, however, the records at Usetsu in the seasons from 1958 to 1961, particularly in 1958–59, may be regarded next to complete in their regularity and totality. On these data, it may be concluded that *Thysanoteuthis* has a greater possibility to be caught by set net at night than in the daytime.

Considerations on the Migration Mechanism

It has been stated that in the adjacent waters to Japan *Thysanoteuthis rhombus* is caught mostly around islands and peninsulas such as the Bonin (Ogasawara) Islands, the Tsushima Islands, Noto Peninsula, Izu Peninsula and Miura Peninsula (SASAKI 1927, 1929a). This statement is considered valid as far as the Pacific coasts of Japan are concerned. On the Japan Sea coasts, however, the squid is caught not only around the islands and promontories but also on the plain coasts and even in the inner part of embayments such as Toyama Bay and Wakasa Bay.

Its frequent appearances around the oceanic islands and peninsulas in the Pacific suggest that *Thysanoteuthis* is an oceanic inhabitant, while its distribution pattern over the world oceans refers this animal to the warm-water, possibly subtropical, species. Then, its occurrences in the Japan Sea must be said quite unusual, because, there, the bulk of the captures are made by coastal set net or by its own stranding on the plain coast in the season opposite to the high water temperature. Why does *Thysanoteuthis* show such a peculiar pattern of occurrence in the Japan Sea ?

There are some other tropical-subtropical pelagic animals that show a similar pattern of occurrence on the west coast of Japan, such as the argonaut, various pufferfishes, ocean sunfishes, ribbon-fishes (Trachipteridae and Regalecidae), the frigate mackerel, sea snakes, sea turtles, etc. (cf. NISHIMURA 1965a, 1965b). I have ever tried to explain in detail such occurrence patterns shown by the balloonfish *Diodon holacanthus* L. and the leatherback turtle *Dermochelys coriacea* (L.) in terms of the hydrographical and climatological peculiarities of the Japan Sea (NISHIMURA 1958, 1964). A similar explanation seems to be applicable to the occurrence of *Thysanoteuthis rhombus* in the Japan Sea, as it goes forth:

Thysanoteuthis may migrate into the Japan Sea from the southern seas, being carried by the warm current flowing into that sea through the Tsushima Straits. Though it is not enough to give any definite conclusion about the time of immigration

of the squid shoals, the appearance of this squid off the northern coast of Yamaguchi Prefecture, the westernmost region of Honshu Island and facing the east part of the Straits, in the fall season from late August to middle November, most frequently in October (K. NAKANO *in litt.*, 2 iii 1962 & 13 ii 1966), seems to allude that the squid shoals enter the Japan Sea possibly in the period from August to early November. This offshore appearance of *Thysanoteuthis*, though not so abundant as its occurrences observed in the inshore waters of the same region in winter, is nevertheless quite regular from year to year (K. NAKANO *op. cit.*) After the middle of November, no record of *Thysanoteuthis* is made off the coast of western Honshu, and either no informations of this squid in the whole summer season along the west coast of middle and northern Honshu. This seems to show that the squid possibly takes an offshore migration route to the north through the Japan Sea from summer to autumn.

It is from November to January of the next year, but most frequently from late November to December, that *Thysanoteuthis* appears in the inshore waters and is found stranded or caught by set net on the west coast of middle Honshu. Thus, drawing toward winter, the offshore population of the squid seems to approach the coastal waters. The bulk of the population is supposed to be perished on the coast, but the individuals escaped stranding or fishing will continue the southward movement along the coast to the westernmost district of Honshu, or even to the northwestern part of Kyushu. On the former coast the squid is caught by set net every year mostly from November to January (K. NAKANO *in litt.*, 2 iii 1962) and on the latter coast from the end of December through February (S. MITO *in litt.*, 24 vi 1960).

Then, what is the factor controlling such a migration pattern of *Thysanoteuthis*? Most probably, as suggested in the cases of the balloonfish and the leatherback turtle (NISHIMURA 1958, 1964), flow patterns of the main stream of the Tsushima warm current in the warm season and the predominancy of the northwest monsoon in the cold season are the factors most effective in the migration of *Thysanoteuthis*. The supposed offshore migration route of *Thysanoteuthis* during the warm season may be related with the offshore main stream of the Tsushima current flowing into the Japan Sea from the west channel of the Tsushima Straits and then keeping its course to the northeast through the central part of the sea. The supposed time of immigration of the squid population into the sea coincides with the peak of volume transport of the warm current through the Tsushima Straits: according to MIYAZAKI (1952), the Tsushima current attains its peak of volume transport in the months August to October (Fig. 4) and the greater portion (about 70%) of the transport is made through the west channel of the Straits. The first occurrences of *Thysanoteuthis* off the north coast of Yamaguchi Prefecture in every early autumn will be understood by taking into consideration such flow patterns of the main stream of the warm current. Another interesting point is that in the northern waters near the Tsugaru Straits or on the west coast of Hokkaido *Thysanoteuthis* is sometimes caught in the season somewhat earlier than on the coasts of middle to south Honshu and northwest Kyushu,

namely from October to November (cf. Table 1). This may indicate the possibility that some squid shoals are transported to the far northern waters in a relatively short time by the swift, jet-like stream in the offshore main belt of the warm current suggested by KASAHARA (1958). It is not impossible that the squid might traverse the Japan Sea within a month if it follows this swift stream in full.

While the squid shoals are on the migratory way in the Japan Sea along the offshore main stream of the Tsushima warm current during the warm season, no individual of them is observed or caught in the coastal waters of middle Honshu. The

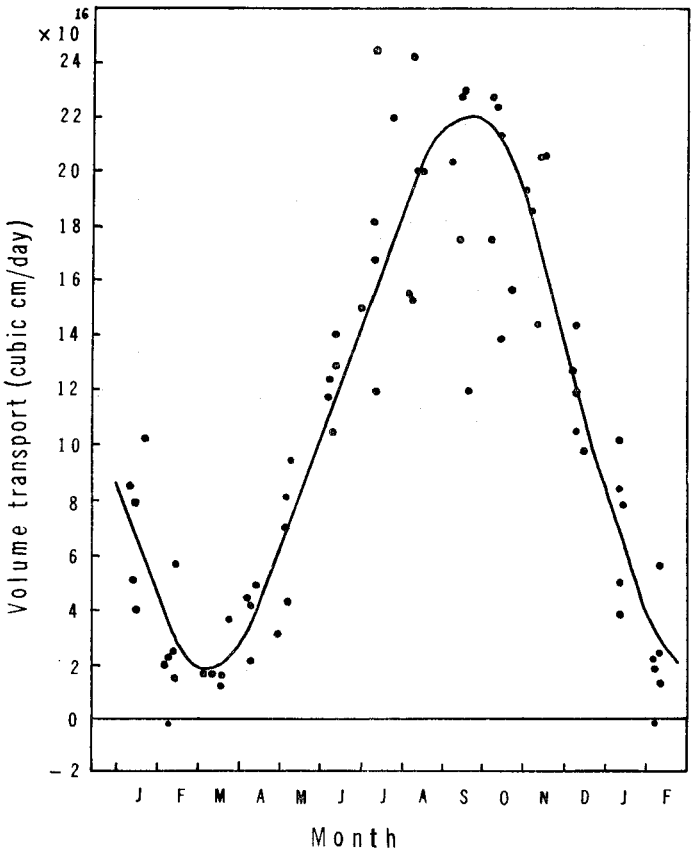

Fig. 4. Seasonal variation in northward volume transport of the warm current through the Tsushima Straits. Dots are values actually observed in the years 1935–1940. (After MIYAZAKI 1952).

definite migratory speed is still unknown; but it is likely that before the bulk of the population reaches the very northern part of the basin the season of the northwest monsoon is open in November. This monsoon is well known for its frequent and severe attacks, often with the velocity more than 30 knots and lasting for 70 hours.

Granting that EKMAN's (1905) theory of wind-driven ocean currents is applicable to the Japan Sea in the winter months, the 'depth of frictional influence' is estimated at 150 m or so and the mean velocity of the surface drift current at about a half knot (NISHIMURA 1958). It is very probable that the squid population in the offshore area of the Japan Sea is carried by this drift current to south or southwest in a con-

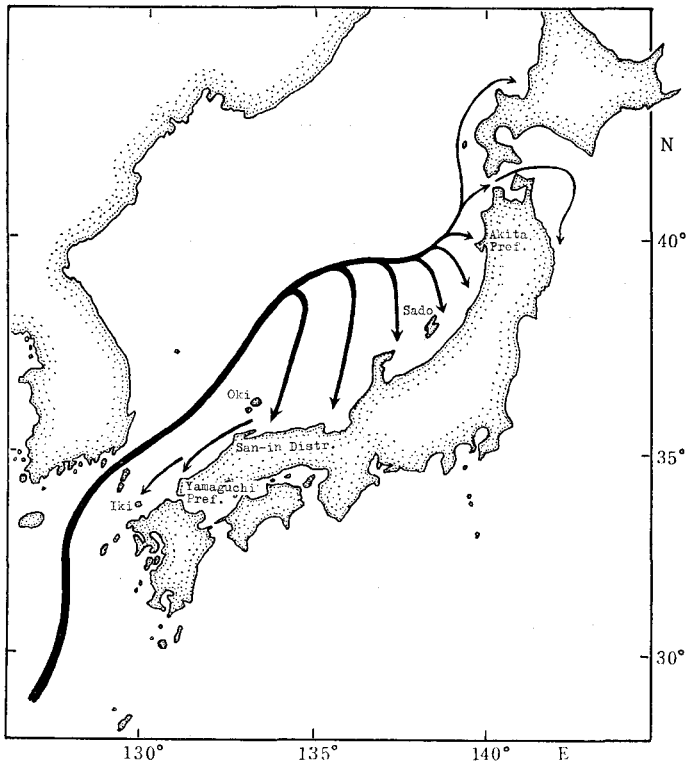

Fig. 5. Supposed main migration routes of *Thysanoteuthis* shoals in the Japan Sea and adjacent waters.

The majority of the shoals are carried to north along the main stream of the Tsushima warm current in the offshore part of the Japan Sea in summer, later to be driven south or southwest by the drift current in winter, though a small portion may follow the coastal northward branch of the warm current which is not shown in this figure. The occurrences of this squid are rather abundant in the area south of Akita Prefecture but seemingly very rare in the area north of the prefecture.

The migration pattern on the Pacific side is obscure, though it is supposed that the squid is distributed widely in the subtropical offshore waters of the western North Pacific.

siderable speed and ultimately reaches the coast of middle to west Honshu. Certain shoals will further go down to the northwestern waters of Kyushu, following the southward current that develops along the coast to the eastern channel of the Tsushima Straits in winter (MIYAZAKI 1952). This migration pattern of *Thysanoteuthis rhombus* schematically illustrated in Fig. 5 is essentially the same as those suggested for the

balloonfish and the leatherback turtle (NISHIMURA 1961, 1964).

The scarcity of the record of *Thysanoteuthis* on the Pacific coast of Japan seems to reflect its natural distribution to some extent. Most fishermen of the Pacific coast of Japan, except for those on the open-sea side of peninsulas such as Izu and Miura or on the oceanic islands such as Izu-Oshima, Hachijo, Torishima and the Bonin Islands, are quite ignorant of *Thysanoteuthis*. It is impossible that the peculiar appearance and remarkable size of this squid will escape the attention of the fishermen, if it occurs in the coastal waters on the Pacific side of Japan. It seems that *Thysanoteuthis* is unable to approach the plain coast on the Pacific side, because of the unfavorable hydrographic and climatological conditions differing from those in the Japan Sea.

Some Biological Aspects

Schooling

It is stated by fishermen on the Japan Sea coast that *Thysanoteuthis rhombus* is generally found in a couple of male and female, and thus two individuals are caught at a time on most cases, and even that when an individual of the couple is fished the other will remain there in search for its disappeared companion. This story was confirmed in some way by Mr. Y. MORITA, former technical expert at the Toyama Prefectural Fisheries Experimental Station, who told me that he had ever observed during one of his research divings on the set-net grounds in Toyama Bay that two individuals of *Thysanoteuthis* were swimming side by side, keeping a close relation with each other, as if their behaviors were controlled by a complicated psychophysiological mechanism.

Though it is difficult to determine whether the squids behave in a true couple or not, some evidences supporting the occurrence of the squid in a pair may be found in Table 4 which shows the frequency distribution of the number of squids fished in

Table 4. Frequency distribution of the number of *Thysanoteuthis* fished in each inhauling throughout the five set-net grounds, A to E in Fig. 3, on the west coast of middle Honshu, 1958–1961.

	Number of *Thysanoteuthis* in each inhauling										
	0	1	2	3	4	5	6	7	8	9	10.....17
Frequency	466	37	48	9	6	1	3	1	1	0	1..... 1

each catch throughout the previously-mentioned, five set-net grounds in middle Honshu during the season when *Thysanoteuthis* appears. Of the total occurrences amounting to 18.8%, the catch of two squids at a time is a little more frequent than that of a single individual and the catch of more than three individuals at a time is quite insignificant. Such a pattern of occurrence may be explained by the following assumptions: (1) *Thysanoteuthis* tends to behave in a group, or 'unit', of two individuals; and

(2) such 'units' are distributed rather sparsely, at least in the areas including these set-net grounds. The catch of a single individual at a time will occur when only a partner of the pair happens to be caught by net. If the density of this squid in its winter approach to the shore is of a concentrated state, then it seems very probable that the distribution of 'units' must be much more sparse in the offshore waters of the Japan Sea during the warm season.

It will be one of the most interesting problems left for future studies to ascertain whether or not the 'unit' really consists of particular male and female as stated by fishermen and actually observed by WELLS (1962) on certain species of *Loligo* in an aquarium. The latter reported of an individual male which selected a particular female and swam around with her for several hours or days, paying no attention to any other females in the shoal.

'Flying'

In his monumental, posthumously published work on the dibranchiate cephalopods of Japan, SASAKI (1929a) stated that one of his specimens of *Thysanoteuthis rhombus* had a label noting that it flew up from sea and came on board, colliding against the sail (p. 304). Probably this note of observation and some similar informations from fishermen were the sources on which he repeated to describe the 'flying behavior' of this squid more definitely in the first edition of "*Illustrated Encyclopedia of the Fauna of Japan*" (1927, p. 1265)[2] and proposed there the Japanese name "*sode-ika*" (sleeved squid) or else "*otobi-ika*" (giant flying-squid) for the species. Since then no scrutiny has ever been made as regards the validity of this statement.

In the early winter of 1962, I had several chances to observe the swimming behavior of *Thysanoteuthis* entrapped in a set net in Ryotsu Bay, Sado Island. As the space was narrowed by inhauling of the net, the captured squids, about 60 cm in mantle length, were observed to swim to and fro just beneath the sea surface by fluttering the fins, and it was my surprise to find that they were rather slow swimmers. In spite of so vigorous action of their fins the swimming speed seemed scarcely attaining 2 knots in all probability, and no sign of the 'jet-propulsion' commonly seen in smaller squids such as *Todarodes*, *Loligo*, etc. was confirmed on them. They were better expressed as tottering or waddling[3] rather than swimming. I am not assured whether or not the captured squids were weakened; but the movement observed on those adult *Thysanoteuthis*, so sluggish as compared with the nimble movement of other smaller oceanic squids like *Todarodes*, made me suspicious of the 'flying behavior' of that giant cephalopod.

Owing to its large body and extraordinarily developed fins, *Thysanoteuthis* has been believed to be a powerful swimmer (REES & MAUL 1956). The actual obser-

2) Here we read as follows: "This is an oceanic species, and is often found flying above the sea surface" [original in Japanese].

3) Seeing the swimming *Thysanoteuthis*, I approved at once to call them at sea "*taru-ika*" (barrel squid) in local name. It looked like just a barrel floating on the sea surface.

vation, however, does not seem to agree this idea; rather frequent strandings of live large adult individuals seem to contradict that idea, too. The stranding of *Thysanoteuthis* is not confined to the Japanese waters: REES & MAUL (1956) reported that once a school of about 20 squids came ashore and were caught on Madeira. On the west coast of middle Honshu, the coastal water temperature still remains about 15°C when the frequent strandings of *Thysanoteuthis* occur there (cf. NAGANUMA 1964), and this temperature does not seem so harmful to that species[4]. The frequent strandings might be due to the apparently weak swimming ability, at least in the adult stage, of that cephalopod.

No doubt, it needs a great energy to make the heavy body of adult *Thysanoteuthis*, attaining more than 4–5 kg up to 20 kg (see below), drive itself fast enough to pass into the atmosphere and subsequently to fly or glide over any appreciable distance; and it is incredible that adult *Thysanoteuthis* is really provided with so strong power enough to attain such an impetus level.

On the other hand, I have asked researchers and fishermen on the Japan Sea coast for any informations of the observation of 'flying' *Thysanoteuthis*. Almost all informations were negative. Mr. K. NAKANO with a career of a skilful fisherman and at the same time an enthusiastic marine life observer in the southern Japan Sea for more than 25 years kindly gave me the following information (*in litt.*, 13 ii 1966):

> I have never observed *Thysanoteuthis rhombus* flying or gliding in the air like flyingfishes, and I believe possibly no one in the southern Japan Sea has ever seen it either. However, the following events are observed every autumn: (1) under powerful electric lamps for fishing small anchovy, *Thysanoteuthis* of smaller size, about 25 cm in mantle length, may come up to the surface in pursuit of anchovy and occasionally *leap out* of the water as high as 40 cm, keeping the body vertically; (2) sometimes *Thysanoteuthis* may *leap out* into the air in escaping the pursuit of ferocious enemies such as *Tylosurus*. *As to the middle- or large-sized individuals of this cephalopod, even such a leaping behavior has never been observed* [translated into English by the author].

It may be concluded that *Thysanoteuthis* can leap out of the water at least nearly two times as high as its mantle length during the young stage but this habit is lost as the animal grows larger; the so-called 'flying behavior' is doubtful even for smaller individuals.

Diel Activity

The catch of *Thysanoteuthis rhombus* by set net shows a trend toward increase at night (p. 339). This seems to be related with the diel activity rhythm of the squid.

4) According to OKUNO & NISHIGUCHI (1961), death by cold starts generally at 12°–11°C in tropical-subtropical marine fishes in aquarium, but the mass mortality occurs below 9°–8°C. Occasionally leatherback turtles are caught still alive on the Japan Sea coast of middle Honshu in midwinter (NISHIMURA 1964) when the water temperature is as low as 9°–8°C. Further, there are evidences suggesting that some populations of the balloonfish winter in the water off the west coast of middle Honshu (NISHIMURA 1961). These facts seem to indicate that the lower fatal temperature for tropical-subtropical marine animals is generally around 9°–8°C or below, though it differs, of course, to some extent according to species.

The set nets, referred to previously, are mostly fixed on the landward side of the 40–50 m bathymetric lines on the west coast of middle and west Honshu. It is, then, supposed that the squids sink down to deeper layers in the daytime but come up to shallower layers and become active at night, when they may be entrapped by net.

A similar diel vertical migration is well known in the common squid *Todarodes pacificus* (SASAKI 1929b).

Body Weight Composition

As I noted previously (NISHIMURA 1960), *Thysanoteuthis* specimens caught at the same time at any localities are very variable in body size. This is also clearly seen in Fig. 6, which shows the body weight composition of the squids caught at Kokonogi,

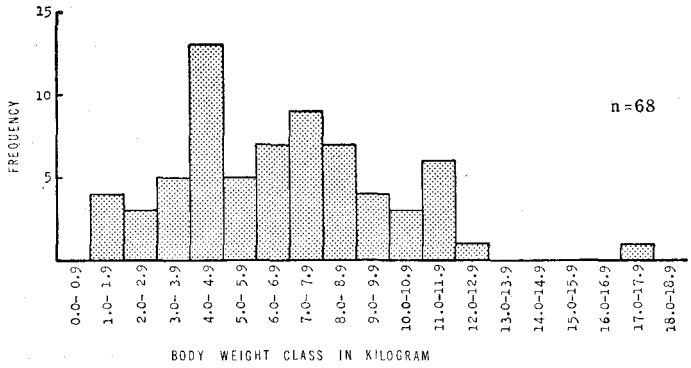

Fig. 6. Body weight composition of *Thysanoteuthis rhombus* fished at Kokonogi, Echizen-machi, Fukui Prefecture, September to October, 1961. (After I. OKACHI's unpublished data).

Echizen-machi in Fukui Prefecture, in the season from September through October, 1961, reproduced here by kind permission of Mr. I. OKACHI. At least four modes are distinguishable in this histogram, respectively at 4.0–4.9 kg, 7.0–7.9 kg, 11.0–11.9 kg and 17.0–17.9 kg. It is thus very likely that different year-classes are included in the catch.

The body weight class of 1.0–1.9 kg, corresponding to the mantle length mode of about 25–27 cm, is considered representing a distinct year-class possibly of 1-year-old individuals, because (1) this is the smallest size class that appears more or less abundantly in the Japan Sea and (2) the mode 4.0–4.9 kg is too large for the growth attained in the first year of life even for the cephalopods among which a very rapid growth is believed general (JAECKEL 1958). Probably this mode represents the size range in the end of the second year of life (see below).

In the same way, the modes 7.0–7.9 kg and 11.0–11.9 kg are supposed here to represent the body weight attained respectively in the ends of the third and the fourth year of life.

Although the reproductive season of *Thysanoteuthis* is not yet precisely known, it may spawn in winter, since HAMABE (1965) records a perfectly mature female in late December near the Oki Islands in the southern Japan Sea.

The life span of this squid is quite obscure. But, the following fragmentary data seem to suggest that the weight classes of 13–14 kg and 15–16 kg, frequently recorded on the individuals stranded

on the coast of middle Honshu in the same, late autumn season (cf. Table 1), may indicate two further successive year-classes. If we regard the individuals at the mode 17.0–17.9 kg in Fig. 6 as belonging to another distinct year-class, then, at least seven year-classes may be distinguishable in the population of *Thysanoteuthis* in the Japan Sea. At last, the individual with the mantle length 80 cm and the weight 19 kg caught at Izu Oshima and another one with 20 kg from Aogashima Island, both in the Pacific (cf. Table 1), may be estimated as old as eight years.

In this connection, it is noteworthy that individuals smaller than 1.0 kg in weight are hardly caught in the Japan Sea. Possibly this means that the main spawning ground of *Thysanoteuthis* is located outside the basin and in far southern waters.

Fluctuation in Migrant Population

Considerable fluctuations are found in the amount of *Thysanoteuthis* migrating into the Japanese waters from year to year. Of late, 1959 was distinctive for the big capture of this squid, both commercial and non-commercial, throughout nearly all districts on the west coasts of middle to south Honshu and northwest Kyushu:

Ryotsu Bay, Sado Island. An unusually large number of the squid were caught by set net in the bay in 1959 (NISHIMURA 1960).

Usetsu, Noto Peninsula. As clearly seen in Table 2, the catch by set net at Usetsu was considerably larger in the 1959–60 season than in the season just before or after it, both with an average catch. The number of net-inhaulings (A), frequency of occurrence (B) and the total number of the squids caught (C) in respective seasons from middle October to late January of the next year are tabulated below again for easy reference:

1958–59 season	Morning catch	A	103;	B	7;	C	11
	Evening catch	A	76;	B	1;	C	1
1959–60 season	Morning catch	A	99;	B	28;	C	100
	Evening catch	A	71;	B	12;	C	26
1960–61 season	Morning catch	A	96;	B	15;	C	30
	Evening catch	A	69;	B	9;	C	13

Oki Islands and Shimane Prefecture. A particularly large number of the squids were caught commercially or stranded ashore in the winter of 1959 (KAMITA 1965). In that winter, more than 300 individuals were stranded on the beach of Tsuma and about 100 were caught in Mita Bay, both on the Oki Islands; evidently this was the biggest record for the district in the last three decades (Y. KIMURA in KAMITA 1965).

Yamaguchi Prefecture. Thysanoteuthis was exceptionally abundant on the coast of Yamaguchi Prefecture in 1959 (K. NAKANO *in litt.*, 13 ii 1966).

Northwest Kyushu including Iki Island. The coastwise drift was unusually marked in the 1959–60 winter. Fishermen walked around the beach all day long for the drifting squids which were then hooked up by them, and thus an unexpectedly large yield was recorded at some fish markets in this region (S. MITO *in litt.*, 24 vi 1960).

Another peak of occurrence was noted in the autumn to winter of 1964 along the west coast of middle to south Honshu:

Toyama Bay. Numerous squids were angled off Uozu, Shin-minato, etc. in the inner part of the bay almost every day from late September through December, 1964, yielding more than 100 metric tons in total landing. This was the biggest catch ever recorded in Toyama Bay (Toyama Pref. Fish. Exp. Stat. 1965; the dates of capture of *Thysanoteuthis* in that report are misprinted according to the information from K. ARAI *in litt.*, 13 iv 1966).

Wakasa Bay. Exceptionally large number of *Thysanoteuthis* were drifted to the coast of Echizen and near-by districts and the catch of more than 200 metric tons was yielded by angling during the months from September to December (SAMON 1964).

San-in District. The catch was much greater in 1964 than in other years on the coast from Shimane to Yamaguchi Prefecture (K. NAKANO *in litt.*, 13 ii 1966).

Thus, it is apparent that fluctuations of a large scale occur in the size of the migrant population of *Thysanoteuthis* in the Japanese waters, though it is still uncertain whether such fluctuations are simply caused by the favorable or unfavorable hydrographic conditions that will help or disturb the immigration of the squid to the Japanese waters or by the outbreak of some prevailing year-classes in the squid stock which will subsequently increase the size of the emigrant population to peripheral areas.

Summary

1. Records of occurrences of *Thysanoteuthis rhombus*, a subtropical oceanic squid, in the Japanese waters were compiled and their localities were plotted on the map. The records, both of the stranded individuals and of the commercial catches made mostly by set net, are distributed from Kyushu to Hokkaido, but much more densely on the Japan Sea side than on the Pacific side. This may be in part due to lesser informations from the Pacific coasts, but more probably the scarcity of the records on the Pacific side is the real aspect of the distribution of this squid in the Japanese waters.

2. The season of occurrence is mainly from late autumn to winter on the Japan Sea coasts. This peculiar occurrence of the animal is seemingly the result of the following processes: the offshore main stream of the warm current in the Japan Sea carries the squid population to the north through the offshore region in summer, and then the drift current induced by the prevailing northwest monsoon in autumn to winter drives the population toward and condenses them in the coastal waters of middle to south Japan. A supposed migration map was presented.

3. An analysis of the statistics of catches by set net seems to suggest the upward migration and possibly increased activity of the squid at night.

4. *Thysanoteuthis* might behave in pairs, though it is left uncertain whether each pair consists of a male and a female.

5. The story of flying or gliding of adult *Thysanoteuthis* in the air is very questionable, though smaller individuals are known to leap into the air under certain circumstances.

6. The size of *Thysanoteuthis* captured in the Japanese waters is very variable, ranging from 1 to 20 kg in weight. At least eight year-classes are estimated in the migrant population to the Japanese waters. Also the amount of the migrant population shows fluctuations of a considerable scale from year to year.

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