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Preliminary results of food habits of the swordfish, *Xiphias gladius*, in the subtropical waters of the western North Pacific

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Introduction

The swordfish *Xiphias gladius* is one of the dominant large pelagic fish distributed worldwide in the subtropical and tropical waters (Sakagawa and Bell, 1980; Nakamura, 1985). This species is thought to be playing an important role as a predator of larger squid and finned fish in oceanic and slope-water ecosystems (Scott and Tibbo, 1968; Stillwell and Kohler, 1985; Hernandez-Garcia, 1995).

Although considerable knowledge of the food habits of *X. gladius* has been accumulated in the North Atlantic (e.g. Scott and Tibbo, 1968; Toll and Hess, 1981; Stillwell and Kohler, 1985; Moreira, 1990), those in the North Pacific especially in the western area is still restricted (Markaida and Sosa-Nishizaki, 1998; Moteki et al., 2001). In this study we aimed to evaluate the food habits of *X. gladius* in the subtropical waters of the western North Pacific.

Materials and methods

We examined the diets of the *Xiphias gladius* (n=59) which were collected in the area bounded by 23-37°N and 142-175°E (Fig. 1). Samples were obtained in the upper ca. 100 m depth at night from March 26 to May 16 in 2000 by commercial vessels using long line. After measuring eye-fork length and/or body wet weight, stomachs were dissected out and frozen at -30°C for further analysis in the laboratory. We identified each prey item in the stomach to the lowest possible taxonomic level. The frequency of occurrence (F_i) of each food item in the total number of stomachs examined was calculated for each species as:

$$F_i (\%) = \frac{\text{no. of stomachs including food item } i}{\text{total no. of stomachs}} \times 100$$

We also measured total length, dorsal mantle length, and standard length for prey species of crustaceans, squids, and fishes, respectively.

Results and discussion

The size range of *X. gladius* examined was from 101 to 240 cm. The total sample was comprised of 22 females, 12 males, and 25 sex unknown.

Stomachs of *X. gladius* from 59 individuals of which 57 (97%) contained food were examined. We identified a total of 18 species belonging to 16 genera in the stomachs (Table 1). *Xiphias gladius* was primarily squid and fish feeder in the western North Pacific as well. The frequency of occurrence was the highest for neon flying squid *Ommastrephes bartrami* (42%) and secondarily highest for pronghead *Brama japonica* (22%) (Table 1). Numerically, *O. bartrami* and *B. japonica* also ranked first and second accounting for 26% and 10%, respectively, showing that these two species are main diets of *X. gladius* between March and May in this study area (Table 1). The size ranges of *O. bartrami* and *B. japonica* individuals eaten by *X. gladius* were 22 to 43 cm in dorsal mantle length and 28 to 34 cm in standard length, respectively (Table 1). We saw no indication of preference of prey species and size with respect to sex or size of *X. gladius*, suggesting that prey species and size is independent of fish body size and sex.

Both fresh and heavily digested individuals of *O. bartrami* often found in the stomach of *X. gladius*. The results of recent research conducted by our institute indicate that diel vertical migration patterns of *X. gladius* and *O. bartrami* are similar, i.e. they migrate up to the epipelagic layer (0-ca. 100m depth) from the mesopelagic (ca. 300-700 m depth) at night in the subtropical waters of the western North Pacific. Considering that this species is often collected by long line both during the daytime and at night in the oceanic region of the western subtropical Pacific (Miyabe *et. al.*, in press), these information strongly suggest that *X. gladius* feed on *O. bartrami* throughout the day in this study area and this probably contributes that *O. bartrami* is the most important prey item of *X. gladius*. According to Carey and Robinson (1981) and Hernandez-Garcia (1995), *X. gladius* feed on prey near the bottom during the daytime and in the surface layer at night in the slope water region, showing that this species feed on prey both day and night. On the other hand, almost all individuals of *B. japonica* fed on by *X. gladius* were relatively fresh. *Brama japonica* is mainly distributed in the upper 100 m layer whole a day in the subtropical waters of central and eastern North Pacific (Machidori and Nakamura, 1971; Kikuchi and Tsujita, 1977; Seki and Mundy, 1991) and hence *X. gladius* can feed on this species only at night. This probably related to the difference in digestion stage composition between *O. bartrami* and *B. japonica*.

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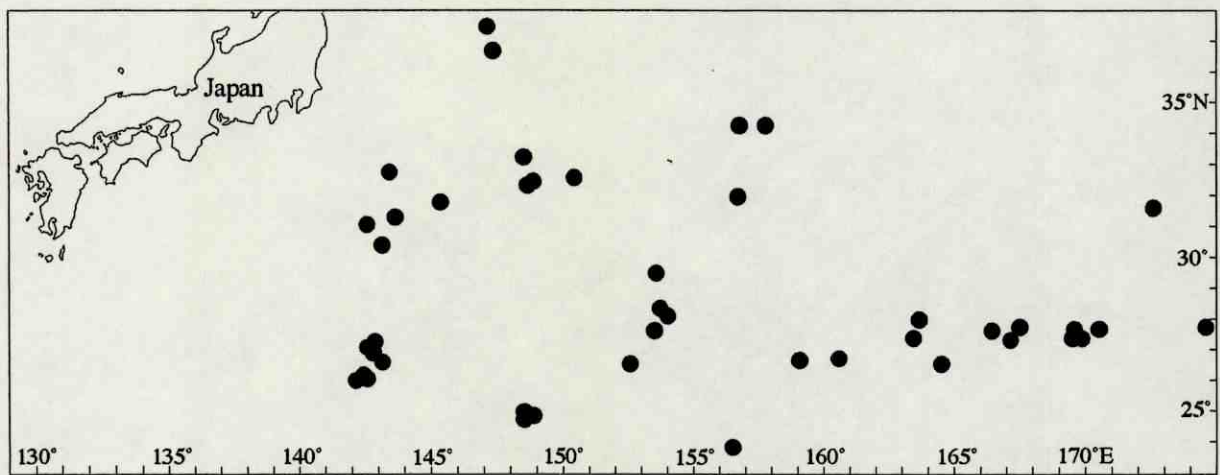


Fig. 1. Locality of the sampling stations in the western North Pacific during March-May, 2000.

Table 1. Prey species composition of *Xiphias gladius* (n=59) in the subtropical waters of the western North Pacific, March 26-June 15, 2000, showing frequency of occurrence, number of each food item and its percentage (in parentheses) of total number of all food items identified. Size was indicated by total length for crustacean zooplanktons, dorsal mantle length for squids, and standard length for fishes.

Prey species	Freq.		No.		Size (cm)		Prey species	Freq.		No.		Size (cm)	
	Occ. (%)	Occ. (%)	(%)	(%)	avg	range		Occ. (%)	Occ. (%)	(%)	(%)	avg	range
Fishes													
Amphipods													
<i>Platyscelus serratulus</i>	1.7	1 (0.5)	1.9	-			<i>Brama japonica</i>	20.0	20 (9.9)	32.2	29.7-	37.2	
							<i>Diaphus gigas</i>	5.5	14 (6.9)	10.9	5.7-	13.0	
Decapods							<i>Alepisaurus ferox</i>	3.4	2 (1.0)	1018.7	1008.1-	1029.2	
Unidentified	1.7	1 (0.5)	5.2	-			<i>Platycephalus indicus</i>	1.7	1 (0.5)	-	-	-	
							<i>Scopelosaurus harrisi</i>	1.7	1 (0.5)	28.8	-	-	
							<i>Myctophum asperum</i>	1.7	1 (0.5)	-	-	-	
Squids							<i>Lampadena luminosa</i>	1.7	1 (0.5)	-	-	14.5	
<i>Ommastrephes bartrami</i>	42.4	52 (25.7)	30.8	22.0-43.1			<i>Brama</i> sp.	8.5	6 (3.0)	31.3	28.5-	34.0	
<i>Eucleoteuthis luminosa</i>	5.1	4 (2.0)	-	-			<i>Lampanyctus</i> sp.	3.4	2 (1.0)	-	-	-	
<i>Thysanoteuthis rhombus</i>	5.1	3 (1.5)	-	-			<i>Etmopterus</i> sp.	1.7	1 (0.5)	-	-	-	
<i>Chiroteuthis</i> sp. (?)	5.1	5 (2.5)	-	-			<i>Epigonus</i> sp.	1.7	1 (0.5)	-	-	-	
<i>Ommastrephes</i> sp.	5.1	4 (2.0)	-	-			Paralepidae	5.1	27 (13.4)	13.6	13.0-	14.2	
<i>Histioteuthis</i> sp.	1.7	1 (0.5)	-	-			Myctophidae	8.5	31 (15.3)	-	-	-	
Unidentified	10.2	12 (5.9)	-	-			Unidentified	10.2	11 (5.4)	-	-	-	