南西水研報
Bull. Nansei Reg. Fish.
Res. Lab. No. 20, 1986

Feeding Habits of Japanese Spanish Mackerel in the Central and Western Waters of the Seto Inland Sea

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Food and feeding habits of Japanese Spanish mackerel *Scomberomorus niphonius* were investigated based on the examination of stomach contents of 714 specimens collected, from May 1981 to June 1984, in the central and western waters of the Seto Inland Sea.

The stomach contents consisted almost entirely of the pelagic and mesopelagic fishes including squids, viz. Japanese anchovy *Engraulis japonica*, sardine *Sardinops melanostictus*, sand lance *Ammodytes personatus*, Atlantic cutlassfish *Trichiurus lepturus* and Japanese common squid *Todarodes pacificus*.

The seasonal and regional differences in diet composition reflected well the changes of food in the environment.

In the adult, the monthly averages of reconstructed stomach contents weight per predator weight indicated two peaks, April and during a period from July to August, which corresponded to the pre- and postspawning periods, respectively. The feeding intensity of young was also high in the growing season.

In most months the percentage of large prey increased with the increase of body length of the predator.

Japanese Spanish mackerel *Scomberomorus niphonius* (CUVIER) is one of the important species in fisheries of the Seto Inland Sea.

Although knowledge of the food and feeding habits is essential to clarify the ecology of this species, brief informations have only been obtained previously (HAYASHI 1919, WHANG *et al.* 1977). According to them, Japanese Spanish mackerel is principally ichthyophagous. A geographical scope in the variation in food component was found that the species feed on sand lance in the central water of the Seto Inland Sea during April and June (HAYASHI 1919), while on anchovy and zooplankton in the southwestern waters of Korea (WHANG *et al.* 1977). However, little is known about variations of food and feeding habits during the course of development and seasons.

The present paper describes the result of an investigation on the analyses of stomach contents of young and adult Japanese Spanish mackerel, sampled nearly every month of the year, in the central and western waters of the Seto Inland Sea.

Materials and Methods

Specimens of 714 Japanese Spanish mackerel were mainly collected, from May 1981

Received November 22, 1985. Contribution No. 177 from the Nansei Regional Fisheries Research Laboratory, Ōno-chō, Hiroshima-ken, 739-04, Japan

Table 1. Number of specimens of Japanese Spanish mackerel classified by month, area, and size group. Range is indicated by fork length in millimeters.

pur.=purse seine net. gill=drift gill net. tro.=trolling. Kami.=Kaminada. Kuni.=Kunisaki. Hime.=Himeshima. Ito.=Itozaki. Hiro.=Hiroshima. Hiuchi=Hiuchi-nada. Nada means a local sea area.

Month	Area	Small size					Gear	Place	Medium size			Large size			Total
	captured	Gear	Place collected	Range Min	Range Max	No		collected	Range Min	Range Max	No	Range Min	Range Max	No	No
Aug.	Beppu Bay					—	gill	Hiji	524	651	42	693	723	3	45
Sept.	Beppu Bay					—	gill	Hiji	552	664	10	685	739	6	16
〃	Iyo-nada	pur.	Kami.	261	415	10	gill	Kami.	574	683	30	688	822	9	49
Oct.	Beppu Bay					—	gill	Hiji	583	683	16	709	719	3	19
〃	Iyo-nada					—	gill	Kami.+Kuni.	581	699	43	704	830	29	72
Nov.	Beppu Bay					—	gill	Hiji	588	680	20			—	20
〃	Suo-, Iyo-nada	gill	Kami.	376	468	5	gill	Buzen+Hime.	587	698	10	701	800	20	35
Jan.	Iyo-nada	tro.	Hime+ Musashi	403	499	20	gill	Hime.+Kuni.	541	689	22	703	838	10	52
Apr.	Iyo-nada					—	gill	Kami.	650	729	12	730	887	23	35
May	Hiuchi and Bingo-Geiyo-seto					—	gill	Toyo+Ito.	573	749	59	750	1021	51	110
〃	Aki-nada					—	gill	Hiro.+Kami.	627	741	17	753	993	18	35
June	Hiuchi	pur.	Tomo	387	460	21	gill	Toyo	622	733	15	772	1030	5	41
〃	Aki-nada					—	gill	Hiro.+Toyo	509	749	58	750	997	68	126
July	Hiuchi	pur.	Tomo	436	544	24					—			—	24
〃	Aki-nada					—	gill	Ito.	628	742	22	906	906	1	23
〃	Beppu Bay					—	gill	Hiji	663	742	6	750	835	6	12

to June 1984, from commercial landings captured in the central and western waters of the Seto Inland Sea, at the places listed in Table 1. Fork lengths of these specimens ranged from 261 to 1,030 mm. Number of specimens and fishing methods used in each month and size group are also shown in Table 1.

Specimens were classified into three size groups based on the relationship between size and age of the present species determined elsewhere (KISHIDA *et al.* 1985). Small-sized group implies specimens of age group 0 captured after September and those of age group 1 captured before July. The boundary of fork length between medium- and large-sized groups were arbitrarily decided at 680 mm in August, 685 mm in September, 700 mm from October to January, 730 mm in April, and 750 mm from May to July. Consequently, the specimens of age group 1 captured after August and those of approximately age group 2 captured before July were included in the medium-sized group. The specimens of age group 2 captured after August and those over age group 3 were included in the large-sized group.

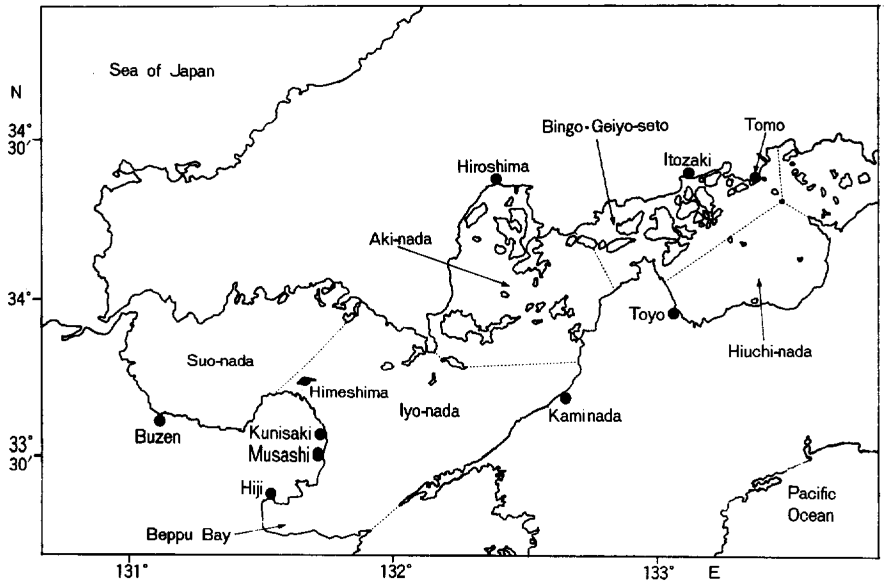

Fig. 1. Map of the central and western waters of the Seto Inland Sea. Closed circles indicate the places where samplings were made.

Fishing gears used were medium-type purse seine net, trolling, and drift gill net for small-sized group, and drift gill net for medium- and large-sized groups. Judging from the operation time of each fishing gear, specimens from the medium-type purse seine net and trolling were caught in the daytime, while those which were taken by the drift gill net were caught at night.

The places of capturing (cf. Fig. 1) were ascertained through the informations provided by the fishermen or the staffs of fish markets.

Following the measurement of the fork length and weight, the stomach was taken out from fresh specimens or from defrosted ones. The stomach contents were weighed and then preserved in 10 % formalin solution.

Pisces in the stomachs were classified into specific level from the structure of their vertebrae after the definition reported by TAKAHASHI (1962). Body weight (BW) of each fish identified was reconstructed from the vertebral column length (VCL), using the VCL-BW relationship established by TATARA *et al.* (1962). Concerning the species which were not described in their report, specimens were collected in the present area of investigation to obtain the relationship between VCL and BW. Then, the body weight was reconstructed using the newly formed relationships. For other Pisces which could not be applied the above methods, body weight was reconstructed using the relation between the degree of digestion and the weight of digested foods (after MATSUMIYA *et al.* 1980). For whitebaits appeared in June in small-sized group, which were not be able to identify to the species level, the reconstructed body weight of whitebait of Japanese anchovy *Engraulis japonica* (HOUTTUYN) included in the same stomach samples was applied.

Cephalopods in the stomachs were classified to species level by the form of beaks referring to HOTTA (1973), and also with beaks of cephalopods previously removed from the present samples. The reconstructed body weight of each cephalopod species was calculated from the relation between the lower rostral length (LRL) and body weight (BW) derived by CLARKE (1962). The identical relationship for cephalopods species occurred in the stomachs of this study was actually determined based on the present specimens. Identification and enumeration were only carried out, in the case when upper beaks alone were found in the stomach.

Crustaceans were classified to the level of sub-class or sub-order. The reconstructed body weight was estimated by their wet weight measured after being blotted dry with filter paper and with the eye observation of degree of remains.

The definition of the empty stomach was made when mucous digestive remains were only seen inside.

When the length of the object was less than 10 mm, the lengths of vertebral column etc. were measured to the nearest 0.01 mm using a digital measurement device attached to the stereoscopic microscope. In the specimen more than 10 mm in size, lengths were measured to the nearest 0.1 mm using a divider and a measuring rule. Weighing was carried out to the nearest 10 mg using an electric digital balance.

Result and Discussion

1. Relationship between the body weight and length of vertebral column, etc. for the reconstruction of prey weight

To obtain the relationship between vertebral column length (VCL) and body weight (BW), the five species of Pisces not reported in TATARA *et al.* (1962) were measured: gizzard-shad *Clupanodon punctatus* (TEMMINCK *et* SCHLEGEL), sardine *Sardinops melanostictus* (TEMMINCK *et* SCHLEGEL), Japanese Spanish mackerel, scaled sardine *Herklotsichthys zunasi* (BLEEKER) and chub mackerel *Scomber japonicus* HOUTTUYN. The scattering diagrams between VCL and BW are shown in Fig. 2, A-E. For VCL measurement the average of six columns in a portion from the forepart of caudal vertebrae was measured following the procedure reported by TATARA *et al.* (1962).

To obtain the relationship between LRL and BW, Japanese common squid *Todarodes pacificus* STEENSTRUP and squids belong to genus *Loligo* were measured (Fig. 2, F-G). Squids of genus *Loligo* collected from the catch of small-scale trawl nets in Suō-nada consisted at least of two species (*L. japonica* HOYLE and *L. kobiensis* HOYLE). Two *Loligo* species were pooled together, because it was difficult to differentiate them with the shape of beaks. As for bottle-tailed cuttlefish *Euprymna morsei* VERRILL, hood length was used instead due to the difficulty in measuring LRL in this species (Fig. 2, H).

The sampling area, number of specimens, and regression coefficient calculated by the least square method for each species are shown in Table 2.

Table 2. Summary of relationships between body weight (W; g) and vertebral column length (L; mm), lower rostral length (L; mm*1) and hood length (L; mm*2) of each species. Range is indicated by fork length or mantle length (*1 and *2). r: Correlation coefficient between $\ln L$ and $\ln W$.

Common name	Scientific name	Range (mm)		No	$\ln W = a \cdot \ln L + b$		r	Area
		Min	Max		a	b		captured
Gizzard-shad	*Clupanodon punctatus*	87	162	17	2.67	1.47	0.99	Suo-nada
Sardine	*Sardinops melanostictus*	153	185	50	2.59	1.51	0.70	Suo-nada
Japanese Spanish mackerel	*Scomberomorus niphonius*	32	478	7	2.65	0.93	1.00	Suo- and Hiuchi-nada
Scaled sardine	*Herklotsichthys zunasi*	100	111	7	1.29	1.68	0.61	Suo-nada
Chub mackerel	*Scomber japonicus*	42	166	3	2.92	−0.37	1.00	Suo- and Hiuchi-nada
Japanese common squid*1	*Todarodes pacificus*	75	136	7	2.11	1.44	0.99	Suo-nada
Calamary*1	*Loligo*	32	107	15	3.04	1.70	0.98	Suo-nada
Bottle-tailed cuttlefish*2	*Euprymna morsei*	10	28	7	3.27	0.50	0.93	Suo-nada

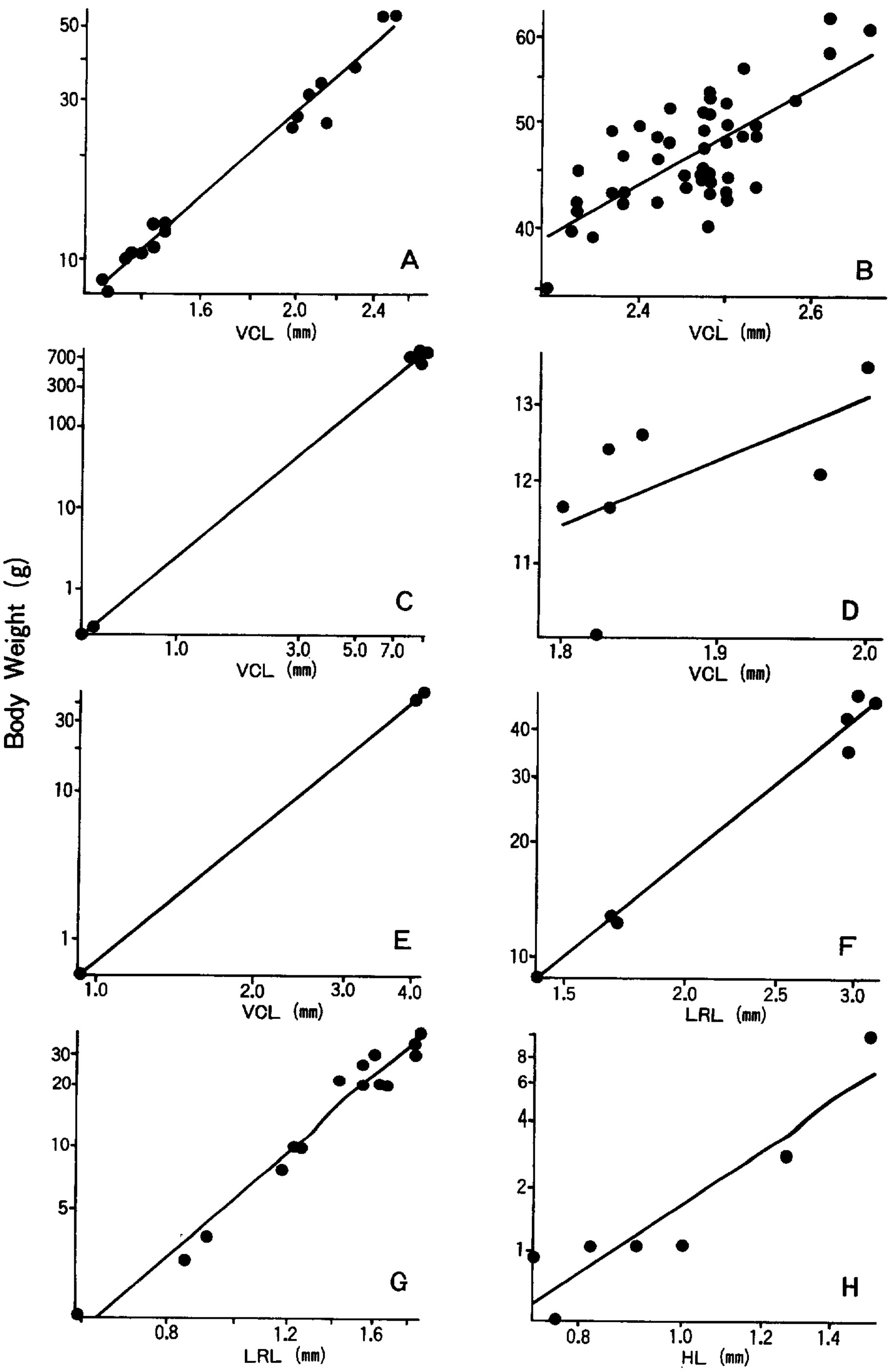

Fig. 2. Relationships (1) between vertebral column length (VCL) and body weight of different species of fish (A—E), (2) between lower rostral length (LRL) and body weight of each squid species (F, G), and (3) between hood length (HL) and body weight of bottle-tailed cuttlefish (H).

A: gizzard-shad. B: sardine. C: Japanese Spanish mackerel. D: scaled sardine. E: chub mackerel. F: Japanese common squid. G: calamary. Scientific name of each species is shown in Table 2.

For round scad *Decapterus maruadsi* (TEMMINCK *et* SCHLEGEL) the value of regression coefficient (m) and constant (n) in the relationship between body length and total length reported by TATARA *et al.* (1962), were substituted by 1.2 and −3.7, respectively, referring to the scattering diagram given in Fig. 9 of the paper.

2. Seasonal variation in feeding activity

The consumption index is defined as follows:

100 Rw/(Bw-Scw)

where Rw is reconstructed weight of stomach contents, Bw is predator body weight, and Scw is stomach contents weight in grams.

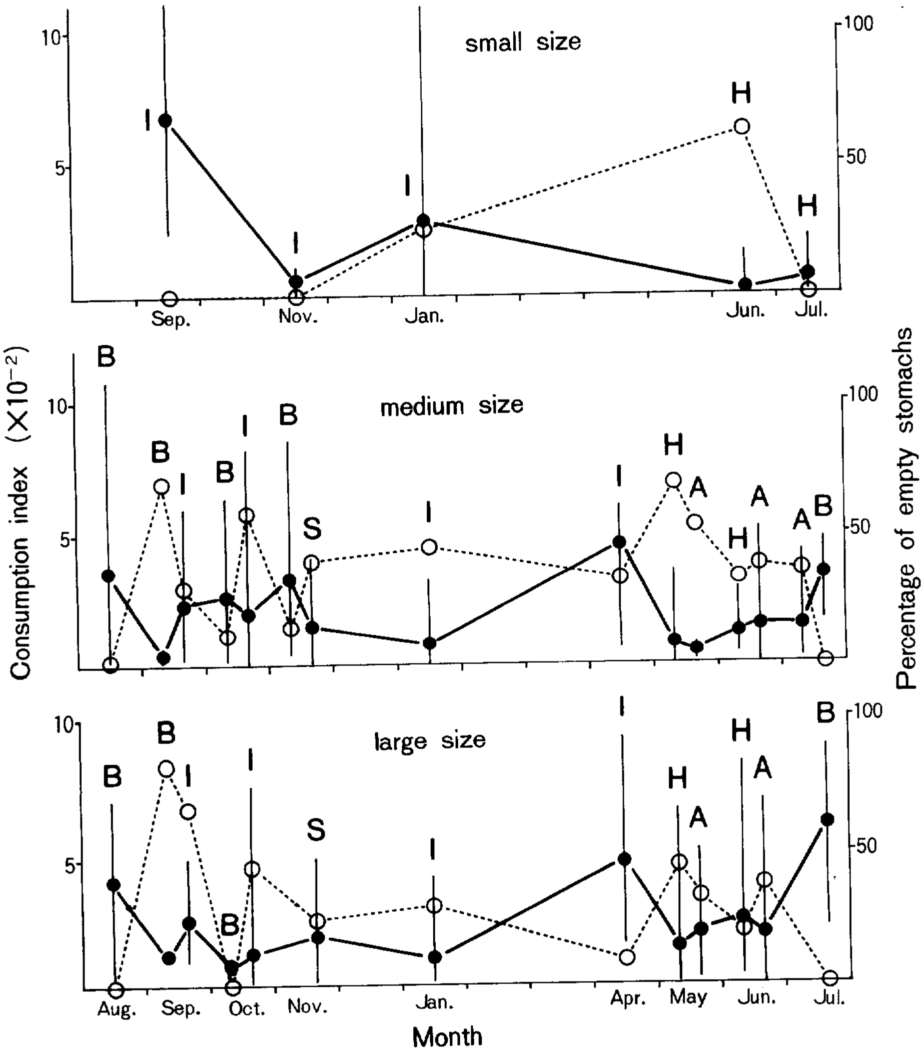

Fig. 3. Monthly and regional changes of mean consumption index for different size groups (closed circle). Vertical lines show the minimum and maximum ranges of the indices. Percentage of empty stomachs is indicated by open circle. B=Beppu Bay. I, S, H, A=Iyo-, Suo- and Iyo-, Hiuchi-, Aki-nada (nada means a local sea area as shown in Fig. 1).

The mean consumption index for each group differentiated by month, area, and predator size is shown in Fig. 3. The size range of each group is identical with that given in Table 1. Specimens with empty stomachs were treated separately from the calculation of this index. The minimum and maximum ranges of the consumption indices and the percentage occurrence of empty stomachs are also shown in the same figure.

Specimens of medium- and large-sized groups were captured at night, i. e., a period between after sunset and before sunrise at the latest, since they were captured by drift gill net. UCHIHASHI (1976) postulated that Japanese Spanish mackerel seems to take food from dawn to dusk, but not during the night, based on his studies concerning the form of brain. Hence, the stomach contents of medium- and large-sized groups are presumably the remains of food ingested before sunset. If the time required to complete digestion is equal regardless of prey taxon, size, and temperature of the environment, the consumption index indicates roughly the gross quantity of consumption per body weight of predator during a certain fixed period before sunset. Thus, the index described above would be appropriate to express the intensity of feeding activity.

As shown in Fig. 3, samples in April, July and August in Beppu Bay showed high consumption indices in medium- and large-sized groups. Although the spawning season of Japanese Spanish mackerel in the investigated area has been found from May to July (KISHIDA *et al.* 1985), the condition factor (Bw/L^3; L is fork length in millimeters) of these groups indicated an obvious decrease in the spawning season, and increased during pre- and postspawning periods (Fig. 4). The decrease of the condition factor in the spawning season may be caused by the diminish of body weight following the spawning or spending activities. The periods of increase of the condition factor corresponded approximately to the periods of active feeding shown in Fig. 3. These facts suggest that this species compensates the decrease of body weight caused by spawning or spending by increasing the feeding activity during pre- and postspawning periods. Further, the samples collected from Beppu Bay in July seemed to belong to a postspawning group, because the mean gonad indices (24.5 for medium-sized and 35.6 for large-sized group)were small in comparison with those in the spawning season reported by KISHIDA *et al.* (1985).

In the small- and medium-sized groups, the consumption indices during summer and fall appeared to be higher than in winter. This trend may correspond to the fact that summer and fall are the growing seasons of this species (KISHIDA *et al.* 1985). However, the consumption indices for June and July in small-sized group appeared to be relatively small, although these months also seem to be in the growing season. This may be caused by the diurnal feeding rhythms, since these specimens were captured in

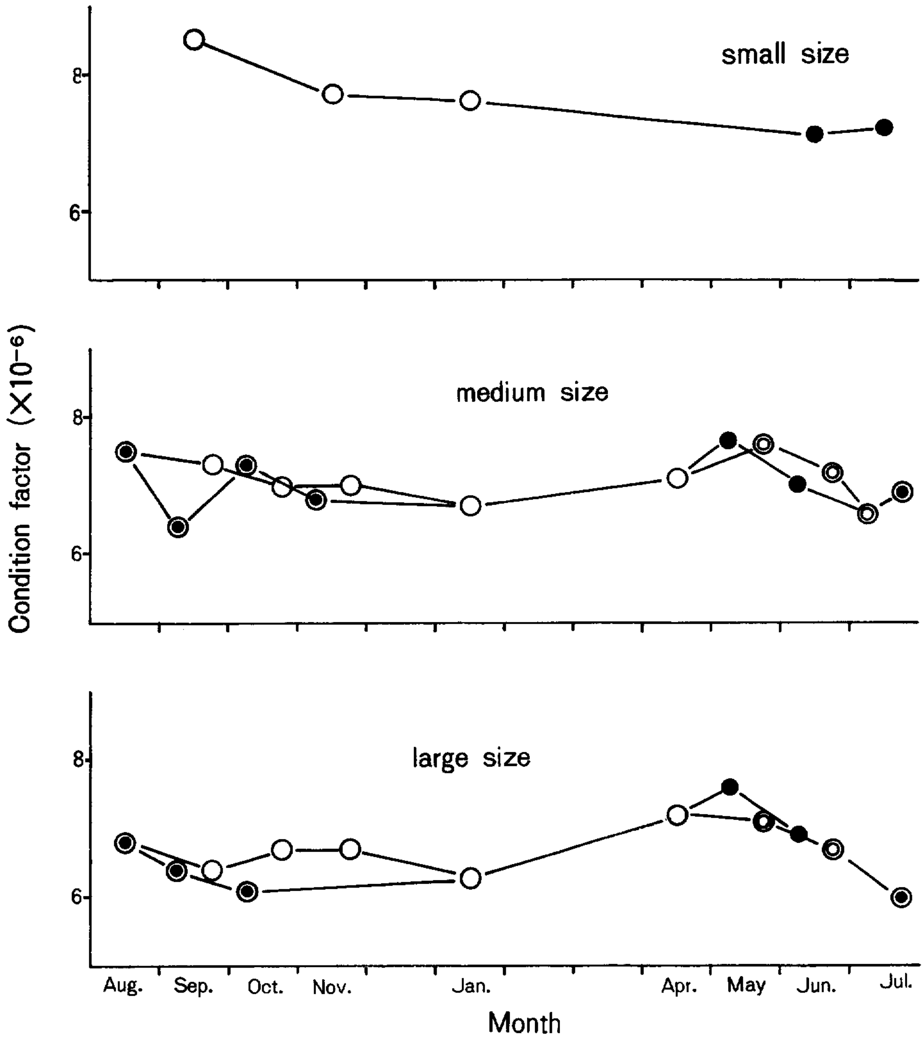

Fig. 4. Monthly change of the average condition factor of Japanese Spanish mackerel for different size groups.
◉: Beppu Bay. ○: Iyo-nada. ●: Hiuchi-nada. ◎: Aki-nada.

daytime, though time of catch is unknown, despite the specimens of medium-sized group were captured at night. Although it seems necessary to examine factors such as the size of prey and water temperature, which presumably affect the speed of digestion, they were remained for future investigation.

Concerning the percentages of empty stomachs, the seasonal variation, which is the reciprocal of feeding activity, was reported for Japanese whiting *Sillago sihama* (FORSKÅL) (KAKUDA 1970). For medium- and large-sized groups of Japanese Spanish mackerel, there was a similar trend throughout the year that the curves for the percentages of empty stomachs were the reciprocal of those for the mean consumption indices (Fig. 3). However, the influence of daily feeding periodicity was unable to consider, because the time of capture by the gill net could not be specified. In the case of bastard halibut *Paralichthys olivaceus* (TEMMINCK *et* SCHLEGEL) which takes prey in daytime (KIYONO 1973) in the same way as Japanese Spanish mackerel, the percentage of empty stomachs reaches the maximum before sunrise (HAMANAKA and KIYONO 1978).

However, concerning the relationship between percentage of empty stomachs and consumption index, there were some exceptions for the present species in the large-sized group in October in Beppu Bay and medium-sized group in April in Iyo-nada. HAYASHI (1983) described that the percentage of fish with diets in the stomach tend to increase with the relative enhancement of the abundance of prey. In October, the abundance (density) of prey was presumably high, because no empty stomach was notified despite the consumption index was small. According to HAYASHI (1983), a high percentage of empty stomachs may partly be caused by low density of prey and in-active feeding as well. In the present study, a relatively large consumption index of medium-sized group was found in April. This value was presumably derived from an active feedind. Nevertheless, the percentage of empty stomachs reached up to 33 %. As will be described later, the diet of this month consisted almost exclusively of sardine over 50 g in weight. The abundance of small prey (cf. Fig. 6), which seems to be captured without great effort by medium-sized group, was probably low. The percentage of empty stomachs was therefore comparatively high.

3. Species and size composition of feed

Among 714 specimens examined in this study, 456 stomachs contained foods. In these stomachs, 25 taxa of food including 16 fish species were identified. The total number of individuals was 3,809. Main foods for small-sized group were Japanese anchovy, sand lance *Ammodytes personatus* GIRARD, Japanese common squid and Atlantic cutlassfish *Trichiurus lepturus* LINNAEUS. While, sardine, Japanese anchovy, Japanese common squid, Atlantic cutlassfish, sand lance, gizzard-shad, round scad and chub mackerel were eaten by medium- and large-sized groups.

The diet composition obtained by the number method (HYNES 1950) is shown in Table 3. Further, the reconstructed weight composition for main food items are shown in Fig. 5 (small-sized group) and Fig. 6 (medium- and large-sized groups). Here, reconstructed weight of each prey was grouped into every 10 g intervals. The total of the reconstructed prey weight for each weight class and each food item was then calculated. The percentages of the total weight of each food item and weight class against the sum total of the weight of reconstructed stomach contents of each group were then

Table 3. Diet composition of Japanese Spanish mackerel determined by the Number Method for each size group, month, and geographical area. Figures in the table indicate the percentage composition defined as follows: 9=100—90%, 8=90—80%, ···, 0=10—0%, dash=zero. Boldfaced figures correspond to the species written with boldfaced letters.

B=Beppu Bay. I: Iyo-nada, S: Suo- and Iyo-nada, H: Hiuchi-nada, A: Aki-nada. S, M, L=small-, medium-, and large-sized group, respectively.

Food items		Predator size	Au.	Sep.		Oct.		Nov.		Ja.	Ap.	May		June		July	
Common name	Scientific name			B	I	B	I	B	S			H	A	H	A	A	B
Japanese anchovy	*Engraulis japonica*	S			9				1	0				—		9	
		M	9	3	8	3	5	0	9	0	—	0	2	9	1	7	0
		L	1	—	3	2	9		9	3	—	0	0	2	3	—	0
Japanese anchovy's whitebait		S			—				—	1				0		—	
Unidentified whitebait		S			—				—	**0**				**6**		—	
Sardine	*Sardinops melanostictus*	S			0				—	—				—		—	
Japanese codlet	*Bregmaceros japonicus*	M	0	—	0	**0**	—	—	—	—	8	—	—	—	0	0	4
		L	5	—	—	—	—		0	0	7	0	1	—	1		4
Atlantic cutlassfish	*Trichiurus lepturus*	S			—				3	—				—		**0**	
Japanese Spanish mackerel	*Scomberomorus niphonius*	M	0	—	—	3	0	5	—	—	—	—	2	—	0	—	—
		L	1	—	1	6	**0**		—	—	0	—	—	—	0		—
Sand lance	*Ammodytes personatus*	S			—				—	8				—		—	
Round scad	*Decapterus maruadsi*	M	**0**	—	**0**	**1**	**2**	—	—	8	—	9	—	—	7	0	—
		L	**1**	—	**1**	—	**0**		—	1	—	8	1	—	5		—
Chub mackerel	*Scomber japonicus*	S			—				—	—				—		0	
Japanese horse mackerel	*Trachurus japonicus*	M	**0**	—	0	**0**	0	—	—	—	—	—	—	—	—	—	**0**
Horse-scad mackerel	*Decapterus muroadsi*	M	**0**	—	—	—	0	—	—	—	—	—	—	—	—	—	—
Scaled sardine	*Herklotsichthys zunasi*	L	1	—	—	—	—		**0**	—	—	—	—	—	—		—
Unidentified Carangidae		M	0	—	—	0	0	—	—	—	—	—	—	—	—	—	0
Yellowspotted bandfish	*Acanthocepola krusensterni*	L	—	—	—	—	—	—		—	—	—	—	—	**0**		0
Gizzard-shad	*Clupanodon punctatus*	M	0	—	0	**0**	—	—	—	—	—	—	—	—	0	—	—
Banded blue-sprat	*Spratelloides gracilis*	L	—	—	—	—	—		—	—	—	0	—	5	0		0
Round herring	*Etrumeus teres*	M	0	—	0	0	0	—	—	—	—	—	—	—	—	—	—
Silverside	*Allanetta bleekeri*	L	—	—	—	**2**	—		—	—	—	—	—	—	—		—
Unidentified fish		S			—				0	—				0		0	
		M	0	3	0	0	0	0	—	0	0	0	3	0	0	0	1
		L	—	9	1	—	0		0	1	0	0	1	1	0		1
Japanese common squid	*Todarodes pacificus*	S			—				—	—				0		0	
Calamary	*Loligo*	M	—	**3**	—	—	**0**	**0**	**0**	0	1	0	3	0	0	0	2
		L	—	—	1	—	**0**		**0**	**0**	1	0	5	—	0		3
Bottle-tailed cuttlefish	*Euprymna morsei*	S			—				**0**	0				—		—	
Unidentified squid		M	—	—	—	**0**	**0**	—	—	0	—	**0**	—	—	—	—	—
		L	—	—	—	—	—		—	4	—	—	—	—	—		—
Shrimp	*Macrura*	S			—				1	0				1		—	
Crab's megalopa	*Brachyura*	M	—	—	0	**0**	—	0	—	—	—	—	—	—	—	—	—
		L	—	—	1	—	—		0	—	—	—	—	—	—		—
Isopod	*Isopoda*	M	**0**	—	—	0	0	—	**0**	—	—	—	—	—	—	0	—
Seaweeds		L	—	—	1	—	—		0	—	—	—	—	—	0		—
Mantis shrimp's larva	*Stomatopoda*	S			—				0	—				—		—	
		M	0	—	0	0	—	3	—	—	—	—	—	—	—	—	—
Copepod	*Copepoda*	S			—				**1**	—				—		—	
Unidentified crustacean		M	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—
Unidentified organism		M	—	—	—	—	**0**	—	**0**	—	—	—	—	—	—	—	—
Indigestible substance*		L	—	—	—	—	0		—	**0**	—	0	—	—	—		—

* Nylon filament, a piece of net, etc.

calculated by month, area, and size. The foods which could not be identified and those of difficult to reconstruct original body weight because of quick digestion were eliminated from these figures.

The monthly occurrence of main food eaten were summarized as the following based on Table 3 and Figs. 5 and 6. Japanese anchovy was the predominant food by number. The total number of this species in the entire specimens was 1,880. The mean body weights for small-, medium-, and large-sized groups were 1.2, 2.4, and 4.2 g, respectively. Although the individual body weight was rather small, this species was important especially for the small- and medium-sized groups during June and November, occupying with high percentages in weight basis. For large-sized group, Japanese anchovy was also the principal food in November in Suō-nada and Iyo-nada. The majority which occurred during January and June in the small-sized group was the whitebait.

Sardine (Total number of individuals: 204, BW in each size group: 12.6, 36.8, and 47.3 g) was the most important prey on a weight basis. This species was less important in the premature stages of Japanese Spanish mackerel. However, it was the dominant food from the beginning of the first maturation (April in medium-sized group), excluding a period from September to November. This feed was most important pery in April and June in Aki-nada, and July and August in Beppu Bay.

Sand lance (Total number of individuals: 1,082, BW in each size group: 2.3, 1.1, and 1.1 g) was the predominant prey for small- and medium-sized groups from January through May, excluding April, when Japanese anchovy diminished its occurrence in the stomachs.

Japanese common squid (Total number of individuals: 129, BW in each size group: 6.2, 16.8, and 25.1g) and gizzard-shad (Total number of individuals: 19, BW in each size group: none, 44.6, and 88.3 g) occurred mainly in the stomachs from May to July. Japanese common squid was most weighty for medium- and large-sized groups in May and for small-sized group in June. Gizzard-shad was prominent for large-sized group in June in Hiuchi-nada.

Atlantic cutlassfish (Total number of individuals: 127, BW in each size group: 2.5, 13.3, and 39.0 g), round scad (Total number of individuals: 63, BW in each size group: none, 3.3, and 59.3 g), and chub mackerel (Total number of individuals: 8, BW in each size group: 0.1, 74.6 g and none) occurred mainly in the stomachs during fall. Atlantic cutlassfish was particularly predominant in October and November in Beppu Bay. Round scad and chub mackerel were relatively notable in September and October in Iyo-nada, but occurred very rarely during other periods. Although the differentiation between chub mackerel and spotted mackerel *Scomber australasicus* CUVIER by the structure of vertebrae has been found impracticable (TAKAHASHI 1962), they were classified as chub mackerel dependind on the information about the area of distribution (TATARA *et al.* 1965).

Japanese Spanish mackerel itself was also found in the stomachs. Eight juveniles (mean BW : 1.1 g) occurred in July in the small-sized group and a young fish (BW: 221 g) in October in the large-sized group.

These animals described above seemed to be the pelagic or the mesopelagic species (TATARA 1977). Thus, the diet of Japanese Spanish mackerel consisted almost entirely of the pelagic and mesopelagic animals, though the diet composition varied seasonally and with the developmental stages of predator. Food of the present species reported by HAYASHI (1919) and WHANG *et al.* (1977) are also the pelagic or the mesopelagic animals. However, yellowspotted bandfish *Acanthocepola krusensterni* (TEMMINCK *et* SCHLEGEL) which occurred in June in the large-sized group (mean BW: 103 g) was defined as the benthic species (HAYASHI and YAMAGUCHI 1962). Thus, this species seemed to be an exceptional diet of Japanese Spanish mackerel.

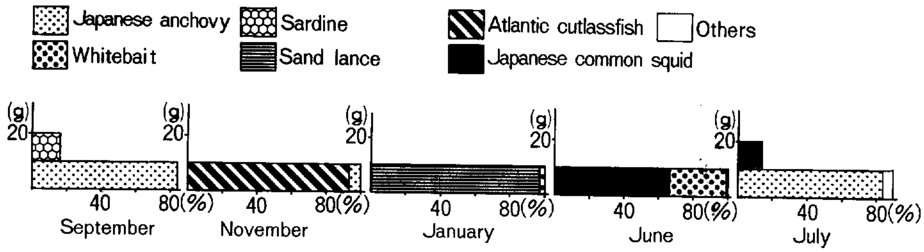

Fig. 5. Monthly change of the reconstructed prey weight composition for small-sized group. For scientific names refer to the legend for Table 3.

A weak similarity of the food composition for specimens collected from different localities were observed despite they belonged to the same size group and were captured in the same month. In October, principal prey in Beppu Bay was Atlantic cutlassfish, whereas Japanese anchovy, round scad, and chub mackerel were abundant in Iyo-nada. In November, the principal prey was Japanese anchovy in Suō-nada and Iyo-nada in the medium-sized group, while Atlantic cutlassfish in Beppu Bay. Further, diet composition of the medium- and large-sized groups in May and June revealed that sardine was presumably important component of diet in Aki-nada than in Hiuchi-nada. The reverse relationship was noticed for sand lance and gizzard-shad. In July, difference was also obvious for medium-sized group. The principal feed was Japanese anchovy in Aki-nada, and sardine in Beppu Bay. These diversities of diet compositions among the

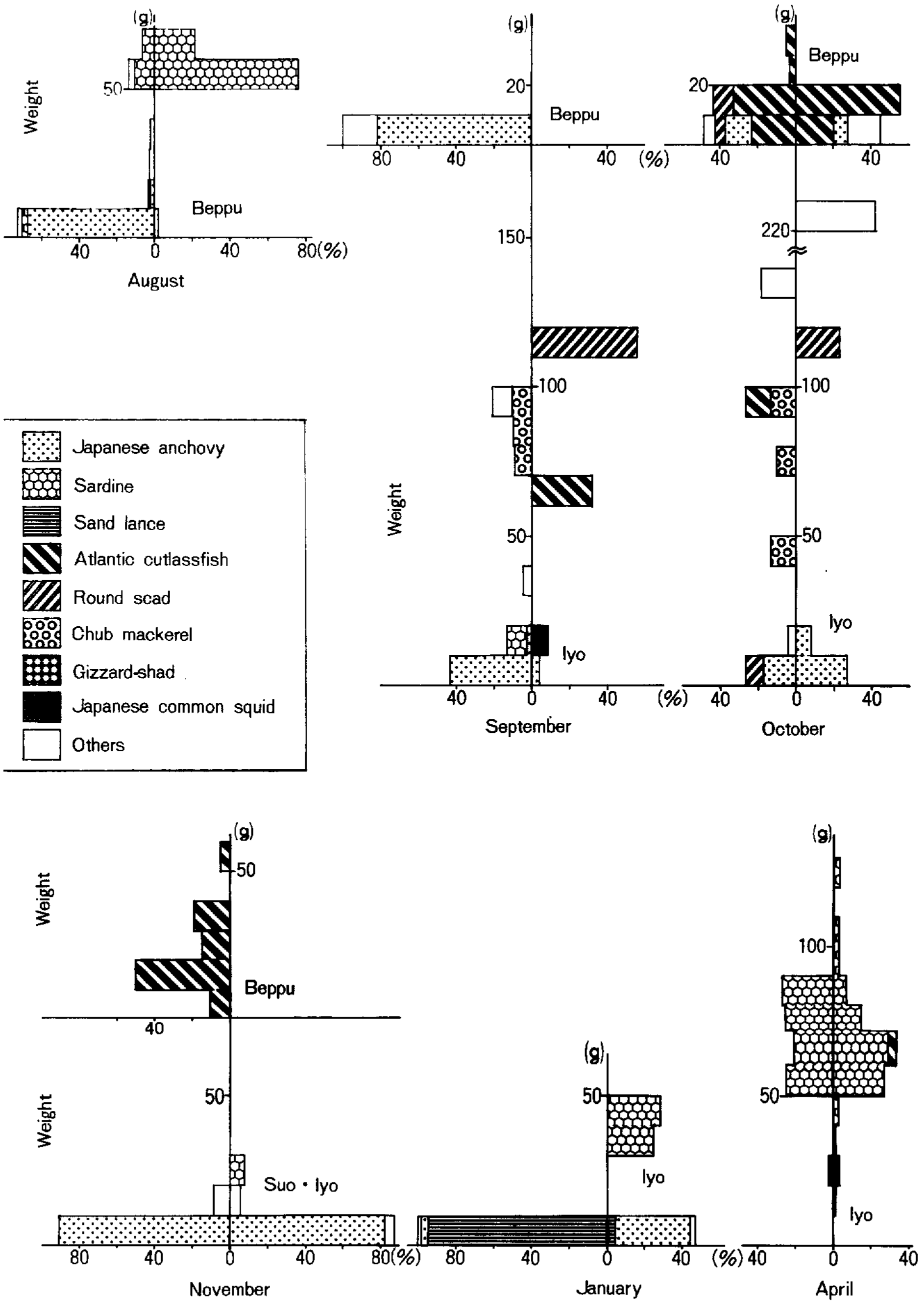

Fig. 6. Monthly and regional changes of the reconstructed prey weight composition. The medium-sized group is shown on the left and the large-sized group on the right side of ordinates. For scientific names refer to the legend for Table 3.

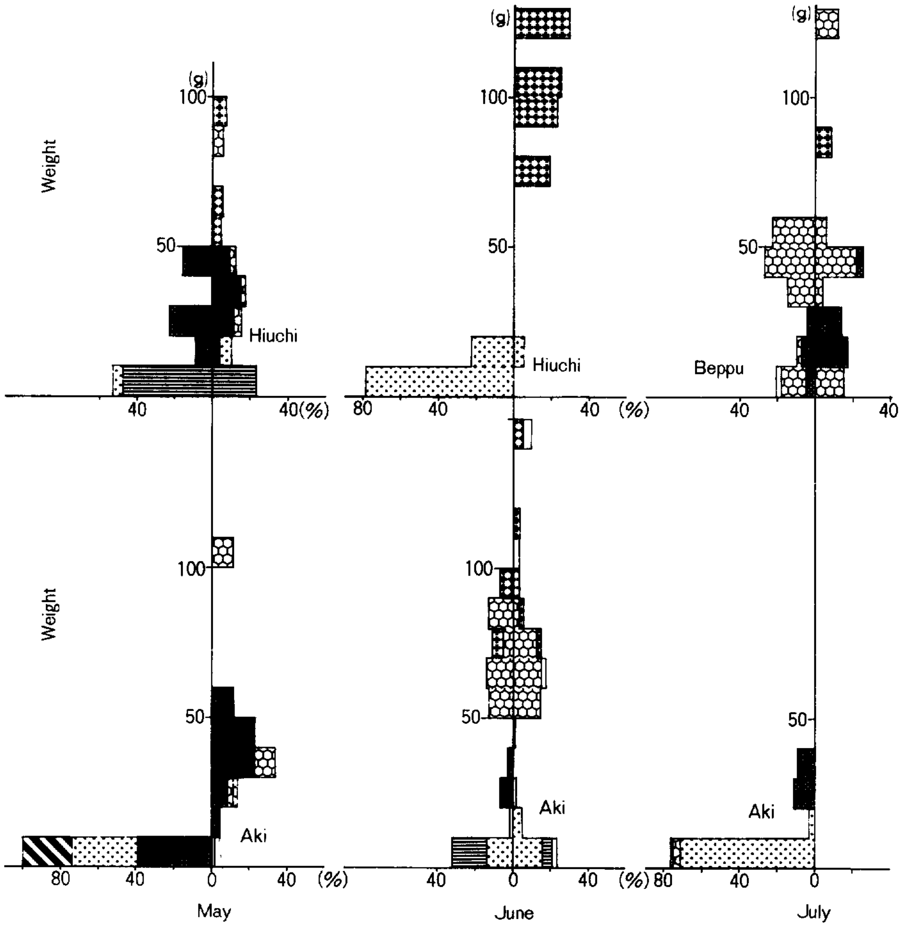

Fig. 6. continued

geographical areas may reflect the difference of food composition in the respective environment. Although the food of Japanese Spanish mackerel was limited mainly to the pelagic and mesopelagic Pisces and cephalopods, the preference for food seemed to be negligible. The seasonal variation in diet composition as described above is presumably ascribed also to the diversity of foods in the environment. The seasonal variation of the food composition should be influenced by the seasonal changes of pelagic and mesopelagic fauna there, and also by the pattern of seasonal migration of Japanese Spanish mackerel in the areas investigated.

As shown in Figs. 5 and 6, the weight composition for small-sized group revealed that the majority was less than 10 g with an upper limit of 20 g. The maximum ratio of prey/predator weight (R) was obtained as 5.0 % with sardine in September.

For medium- and large-sized groups, the upper limits of the weight of feed increased. The largest prey for the medium-sized group was round herring *Etrumeus teres* (DEKAY), 133 g in weight, and 221 g of Japanese Spanish mackerel was eaten by the large-sized group. Both species were found in specimens collected in October. Thus, the maximum value of R was obtained as 5.7 % in medium- and 7.4 % in large-sized groups.

The upper limits of the weight of prey in each month and area for medium- and large-sized groups indicated considerable fluctuations. This suggests that environmental characteristic of different research area is not identical from the viewpoint of prey size. However, the upper limit of the weight of prey of large-sized group was greater than that of medium-sized group regardless of sampling month and area. The degree of dependence on small prey including Japanese anchovy and sand lance decreased in the large-sized group. Hence, it is noticed that the percentage of large prey increased with the enlargement of predator size, although this tendency could be restricted by the feature of food in the environment.

Acknowledgments

I am indebted to Y. KAMIJYO and Y. YOKOMATSU of Oita Prefectural Shallow Sea Fisheries Experimental Station, I. HAYASHI of Fukuoka Prefectural Buzen Fisheries Experimental Station and the staff of Toyo Branch, Ehime Prefectural Fisheries Experimental Station, for their co-operation in collecting the specimens. I am also grateful to H. ITO of Nansei Regional Fisheries Research Laboratory for his kind supply of samples. A special thanks to K. UEDA and K. TAKAO of NRFRL for their support throughout this study. Thanks are also due to M. ANRAKU of NRFRL for the improvement of manuscript.

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瀬戸内海中西部域におけるサワラの食性

岸田　達

1981年５月から1984年６月までの間に瀬戸内海中西部域で漁獲されたサワラ714尾の胃内容物を調査し，以下の知見を得た。

1．産卵期の前後である４月及び７月の一部と８月には，親魚群の摂餌活動が活発化する。

2．未成魚群の成長期にも摂餌活動が活発な傾向がうかがえた。

3．全体をとおしての主な餌生物は，カタクチイワシ，マイワシ，イカナゴ，タチウオ，マルアジ，スルメイカなど，表・中層性の動物であった。

4．餌組成は，季節・海域によって差異がみられた。

5．捕食者が大きくなると，大型の餌の比率が増加する傾向がみられた。