PRELIMINARY STOMACH CONTENTS ANALYSIS OF PELAGIC FISH COLLECTED BY SHOYO-MARU 2002 RESEARCH CRUISE IN THE ATLANTIC OCEAN

Keisuke Satoh[1], Kotaro Yokawa[1], Hirokazu Saito[1], Hiromasa Matsunaga[1], Hiroaki Okamoto[1] and Yuji Uozumi[1]

SUMMARY

Stomach contents of eleven pelagic fish species were investigated. The fishes were caught by longline operations of the Japanese research vessel Shoyo-Maru research cruise from 23 June to 16 October 2002 in the North and tropical Atlantic Ocean. Five hundred and sixty-nine stomachs collected in the cruise were investigated and at least 50 families of prey were identified. The results indicated that dolphin was indicated to be a typical piscivor and lancetfish was an opportunistic feeder. The diet compositions of Atlantic sailfish, white marlin, and longbill spearfish were very similar to each other. For tuna and billfish except for Atlantic blue marlin, bramidae and gempylidae were suggested to be important prey organisms in this study. From the viewpoint of prey-predator relationships, the two families (bramidae and gempylidae) appear to play an important role in the ecosystem of the open ocean for large pelagic species.

RÉSUMÉ

Les contenus stomacaux de onze poissons pélagiques ont été examinés. Les poissons ont été capturés à la palangre dans le cadre de la campagne de recherche menée par le navire de recherche japonais Shoyo-Maru du 23 juin au 16 octobre 2002 dans l'océan Atlantique nord et tropical. Au total, 569 estomacs prélevés pendant la campagne ont été examinés et au moins 50 familles de proie ont été identifiées. Les résultats ont indiqué que le dauphin était un piscivore typique et que l'Alepisaurus spp s'alimentait de manière opportuniste. Les régimes alimentaires du voilier, du makaire blanc et du makaire bécune étaient très similaires. Pour les thonidés et les istiophoridés, à l'exception du makaire bleu de l'Atlantique, on a suggéré que, dans cette étude, les bramidae et les gempylidae étaient d'importants organismes servant de proie. Du point de vue des rapports proie-prédateur, les deux familles (bramidae et gempylidae) semblent jouer un rôle important dans l'écosystème en haute mer pour les espèces de grands pélagiques.

RESUMEN

Se investigaron los contenidos estomacales de once especies de peces pelágicos. Los peces fueron capturados en el Atlántico norte y tropical en operaciones de palangre durante la campaña de investigación del buque japonés de investigación Shoyo-Maru desde el 23 de junio al 16 de octubre de 2002. Se han investigado quinientos sesenta y nueve estómagos recogidos en esta campaña y se identificaron al menos 50 familias de presas. Los resultados indicaron que el delfín es un piscívoro típico y el pez lanceta se alimenta de forma oportunista. La composición de las dietas del pez vela, la aguja blanca y la aguja picuda era muy similar. Este estudio sugirió que para los túnidos y los marlines, excepto para la aguja azul del Atlántico, los bramidae y gemplydae son importantes organismos de presa. Desde el punto de vista de las relaciones presa-predador, las dos familias (bramidae y gemplydae) parecen desempeñar un papel importante para las grandes especies pelágicas en el ecosistema de los océanos.

KEYWORDS

Stomach content, longline, pelagic fish

[1] National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan. e-mail: kstu21@fra.affrc.go.jp

1 Introduction

Several studies on the stomach contents were reported for large pelagic fishes (e.g. Matthews *et al*., 1977, Moteki *et al*., 2001, Abitia *et al*., 1999, and Rosas *et al*., 2002), however, very little is known on the trophic biology for marlins such as Atlantic sailfish (*Istiophorus albicans*, Jolley (1977) cited in Rosas *et al*. (2002), Nakamura (1985)) and longbill spearfish (*Tetraptrus pfluegeri*, Nakamura (1985)). In 2002, a research cruise of R/V Shoyo-Maru was conducted to investigate the spawning activity of bluefin tuna in North Central Atlantic and the habitat preference and stock structure of marlins and swordfish in the tropical Atlantic. The stomach contents were collected by longline operations during this research cruise, and identified to the lowest possible taxon. Then, the importance of each prey organisms was investigated and compared among the large pelagic fishes. The purpose of this paper is to report the results of this study on the diet of pelagic fishes including such as marlines.

2 Materials and methods

During the Shoyo-Maru cruise from 23 June to 16 October 2002 in the Atlantic from 60° to 21°W and from 42°N to 9°S, fifty seven long line operations were made (Fig. 1, Table 1). Detail information on the type of gear configuration and oceanographic observation during the first two legs were reported by Okamoto *et al*. (2003). For the next two legs the fishing gear configuration was different from the previous legs but the oceanographic observations were conducted similarly. As the oceanological information in each sampling site, surface temperature and depth of thermocline were referred from CTD observation.

Each specimen caught by longline operation was weighed and measured on the deck and its stomach was weighed and kept in formalin diluted to about 10% by salt water. The prey species in the stomach was identified to the lowest possible taxon. The wet weight and standard length (or total length or mantle length) were measured.

To estimate the importance of each food items among the forage, an Index of Relative Importance IRI (Pinkas *et al*., 1971) was calculated as follows,

$$IRI_i = (\%N_i + \%W_i) \cdot \%F_i$$

where $\%N_i$ is the percentage of food item i in number, $\%W_i$ is percentage of food item i in weight and $\%F_i$ is percentage of occurrence frequency in the food item i. Although the IRI may not be good index as pointed out by MacDonald and Green (1983), this index was used in this paper because IRI was often used in other studies on stomach contents and it is easy to compare with the results of other studies.

To estimate the importance of each food item among the stomach contents, IRI expressed on a percent basis (Cortes, 1997) was also calculated.

$$\%IRI_i = \frac{100 \cdot IRI_i}{\sum_i^n IRI_i}$$

where n is the total number of food categories considered at a given taxonomic level.

To assess the food composition similarity among the predator, Pianka's α index (Pianka ER, 1973) was calculated.

$$\alpha_{jk} = \frac{\sum_i p_{ij} \cdot p_{ik}}{\sqrt{\sum_i (p_{ij})^2} \cdot \sqrt{\sum_i (p_{ik})^2}}$$

where p_{ij} is %F of prey item i in stomach of predator j, p_{ik} is %F of prey item i in stomach of predator k. The index distributes between 0 and 1, and the similarity is higher as the index is closer to 1.

The matrix of Pianka's α index was used as input data for cluster analysis based on Euclidean distance and UPGMA (unweighted pair-group method using arithmetic average) algorithm (Duque and Winemiller, 2003). However, the Pianka's α index was standardized to convert into Euclidian distance (Ds) using logarithmic transformation, $Ds = -\ln\alpha_{jk}$ (Nei, 1987). The most commonly used genetic distance measure was developed by Nei (1987). Nei's standard genetic distance Ds is calculated by logarithmic transformation of genetic identity and the equation to measure this genetic identity is identical to the equation of Pianka's α index.

3 Results

3. 1. Oceanographic condition

Operation date, location, sea surface temperature and the mixed layer depth of each longline operation were shown in Table 1 and Fig. 1. The thermocline depths during the first two legs were shallower than 50m except for 10th operation, although the depths were not clearly detected in several cases. In the later two legs, thermoclines were about 50m in the first five stations and 80-130m depth layer in the next 18 stations except for 41st operation. In the remaining stations, thermoclines were about 50m depth. The typical temperature profiles at five stations were shown in Fig. 2.

3. 2. Stomach contents

The total catch number was 1,323 and the number of stomach contents analyzed was 568 (Table 2). The ratios of empty stomach to total stomach observed were calculated (Fig. 3). The quite low ratios of blue shark and shortfin mako were considered to be biased low because these species were not lifted on deck but tagged and released when they were alive. The ratio of lancetfish seemed to be less precise because their impeccable body could not always be retrieved on the deck. The ratios were over 50% for the species, which the number of specimen was larger than 10 individuals.

The number of predator species was 24 (Table 2). The list of food items identified was shown in Table 3. At least 50 food items in total were identified from the stomach contents, however the cephalopods were identified only to order level. The %F, %N, %W, IRI, and %IRI of each large category of food items (pisces, cephalopods, other mollusks, crustaceans, and miscellaneous) were shown by each pelagic species in Table 2.

The %IRI and the Pianka's α index (Table 4) were shown in Fig. 4 for the species, whose number of specimen was larger than 10 individuals. The prey composition of lancetfish (*Alepisaurus ferox*) was very different from other species, similarity index α was ranged 0.546 to 0.786, and %IRI for pisces and cephalopod was lower than other pelagic species. Dolphin (*Coryphaena hippurus*) had different stomach composition comparing with other species because of its high %IRI for pisces. The high α index (0.989) between albacore (*Thunnus alalunga*) and bigeye tuna (*Thunnus obesus*) was derived from their higher IRI for crustaceans compared to other pelagic species. In general, other species showed highest %IRI for pisces and second highest value for cephalopod.

Bigeye tuna (*Thunnus obesus*)

The number of specimen was 77 and pisces were dominant (%IRI=68.5%) in their stomachs, followed by cephalopods (23.1%) and crustaceans (8.2%, Table 2). At least 21 families of pisces were found in the stomachs of bigeye tuna. Based on %IRI for pisces identified to family level, bramids (43.0%), myctophids (39.2%), and gempylids (12.4%) were dominant (Table 5). This fish prey composition at family level was relatively similar to albacore among species studied (Table 6). Oplophoridae (decapoda) was dominant species (93.2%) in crustaceans but found at relatively small area from 21°to 23°W and from 7° to 8°S.

Yellowfin tuna (*Thunnus albacares*)

Forty seven yellowfin tuna were investigated. The most important prey item was pisces (73.1%)、and secondly cephalopod (25.5%). The importance of crustaceans was quite low (0.3%, Table 2). Twelve families of pisces were found and the most dominant families in terms of %IRI were bramids, molids and scombrids (53.8%, 24.1% and 13.3%, respectively, Table 5). This composition was similar to those of longbill spearfish, Atlantic sailfish, and white marlin with α index of 0.777, 0.829 and 0.849, respectively (Table 6).

Albacore (*Thunnus alalunga*)

The number of sample was 19. Based on %IRI, pisces was dominant (67.0%) followed by cephalopod and crustaceans (22.1% and 9.3%, respectively, Table 2). Ten families of pisces were found (Table 6-1) and alepisaurids, bramids, gempylids and paralepidids dominated with high %IRI (31.7%, 24.6%, 17.1% and 16.8%, respectively). The high rank of alepisaurids in albacore stomach was distinctive of other tuna and billfish species. The prey fish composition at family level for albacore was different from yellowfin tuna but similar to bigeye tuna (Table 6). Although the %IRI was low, platyscelids (crustaceans) occurred only in albacore stomach among tuna species.

Longbill spearfish (*Tetrapturus pfluegeri*)

The number of specimen was 53. %IRI of pisces (76.9%) was highest and cephalopods had the second highest value (20.4%) while other categories were nearly non-existent (Table 2). Twelve families of pisces were found in the stomachs of longbill spearfish. Based on %IRI for pisces, gempylids (38.8%), exocoetids (25.0%) and scombrids (19.0%) were dominant. Bramids (9.7%) was low (Table 5).

Atlantic sailfish (*Istiophorus albicans*)

The number of specimen was 42. In the large prey category, the food composition was similar to longbill spearfish and Atlantic blue marlin (Table 2). Fishes consumed by Atlantic sailfish belonged to twelve families. The most dominant families in terms of %IRI were bramids, gempylids, molids and scombrids (49.4%, 20.9%, 13.0% and 8.0%, respectively, Table 5).

White marlin (*Tetrapturus albidus*)

The number of specimen was 32. The %IRI for pisces (57.2%) were dominant but relatively low compared with other tunas and marlines. Cephalopods had the second highest value (42.6%, Table 2). The %IRI of cephalopod was higher than other billfishes. Six families of pisces were identified. Based on %IRI of pisces, bramids, gempylids and scombrids (50.0%, 27.5% and 19.9%, respectively) were dominant (Table 5).

Atlantic blue marlin (*Makaira nigricans*)

Seventeen Atlantic blue marlin were investigated. Food items in the large category was similar to longbill spearfish and sword fish (Table 2). Six families of pisces were identified. Based on %IRI of pisces, gempylids, scombrids, exocoetidae and alepisauridae (37.9%, 28.2%, 15.7% and 10.3%, respectively) were dominant. No bramidae was observed (Table 5). The composition was very different from other pelagic species (Table 6).

Swordfish (*Xiphias gladius*)

The number of specimen is 32. The %IRI of pisces (85.7%) was highest, and secondly cephalopods (14.0%) and that for other categories were less than 0.3 % (Table 2). Among pisces nine families were identified and berycids (91.3%) were dominate. This family was fed by 10 sword fishes within small area of 47°W and 14° N. The composition was different from other pelagic species, however sword fish is known to eat cephalopod mainly, thus the high frequency of berycids is likely to be accidentaly(Table 6).

Dolphin (*Coryphaena hippurus*)

The number of specimen is 27. The %IRI of pisces (97.8%) was quite high (Table 2). This species was most clearly characterized as piscivorous among the studied species, whose number of specimen was larger than 10. Eight families of pisces were occurred. Based on %IRI for pisces, coryphaenidae, exocoetids, and balistids (39.3%, 34.9%, and 20.6%, respectively) were dominant (Table 5). The coryphaenidae included only one species *C. hippurus*. This suggested that the cannibalism was occurred in high frequency during this survey period. The similarity index was generally low between dolphin and other species (ranged from 0.152 to 0.559, Table 6).

Wahoo (*Acanthocybium solandri*)

The number of sample was 21. The %IRI of pisces was high (89.1%), and cephalopods had the second highest value (10.8%, Table 2). The species had strong piscivorous features. Six families of pisces were occurred. Based on %IRI for pisces, bramids and diodontids (49.7% and 44.1%, respectively) were dominant (Table 5). The similarity index was almost low ranging from 0.072 to 0.610 (Table 6).

Lancetfish (*Alepisaurus ferox*)

The number of specimen was 168 and %IRI of others (37.2%) was highest, and crustaceans had the second highest value (30.9%) and pisces (26.3%) was third (Table 2). Lancetfish was considered to be the most opportunistic feeder among species studied. In category of pisces, 21 families were occured. Based on %IRI for pisces, alepisaurids, sternoptychids, and paralepidids (44.3%, 36.7%, and 12.4%, respectively) were dominant (Table 5). Alepisaurids included *A. ferox* in great proportion and *A. brevirostris*. This suggested the occurrence of cannibalism. At family level the fish prey similarity index was very low except for albacore (Table 6). A low value of %F with coryphaenidae and alepisauridae in dolphin and lancetfish stomach in Pacific Ocean suggested that the cannibalism did not always occur high frequency (Moteki *et al*., 2001).

The prey category "miscellaneous" was almost composed of salpidae (thaliacea) (98.7%). crustaceans was mainly composed of phronimidae (amphipoda) (91.6%) and *Phronima sedentaria* had the great majority of the family. To elucidate the geographic distribution of the two species, the wet weight (g) per wet weight of lancetfish (*A. ferox*) were calculated at each station (Fig. 5). The figures showed that the occurrence of *P. sedentaria* were clearly associated with salpidae. Genus *Phronima* intrudes and processes tunica of salpidae and takes off organ of salpidae to live in it (Nishikawa, 2003). The *P. sedentaria* appeared in 78.9% of *A. ferox* individual with the salpidae as a stomach contents. A simple regression analysis was adopted between wet weight of salpidae and *P. sedentaria* and obtained a high degree of positive correlation and a following regression; Wet weight of salpidae (g) = 2.617* Wet weight of *P. sedentaria* (g) + 4.854, r^2=0.876, p<0.01, n=118). Further analysis on this association is still on-going.

Cluster analysis

The result of cluster analysis based on large categories and fish prey at family level were shown in Fig. 6 and Fig. 7, respectively. According to large categories analysis dolphin was indicated to be typical piscivorous. Atlantic sailfish, white marlin, and longbill spearfish were quite similar to each other. Atlantic blue marlin, swordfish, yellowfin tuna and wahoo were fish-eater. Lancetfish was most opportunistic feeder.

When only fish prey was considered (Fig. 7), yellowfin tuna, Atlantic sailfish, white marlin and longbill spearfish were grouped at first. Albacore and lancetfish was similar to each other. There is a certain difference in its prey preference among remaining species and above-mentioned two groups. The prey fish composition of Atlantic blue marlin was most different from other tuna and billfish.

4 Discussion

The large category and the fish prey composition analyses provided interesting feeding habits of the large pelagic fishes. Dolphin was indicated to be most piscivorous and lancetfish was opportunistic feeder. The diet composition of Atlantic sailfish, white marlin and longbill spearfish were very similar to each other. This group feeds primarily on pisces and cephalopod, and among pisces they feed generally on bramidae, scombridae, and gempylidae. This similarity is expected from their similarity in habitat, i.e., near-surface swimming depth. Atlantic blue marlin ate mainly pisces and its prey composition was characterized the mixture of surface species (exocoetidae) and mid-water species (alepisauridae), and the absence of bramidae. The present result on swordfish was biased, as Moteki *et al*. (2001) showed that sword fish diet was not so different from bigeye. Swordfish is known to prefer on cephalopod.

For tunas and billfish except for Atlantic blue marlin, bramidae and gempylidae were suggested to be important prey organisms in this study, because of their high occurrence in stomach contents both in frequency and volume. We compared the present results with other studies (Matthews *et al*., 1977, Moteki *et al*., 2001, Abitia *et al*., 1999, and Rosas *et al*., 2002) on this matter. Table 7 showed that tuna and billfish preferred bramiae and gempylidae and this tendency was also detected not only in Atlantic but also in the other ocean basins. From the viewpoint of prey-predator relationships, the two families (bramidae and gempylidae) appear to play an important role in the ecosystem of the open ocean for large pelagic species.

Acknowledgement

We thank captain and crew of Shoyo-Maru. I am grateful to N. Miyabe for reviewing the manuscript and suggesting many improvements.

References

ABITA, C. L. A., M. F. Galvin, S. F. J. Gutierrez, R. J. Rodriguez, P. B. Aguilar, and H. A. Moehl. 1999. Diet of blue marlin *Makaira mazara* off the coast of Cabo San Lucas, Baja California Sur, Mexico. *Fish. Res*., **44**: 95-100.

CORTES E. 1997. A critical review of methods of studying fish feeding based on analysis of stomach contents: application to elasmobranch fishes. Can. J. Fish. Aquat. Sci., 54: 726-738.

DEQUE A. B. and K. O. Winemiller. 2003. Dietary segregation among large catfishes of the Apure and Arauca rivers, Venezuela. J. Fish Biol., 63: 410-427.

JOLLEY Jr., J. W. 1977. The biology and fishery of Atlantic Sailfish Istiophorus platypterus, from southeast Florida. Florida Mar. Res. Pub. 28: 1-31

MATTHEWS, F. D., D. M. Damkaer, L. W. Knapp, and B. B. Collette. 1977. Food of western Atlantic tunas (Thunnus) and lancetfishes (Alepisaurus). NOAA Technical Report NMFS SSRF, 706: 1-19.

MACDONALD, J. S., and Green R. H. 1983. Redundancy of variables used to describe importance of prey species in fish diets. Can. J. Fish. Aquat. Sci., 40: 635-637.

MOTEKI, M., M. Arai, K. Tsuchiya, and H. Okamoto. 2001. Composition of piscine prey in the diet of large pelagic fish in the eastern tropical Pacific Ocean. Fish. Sci., 67: 1063-1074

NAKAMURA, I., 1985. FAO, Species Catalogue, Vol. 5. Billfishes of the World. An Annotated and Illustrated Catalogue of Marlines, Sailfish, Spearfish and Swordfish Known to Date. FAO Fish Synop., Vil 125, No. 5.

NEI, M. 1987. Molecular evolutionary genetics. Columbia University Press. New York.

NISHIKAWA, J. 2003. Prey-predator relationships concerning the marine gelatinous zooplankton, salps. Bull. Plankton Soc. Japan, 50: 98-103 (in Japanese attached with English abstract).

OKAMOTO, H., K. Satoh, Y. Uozumi, H. Matsunaga, and Z. Suzuki. 2003. Brief report of the R/V Shoyo-maru 2002 cruise for Atlantic bluefin spawning activity survey in the Central North Atlantic in support of the BYP. SCRS/2002/170. Col. Vol. Sci. Pap. ICCAT, 55(1):1271-1277.

PIANKA, ER. 1973. The structure of lizard communities. Ann. Rev. Ecol. Syst, 4: 53-74.

PINKAS, L., M. S. Oliphant, and I. L. K. Iverson. 1971. Food habitats of albacore, bluefin tuna, and bonito in California waters. Fish. Bull., 152: 1-139.

ROSSA, A. J., H. A. Hernandez, M. F. Galvin, C. L. A. Abita, M. A. F. Muhlia. 2002. Diet composition of sail fish (Istiophorus platypterus) from the southern Gulf of California,Mexico. Fish. Res., 57: 185-195.

Table 1. Longline operation date, location, thermocline depth (m) and sea surface (temperature ºC)

Leg	Operation	Date	Latitude	Longitude	thermocline depth (m)	Sea surface temperature (℃)
1	1	2002/6/23	30°00'N	50°13'W	40	25.4
	2	2002/6/24	31°02'N	50°03'W	35	25.8
	3	2002/6/26	33°46'N	48°40'W	25	24.1
	4	2002/6/27	34°38'N	48°27'W	41	23.0
	5	2002/6/28	35°02'N	49°34'W	34	22.8
	6	2002/6/30	34°09'N	53°20'W	13	24.8
	7	2002/7/1	33°46'N	54°00'W	not well-determined	24.6
	8	2002/7/2	33°42'N	55°48'W	not well-determined	25.7
	9	2002/7/3	34°06'N	55°24'W	10	24.3
	10	2002/7/5	34°25'N	57°10'W	67	25.8
	11	2002/7/7	37°39'N	56°15'W	22	22.7
	12	2002/7/9	39°42'N	60°00'W	28	24.7
	13	2002/7/12	34°02'N	59°56'W	24	25.9
2	14	2002/7/26	40°03'N	50°35'W	30	24.3
	15	2002/7/28	41°46'N	46°00'W	28	23.7
	16	2002/7/30	38°44'N	48°26'W	35	25.5
	17	2002/7/31	39°25'N	49°04'W	29	23.2
	18	2002/8/1	39°51'N	48°31'W	30	23.7
	19	2002/8/3	42°00'N	40°52'W	35	23.3
	20	2002/8/4	42°42'N	41°49'W	18	21.9
	21	2002/8/5	42°11'N	41°53'W	46	21.2
	22	2002/8/6	40°14'N	40°18'W	10	25.7
	23	2002/8/8	35°51'N	43°18'W	24	26.1
	24	2002/8/9	36°46'N	46°10'W	28	25.8
	25	2002/8/10	34°44'N	46°29'W	19	26.3
	26	2002/8/12	33°59'N	37°38'W	26	27.3
	27	2002/8/13	33°25'N	37°03'W	25	27.0
	28	2002/8/15	33°25'N	28°38'W	35	25.1
	29	2002/8/16	31°50'N	27°53'W	50	23.9
	30	2002/8/17	30°24'N	28°42'W	44	25.0
3	31	2002/8/30	7°43'N	23°59'W	19	27.7
	32	2002/8/31	5°49'N	22°41'W	56	27.6
	33	2002/9/1	4°59'N	22°29'W	63	27.7
	34	2002/9/2	5°15'N	22°34'W	52	27.7
	35	2002/9/3	5°24'N	21°59'W	50	27.7
	36	2002/9/7	7°59'S	21°10'W	88	25.3
	37	2002/9/8	7°45'S	21°18'W	85	25.2
	38	2002/9/9	7°49'S	21°25'W	91	25.4
	39	2002/9/11	8°14'S	24°39'W	97	25.4
	40	2002/9/12	7°39'S	23°59'W	96	25.1
	41	2002/9/13	7°45'S	22°13'W	56	25.1
	42	2002/9/14	7°59'S	21°00'W	83	25.3
	43	2002/9/16	8°31'S	21°48'W	102	25.2
	44	2002/9/17	8°29'S	22°00'W	110	25.2
	45	2002/9/18	8°20'S	21°59'W	98	25.1
4	46	2002/9/29	8°22'S	29°40'W	110	26.3
	47	2002/9/30	8°22'S	29°39'W	96	26.2
	48	2002/10/1	8°21'S	29°40'W	92	26.2
	49	2002/10/2	8°51'S	29°39'W	98	26.3
	50	2002/10/3	9°05'S	29°42'W	82	26.2
	51	2002/10/7	4°00'N	41°05'W	123	27.8
	52	2002/10/8	3°30'N	40°30'W	118	27.8
	53	2002/10/9	3°44'N	40°29'W	129	27.7
	54	2002/10/13	14°50'N	47°55'W	40	27.9
	55	2002/10/14	14°49'N	47°55'W	46	28.0
	56	2002/10/15	14°53'N	47°55'W	55	28.0
	57	2002/10/16	14°52'N	47°55'W	49	28.0

Table 2. The total catch number, number of specimen, frequency of occurrence (%F), percentage of food items by number (%N), by weight (%W) and the index of relative importance for each food item (IRI) and %IRI of 24 species examined for stomach conten

	species	Bigeye tuna	Yellowfin tuna	Albacore	Longbill spearfish	Atlantic sailfish	White marlin	Atlantic blue marlin	Swordfish	Dolphin	Wahoo	Lancetfish	Pelagic stingray
		Thunnus obesus	*Thunnus albacares*	*Thunnus alalunga*	*Tetrapturs pfluegeri*	*Istiophorus albicans*	*Tetrapturus albidus*	*Makaira nigricans*	*Xiphias gladius*	*Coryphaena hippurus*	*Acanthocybium solandri*	*Alepisaurus ferox*	*Dasyatis violacea*
	number of specimen	77	47	19	53	42	32	17	32	27	21	168	9
	Total stomach number observed												
	Total catch number	91	61	39	77	51	66	42	53	39	29	331	37
%F	Pisces	92.2	83.0	78.9	94.3	100.0	87.5	94.1	90.6	92.6	95.2	63.5	22.2
	Cephalopod	79.2	57.4	57.9	79.2	83.3	84.4	52.9	53.1	22.2	42.9	30.6	33.3
	Other Mollusca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.1	0.0
	Crustacea	29.9	8.5	31.6	1.9	0.0	0.0	5.9	15.6	3.7	0.0	66.5	55.6
	Others	11.7	25.5	21.1	3.8	2.4	9.4	11.8	6.3	7.4	4.8	78.8	44.4
%N	Pisces	68.7	93.0	73.3	91.5	79.3	68.8	90.7	93.6	97.5	93.2	43.2	13.3
	Cephalopod	24.6	5.2	22.0	8.3	20.6	30.8	8.9	6.3	2.2	6.2	15.7	23.0
	Other Mollusca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0
	Crustacea	5.4	0.2	2.8	0.0	0.0	0.0	0.1	0.1	0.1	0.0	11.2	59.4
	Others	1.3	1.6	1.8	0.2	0.1	0.4	0.2	0.0	0.3	0.6	27.1	4.3
%W	Pisces	43.6	32.7	32.8	61.1	62.4	42.4	57.4	60.1	82.7	62.7	10.5	2.4
	Cephalopod	19.5	58.0	25.7	38.4	37.4	55.1	35.3	36.5	13.6	35.8	3.0	4.8
	Other Mollusca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0
	Crustacea	36.2	4.0	33.9	0.2	0.0	0.0	1.5	2.6	1.2	0.0	49.0	85.7
	Others	0.6	5.3	7.7	0.4	0.2	2.5	5.9	0.9	2.5	1.5	34.2	7.1
IRI	Pisces	10358	10428	8378	14397	14174	9728	13937	13923	16684	14847	3411	348
	Cephalopod	3492	3634	2763	3696	4835	7246	2341	2274	351	1802	571	927
	Other Mollusca	0	0	0	0	0	0	0	0	0	0	166	0
	Crustacea	1243	36	1158	0	0	0	9	42	5	0	4005	8061
	Others	23	174	200	2	1	28	72	5	20	10	4828	508
%IRI	Pisces	68.5	73.1	67.0	79.6	74.6	57.2	85.2	85.7	97.8	89.1	26.3	3.5
	Cephalopod	23.1	25.5	22.1	20.4	25.4	42.6	14.3	14.0	2.1	10.8	4.4	9.4
	Other Mollusca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
	Crustacea	8.2	0.3	9.3	0.0	0.0	0.0	0.1	0.3	0.0	0.0	30.9	81.9
	Others	0.2	1.2	1.6	0.0	0.0	0.2	0.4	0.0	0.1	0.1	37.2	5.2

	species	Dagger pomfret	Opah	Bigscale pomfret	Blue shark	Pompano dolphin	Snake mackerel	Shortfin mako	Loggerhead turtle		Skipjack tuna	Smooth hammerhead	Sunfish
		Teractes rubescens	*Lampris guttatus*	*Taractichthys longipinnis*	*Prionace glauca*	*Coryphaena equiselis*	*Gempylus serpens*	*Isurus oxyrinchus*	*Caretta caretta*	*Manta birostris*	*Katsuwonus pelamis*	*Sphyrna zygaena*	*Mola mola*
	number of specimen	5	4	3	3	2	2	1	1	1	1	1	1
	Total stomach number examined												
	Total catch number	7	6	4	310	3	9	18	40	4	2	2	2
%F	Pisces	80.0	50.0	100.0	33.3	100.0	100.0	100.0	0.0	0.0	100.0	0.0	0.0
	Cephalopod	40.0	75.0	33.3	66.7	0.0	100.0	100.0	100.0	0.0	0.0	100.0	100.0
	Other Mollusca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Crustacea	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	100.0
	Others	20.0	75.0	0.0	100.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0	100.0
%N	Pisces	96.1	29.9	95.6	11.5	100.0	99.5	100.0	0.0	0.0	66.6	0.0	0.0
	Cephalopod	2.4	57.5	4.4	75.1	0.0	0.5	0.0	4.9	0.0	0.0	100.0	18.4
	Other Mollusca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Crustacea	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.4	0.0	27.9
	Others	0.0	12.6	0.0	13.5	0.0	0.0	0.0	95.1	100.0	0.0	0.0	53.7
%W	Pisces	83.3	31.3	93.8	5.6	100.0	77.8	50.0	0.0	0.0	0.5	0.0	0.0
	Cephalopod	8.3	31.3	6.3	50.0	0.0	22.2	50.0	15.4	0.0	0.0	100.0	0.2
	Other Mollusca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Crustacea	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99.5	0.0	52.2
	Others	4.2	37.5	0.0	44.4	0.0	0.0	0.0	84.6	100.0	0.0	0.0	47.6
IRI	Pisces	14356	3055	18931	568	20000	17725	14999	0	0	6709	0	0
	Cephalopod	431	6659	356	8338	0	2275	5001	2030	0	0	20000	1861
	Other Mollusca	0	0	0	0	0	0	0	0	0	0	0	0
	Crustacea	113	0	0	0	0	0	0	0	0	13291	0	8013
	Others	83	3758	0	5790	0	0	0	17970	20000	0	0	10126
%IRI	Pisces	95.8	22.7	98.2	3.9	100.0	88.6	75.0	0.0	0.0	33.5	0.0	0.0
	Cephalopod	2.9	49.4	1.8	56.7	0.0	11.4	25.0	10.2	0.0	0.0	100.0	9.3
	Other Mollusca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Crustacea	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.5	0.0	40.1
	Others	0.6	27.9	0.0	39.4	0.0	0.0	0.0	89.8	100.0	0.0	0.0	50.6

Table 3. Food items identified from stomach contents.

Phylum	Class (Subclass)	Order	Family	Species
Arthropoda	Crustacea			*Crustacea spp.*
		Euphausiacea		
		Decapoda	Portunidae	
			Oplophoridae	
		Amphipoda		*Amphipoda spp.*
			Platyscelidae	
			Brachyscelidae	
			Hyperiidae	
			Phronimidae	
				Phronima sedentaria
			Phrosinidae	
				Phrosina semilunata
		Isopoda		
				Isopoda spp.
			Idoteidae	
Mollusca	Gastropoda	Heteropoda	Atlantidae	
			Carinariidae	
	Cephalopoda			*Cephalopoda spp.*
		Decapoda		
				Decapoda sp. A
				Decapoda sp. B
				Decapoda sp. C
				Decapoda sp. D
				Decapoda sp. E
				Decapoda sp. F
				Decapoda sp. small
		Octopoda	Argonautidae	
				Argonautidae sp. A
				Argonautidae sp. B
				Argonautidae sp. C
				Argonautidae sp. D
				Argonautidae sp. E
				Argonautidae sp. F
Annelida	Polychaeta			*Polychaeta spp.*
		Phyllodocida	Alciopidae	
Chordata	Thaliacea			
Vertebrata	Osteichthyes			
		Lampriformes	Trachipteridae	
			Regalecidae	
		Lophiiformes		
		Stromateodei	Nomeidae	
				Psenes maculatus
		Scorpaeniformes	Dactylopteridae	
		Beryciformes	Anoplogastridae	
				Anoplogaster cornuta
			Berycidae	
				Beryx splendens
				Beryx sp.
			Diretmidae	*Diretmoides sp.*
			Trachichthyidae	
			Holocentridae	
		Echeneoidei	Echeneoididae	
		Scombroidei	Gempylidae	
				Lepidocybium flavobrunneum
				Gempylus serpens
				Diplospinus multistriatus
			Scombridae	
		Percoidei	Carangidae	
			Chiasmodontidae	
			Coryphaenidae	
				Coryphaena hippurus
			Bramidae	
			Chaetodontidae	
		Beloniformes		
			Exocoetidae	
		Gadiformes	Macrouridae	
		Acanthuroidei	Acanthuridae	
		Myctophiformes	Omosudidae	
				Omosudis lowei
			Scopelarchidae	
			Myctophidae	
			Paralepididae	
			Alepisauridae	
				Alepisaurus brevirostris
				A. ferox
		Tetraodontiformes		
			Ostraciidae	
			Diodontidae	
				Chilomycterus affinis
				Diodon sp.
			Tetraodontidae	
			Molidae	
				Ranzania laevis
				Mola mola
			Balistidae	
		Zeiformes	Caproidae	
			Zeidae	
				Zenion japonicum
		Scombrolabracoidei	Scombrolabracidae	
				Scombrolabrax heterolepis
		Syngnathiformes	Fistulariidae	
			Syngnathidae	
				Hippocampus kuda
		Stomiiformes	Astronesthidae	
			Chauliodontidae	
				Chauliodus sloani
			Sternoptychidae	
				Argyropelecus sp.
				Sternoptyx sp.

Table 4 Similarity indices (Pianka's α-indices) among eleven species based on frequency of occurrence of food items (5 categories; pisces, cephalopods, other molluscs, crustaceans, and miscellaneous).

species	Bigeye tuna *Thunnus obesus*	Yellowfin tuna *Thunnus albacares*	Albacore *Thunnus alalunga*	Longbill spearfish *Tetrapturus pfluegeri*	Atlantic sailfish *Istiophorus albicans*	White marlin *Tetrapturus albidus*	Atlantic blue marlin *Makaira nigricans*	Swordfish *Xiphias gladius*	Dolphin *Coryphaena hippurus*	Wahoo *Acanthocybium Solandric*	Lancetfish *Alepisaurus ferox*
Bigeye tuna	-	0.971	0.989	0.973	0.968	0.970	0.964	0.980	0.873	0.931	0.696
Yellowfin tuna		-	0.974	0.970	0.967	0.970	0.986	0.978	0.920	0.960	0.720
Albacore			-	0.941	0.934	0.937	0.957	0.972	0.884	0.920	0.786
Longbill spearfish				-	0.9998	0.996	0.979	0.977	0.894	0.962	0.561
Atlantic sailfish					-	0.996	0.978	0.975	0.894	0.963	0.546
White marlin						-	0.966	0.961	0.862	0.941	0.570
Atlantic blue							-	0.994	0.962	0.993	0.641
Swordfish								-	0.952	0.983	0.656
Dolphin									-	0.981	0.605
Wahoo										-	0.579
Lancetfish											-

Table 5. Families of fish eaten by eleven species of large pelagic fish. %IRI by predators are shown.

species	Bigeye tuna *Thunnus obesus*	Yellowfin tuna *Thunnus albacares*	Albacore *Thunnus alalunga*	Longbill spearfish *Tetrapturus pfluegeri*	Atlantic sailfish *Istiophorus albicans*	White marlin *Tetrapturus albidus*	Atlantic blue marlin *Makaira nigricans*	Swordfish *Xiphias gladius*	Dolphin *Coryphaena hippurus*	Wahoo *Acanthocybium Solandric*	Lancetfish *Alepisaurus ferox*
Astronesthidae	0.0										
Chauliodontidae											0.0
Sternoptychidae	1.2		2.7					0.1			36.7
Omosudidae	0.2		0.7				4.6				2.1
Scopelarchidae											0.0
Myctophidae	39.2	0.1	1.8					0.1			0.0
Paralepididae	0.3	0.2	16.8								12.4
Alepisauridae	0.4		31.7	0.1			10.3	0.2			44.3
Exocoetidae	0.0	1.5		25.0	0.1		15.7		34.9		
Fistulariidae					0.0						
Syngnathidae											0.1
Macrouridae											0.0
Holocentridae		0.2		0.7	5.5				0.3		
Anoplogastridae	0.0		1.1								0.6
Berycidae								91.3			0.0
Diretmidae	1.7							0.1			
Trachichthyidae	0.0										
Trachipteridae	0.0										0.0
Regalecidae											0.0
Caproidae	0.4		1.3								
Zeidae	0.2										
Carangidae		0.2			0.1						
Chiasmodontidae	0.0	0.1		1.3	0.2					0.8	0.0
Coryphaenidae	0.2			2.6					39.3		
Bramidae	43.0	53.8	24.6	9.7	49.4	50.0		5.8	2.8	49.7	0.3
Chaetodontidae										3.5	
Echeneoididae		0.4									
Scombrolabracidae	0.1		2.2								
Gempylidae	12.4	0.2	17.1	38.8	20.9	27.5	37.9	0.6	1.2	0.3	3.1
Scombridae	0.5	13.3		19.0	8.0	19.9	28.2	0.1		1.5	0.0
Acanthuridae					0.0						
Nomeidae	0.2							1.8	0.6		0.0
Dactylopteridae				0.8	2.2	0.1	3.3				
Ostraciidae									0.2		
Diodontidae				0.0						44.1	0.2
Tetraodontidae	0.0				0.1						0.0
Molidae		24.1		2.1	13.0	2.5					0.0
Balistidae		6.0		0.0	0.5				20.6		
Unidentified											

Table 6. Similarity indices (Pianka's α-indices) among eleven species based on frequency of occurrence of prey fish at familial level.

species	Bigeye tuna *Thunnus obesus*	Yellowfin tuna *Thunnus albacares*	Albacore *Thunnus alalunga*	Longbill spearfish *Tetrapturus pfluegeri*	Atlantic sailfish *Istiophorus albicans*	White marlin *Tetrapturus albidus*	Atlantic blue marlin *Makaira nigricans*	Swordfish *Xiphias gladius*	Dolphin *Coryphaena hippurus*	Wahoo *Acanthocybium solandri*	Lancetfish *Alepisaurus ferox*
Bigeye tuna	-	0.615	0.660	0.507	0.580	0.654	0.189	0.523	0.194	0.434	0.346
Yellowfin tuna		-	0.439	0.777	0.829	0.844	0.243	0.467	0.477	0.565	0.113
Albacore			-	0.433	0.481	0.529	0.387	0.421	0.152	0.319	0.810
Longbill spearfish				-	0.853	0.800	0.588	0.401	0.559	0.518	0.203
Atlantic sailfish					-	0.937	0.361	0.469	0.324	0.539	0.181
White marlin						-	0.286	0.533	0.240	0.610	0.179
Atlantic blue marlin							-	0.155	0.314	0.145	0.406
Swordfish								-	0.154	0.352	0.232
Dolphin									-	0.137	0.072
Wahoo										-	0.134
Lancetfish											-

Table 7. The occurrence of bramidae and gempylidae in tuna and billfish stomach contents in other studies.

species	Bramidae	Gempylidae	Literature	Region
Bigeye tuna	High	low	Moteki *et al.* (2001)	Pacific
	High	no	Mattews *et al*. (1977)	Atlantic
Yellowfin tuna	High	low	Moteki *et al.* (2001)	Pacific
	High	low	Mattews *et al*. (1977)	Atlantic
Albacore	High	High	Mattews *et al*. (1977)	Atlantic
Sword fish	High	low	Moteki *et al.* (2001)	Pacific
Blue marlin	no	no	Abita *et al.* (1999)	Pacific
Sailfish	no	low	Rosas *et al.* (2002)	Pacific

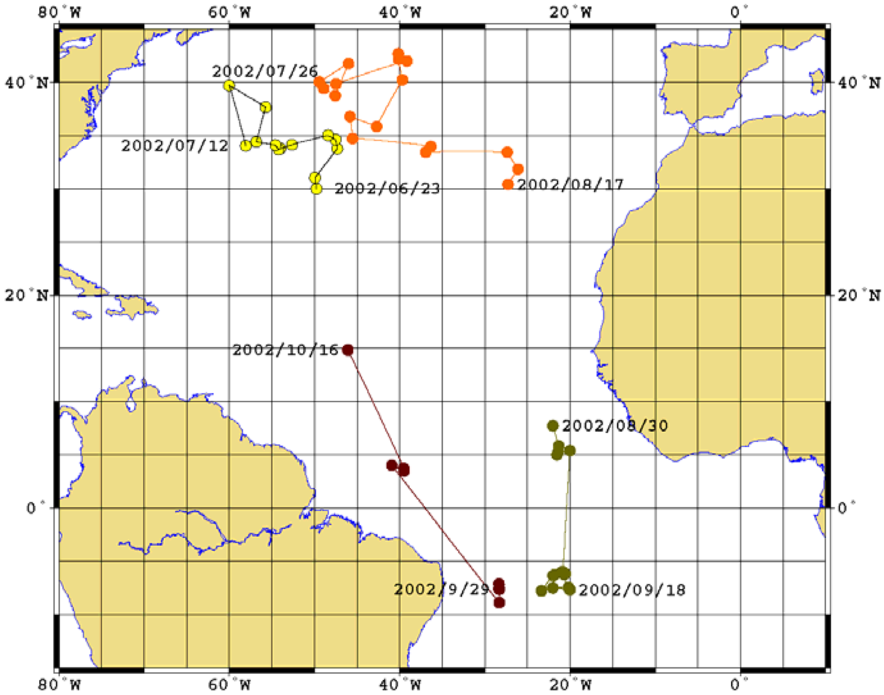

Figure 1. Location of Long line operation. Four legs were conducted.

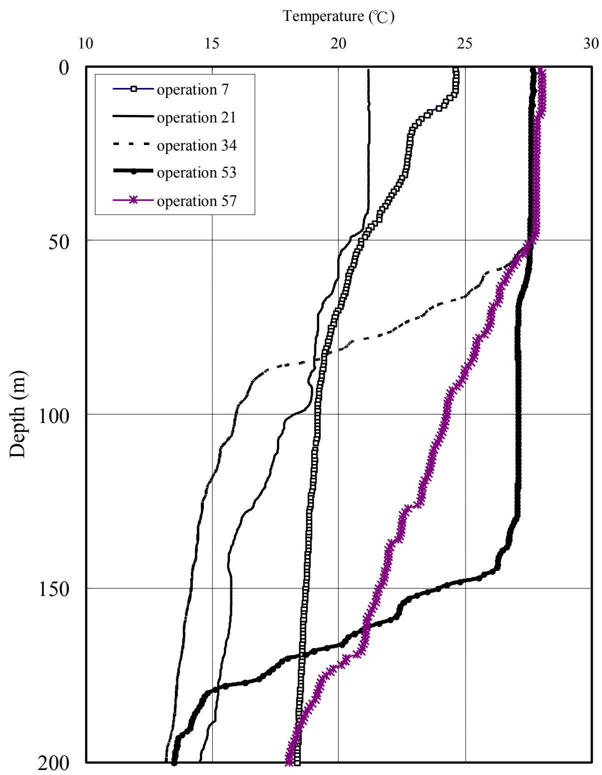

Figure 2. Vertical temperature profile

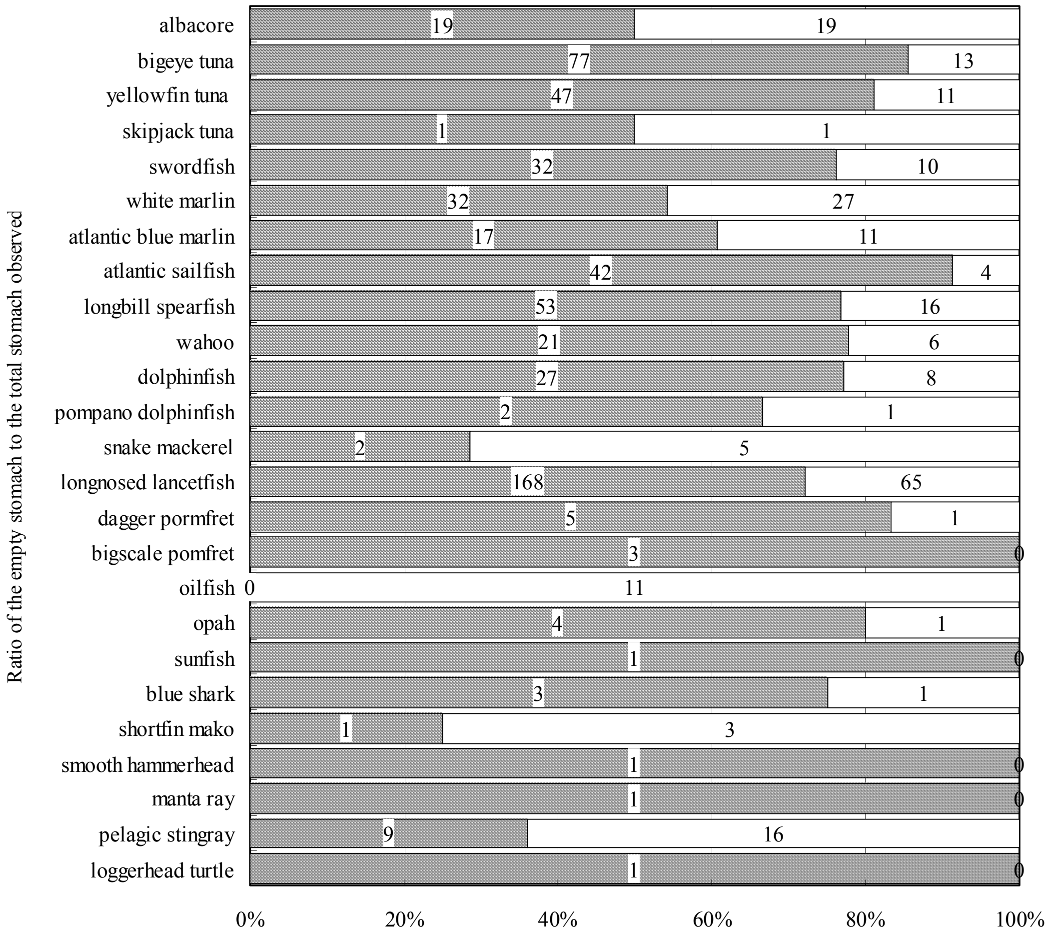

Figure 3. The ratios of the empty stomach to the total observed stomach. Open column shows empty stomach.

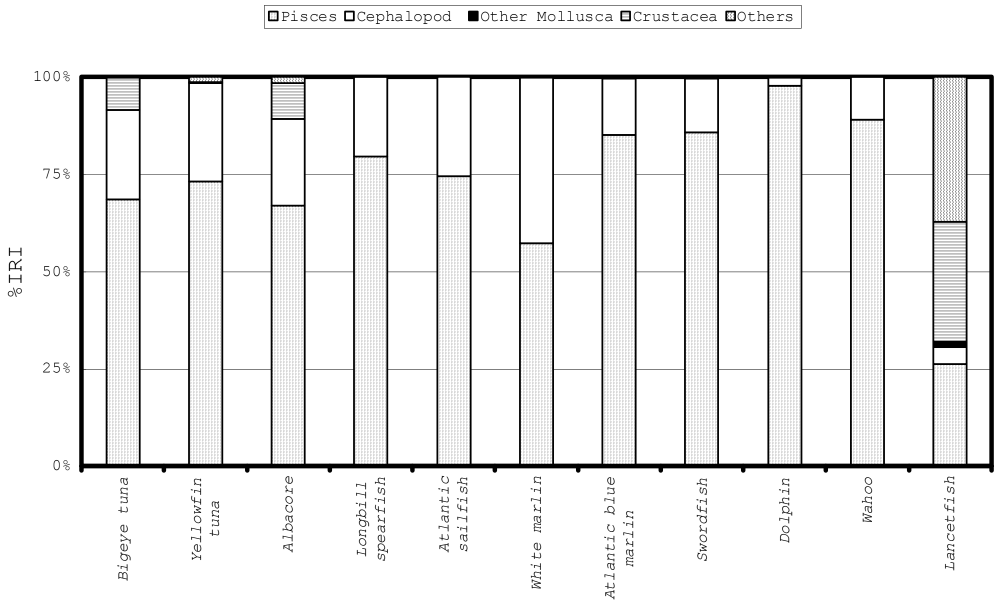

Figure 4. Relative importance of each food item for major pelagic species studied.

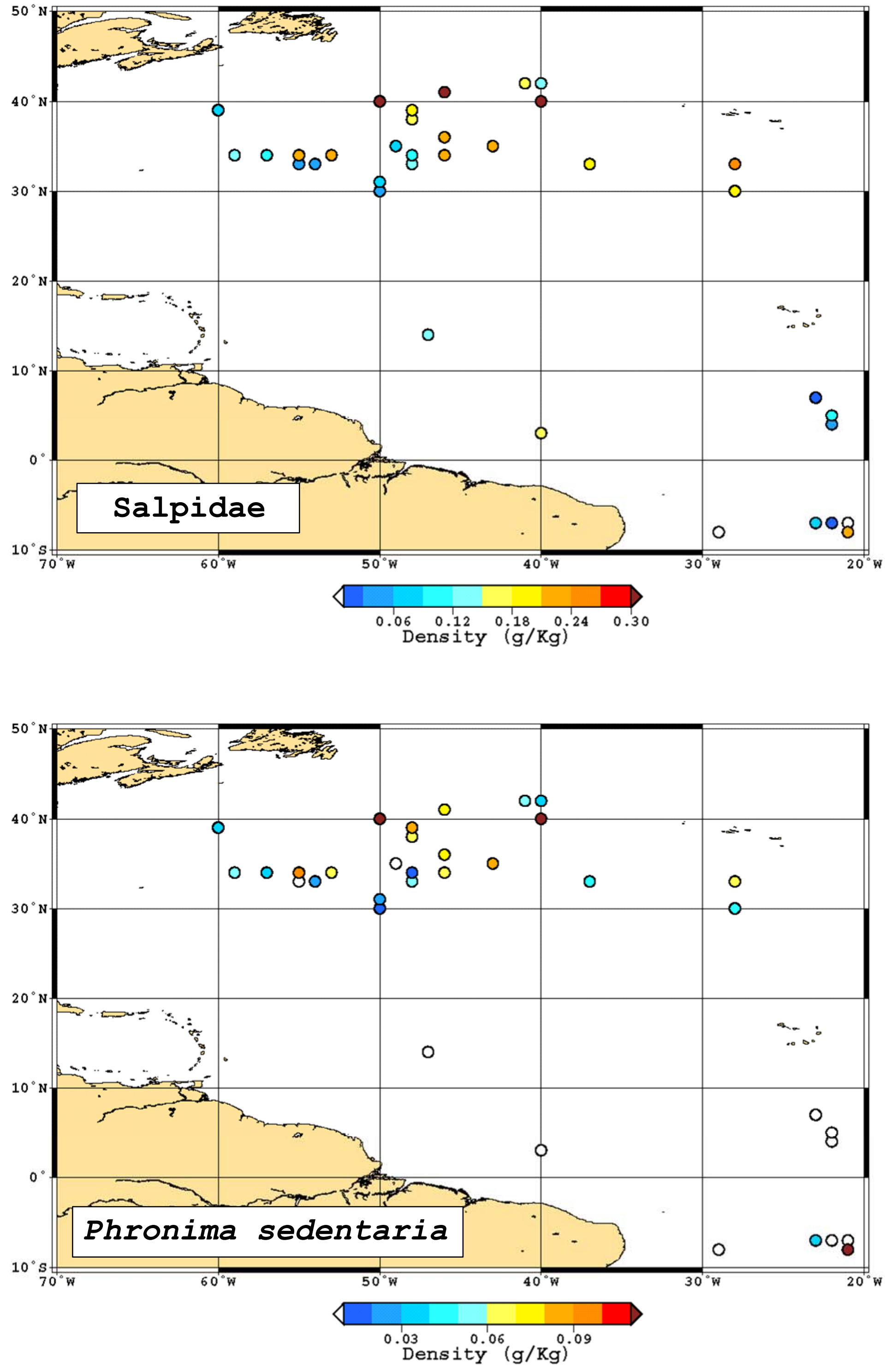

Figure 5. Density of salpidae (Upper panel) and *Phronima sedentaria* (Lower panel) wet weight (g) per 1 kilogram wet weight of *Alepisaurus ferox* at each station.

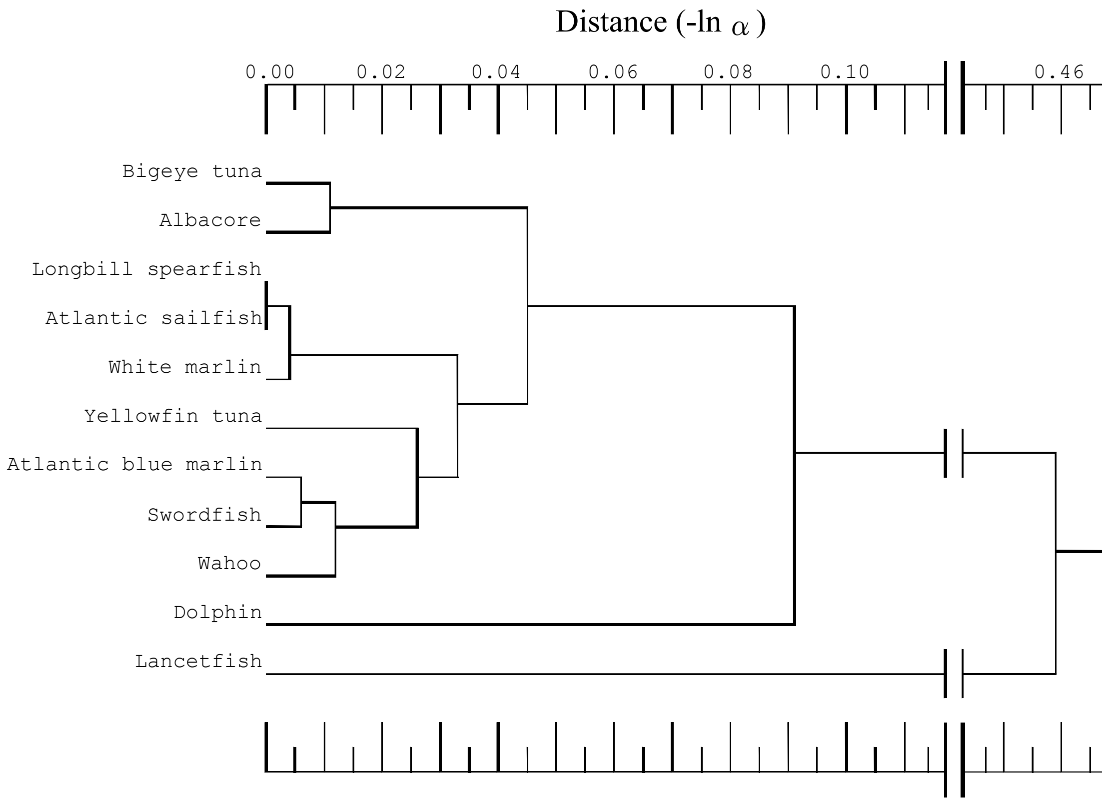

Figure 6. Dendrogram resulting from cluster analysis (UPMAG method) based on large categories (pisces, cephalopods, other molluscs, crustaceans, and miscellaneous) similarity of eleven large pelagic fish.

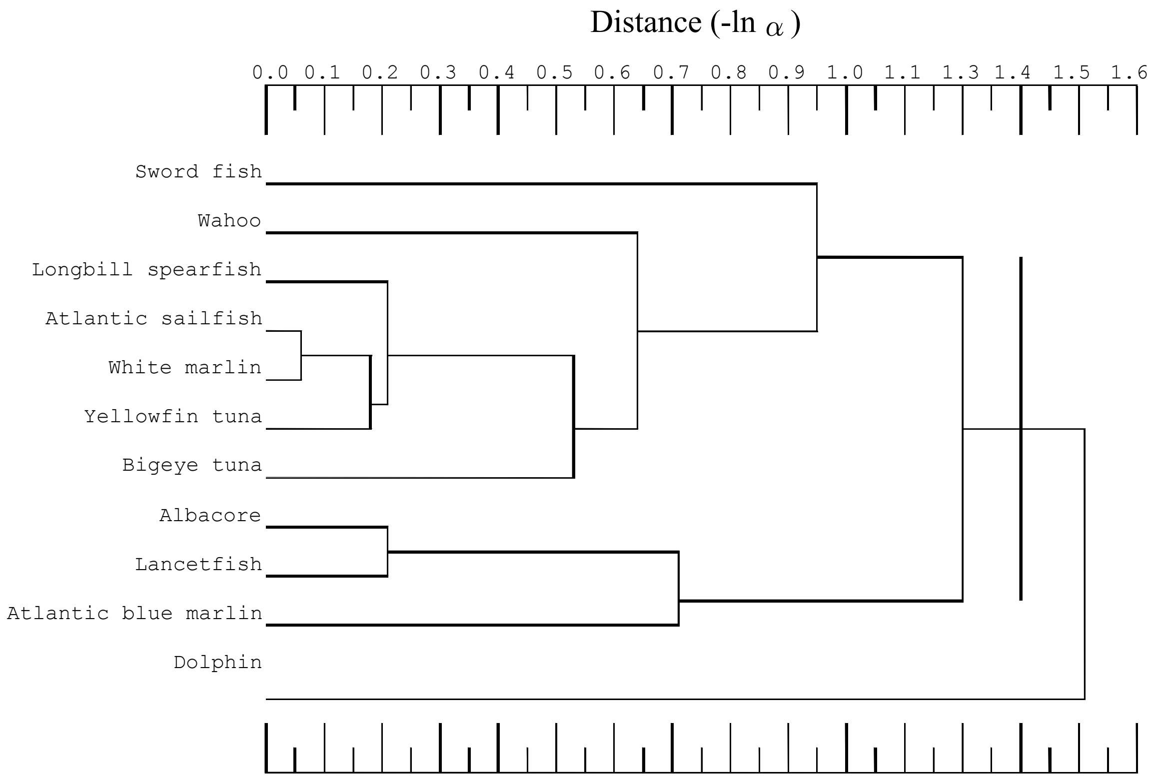

Figure 7. Dendrogram resulting from cluster analysis (UPMAG method) based on fish prey similarity of eleven large pelagic fish.

Appendix Table 1. Families of fish eaten by eleven species of large pelagic fish. %F as percentage of food item i by frequency of occurrence by predators are shown.

species	Bigeye tuna *Thunnus obesus*	Yellowfin tuna *Thunnus albacares*	Albacore *Thunnus alalunga*	Longbill spearfish *Tetrapturus pfluegeri*	Atlantic sailfish *Istiophorus albicans*	White marlin *Tetrapturus albidus*	Atlantic blue marlin *Makaira nigricans*	Swordfish *Xiphias gladius*	Dolphin *Coryphaena hippurus*	Wahoo *Acanthocybium solandri*	Lancetfish *Alepisaurus ferox*
Astronesthidae	1.3										
Chauliodontidae											0.6
Sternoptychidae	9.1		10.5					3.1			33.3
Omosudidae	5.2		5.3				5.9				11.3
Scopelarchidae											1.8
Myctophidae	29.9	2.1	5.3					6.3			1.2
Paralepididae	5.2	2.1	15.8								20.2
Alepisauridae	2.6		15.8	1.9			5.9	6.3			23.2
Exocoetidae	1.3	6.4		18.9	2.4		5.9		22.2		
Fistulariidae					2.4						
Syngnathidae											2.4
Macrouridae											1.2
Holocentridae		2.1		5.7	14.3				3.7		
Anoplogastridae	1.3		5.3								5.4
Berycidae								31.3			1.2
Diretmidae	9.1							3.1			
Trachichthyidae	1.3										
Trachipteridae	1.3										0.6
Regalecidae											0.6
Caproidae	6.5		5.3								
Zeidae	3.9										
Carangidae		2.1			2.4						
Chiasmodontidae	1.3	2.1		7.5	7.1					3.7	1.2
Coryphaenidae	1.3			3.8					18.5		
Bramidae	31.2	25.5	15.8	22.6	59.5	34.4		21.9	7.4	18.5	3.6
Chaetodontidae										7.4	
Echeneoididae		4.3									
Scombrolabracida	2.6		5.3								
Gempylidae	9.1	2.1	10.5	17.0	33.3	15.6	5.9	6.3	7.4	3.7	14.3
Scombridae	3.9	10.6		11.3	14.3	9.4	5.9	3.1		7.4	0.6
Acanthuridae					2.4						
Nomeidae	1.3							9.4	3.7		1.2
Dactylopteridae				7.5	21.4	3.1	5.9				
Ostraciidae									3.7		
Diodontidae				1.9						22.2	3.6
Tetraodontidae	1.3				2.4						0.6
Molidae		8.5		9.4	28.6	9.4					0.6
Balistidae		10.6		1.9	9.5				22.2		
Unidentified	85.7	66.0	68.4	84.9	97.6	84.4	82.4	75.0	74.1	74.1	7.1

Appendix Table 2. Families of fish eaten by eleven species of large pelagic fish. %N as the percentage of food item i by number by predators are shown.

species	Bigeye tuna *Thunnus obesus*	Yellowfin tuna *Thunnus albacares*	Albacore *Thunnus alalunga*	Longbill spearfish *Tetrapturus pfluegeri*	Atlantic sailfish *Istiophorus albicans*	White marlin *Tetrapturus albidus*	Atlantic blue marlin *Makaira nigricans*	Swordfish *Xiphias gladius*	Dolphin *Coryphaena hippurus*	Wahoo *Acanthocybium solandri*	Lancetfish *Alepisaurus ferox*
Astronesthidae	0.2										
Chauliodontidae											0.2
Sternoptychidae	2.3		3.3					0.0			41.3
Omosudidae	0.7		1.7				2.6				4.3
Scopelarchidae											0.7
Myctophidae	25.8	0.6	5.0					0.0			0.4
Paralepididae	0.7	1.3	10.0								20.4
Alepisauridae	0.3		6.7	0.3			2.6	0.0			13.3
Exocoetidae	0.2	1.9		5.3	0.2		2.6		16.4		
Fistulariidae					0.2						
Syngnathidae											0.9
Macrouridae											0.7
Holocentridae		1.3		1.6	7.6				1.5		
Anoplogastridae	0.2		1.7								2.2
Berycidae								24.1			0.4
Diretmidae	3.1							0.0			
Trachichthyidae	0.3										
Trachipteridae	0.3										0.2
Regalecidae											0.2
Caproidae	1.2		3.3								
Zeidae	0.8										
Carangidae		0.6			0.2						
Chiasmodontidae	0.2	0.6		2.5	0.7					1.5	0.4
Coryphaenidae	0.2			0.6					7.5		
Bramidae	17.9	36.1	18.3	7.2	22.5	19.3		6.9	6.0	7.5	1.3
Chaetodontidae										6.0	
Echeneoididae		1.3									
Scombrolabracida	0.3		5.0								
Gempylidae	25.5	1.3	11.7	33.8	11.7	18.7	28.2	0.0	3.0	1.5	7.6
Scombridae	0.5	6.5		5.3	4.9	7.3	5.1	0.0		3.0	0.4
Acanthuridae					0.2						
Nomeidae	0.2							1.7	1.5		0.4
Dactylopteridae				1.9	2.9	0.7	2.6				
Ostraciidae									1.5		
Diodontidae				0.3						16.4	1.3
Tetraodontidae	0.3				0.5						0.2
Molidae		5.8		3.1	11.2	2.7					0.2
Balistidae		8.4		0.3	1.7				19.4		
Unidentified	18.9	34.2	33.3	37.8	35.2	51.3	56.4	67.2	43.3	43.3	2.8

Appendix Table 3. Families of fish eaten by eleven species of large pelagic fish. %W as the percentage of food item i by weight by predators are shown.

species	Bigeye tuna *Thunnus obesus*	Yellowfin tuna *Thunnus albacares*	Albacore *Thunnus alalunga*	Longbill spearfish *Tetrapturus pfluegeri*	Atlantic sailfish *Istiophorus albicans*	White marlin *Tetrapturus albidus*	Atlantic blue marlin *Makaira nigricans*	Swordfish *Xiphias gladius*	Dolphin *Coryphaena hippurus*	Wahoo *Acanthocybium solandri*	Lancetfish *Alepisaurus ferox*
Astronesthidae	0.0										
Chauliodontidae											0.2
Sternoptychidae	1.0		1.1					0.7			6.1
Omosudidae	0.4		0.8				1.2				3.5
Scopelarchidae											0.5
Myctophidae	6.1	0.2	0.9					0.6			0.0
Paralepididae	0.7	0.2	8.5								5.9
Alepisauridae	3.4		28.3	0.3			5.9	0.9			68.9
Exocoetidae	0.5	2.3		19.7	1.2		10.3		22.8		
Fistulariidae					0.1						
Syngnathidae											0.7
Macrouridae											0.2
Holocentridae		0.1		0.8	6.3				0.3		
Anoplogastridae	0.0		1.9								2.5
Berycidae								66.2			0.6
Diretmidae	1.4							0.6			
Trachichthyidae	0.0										
Trachipteridae	0.1										0.1
Regalecidae											0.5
Caproidae	0.3		1.0								
Zeidae	0.3										
Carangidae		1.4			0.7						
Chiasmodontidae	0.1	0.0		0.6	0.5					2.9	0.0
Coryphaenidae	3.3			12.2					45.6		
Bramidae	15.6	2.1	8.8	0.9	7.7	5.2		1.4	3.5	45.6	1.7
Chaetodontidae										3.5	
Echeneoididae		0.3									
Scombrolabracida	0.1		2.2								
Gempylidae	7.7	0.5	16.6	9.4	11.0	11.0	2.9	2.9	1.1	0.3	1.9
Scombridae	2.8	16.3		26.3	15.5	28.4	18.0	0.6		1.1	0.1
Acanthuridae					0.0						
Nomeidae	2.8							4.1	2.9		0.1
Dactylopteridae				0.2	0.7	0.1	0.1				
Ostraciidae									0.0		
Diodontidae				0.0						22.8	1.4
Tetraodontidae	0.3				0.7						2.1
Molidae		45.5		1.1	5.3	1.8					2.6
Balistidae		1.8		0.1	0.3				3.7		
Unidentified	53.0	29.3	29.9	28.3	49.9	53.4	61.6	22.1	20.1	20.1	0.5

Appendix Table 4. Families of fish eaten by eleven species of large pelagic fish. IRI as index of relative importance by predators are shown.

species	Bigeye tuna Thunnus obesus	Yellowfin tuna Thunnus albacares	Albacore Thunnus alalunga	Longbill spearfish Tetrapturus pfluegeri	Atlantic sailfish Istiophorus albicans	White marlin Tetrapturus albidus	Atlantic blue marlin Makaira nigricans	Swordfish Xiphias gladius	Dolphin Coryphaena hippurus	Wahoo Acanthocybium Solandric	Lancetfish Alepisaurus ferox
Astronesthidae	0.3										
Chauliodontidae											0.2
Sternoptychidae	29.9		46.8					2.2			1579.1
Omosudidae	5.3		13.0				22.4				88.7
Scopelarchidae											2.1
Myctophidae	952.8	1.8	31.3					3.9			0.6
Paralepididae	7.1	3.1	292.4								532.0
Alepisauridae	9.7		551.8	1.2			49.7	5.6			1906.5
Exocoetidae	0.8	26.8		471.6	3.3		75.8		871.2		
Fistulariidae					0.8						
Syngnathidae											3.7
Macrouridae											1.1
Holocentridae		3.1		13.6	198.2				6.7		
Anoplogastridae	0.2		18.8								24.9
Berycidae								2824.3			1.3
Diretmidae	41.0							1.9			
Trachichthyidae	0.5										
Trachipteridae	0.6										0.2
Regalecidae											0.4
Caproidae	9.4		22.6								
Zeidae	4.4										
Carangidae		4.3			2.3						
Chiasmodontidae	0.3	1.4		23.7	8.6					16.1	0.5
Coryphaenidae	4.5			48.3					982.6		
Bramidae	1046.5	976.7	428.1	183.6	1794.7	842.9		180.6	70.1	982.6	10.8
Chaetodontidae										70.1	
Echeneoididae		6.8									
Scombrolabracida	1.2		37.9								
Gempylidae	301.8	3.8	297.0	732.7	759.0	463.7	183.0	17.8	30.5	6.7	135.4
Scombridae	12.7	242.0		358.1	292.0	335.2	135.9	1.9		30.5	0.3
Acanthuridae					0.7						
Nomeidae	3.8							54.1	16.1		0.6
Dactylopteridae				15.7	78.5	2.5	15.8				
Ostraciidae									5.6		
Diodontidae				0.6						871.2	9.6
Tetraodontidae	0.9				2.9						1.4
Molidae		436.5		39.9	472.5	42.0					1.7
Balistidae		108.5		0.7	19.2				514.4		
Unidentified	6166.3	4190.2	4328.2	5612.9	8312.0	8838.7	9715.3	6698.7	4691.8	4691.8	23.8