EXAMINATION OF FOOD OF YELLOWFIN TUNA (THUNNUS ALBACARES) AND BIGEYE TUNA (T. OBESUS) FROM THE OPEN WATERS OF THE CENTRAL ATLANTIC

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SUMMARY

Food contents from stomachs of 132 yellowfin and 23 bigeye tuna caught with longlines were analyzed. After food components taxonomic identification, weight, frequency of occurrence and numerical methods were applied to analyze food of tunas. Fish constituted about 70-80 percent of the food weight, cephalopods 19-27 percent, crustaceans 0.5-1 percent. In both tuna species the most important fish food components came from family: Alepisauridae, Gempylidae, among cephalopods: Ommastrephidae, Onychoteuthidae and among invertebrates were Hyperiidea and Gastropoda. The food of yellowfin contained more species, especially of fish, than that of the bigeye. The presence of greater quantities of fish: Gonostomatidae, Alepisaurus sp, Brama dussumieri, Paralepis spp. and squid: Ornitoteuthis antillarum, Onychia sp. is an indicator of feeding concentrations of tunas.

RESUME

Le contenu alimentaire stomacal de 132 albacores et 23 thons obèses capturés à la palangre a été analysé. Une fois effectuée l'identification taxonomique de composition alimentaire, le poids, fréquence et méthodes numériques ont été appliquées pour l'analyse trophique des thonidés.

Les poissons représentaient environ 70-80 % du poids des aliments: 19-27 % de céphalopodes, 0,5-1 % de crustacés. Dans chacune des espèces de thonidés, les composantes alimentaires les plus importantes provenaient des familles Alepisauridae, Gempylidae, parmi les céphalopodes: Ommastrephidae, Onychoteuthidae et parmi les invertébrés, Hyperiidae et Gastropoda. Les aliments de l'albacore contenaient plusieurs espèces, en particulier des poissons, plus que pour le thon obèse. La présence de plus grandes quantités de poisson: Gonostomatidae, Alepisaurus sp, Brama dussumieri, Paralepis spp. et calmar: Ornitoteuthis antillarum, Onychia sp. est un indice des concentrations alimentaires des thonidés.

RESUMEN

Se analizó el contenido de los estómagos de 132 rabiles y 23 patudos capturados con palangre, por medio de identificación taxonómica, peso, frecuencia de aparición y métodos numéricos. El 70-80% del peso del alimento eran peces, el 19-27% cefalópodos y el 0,5-1% crustáceos. En ambas especies de túnidos, el componente de peces encontrado en sus estómagos era de las familias Alepisauridae y Gempylidae, y entre los cefalópodos, Ommastrephidae y Onychoteuthidae; entre los invertebrados se encontraban Hyperiidea y Gastropoda. El rabil ingiere más peces que el patudo. La presencia de una mayor cantidad de peces (Gonostomatidae, Alepisaurus sp, Brama dussumieri, Paralepis spp) y calamares (Ornitoteuthis antillarum, Onychia sp) es indicio de concentraciones tróficas de peces.

Introduction

A study of fishing prospects for large pelagic fish in the Atlantic was conducted at the Sea Fisheries Institute in 1981-1985. In four cruises of the research vessel "Wieczno", longline fishing was accompanied by biological investigations, covering also the collection of materials concerning the feeding of yellowfin and bigeye tunas, belonging to most important commercial species.

Due to the fact that tunas are at the top of the trophic pyramid in the pelagic layer, it is very important to get to know their feeding habits, including food components /Dragovich, 1972/.

A practical aspect of these investigations is the determination of the relationship between the areas abundant in food /areas of high biological productivity/ and the occurrence of tuna concentrations as well as the effect of the kind of food on the degree of their concentration formation.

Material and method

The investigations covered all yellowfin and bigeye tunas caught with longlines during the cruise of the "Wieczno" between July and November 1983 in the open waters of the Central Atlantic. The study area is presented in Fig. 1.

A total of 169 yellowfin and 66 bigeye tunas was caught during the cruise. Length distribution for the two species and the share of empty stomachs are shown in Fig. 2.

The length of yellowfin tuna ranged from 45 to 172 cm, the weight - from 2 to 92 kg. The bigeye had lengths of 52-192 cm and weights of 3-135 kg.

Food components were removed while gutting the fish, after morphometric measurements. When the abdominal cavity was opened, the whole stomach up to oesophagus was severed and placed on a large tray. It was then cut longitudinally, its contents being placed in a labelled jar which was filled with a 10 % formalin solution. A stomach in which only bait was found was treated as empty.

In a land-based laboratory the jar contents were divided into four main food components: fish, cephalopods, crustaceans and other components. Each of these groups was weighed. Next, each of the components was identified to the lowest possible taxonomic unit and the specimens identified were measured with an accuracy of 0,5 cm /FL in fish, ML in cephalopods/.

The identification and the accuracy of measurements depended to a large degree on the degree of digestion and mechanical damage of the components. It was often possible to determine only family and order, especially in the case of fish and cephalopods. That is why the number of identified taxa from each food component group, presenting the picture of food diversity, will not be used here as the basis for a quantitative analysis of food components.

In the case of cephalopods, their identification was especially difficult because many of their external characteristic features were quickly destroyed in the digestive process. Fish were identified by dr T. Linkowski /Sea Fisheries Institute/ cephalopods by dr M. Lipiński /Sea Fisheries Institute/. Other invertebrates were identified at the Institute of Environmental Biology, University of Łódź.

The relative importance of a given food component, which might be viewed as the amount of energy furnished by this component to its consumer, may be expressed as number and size /dimensions/ or weight of each organism consumed. The frequency with which a given organism is consumed, in turn, may lead to a rough estimate of its availability to the predator /Matthews et al. 1977/. In order to analyse food composition of yellowfin and bigeye tunas, the following methods were used:

a/ weighing, i.e., determination of the percentage of weight of main food groups in total weight of food found in the stomachs,

b/ method based on frequency of occurrence, i.e., determination of percentage of occurrence of individual components, both in the stomachs of individual length classes of tunas and in the total number of stomachs examined,

c/ numerical method, i.e., determination of frequency of occurrence /in percent/ of a number of specimens of the same taxonomic group in one stomach.

In order to arrive at a preliminary determination of the importance of two main groups of food components - fish and cephalopods - a number of longline sets typical from this point of view, has been selected. Data concerning them were presented in the tables, their position being shown on the map.

Results

The list of all identified food components is presented in Table 1. It is shown which components occurred in the food of both species and which in one only. Tables 2 and 3 present the frequency of occurrence /in percent/ of individual food components in the stomachs depending on the length class of tunas.

1. Share of main food groups as regards weight.

In both species of tunas, fish constituted the bulk of food: 72 % in yellowfin tuna and 81 % in the bigeye. Cephalopods constituted 27 and 19 %, respectively, and crustaceans 1 % in yellowfin and below 0,5 % in bigeye tuna.
A graphic representation of the share of main food groups /weight/ in the two species is shown in Fig. 3.

The weight of food contents was similar in both species. It reached a maximum of 474 g and a minimum of 3 g in yellowfin tuna; in bigeye tuna 409 and 5 g, respectively. Mean weight of stomach contents in yellowfin tuna was 129,7 g, in bigeye tuna - 126,4 g. Mean weights of three main food groups differed in the two species. In yellowfin tuna, mean weight of fish in the food was greater /102 g/ and mean weight of cephalopods was smaller /23,8 g/; mean weight of crustaceans was two times lower – 0,6 g. Maximum and minimum weights of the three main food groups in the stomachs of both species are presented below.

Yellowfin tuna

Weight /g/	Fish	Cephalopods	Crustaceans
max	341	166	101
min	3	0,5	0,1
x̄	94,0	94,0	1,2

Bigeye tuna

max	309	103	23,4
min	5	0,7	0,1
x̄	102,0	23,8	0,6

2. Frequency of occurrence of food components

2.1. Fish

They occurred in 100 % of stomachs of yellowfin tuna and in 87 % of stomachs of bigeye tuna. They were represented by 21 species from 18 families. It was impossible to identify representatives of 4 families because of a high degree of digestion. Out of all the families, 9 occurring most frequently have been selected and divided into pelagic and bathypelagic fish. The frequency of their occurrence in the food of both species is presented in Fig. 4.

2.1.1. Yellowfin tuna

Out of a total number of 20 families found in the food of the yellowfin, 12 families were found in this species only, while 8 occurred also in stomachs of the bigeye. Nine families had a frequency of occurrence of at least 10 %. These were Alepisauridae – 39 %, Gempylidae – 31 %, Paralepididae – 28 %, Bramidae – 22 %, Chiasmodontidae – 21 %, Exocoetidae – 15 %, Scombridae – 14 %, Sternoptychidae – 12 %, and Gonostomatidae – 11%.

In the stomachs of fish with a length of up to 99,9 cm, only Alepisaurus ferox, Bramidae, Nealotus tripes were found. In the length class of 100,0–109,9 cm, representatives of the family Exocoetidae were encountered most frequently. In tunas with a length of 120–185 cm representatives of the families Alepisauridae, Paralepididae, Bramidae, and Scombridae were most frequent.

As may be seen in Table 4, fish species or families most often encountered in the food were represented by 1–8 specimens in one stomach, with 40–60 % of stomachs with this component occurring most frequently as 1–2 specimens. It was different with small-sized fish from the family Gonostomatidae, represented by the greatest number of specimens – up to 480 specimens in one stomach.

The length of fish consumed by yellowfin tuna ranged from 2 to 57 cm. Largest among them were: Alepisaurus ferox /mean length 38,0 cm/, Paralepis spp. /mean length 18,3 cm/, and Gempylus serpens /mean length 17,5 cm/. Gonostomidae were the smallest /mean length 3,5 cm/.

2.1.2. Bigeye tuna

There were ten families of fish in the food of bigeye tuna; eight of them the same as in yellowfin tuna, and two families, Ariommidae and Ophidiidae occurred only in the bigeye. Only five families occurred with a frequency of at least 10 %: Paralepididae – 40 %, Gempylidae – 30 %, Alepisauridae – 22 %, Sternoptychidae – 17 %, and Gonostomatidae – 13 %. There were no fish inhabiting the pelagic layer, which were found in the food of yellowfin tuna. The relatively smaller number of fish families in the food and the occurrence of families inhabiting deeper waters only may reflect a narrower and slightly different food spectrum of the bigeye and the fact that it feeds in deeper water layers than the yellowfin.

In bigeye tunas with a length of up to 99,9 cm, six families were most frequent. In fish with lengths of 120,0-149,9 cm the frequency of occurrence of the majority of species and families was the highest. In bigeye with a length over 150 cm, the lowest frequency of occurrence of fish in food was observed.

Similarly to yellowfin tuna, fish species or families found in the stomachs of the bigeye were represented most frequently by 1-4 specimens. The most numerously represented family - Gonostomatidae - was represented by not more than 25 specimens in one stomach.

The length of fish consumed ranged from 2 to 38 cm. Largest among them were Alepisaurus ferox /mean length 25 cm/, Gempylus serpens /mean length 24,7 cm/, and Brama dussumieri /mean length 11 cm/. Gonostomatidae were the smallest /mean length 3,5 cm/.

It is characteristic for both species of tunas that smallest fish /i.e., Gonostomatidae/ occurred frequently and in large numbers in the food while large fish /e.g. Alepisaurus ferox or Gempylus serpens/ were also encountered frequently but were represented either by one or several specimens in one stomach.

2.2. Molluscs

Cephalopods constituted the bulk of weight among molluscs occurring in the food of yellowfin and bigeye tunas. Gastropods occurred very frequently but as regards weight, had a very slight share in the food. In yellowfin tunas, 20 specimens in one stomachs were encountered while in the bigeye 1-8 specimens.

Cephalopods occurred in 92 % of stomachs of yellowfin tuna and in 74 % of stomachs of the bigeye. They were represented by 15 species from 11 families.

The frequency of occurrence of major cephalopod groups are presented in Fig. 5. It may be seen clearly that the frequency of their occurrence was almost identical in both tuna species. Among cephalopods - the squid /Teuthoidea/ constituted the largest group of food in both species of tunas as regards weight, number of species and frequency of occurrence; the predominant family was Ommastrephidae. Squid of this family were encountered in over half of analysed stomachs of both tuna species. The dominant species was Ornitoteuthis antillarum. In stomachs of yellowfin tuna, where it occurred in over 70 % of specimens, it numbered 1-6 individuals in one stomach; in the remaining tunas it numbered from 7 to 30 individuals. In stomachs of the bigeye it occurred singly.

Octopuses /Octopoda/ constituted a smaller group while cuttlefish /Sepioidea/ occurred in trace quantities. Among octopuses the most important species was Argonauta argo, encountered in the food of 8-9 % of both tunas.

Cephalopods consumed by the tunas had a length of 1-14,5 cm. Largest among them were Ommastrephes pteropus /mean length 14,5 cm/ and Thysanoteuthis rhombus /mean length 10,4 cm/. The most numerous species - O. antillarum - had similar size in both tuna species /2-7 cm, mean 5,5 cm/. The smallest cephalopods consumed were Argonauta argo /1-2,5 cm, mean 2 cm/ and Amphitretes pelagicus /2-2,5 cm, mean 2,2 cm/.

2.3. Crustaceans

Crustaceans had the lowest share in the food of yellowfin and bigeye tunas as regard weight /1 and 0,5 %, respectively/ but occupied first position as regards frequency of occurrence. Among crustaceans, most often encountered were Hyperiidea /Amphipoda/ represented by nine species from six families. It was impossible to classify the remaining crustaceans /with the exception of Decapoda/ below order.

Four families occurred in the food of both tunas: Phrosinidae, Lycaeidae, Platyscelidae, Pronoidae. Phrominidae and Oxycephalidae occurred only in yellowfin tuna. Four species of Hyperiidae occurred most frequently in both tuna species: Platyscelus ovoides, P. serratulus, Phrosina semilunata and Brachyscelus crusculum. In stomachs of the yellowfin, these species were represented most frequently by 1-6 individuals, with a maximum of 157 individuals of Phrosina semilunata.

In stomachs of the bigeye, these species were less numerous, usually 1-4 specimens, with a maximum of 22 individuals /P. semilunata/.

It is highly probably that substantial numbers of crustaceans in the food of tunas may come from the stomachs of lancetfish Alepisaurus ferox and A. brevirostris, which to a large extent feed on these crustaceans and are consumed by tunas. A high correlation between the occurrence of lancetfish and Hyperiidae in stomachs of tunas was observed.

2.4. Other components

Other food components include single specimens of Polychaeta in the food of yellowfin tuna and Salpae encountered in over 30 % of yellowfin tunas and in about 9 % of bigeye tunas. Both of these components constituted a negligible share in the weight of total food of tunas.

3. Effect of kind of food on catch results

The overwhelming majority of yellowfin tunas was caught during their feeding migrations so it was decided to check whether and what kind of food affects the formation of tunas feeding concentrations and thus the prospects of higher yields.

Out of 62 longline sets, those sets in which CPUE was about 40 kg/100 hooks and in which the main species caught were yellowfin with bigeye tuna were selected. Taking into account the weight of fish and their relative shares in the food of tunas, these sets were compiled in two tables /Tables 5 and 6/.

Table 5 lists longline sets in which the weight of fish was greater /three times on the average/.

Longline sets listed in Table 6 did not exhibit such a marked prevalence of cephalopods, which, however, constituted on the average over half of the weight.

Tunas in sets in Tables 5 and 6 represented 2nd-4th degree of stomach fullness /4-full stomach/.

The location of longline sets presented in Tables 5 and 6 is shown on the map in Fig. 1.

In Table 5 the mean share of fish weight in the food equalled 76 % and reached 99 % in some sets. Most frequently encountered components were: Alepisaurus ferox, Paralepis spp., Gonostomatidae, and Bramidae. A. ferox, Paralepis spp. and Bramidae constituted the bulk of the weight. CPUE attained was high - up to 86 kg/100 hooks.

In Table 6 mean share of fish weight in the food dropped to 48 % while the share of cephalopods increased to 51 % - twice the mean share of cephalopods in all the analysed food of tunas /19-27 %/. In some longline sets cephalopods constituted up to 66 % of the food weight. CPUE attained was slightly lower but still good for commercial fishing operations. The main component as regards weight and frequency of occurrence was Ornitoteuthis antillarum. In the northern part of the study area Onychia sp. was a frequent food component.

No overwhelming prevalence of either cephalopods or fish in the food of tunas was noted in the whole study area. Fish occurred in the food slightly more frequently in the northern part of the area while cephalopods were distributed quite unevenly, with slightly more in the south. A substantial part of the northern area was under the influence of upwelling created in the eddies of Canary Current and North-Equatorial Current, where better feeding conditions for tunas could have prevailed.

Discussion

Feeding and food of tunas have been described by many researchers but qualitatively faithful comparisons between various studies are difficult because of, among others, the usually incomplete /for many reasons/ identification of organisms, different periods of catches, and different fishing techniques used. Dragovich /1972/ says that the differences in the food composition of yellowfin tuna between his study and that of Sund and Richardson /1967/, carried out in the same area, were substantial. Quantitative analyses of food conducted by many authors usually included a comparison of main groups of food components: fish, molluscs, and crustaceans.

In the area where the "Wieczno" was fishing, studies of the food of yellowfin and bigeye tunas caught with longlines were carried out by, among others, Williams /1966/, Maksimov /1972/, Valle et al. /1980/. More studies of tunas food originated in the Gulf of Guinea or off the whole coast of West Africa and the fish examined came from purse seine catches/were therefore generally smaller/.

Comparing the results of this study with those of Valle et al. concerning the weight share of main food groups, their share in the food of yellowfin tuna was very similar, while the food of bigeye tuna differed; Valle et al. observed more cephalopods /32 %/ and crustaceans /2,3 %/ and less fish /65,3 %/.

As far as frequency of occurrence is concerned, the same food groups predominated in similar proportions in Valle et al.

Different families of fish and crustaceans occurred there but this was not so important as their share in the weight of food did not exceed 2 %.

Comparing the weight of stomach contents in fish caught with longlines by the "Wieczno" with that of fish caught with purse seine /study of Dragovich and others/, the former is distinctly greater. It thus appears that the length of fish in longline catches is greater and larger fish require more food to satisfy their energetic requirements /Dragovich 1972/. Large tunas consumed larger-sized specimens of fish and cephalopods. Alepisaurus ferox with a length of 57 cm or squid with a length of 14 cm were encountered in the "Wieczno" catches in the stomachs of yellowfin tunas of 150-160 cm in length; this is related to anatomical features, among others, maximum expansibility of mouth and stomach of the predator. On the other hand, the size of gill rakers determines the minimum size of food components which may be retained in the mouth /Magnuson and Heitz 1971/.

Large tunas are more capable of swift movement enabling them the capture of larger marine organisms.

Matthew's /1977/ assertion that the frequency of occurrence of the smallest organisms in the food decreases generally with an increase in the length of tuna, was confirmed only in several cases in this study. The majority of small organisms, crustaceans, cephalopods and small fish exhibited rather an increasing frequency or remained at a stable level with an increase in the length of tunas /e.g. Gastropoda, O. antillarum, all Hyperiidae with the exception of Phrosina semilunata in yellowfin tuna/ Gonostomatidae, Chiasmodontidae/.

The differences in depth intervals where yellowfin and bigeye tunas are feeding are most likely one of the types of feeding selectivity. The bigeye found in the catches of the "Wieczno" was feeding in deeper waters than the yellowfin. This is evident in the food group of fish /Fig. 4/; the food of the bigeye did not include pelagic fish from the families Scombridae, Exocoetidae, while the yellowfin was feeding in the upper water layers inhabited by these families. This confirms the observations of Dragovich /1972/. A practical recommendation would be to place hooks at a deeper level in the bigeye directed fishery.

It may be said that certain groups of organisms found in greater quantities in stomachs of tunas caught with longlines may be good indicators and serve to determine whether feeding concentrations of tunas are formed in a given area, which would lead to higher yields. Such indicator species in the case of yellowfin and bigeye tuna would include: Gonostomatidae, Alepisaurus ferox, Brama dussumieri, Paralepis spp. as well as squid: Ornitoteuthis antillarum and Onychia sp. High CPUE attained by the "Wieczno" /Table 5 and 6/ seems to confirm this assertion.

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Table 1. Food components found in the stomachs of yellowfin /YFT/ and bigeye /BET/ tuna /n.id. - not identified/

ANNELIDAE

Polychaeta n.id. /YFT/

MOLLUSCA

Gastropoda n.id. /YFT/ /BET/

Cephalopoda

Sepioidea

- Sepiolidae
  - Heteroteuthis sp. /YFT/ /BET/
  - Sepiola sp. /BET/

Teuthoidea

- Enoploteuthidae
  - Abraliopsis sp. /YFT/
- Onychoteuthidae
  - Onychia sp. /YFT/ /BET/
  - Moroteuthis sp. /YFT/
  - Moroteuthis robsoni /YFT/ /BET/
  - Onychoteuthis banksi /YFT/ /BET/
- Histioteuthidae
  - Histioteuthis sp. /YFT/ /BET/
  - Histioteuthis bonneli /YFT/
- Ommastrephidae
  - Ornitoteuthis antillarum /YFT/ /BET/
  - Ommastrephes pteropus /YFT/ /BET/
  - Hyaloteuthis pelagica /YFT/
- Hiroteuthidae n.id. /BET/
- Thysanoteuthidae
  - Thysanoteuthis rhombus /YFT/ /BET/
- Cranchiidae
  - Cranchia scabra /YFT/
  - Leachia sp. /BET/
- Taoninae n.id. /YFT/
- Mastigoteuthidae n.id. /BET/
- Brachioteuthidae
  - Brachioteuthis sp. /YFT/ /BET/
- Lepidoteuthidae
  - Pholidoteuthis boschmai /BET/
- Octopoteuthidae
  - Octopoteuthis sp. /YFT/

Octopoda

- Argonautidae
  - Argonauta argo /YFT/ /BET/
- Amphitretidae
  - Amphitretus pelagicus /YFT/ /BET/
- Octopodidae
  - Octopus sp. /YFT/

ARTHROPODA

Crustacea

Copepoda n.id. /YFT/ /BET/

Isopoda n.id. /YFT/

Amphipoda

Hyperiidea

Table 1
(cont.)

Phronimidae
Phronima sedentaria /YFT/

Phrosinidae
Phrosina semilunata /YFT/ /BET/

Lycaeidae
Brachyscelus crusculum /YFT/ /BET/

Platyscelidae
Platyscelus ovoides /YFT/ /BET/
Platyscelus serratulus /YFT/ /BET/

Pronoidae
Eupronoe /YFT/
Parapronoe /YFT/ /BET/
Sympronoe /YFT/

Oxycephalidae
Streetsia steenstrupi /YFT/

Euphausiacea n.id. /YFT/ /BET/

Decapoda

Eucyphidea n.id. /BET/
Palinura n.id. /YFT/

Brachyura n.id. /YFT/ /BET/

CHORDATA

Salpae n.id. /YFT/ /BET/

Teleostomi

Salmoniformes

Gonostomatidae n.id. /YFT/ /BET/
Maurolicus muelleri /BET/

Sternoptychidae n.id. /YFT/
Sternoptyx pseudoobscura /BET/

Myctophiformes

Paralepididae n.id. /YFT/ /BET/
Paralepis spp. /YFT/

Alepisauridae
Alepisaurus sp. /YFT/ /BET/
Alepisaurus ferox /YFT/ /BET/
Alepisaurus brevirostris /YFT/

Myctophidae n.id. /YFT/ /BET/
Notoscopelus sp. /YFT/

Diceratidae n.id. /YFT/

Beloniformes

Exocoetidae
Exocoetus volitans /YFT/

Gadiformes

Ophidiidae
Holocomycteronus sp. /BET/

Beryciformes

Anoplogasteridae
Anoplogaster cornutus /YFT/

Diretmidae
Diretmus argenteus /YFT/

Lampridiformes

Trachipteridae
Trachipterus esmarki /YFT/

Scorpaeniformes

Scorpaenidae n.id. /YFT/

Table 1
(cont.)

Dactylopteriformes

Dactylopteridae
Dactylopterus volitans /YFT/ /BET/

Perciformes

Moronidae
Dicentrarchus sp. /YFT/

Brotulidae n.id. /YFT/

Bramidae n.id. /YFT/ /BET/
Brama dussumieri /YFT/

Chiasmodontidae
Pseudoscopelus sp. /YFT/
Chiasmodon sp. /YFT/
Chiasmodon niger /YFT/

Gempylidae
Prometeus sp. /YFT/
Gempylus serpens /YFT/ /BET/
Nealotus tripes /YFT/ /BET/

Scombridae
Katsuwonus pelamis /YFT/

Centrolophidae n.id. /YFT/

Nomeidae
Cubiceps sp. /YFT/

Ariommidae
Ariomma sp. /BET/

Tetraodontiformes

Balistidae n.id. /YFT/

Diodontidae
Diodon sp. /YFT/

Triodontidae n.id. /YFT/

Table 2. Percentage frequency of respective food items separated from 123 yellowfin tuna stomachs /n.id. - not identified/

Food items	Length class of fish /FL/ - cm				% of total
	<99,9	100,0-119,9	120,0-149,9	150,0-185,0	
	N = 6	N = 17	N = 45	N = 64	Σ = 132
Polychaeta n.id.			2	3	2
Gastropoda n.id.	17	18	29	53	39
Sepiolidae					
Heteroteuthis sp.			2		1
Teuthoidea n.id.	33	35	16	36	29
Enoploteuthidae					
Abraliopsis sp.	33				2
Onychoteuthidae n.id.			2	6	4
Onychia sp.	17	24	11	20	17
Moroteuthis sp.		12	7	3	5
Moroteuthis robsoni		6	2		2
Onychoteuthis banksi				1	1
Histioteuthidae					
Histioteuthis sp.			2	6	4
Histioteuthis bonnelli			2		1
Ommastrephidae n.id.	33	12	16	13	14
Ornithoteuthis antillarum	17	35	40	47	42
Ommastrephes pteropus			4	3	3
Hyaloteuthis pelagica			2		1
Thysanoteuthidae					
Thysanoteuthis rhombus			2	3	2
Cranchiidae n.id.		6	2	11	7
Cranchia scabra		6	2	5	4
Taoninae n.id.				5	2
Brachioteuthidae n.id.				1	1
Brachioteuthis sp.				3	2
Octopoteuthidae					
Octopoteuthis sp.			4		2
Octopoda n.id.		24	38	30	30
Argonautidae					
Argonauta argo		12	2	13	8
Amphitretidae					
Amphitretus pelagicus			2	11	5
Octopodidae					
Octopus sp.				1	1
Copepoda n.id.		12	11	11	11
Isopoda n.id.			4	1	2
Amphipoda					
Phronimidae					
Phronima sedentaria		18	18	22	19
Phrosinidae					
Phrosina semilunata	17	29	51	14	29
Lycaeidae					
Brachyscelus crusculum	17	18	27	44	33
Platyscelidae					
Platyscelus ovoides		6	11	44	26
Platyscelus serratulus		24	16	34	25
Pronoidae					
Eupronoe		6		5	3
Sympronoe			4	1	2
Parapronoe	17		4	13	6

Table 2 (cont.)

	<99,9	100,0-119,9	120,0-149,9	150,0-185,0	% of total
	N = 6	N = 17	N = 45	N = 64	Σ = 132
Oxycephalidae					
Streetsia steenstrupi			2		1
Euphausiacea n.id.		6	20	16	15
Palinura n.id.	33			1	2
Brachyura n.id.		6	2	9	6
Salpae n.id.		29	20	42	31
Pisces					
Gonostomatidae n.id.		12	7	14	11
Sternoptychidae n.id.			11	9	8
Sternoptyx pseudoobscura			2	6	4
Paralepididae n.id.		6	16	11	11
Paralepis spp.		12	11	25	17
Alepisauridae n.id.			2	3	2
Alepisaurus sp.			11	19	13
Alepisaurus ferox	33	12	11	27	20
Alepisaurus brevirostris			4	6	4
Myctophidae n.id.			2		1
Notoscopelus sp.		6			1
Diceratidae n.id.			2		1
Exocoetidae n.id.		24	13	5	10
Exocoetus volitans		18	4	1	5
Anoplogasteridae					
Anoplogaster cornutus			2	3	2
Diretmidae					
Diretmus argenteus				1	1
Trachipteridae					
Trachipterus esmarki				3	2
Scorpaenidae n.id.			2		1
Dactylopteridae					
Dactylopterus volitans			2		1
Moronidae					
Dicentrarchus sp.		6			1
Brotulidae n.id.		6			1
Bramidae n.id.	17		9	13	10
Brama dussumieri			27	6	12
Chiasmodontidae n.id.		6			1
Pseudoscopelus sp.		6	11	13	11
Chiasmodon sp.		6	8	9	8
Chiasmodon niger			4		2
Gempylidae n.id.		6	13	16	13
Prometeus sp.			2		1
Gempylus serpens			20	13	13
Nealotus tripes	17	12	2	3	5
Scombridae n.id.		6	18	13	13
Katsuwonus pelamis			4		2
Centrolophidae n.id.		6	4	3	4
Nomeidae					
Cubiceps sp.			2	1	2
Balistidae n.id.		6			1
Diodontidae n.id.		6		5	3
Diodon sp.				3	2
Triodontidae n.id.			2	3	2
Other fishes n.id.			9		5
Fish remains n.id.	67	53	49	50	52

Table 3

Percentage frequency of respective food items separated from 23 bigeye tuna stomachs /n.id. - not identified/

Food items	Length class of fish /FL/-cm				% of total
	<99,9	100,0-119,9	120,0-149,9	150,0-185,0	
	N = 4	N = 4	N = 8	N = 7	$\sum$ = 23
Gastropoda n.id.			13	29	13
Sepiolidae					
Heteroteuthis sp.	25				4
Sepiola sp.				14	4
Teuthoidea n.id.	50		63	28	39
Onychoteuthidae n.id.		25	13	14	13
Onychia sp.	25	25		14	13
Moroteuthis robsoni				14	4
Onychoteuthis banksi			13		4
Histioteuthidae					
Histioteuthis sp.			25	28	17
Ommastrephidae n.id.	25		13		9
Ornitoteuthis antillarum		25		28	13
Ommastrephes pteropus		25			4
Hiroteuthidae n.id.			13		4
Thysanoteuthidae					
Thysanoteuthis rhombus				14	4
Cranchiidae n.id.	25		25		13
Leachia sp.	25				4
Mastigoteuthidae n.id.			13		4
Brachioteuthidae					
Brachioteuthis sp.	25				4
Lepidoteuthidae					
Pholidoteuthis baschmai		25			4
Octopoda n.id.	25		50	28	30
Argonautidae					
Argonauta argo		25		14	9
Amphitretidae					
Amphitretus pelagica			13		4
Copepoda n.id.					
Phrosinidae					
Phrosina semilunata		25	25	28	22
Lycaeidae					
Brachyscelus crusculum		25	12	43	22
Platyscelidae					
Platyscelus ovoides				14	4
Platyscelus serratulus			12		4
Pronoidae					
Parapronoe sp.			25		9
Euphausiacea n.id.	25	25		14	13
Eucyphidea n.id.				14	4
Brachyura n.id.			12		4
Salpae n.id.			25		9
Pisces					
Gonostomatidae n.id.		25	13		9
Maurolicus muelleri			13	14	4
Sternoptychidae					
Sternoptyx pseudoobscura	50	25	13		17
Paralepididae n.id.	25	75	37	28	39
Dactylopteridae					
Dactylopterus volitans		25			4
Alepisauridae					
Alepisaurus sp.			25.0	14.0	13
Alepisaurus ferox	25				
Ophidiidae					
Holcomycteronus sp.	25		12		9

Table 3 (cont.)

	<99,9	100,0-119,9	120,0-149,9	150,0-185,0	% of total
	N = 4	N = 4	N = 8	N = 7	$\sum$ = 23
Myctophidae n.id.	25				4
Bramidae n.id.				14	4
Gempylidae					
Gempylus serpens		50	37	[illegible]	26
Nealotus tripes	25				4
Ariommidae					
Ariomma sp.		25	12		9
Fish remains n.id.	50	75	50	43	52

Table 4. Importance of individual food components based on number of their occurrence in yellowfin and bigeye tuna stomachs

Percentage of yellowfin tuna stomachs in which 1 or more identified food components were found									Food components	Percentage of bigeye tuna stomachs in which 1 or more identified food components were found								
1	2	3-4	5-6	7-8	9-10	11-12	13-20	20		1	2	3-4	5-6	7-8	9-10	11-12	13-20	20
34	14	16	14	8	2		8	4	Gastropoda	67				33				
84	8	8							Onychia sp.	67		33						
									Histioteuthis sp.	50	50							
22	13	28	13	8	8	1	4	3	Ornitoteuthis antillarum	100								
38	28	25	9						Octopoda	86	14							
18	27	15	16	5	5	4	3	5	Phrosina semilunata		20	40	20					20
45	11	24	7	2	9	2			Brachyscelus crusculum	80	20							
25	10	35	23	2			5		Platyscelus sp.	50		50						
55	5	10		5	5	5	10	5	Euphausiacea	33				33				34
46	21	18	10	5					Salpae		100							
8	8	8		8	22		8	38	Gonostomatidae	25		25				25		25
40	30	30							Paralepididae	33	23	33	11					
59	22	7	12						Alepisaurus sp.	50	50							
48	26	16	5	5					Brama dussumieri	100								
33	40	20	7						Gempylus serpens	67		33						

Table 5. Longline sets with higher CPUE and higher share of fish as a food component of yellowfin tuna.

Set No.	Date	CPUE kg/100 hooks	Main representatives of fish in food of yellowfin tuna	Weight percentage of 3 main food groups		
				Fishes	Cephalopods	Crustaceans
21	01.09.	58	Alepisaurus ferox, Paralepis spp.	70	27	3
25	05.09.	29	A.ferox, Gempylidae, Paralepis spp.	73	25	2
26	06.09.	76	Gonostomatidae, A.ferox	60	37	3
27	07.09.	61	A.ferox	61	38	1
37	25.09.	55	Bramidae, A.ferox, Pseudoscopelus sp.	79	16	5
41	29.09.	78	Scombridae, Paralepis spp., Gonostomatidae	72	27	1
50	23.10.	86	Chiasmodon sp., Centrolopidae, Bramidae,	99	-	1
54	27.10.	44	Bramidae, Paralepis spp. Gonostomatidae	93	6	1
				$\bar{x}$ = 76	$\bar{x}$ = 22	$\bar{x}$ = 2

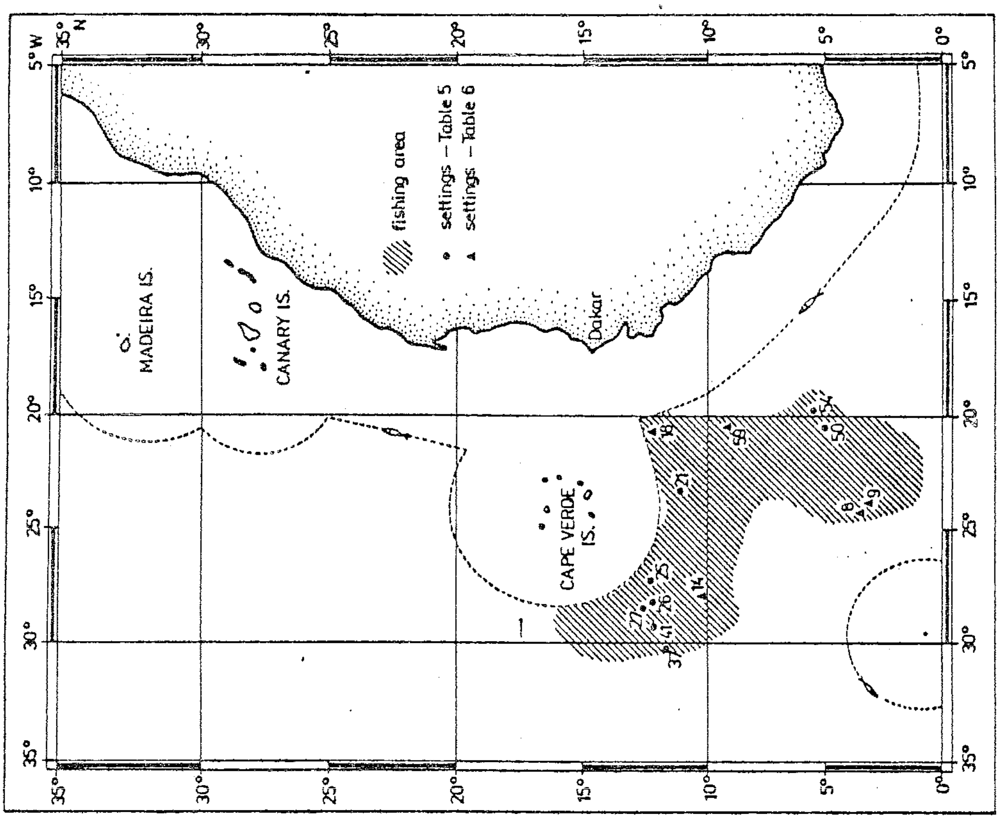

Fig.1. Fishing area in the cruise of r/v"Wieczno" and locations of longline sets presented in Table 5,6.

Table 6. Longline sets with higher CFUE and higher share of cephalopods as a food component of yellowfin tuna.

Set No.	Date	CPUE kg/100 hooks	Main representatives of cephalopods in food of yellowfin tuna	Weight percentage of 3 main food groups		
				Fishes	Cephalopods	Crustaceans
8	12.08.	64	Thysanoteuthis sp, Ornitoteuthis antillarum	33	66	1
9	13.08.	66	O. antillarum	54	42	4
14	20.08.	58	O. antillarum	56	44	-
18	29.08.	55	Onychia sp, Cranchiidae, Octopoda, O.antillarum	53	46	1
59	02.11.	27	O.antillarum, Octopoda, Onychia sp.	45	55	-
				$\bar{x}$ = 48	$\bar{x}$ = 51	$\bar{x}$ = 1

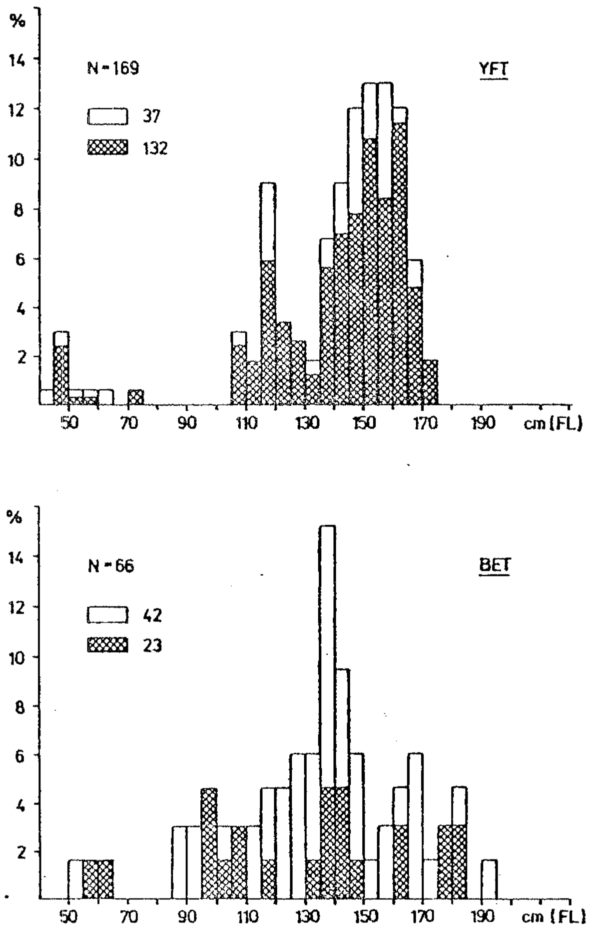

Fig.2. Length frequency distribution of yellowfin /YFT/ and bigeye /BET/ tuna from which stomach samples were taken / - empty stomachs, - full or partially filled stomachs/.

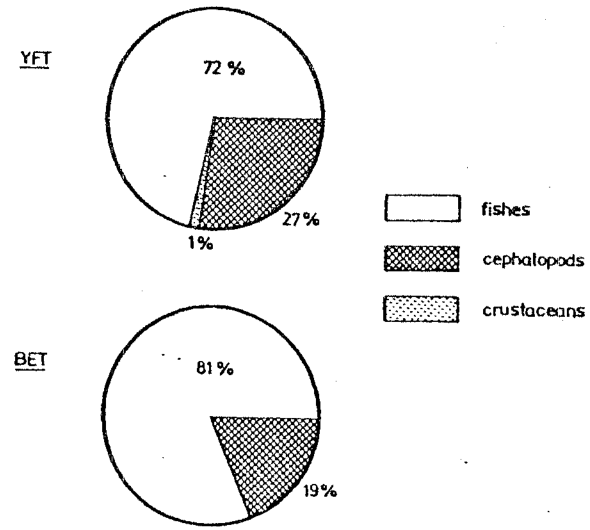

Fig.3. Weight percentage of fishes, cephalopods and crustaceans in the food of yellowfin /YFT/ and bigeye /BET/ tuna.

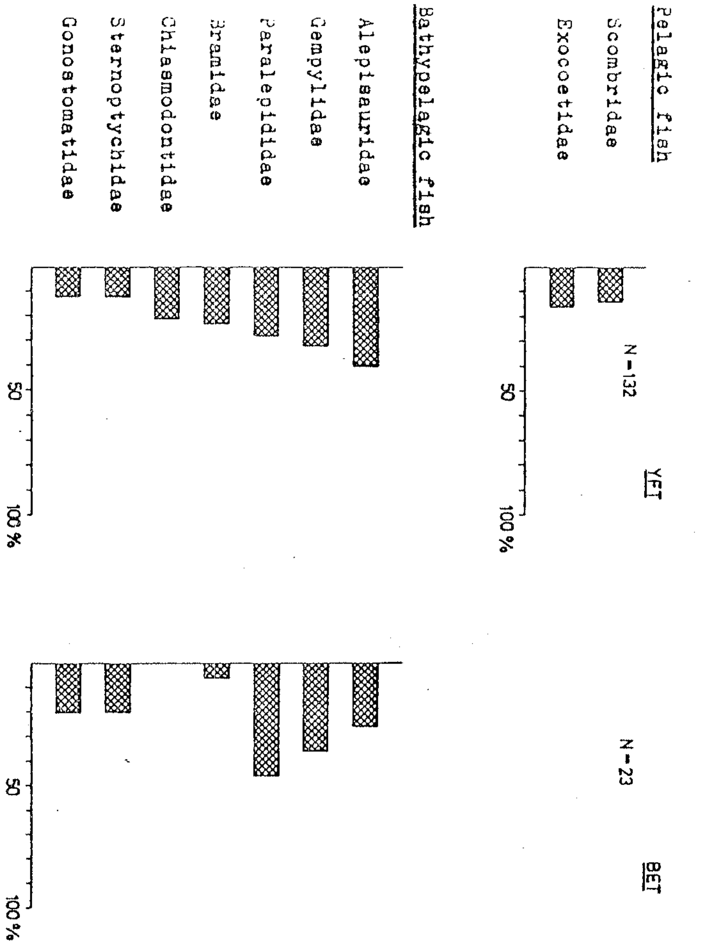

Fig.4. Frequency of occurrence 9 principal groups of fish in the food of yellowfin /YFT/ and bigeye /BET/ tuna.

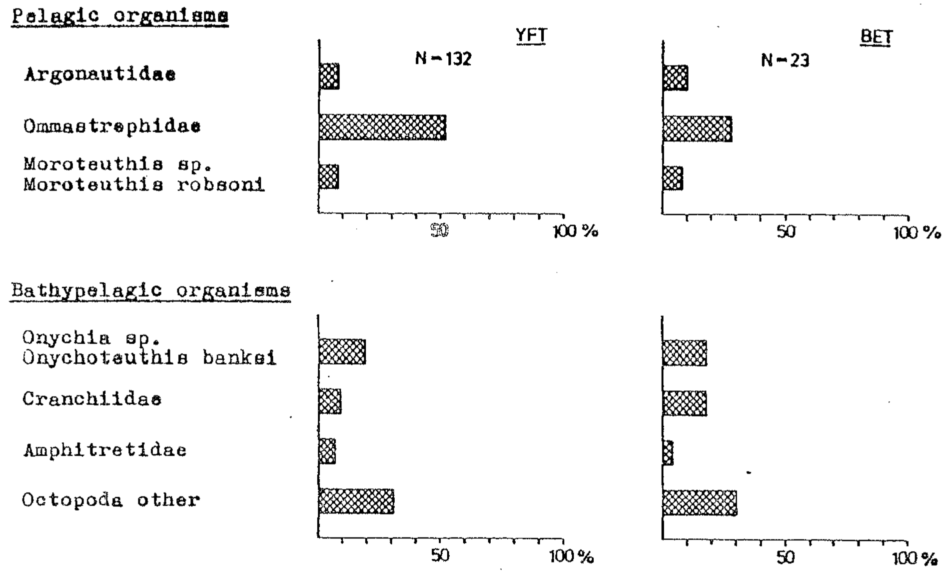

Fig.5. Frequency of occurrence principal cephalopod groups in the food of yellowfin /YFT/ and bigeye /BET/ tuna.

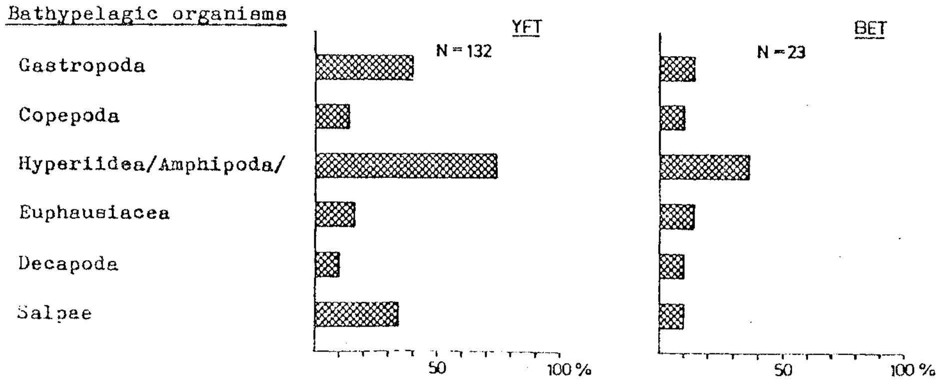

Fig.6. Frequency of occurrence principal other non-vertebrata groups in the food of yellowfin /YFT/ and bigeye /BET/ tuna.