Received: 7 October 2013

Seasonality, morphometrics and feeding behaviour of yellowfin tuna (*Thunnus albacares*) caught by sports fishers in the Kenyan waters

By

Ndegwa Stephen

State Department of Fisheries, P.O. Box 90423, Mombasa, Kenya

Abstract

Yellowfin tuna (*Thunnus albacares*) are among the major target species caught by sports fishers in Kenyan waters. The study on the feeding habits of the tuna was conducted between November 2012 and January 2013 which is the peak season for yellowfin tuna in the Kenyan waters. For seasonality data, a 19 year daily catch data from 1987 to 2011 was used. The yellowfin tuna were most abundant in the coastal waters during the months of October and November. There were two distinct size classes caught during this study. The smaller ones had an average weight 7.2 ± 1.0 kgs and had an average fork length of 73.4 ±5.6 cm. The larger ones had an average weight 26.1 ± 4.4 kgs and had an average fork length of 110.8 ±7.0 cm. The major food contents in the fish stomachs were crabs (*Charybdis smithii*), Sepia spp., anchovies (*Stolephorus commersonii*) and Kawakawa (*Euthynus affinis*). The study also compared the feeding habits of tuna and sailfish and found a similarity in stomach content of the larger yellowfin tuna and the sailfish while that of the smaller yellowfin tuna was different from the larger tuna and sailfish.

Introduction

Large scale fishing in the Western Indian Ocean (WIO) had been low since the entry of the Japanese longliners in the 1950's. However, after the entry of the European purse seiners in the mid 80s, the exploitation of large pelagic fishes has been on the increase reaching the peak in 2005. The catches after that have been on a decline. This high exploitation of the resource could have brought about changes in the foraging behavior of the target species following concerted extraction. Such a removal of top predators could have repercussions on the food web structure through top-down, trophic cascades (Kitchell et al., 1999; Essington et al., 2002). Among the target species are the tunas and the billfishes. Our knowledge of the biological components and the predator–prey interactions in the Western Indian Ocean is still scarce despite increase in fishing effort.

Analysis of the stomach contents of marine top predators can be useful for many different investigations. Besides indicating what the predator depends on for food, the predator's distribution, diving prowess, foraging behavior and ecology (Clarke and Macleod, 1976; Clarke and Kristensen, 1980; Thompson et al., 1991), analysis of stomachs content can tell us about the ecology of the prey species, their distribution (Clarke, 1980; Potier et al. 2007), seasonal fluctuations and sometimes growth (Clarke, 1993).

Several studies have investigated the diet of large pelagic fish predators in the Indian Ocean. Watanabe (1960) has analysed the food composition of 35 bigeye tunas (*Thunnus obesus*) and 91 yellowfin tunas (*Thunnus albacares*) caught in the eastern Indian Ocean during the 1956–1957 period. Kornilova (1981) studied the detailed food composition of yellowfin tuna and of bigeye tuna in the equatorial Indian Ocean from 1969 to 1973, and she provided an advanced taxonomic identification of the prey. Other studies have analysed the main prey groups eaten by yellowfin tuna and skipjack tuna (*Katsuwonus pelamis*) in the Seychelles and in the Mozambique area (Roger, 1994), and around India (Maldeniya, 1996). Potier et al. (2004) investigated the feeding partitioning among yellowfin and bigeye tunas in the western Indian Ocean using preliminary data from longline and purse seine caught fish. Potier et al. (2007) also investigated the resource partitioning among three large pelagic fish predators, yellowfin tuna, swordfish (*Xiphias gladius*) and lancetfish (*Alepisaurus ferox*) in the Seychelles area. These previous studies have investigated the diet of large pelagics offshore from purse seiners and longliners in the WIO region.

The study was meant to collect length data of the yellowfin tuna caught for comparison with previous data collected since 1987 which only concentrated on weight data. The second aim was to study the feeding behavior of yellowfin tuna among the coastal waters of the northern Kenya banks where the concentration of recreational fishing activities occurs highly. By considering large pelagic predators to be efficient biological samplers for collecting information on micronektonic organisms, due to their opportunistic feeding behavior, the study will derive information on the micronekton fauna of this area that is poorly documented. These data are essential not only for estimating the feeding strategy of the large pelagics in this region, but also for establishing new methods for the sustainable exploitation of this important fisheries resource based on ecosystemic information, which is recognized worldwide as an important management approach for future fisheries (World Summit on Sustainable Development 2002, Garcia & Zerbi 2003).

Objectives

The general objective of this study was to study the morphometrics and feeding habits of yellowfin tuna off the coast of Kenya to get an insight into their role in the ecosystem.

Specific objectives

1. To measure the morphometrics of the yellowfin tuna in northern Kenya banks caught by sports fishing vessels
2. To identify the composition of the micronekton in the area based on stomach content of the predators.
3. To compare the feeding habit of tuna and sailfish

Materials and Method

Study Area

The study was undertaken in the Malindi area of the Kenyan coastline as indicated in the map below. Malindi area is on the northern part of the Kenyan coastline and has the highest concentration of the sports fishing activities due to availability of sea mounts and the proximity to the Somali current upwelling zone (Figure 1)

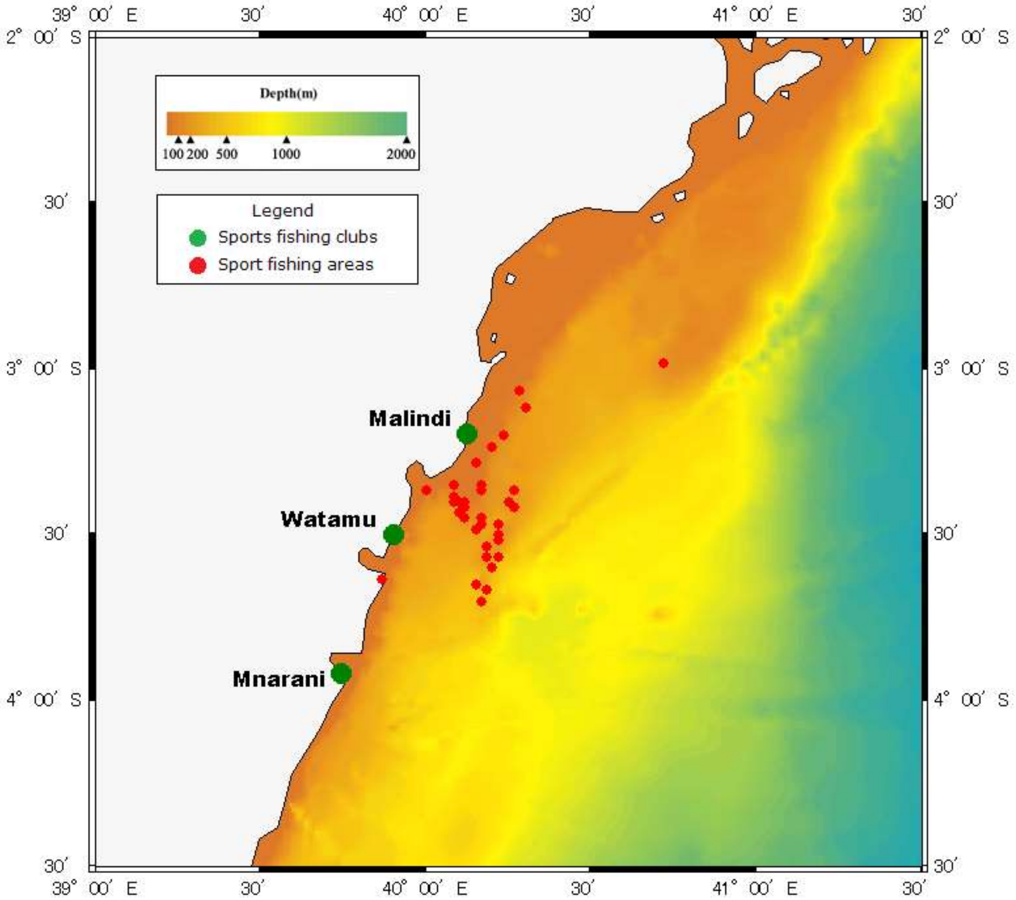

Figure 1: Fishing grounds used by the sports fishers

A normal day's expedition for a fishing boat takes about eight to ten hours. The boats leave at 6:00 AM and return at about 4:00 PM. The boats that fish near the coastline usually take a shorter period than those that fish further in the deeper waters. While on board the vessel, a GPS was switched on throughout the trip to capture the positions where the boat traversed during the expedition and also take the points where a positive catch was recorded.

Figure 2: An active log of a boat trip during the data collection

Data collection

For the past over 20 years, sports fishing clubs have been collecting individual weights of yellowfin tuna caught but did not record the lengths. The study opted to collect more morphometric data to be used to validate previous datasets so as to make them relevant for future studies of the yellowfin tuna caught in the coastal waters in Kenya. For any predator population, some degree of variation in diet might be expected in relation to sex, age, maturity, season, year and area. This sampling was expected to detail on the age, sex and area. The data was collected on board the vessel during fishing trips and also at the Watamu and Malindi landing sites between October 2012 and January 2013.

The data parameters collected for the two species are as below.

- Date and time
- Body wet weight
- Fork length
- Sex (Where possible)
- Area fished

Stomachs contents

The stomachs were removed and fixed with 10% formaldehyde for further analysis in the laboratory. All fresh and minimally digested cephalopod and fish prey were identified to the lowest taxonomic level possible and wet weight recorded to calculate their proportions by wet mass in the diet. The contents were divided into broad prey classes (crustaceans, fishes, squids, others). Heavily digested cephalopod and fish prey items were counted based on the number of beaks and intact vertebral columns, respectively.

Photo 1:Stomach samples in laboratory awaiting analysis

Data analysis

The stomach content index (SCI) was calculated as:

SCI (%) = (wet wt of stomach contents including both fresh and digested items/BW excluding wet wt of stomach contents) × 100

Afterwards we calculated the proportion of each prey item among the total number of food items identified ***(N)***, the wet wt contribution of each food item to the total wet wt of the stomach contents ***(W)***, and the frequency of the occurrence ***(F)*** of each food item in the total number of stomachs to be examined. Using these 3 indices, an index of the relative importance (IRI; Pinkas et al. 1971) of each food item *i* was calculated using the equation:

$IRI_i = (N_i + W_i) \times F_i$

Comparison of the diets

Results

Peak season

From the 19 years complete data, it is clear that the peak season for yellowfin tuna is between September and November. The March to August season when the sea is rough has a poor catch report and the figure below illustrates.

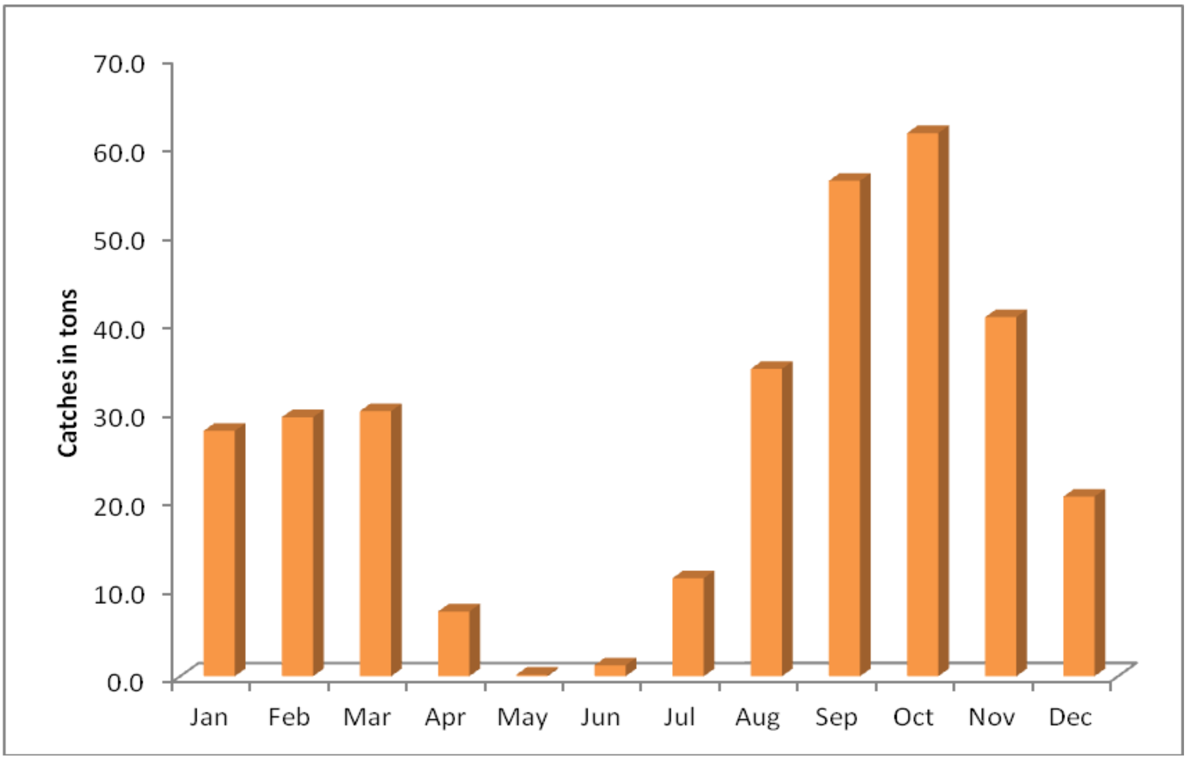

Figure 3: Total catches of yellowfin tuna by month

Catch per boat

For the 19 years period of sailfish catches, a total of 147 boats caught yellowfin tuna during their fishing expedition. From these boats most catches were dominated by seven boats which between them caught 70% of the yellowfin tuna with the rest 16% being attributed to all the other boats (Fig 4).

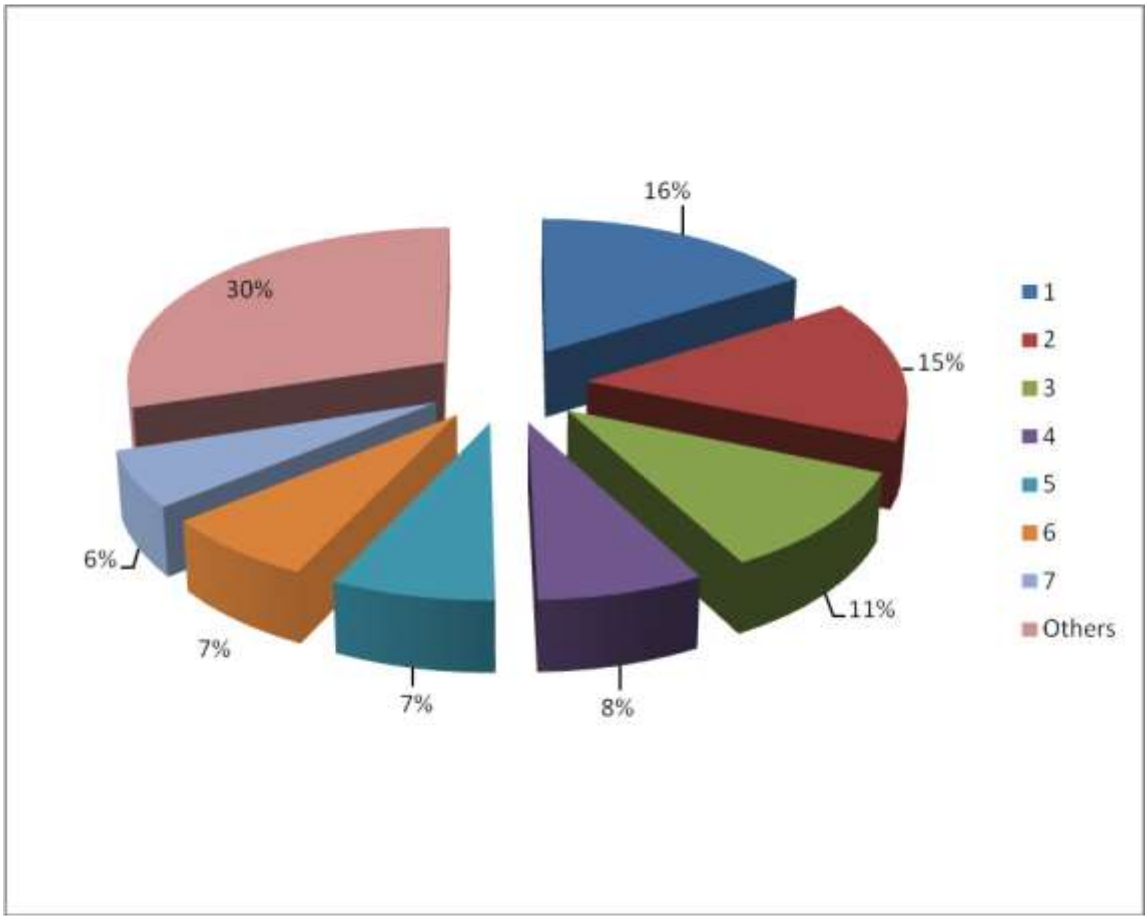

Figure 4: Total catches by boats

Mean Weight

The mean weight of 101 samples the yellowfin tuna caught during the study was 16.3 ±10.0 Kgs (range 2.5 – 37 Kgs). The mean weight was slightly higher than that for all the individuals caught for the past 19 years was 11.6 ± 10.6 Kgs (n=36591). There were two distinct size classes caught during this study. The smaller ones weighed 7.2 ± 1.0 kgs on average while the larger fish on average weighed 26.1 ± 4.4 kgs. The average catches of yellowfin tuna have been 16.9 tons per year (Fig. 5)

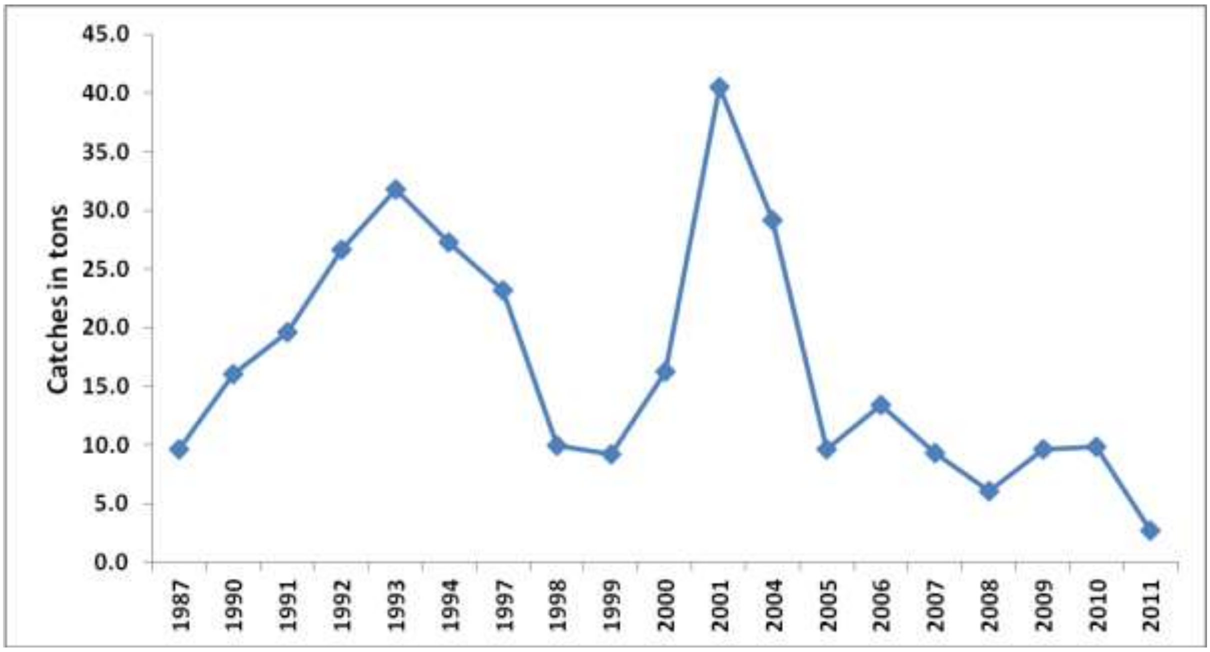

Figure 5: Total Malindi yellowfin tuna catches over the past 19 years

Length

There were two distinct size classes caught during this study. The smaller ones had an average weight 7.2 ± 1.0 kgs and had an average fork length of 73.4 ±5.6 cm. The larger ones had an average weight 26.1 ± 4.4 kgs and had an average fork length of 110.8 ±7.0 cm. The length frequency distribution is shown in (Fig.6) below.

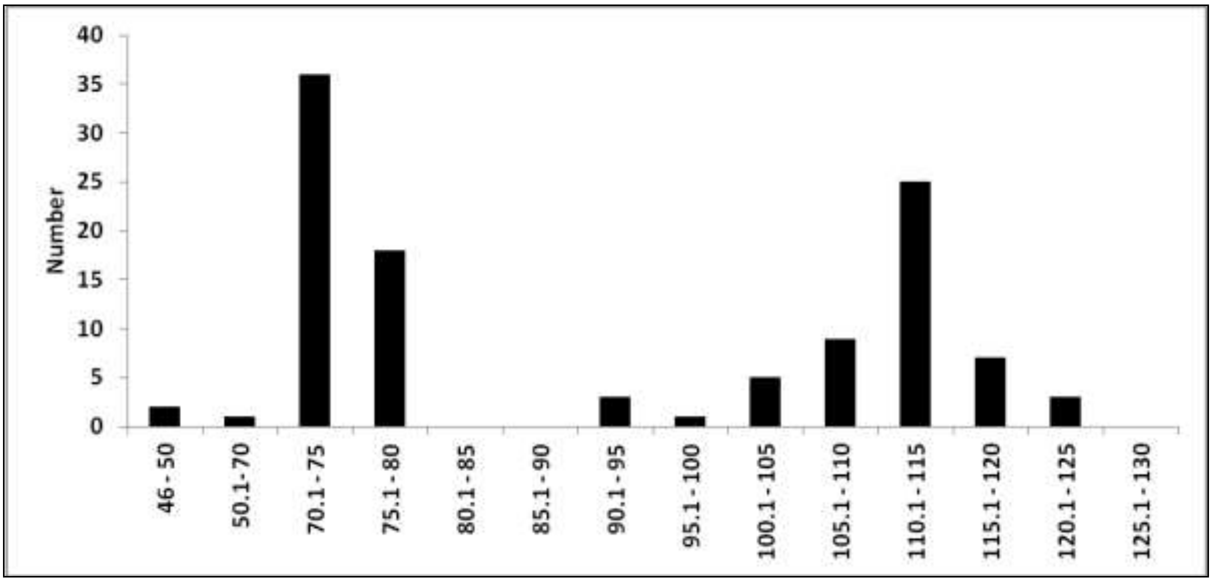

Figure 6: Length frequency distribution of the yellowfin tuna

Length-weight relationship

The relationship between fork length and body weight was calculated as $W=0.00002L^{2.9847}$ depicting a positive allometric growth (Fig.7)

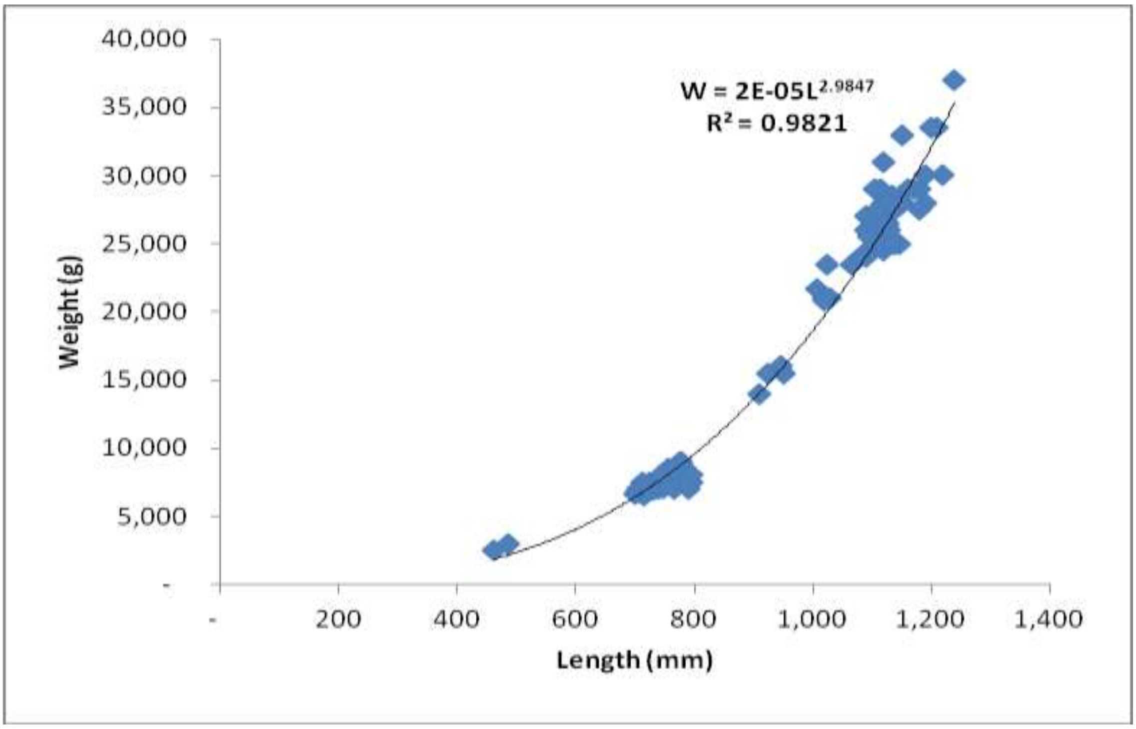

Figure 7: Length weight relationship of yellowfin tuna

Feeding

The crustacean *Charybdis smithii*,and fish *Stolephorus commersonii and Sepia Spp.* were found to be the most important food items consumed by yellowfin tuna (Table,1). The three composed of 79.5 of the Index of Relative Importance (IRI).

Food Item	N	N%	W	W%	O	O%	IRI	%IRI
Sardinella gibbosa	12	1.20	217.2	2.38	6	2.54	9	0.33
Stolephorus commersonii	200	19.92	729.5	8.00	18	7.63	213	**7.83**
Sepia Spp.	123	12.25	486.1	5.33	31	13.14	231	**8.49**
Lobster	3	0.30	2.6	0.03	2	0.85	0	<0.10
Arothron immaculatus	1	0.10	5	0.05	1	0.42	0	<0.10
Gnathanodon speciosus	1	0.10	11	0.12	1	0.42	0	<0.10
Ostracion cubicus	1	0.10	8.8	0.10	1	0.42	0	<0.10
Flying fish	6	0.60	15.8	0.17	2	0.85	1	<0.10
Trichiurus lepturus	2	0.20	6.2	0.07	1	0.42	0	<0.10
Puffer fish	1	0.10	0.4	0.00	1	0.42	0	<0.10
Euthynus affinis	15	1.49	2703.2	29.66	14	5.93	185	6.80
Crab	1	0.10	0.9	0.01	1	0.42	0	<0.10
Penaeus Spp.	20	1.99	8.6	0.09	9	3.81	8	0.29
Isopode	22	2.19	4.1	0.04	5	2.12	5	0.17
Unknown	46	4.58	224.2	2.46	20	8.47	60	2.19
Mantis shrimp	97	9.66	41.235	0.45	29	12.29	124	4.57
Molluscs	6	0.60	1.6	0.02	4	1.69	1	<0.10
Larval crustacean	12	1.20	10.5	0.12	8	3.39	4	0.16
Charybdis smithii	336	33.47	4200	46.09	51	21.61	1719	63.21
Unknown fish	97	9.66	288.2	3.16	29	12.29	158	5.79
Carangid	2	0.20	148.2	1.63	2	0.85	2	<0.10
	1004	**100**	**9113**	**100**	**236**	**100**	**2720**	**100**

Table 1: Percentage Indices of food items of yellowfin tuna

A total of 1004 food items were counted in the 101 stomachs analysed. The most important prey in terms of numbers were *Charybdis smithii* (33.5%), *Stolephorus commersonii* (19.9%) and *Sepia spp*. (12.3%). By weight, the most important prey were *Charybdis smithii* (46.1%) and *Euthynus affinis* (29.7%). The most frequent prey in the stomachs were *Charybdis smithii* (21.6%), *Sepia spp.* (13.1%) *and* Mantis shrimp (12.3%). According to the percent of the Index of Relative Importance (IRI) only three food items represented more than 79.5% of the diet, with the most important *Charybdis smithii (*63.2%), Sepia spp. (8.5%) and *Stolephorus commersonii* (7.8%) (Fig.8).

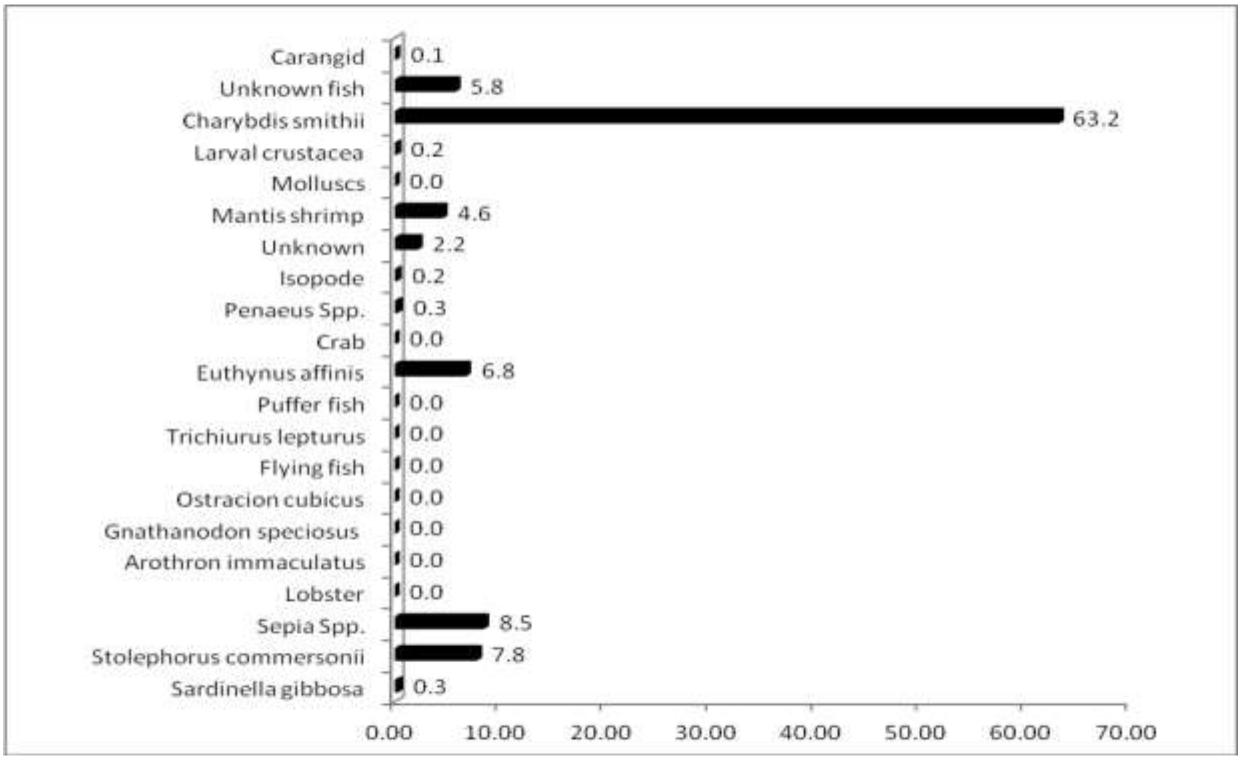

Figure 8: Most important prey of yellowfin tuna from Kenyan coastal waters. Percent of the Index of Relative Importance

There was a remarkable difference in the diet composition of the large yellowfin tuna and the small ones though in both instances, the crab was the main food component. The larger yellowfin tuna diet was somehow similar to the sailfish as the figures 9, 10 and 11 indicate.

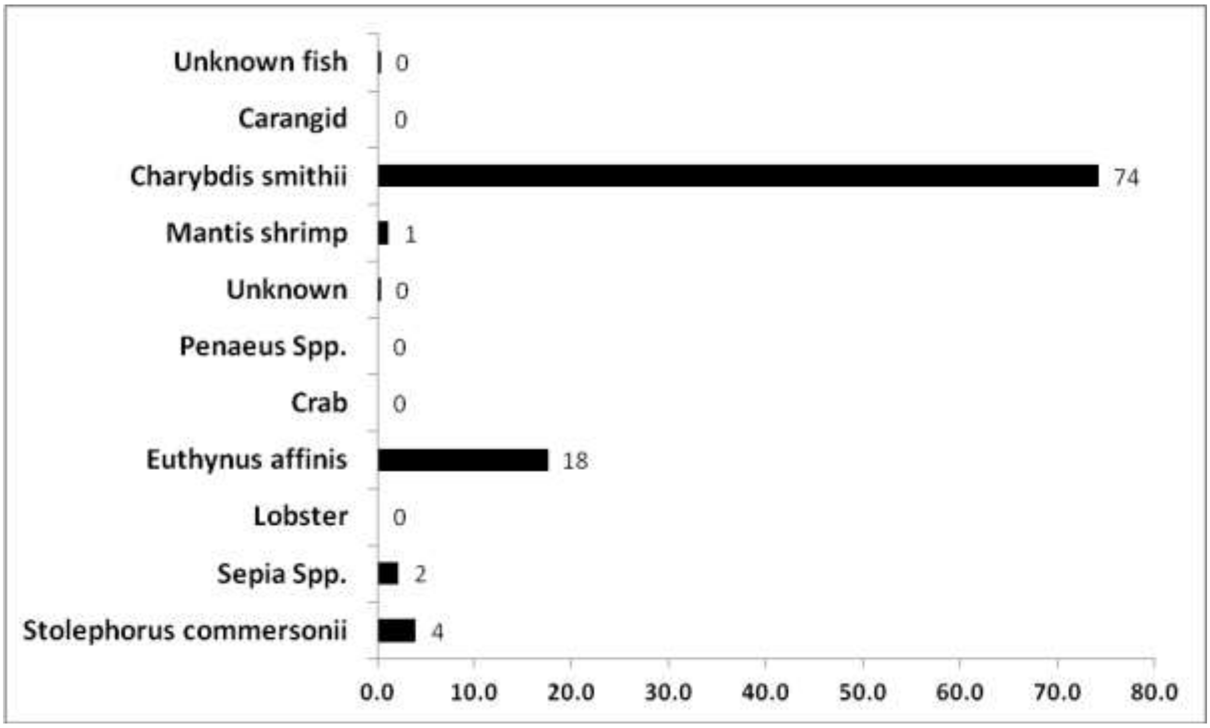

Figure 9: Most important prey of large yellowfin tuna from Kenyan coastal waters. Percent of the Index of Relative Importance

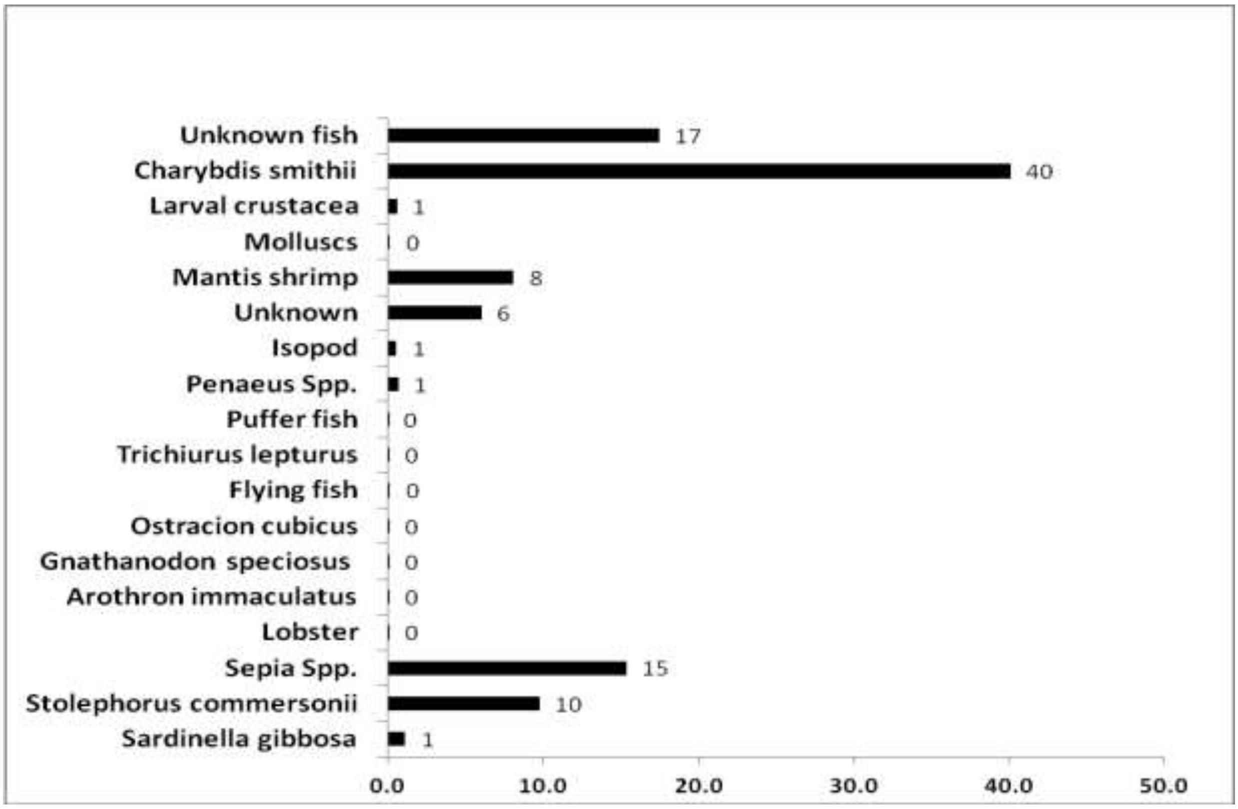

Figure 10: Most important prey of small yellowfin tuna from Kenyan coastal waters. Percent of the Index of Relative Importance

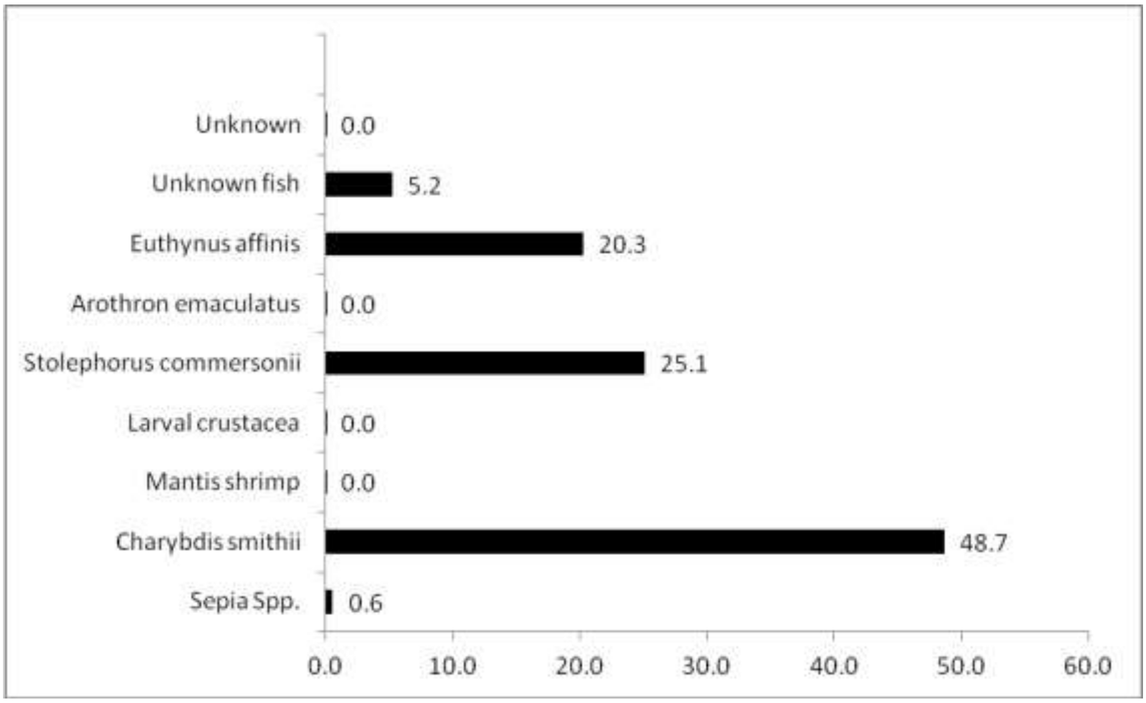

Figure 11: Most important prey of sailfish from Kenyan coastal waters. Percent of the Index of Relative Importance

References

Clarke, M.R., 1993. Age determination and common sense – a free discussion on difficulties encountered by the author. In: Okutani, T., O'Dor, R.K., Kubodera, T. (Eds)

Clarke M.R., 1986. A handbook for the identification of cephalopod beaks. Clarendon Press, Oxford

Clarke, M.R., MacLeod, N., 1976. Cephalopods remains from sperm whales caught off Iceland. J. Mar. Biol. Assoc. UK 56, 733 – 749.

Clarke, M.R., Kristensen, T.R., 1980. Cephalopod beaks from the stomachs of two northern bottlenosed whales (*Hyperoodon ampullatus*). J. Mar. Biol. Assoc. UK 60, 151 – 156.

Essington, T.E., Schindler, D.E., Olson, R.J., Kitchell, J.F., Boggs, C., Hilborn, R., 2002. Alternative fisheries and the predation rate of yellowfin tuna in the eastern Pacific Ocean. Ecol. Appl. 12, 724–734.

Jose´ Rosas-Alayola, Agustı´n Herna´ndez-Herrera, Felipe Galvan-Magan˜a, L. Andres Abitia-Ca´rdenas and Arturo F. Muhlia-Melo. 2002. Diet composition of sailfish (Istiophorus platypterus) from the southern Gulf of California, Mexico. J. Fish. Res. 57, 185 – 195

Kitchell, J.F., Boggs, C.H., He, X.,Walters, C., 1999. Keystone Predators in the Central Pacific. Ecosystem Approaches for Fisheries Management. University of Alaska Sea Grant, Fairbanks, pp. 665–683.

Kornilova, G.N., 1981. Feeding of yellowfin tuna, *Thunnus albacares*, and bigeye tuna *Thunnus obesus*, in the equatorial zone of the Indian Ocean. J. Ichthyol. 20, 111–119.

Maldeniya, R., 1996. Food consumption of yellowfin tuna, *Thunnus albacares*, in Sri Lankan waters. Environ. Biol. Fish. 47, 101–107.

Pinkas L, Oliphant M.S., Iverson I.L.K. 1971. Food habits of albacore, bluefin tuna, and bonito in California waters. Calif Dept Fish Game Fish Bull 152:1–105.

Potier, M., Marsac, F, Cherel, Y., Lucas, V., Sabati´e, R., Maury, O., M´enard, F. 2007. Forage fauna in the diet of three large pelagic fishes (lancetfish, swordfish and yellowfin tuna) in the western equatorial Indian Ocean. J. Fish. Res. 83, 60 – 72.

Roger, C., 1994. Relationships among yellowfin and skipjack tuna, their preyfish and plankton in the tropical western Indian Ocean. Fish. Oceanogr. 3, 133–141.

Thompson, P.M., Pierce, G.J., Hislop, J.R.G., Miller, D., Diack, J.S.W. 1991. Winter foraging by common seals, (Phoca vitulina) in relation to food availability in the inner Moray Firth, NE Scotland. J. Anim. Ecol. 60, 283 – 294.

van Couwelaar M, Angel MV, Madin LP (1997) The distribution and biology of the swimming crab *Charybdis smithii* McLeay, 1838 (Crustacea: Brachyura: Portunidae) in the NW Indian Ocean. *Deep-Sea Research II* **44**: 1251–1280

Watanabe, H., 1960. Regional differences in food composition of the tunas and marlins from several oceanic areas. Rep. Nankai Reg. Fish. Res. Lab. 12, 75–85.

Williams, F., 1963. Longline fishing for tuna off the coast of East Africa. Ind. J. Fish. 10, 233–322.

World Summit on Sustainable Development (2002) Plan of implementation. International Union for Conservation of Nature, Johanesburg

Zamorov VV, Spiridinov VA, Napadovsky GV (1992). On the role of the swimming crab *Charybdis smithii* (McLeay 1838) in the feeding habit of yellowfin tuna *Thunnus albacares* (Bonnaterre). *Workshop on Stock Assessment of Yellowfin Tuna in the Indian Ocean, Colombo, Sri Lanka, 7–12/10/91. IPTP Collection Volume Working Document* **6**: 70–75