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Fishery and Feeding Habits of Kawakawa (*Euthynnus affinis* -Cantor 1849) and Narrow barred Spanish mackerel (*Scomberomorus commerson* - Lacepède 1800) in the Coastal Waters of Dar es Salaam Tanzania

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Euthynnus affinis and *Scombermorus commerson* is one of the most important commercial species in the Western Indian Ocean region. However, information on the fishery and feeding habits are scanty to enable responsible fishing patterns. Data on fishery and feeding habit of *S. commerson* and *E. affinis* were collected from artisanal fishermen fleets in the coastal waters of Dar es Salaam Tanzania from 2008 to 2009. Hooks and lines, ring nets and gill nets operated mostly from both mechanized and non-mechanized crafts were observed as the major exploitation gears used by artisanal fishermen. Fishing for *E. affinis* and *S. commerson* were carried out throughout the year; however the peak landings were registered from November to February and from June to July, respectively. The study observed a significant higher catch per unit effort of *E. affinis* and *S. commerson* during northeast and southeast monsoon seasons, respectively ($p<0.05$). The presence of a wide variety of prey (i.e. fishes, crustaceans and cephalopods and gastropods) in the stomach of these two fish species indicates carnivorous feeding habits. Index of Relative Importance (*IRI*) of the prey items showed that the main food items in the stomach of *E. affinis* and *S. commerson* were *Atherina breviceps*, *S. ocelatus*, *Engraulis spp,* and unidentified small fish and *Eutrumes teres*. Diet overlap was observed between these two fish species for prey items crustaceans, cephalopods and fish ($C_{mh} > 0.6$) suggesting that these fish feed on the same food items. The present study provides a snapshot on the fishery and feeding ecology of the two fish species, however more research has to be carried out to understand its biology for proper management measures.

Key Words: *Euthynnus affinis*, *Scombermorus commerson*, fishery, feeding habits, catch per unit effort, diet overlap, Tanzania

INTRODUCTION

Narrow bared Spanish mackerel, *Scomberomorus commerson* and Kawakawa, *Euthynnus affinis* are recognized as keystone large pelagic fish of the tradition fisheries for their important roles in marine fisheries and ecosystem in the Western Indian Ocean (WIO) region (Kimaro, 1993). These species play a key ecological role as high-level predator in oceanic pelagic ecosystem because they occupy high trophic levels and consuming vast quantities of prey to satisfy their high energy requirements (Brill, 1987; Korsmeyer and Dewar, 2001). Fishing for *E. affinis* and *S. commerson* in the coastal waters of Tanzania and the WIO region especially by the artisanal fishers has been going on for the past century to date. In recent years it has gained importance and the catch contributes significantly to the marine fish landings. However, information on fishery and feeding behavior and the impact of fisheries on the pelagic ecosystem is not known. The ecological role of top predators in marine food webs is of importance because it plays a vital role in the assessment of the effects of fishing on ecosystems (Essington et al, 2002; Schindler et al. 2002; Cox et al. 2002; Watters et al. 2003). Food and feeding habits is an important factor in governing growth, condition, fecundity, migrations patterns and breeding patterns of fish (Rao, 1974). In bionomic studies of an individual species it stands as important biological information in describing assemblages and the analysis of ecosystem energetic and regulation (Sheldon and Meffe, 1993). Stomach content analysis of fish has been reported as a common method for assessing the diet of fish, describing food chain and webs shared by different species (Rice, 1988) and further providing information about the fish habitats.

Studies by Duffy and Hay (2001) revealed that predator pressure influence the evolution of populations, structure and function of nearly all marine communities and ecosystems. As a result stomach content analysis, even in its most casual and anecdotal form can yield supplementary but immediately valuable information. This is because predators are often better sampling devices than most commercial fishing gears (Caddy and Sharp 1986). Further studies conducted in the tropical and temperate seas have revealed that the removal of marine predators often causes profound changes in community organization, habitat structure and ecosystem processes (Kitchell et al. 1999; Essington et al. 2002 and Duffy and Hay 2001). As for *S. commerson*, high demand have triggered over-exploitation as growth over-fishing and recruitment failure has been of particular concern in the poorly studied WIO region (Dudley et al. 1992; King Fish Task Force, 1996). Griffiths et al. (2007) showed that tuna residing in Australian coastal ecosystems can have a significant interaction with fisheries where the commercial target species and the prey of the predator are shared. It is now recognized that ecosystem approaches to fisheries management is gaining increasing importance however it is a challenge to put in practice this method in the WIO due the rapid expansion of large pelagic fisheries (Potier et al. 2004). Therefore better information of the feeding of these two predators is required in this region.

There are few published information on the fishery and diet of *Thunnus albacares*, *Thunnus obesus* and *Euthynnus affinis* in the WIO region and India (Zamorov et al. 1992; Pillai and Pillai, 1998; Varghese et al. 2002; Potier et al. 2004; Prathibha; Griffith et al. 2009 and Ramomohan, 2009). Furthermore, feeding habits of *S. commerson* has been studied in Solomon Island (Blaber et al. 1990) and Egyptian Mediterranean coast (Bakhoum, 2007). Unfortunately, information on the fishery and predator–prey interactions for these two large pelagic fishes is scarce in the WIO region. The objective of this study was to investigate the fishery, fishing season, length ranges contributing to the fishery and feeding habits of *E. affinis* and *S. commerson* in the coastal waters of Dar es Salaam Tanzania.

MATERIAL AND METHODS

Study Site and Sampling Protocols

This study was conducted off the coastal waters of Dar es Salaam region, Tanzania (Fig. 1) for two monsoon seasons starting from April - September 2008 and from November 2008 to February 2009. The northeast monsoon (November – February) is characterized by weaker winds, while during the southeast monsoon (April - September) the winds are stronger (Francis, 1992). Sea surface temperature of coastal waters varies in a similar pattern, with an average of 28 °C during February and March and between 25 and 26 °C in June and July. June and July is the coolest period with an average temperature of 24°C while January, February and March is the warmest time of the year with an average temperature of 30°C. The specimen for the present study was collected from the artisanal fishermen ring net (3 inches mesh size) and gill net (7 inches mesh size) for *E. affinis* and *S. commerson*, respectively. Biological specimen were placed in an ice chest and brought to the laboratory at the University of Dar es Salaam for biological analysis.

Fig 1: Map of Dar es Salaam Showing the Study Sampling Site

Fishery Assessment

Monthly observations were made from April to September 2008 and from November 2008 to February 2009 at the coastal waters of Dar es Salaam to collect statistics on crafts, gears and catch landed. *E. affinis* and *S. commerson* catch landing were obtained from the artisanal fishermen boat. The catch estimated for different months was then pooled to get the seasonal variation of catch for *E. affinis* and *S. commerson*. The number of artisanal fishers involved in the fishery per boat and time spent fishing were recorded. Fish species were visually counted and catch per unit effort (CPUE) was calculated as: $CPUE = C \big/ ft$ where C is the catch, *f* is the number of fishers and *t* is the time spent during fishing (time with gear in water). Sea surface temperature at 0.5 m depth was recorded using Water Quality Probes.

Stomach Content Analysis

Specimen's total length in nearest centimeter (TL$\pm$0.1) and body wet weight to the nearest gram (W$\pm$0.1) were recorded. During the preset study, a total of 317 fish specimens of different length group (180 during northeast monsoon and 137 in southeast monsoon season) were examined to study the feeding biology of *E. affinis*. For *S. commerson* a total of 172 fish samples (64 in northeast monsoon and 108 in southeast monsoon season) were examined to study feeding habits. In the laboratory, samples of *E. affinis* and *S. commerson* were dissected along the esophagus and intestine to remove stomach contents. Each sample of stomach contents was thawed drained and a two-step procedure was applied:

I: The total weight of each stomach contents was measured. Accumulated items, i.e. indigestible hard parts of the prey items that accumulated overtime (cephalopod beaks without flesh attached and eroded otoliths) were sorted and excluded from analysis because they overemphasize the importance of some prey in the fish diets. The contents were divided into broad prey category of five (fish, crustaceans, cephalopods, gastropods and others). Prey items were identified to the lowest possible taxonomic level according to Bianchi (1985) and Rudy Van Der Elst, (1993).

II: Each identified and unidentified fish species were sorted, counted and weighed to calculate the proportion of wet by mass in the diet. For the remaining prey category (i.e crustaceans, cephalopods, gastropods, others), the different items constituting a single category were sorted, counted and weighed. Identifiable fresh remains were used to determine the number of each prey item.

The contribution of each type of food to the diet was expressed as percentage by number (%N), percentage frequency of occurrence (%F) and percentage by weight (%W). Index of relative importance was estimated following Windell and Bowen (1978). The degree of diet overlaps between the two fish species were calculated following Morisita-Horn Quantitative Index of similarity (Horn, 1966; Smith and Zaret, 1982).

$$C_{mh} = \frac{2\sum_{i=1}^{S} an_i \times bn_i}{(da + db)(aN \times bN)}$$

Where, S = total number of species of prey in the stomach of predators, aN total number of prey in the stomach of predator A, bN = total number of prey in the stomach of predator B, an_i = number of individuals of prey i in the stomach of predator A, bn_i = number of individuals of prey i in the stomach of predator B. The trophic overlap was classified according to the scale proposed by Langton (1982) where by values between 0.0 and 0.29 indicate low overlap, 0.30 and 0.65 indicate middle overlap and 0.66 to 1 indicate high overlap (Keast, 1978).

The feeding intensity of both species was assessed based on visual estimations on the enlargement of the gut and the quantity of food contained in it. Assessment of various stomach condition on the basis of degree of fullness were expressed as Gorged, Full, ¾ Full, ½ Full, ¼ Full, Trace and Empty Stomach as adopted from Pilay (1952). However, to guarantee that both quantitative and qualitative estimations are considered, the Index of Preponderance (IP) was used for the quantification of the food items (Natarajan and Jhingram, 1961). The IP was calculated using the following equation:

$$IP = 100\ (V_iO_i)/\sum V_iO_i$$

Where, V_i and O_i is the volume and occurrence index of food items in percentage.

Data Analysis

Catch per unit effort (CPUE) data were tested for normality and variations between northeast and southeast monsoon seasons were calculated using two sample t tests ($p < 0.05$). Correlation between CPUE of *E. affinis* for the day-time fishing and *S. commerson* for night time fishing and sea surface temperature were assessed using GraphPad InStat statistical package.

RESULTS

Gears and Craft

Traditional non-mechanized and mechanized crafts are used for *E. affinis* and *S. commerson* fishing in the coastal waters of Dar es Salaam Tanzania. The traditional crafts used for this particular fishery includes open wooden boats (locally known as *mashua* and *boti*). Crafts for the *E. affinis* day time fishing are equipped with outboard engines of either 12 hp or 25 hp. However, for the night fishing trips targeting *E. affinis*, *S. commerson* and other large pelagic fishes, though crafts are equipped with outboard engines, the main means of propulsion is by sail. The outboard engine supplements the sails and is mostly used when wind conditions are unfavorable. On good windy days, these crafts get a speed of more than 12 knots per hour.

Ring net fishing (2 ½-3 inches mesh) is the only gear used during the day fishing trips to catch schools of *E. affinis*. Small wooden open boat about 12 m LOA, motorized by 12 or 25 Hp engine are used for up to 7 hours of fishing trips at sea. While ring net is specifically targeting small pelagic fishes such as sardine, *E. affinis* is caught in large quantity by this gear as the species prefers to feed in areas where there is schools of sardine. Entanglement nets (locally known *Jarife*) with mesh size 5 – 7 inches are used as drift or floating gillnets to catch both *S. commerson* and *E. affinis* during night fishing trips. Gillnet fishing for these two fish species was restricted to moonless nights for both seasons. This study observed that gill nets and hooks and line are operated simultaneously during the night to target *S. commerson*. Few fishermen targeting *S. commerson* and other large pelagic fishes using hooks and line during the day. The most popular bait used includes Sardines (*Sardinella albella, S. ocelatus* and *S. barracuda*).

Fishery

Euthynnus affinis and *S. commerson* are commonly caught beyond the depth of 20 meters. *S. commerson* fishery was observed to be restricted during the night while *E. affinis* fishing is conducted during the day and night fishing trips. However, the size of the catch in terms of length varied between day and night. Large sized individuals of *E. affinis* ranging from 45 cm to 82 cm total length were caught during the night together with *S. commerson*. Total length of the individuals *E. affinis* caught during the day ranged from 32 cm to 63 cm. The total length of *S. commerson* caught during the night fishing trips ranged from 66 to 119 cm. Ring net fishing which was restricted during the day is the most productive method for *E. affinis* fishery in terms of catch and its output accounts for about 75% of the total production of this species. Night fishing for *E. affinis* and *S. commerson* starts around 19.00 hrs to 04.00 hrs. When the weather is conducive especially during northeast monsoon fishermen take 1-2 hours to reach the fishing ground and an equal time to return. Fishing for *E. affinis* especially during the day starts early in the morning from 6 am to 13 pm. The fishermen engaged in hooks and line fishing start early in the morning around 8.00 am and return after fishing around 14 pm or they start around 18 pm and return early in the morning the next day by 6.00 am. Hooks and lines operations are commonly conducted in calm conditions from September to March while the operations are suspended when wind conditions are not conducive i.e. May to July.

Fishing Season

Euthynnus affinis and *S. commerson* fishing is carried out throughout the year. However, peak landings for *E. affinis* were observed during November to February. On the other hand, the peak landings for *S. commerson* were registered from June to July. A total of 1,564 and 506 *E. affinis* were caught during the day in the northeast (NEM) and southeast monsoon (SEM) season, respectively. The numbers of the same species caught during the night were 277 and 244 for the northeast monsoon and southeast monsoon seasons, respectively. The catch per unit of effort (CPUE) for the day and night fishing trips was highest in February and September but lowest in June (Fig. 2a). For the night-time fishing trips, higher CPUE of *E. affinis* was revealed during NEM than during SEM ($t = 2.011$, $p = 0.045$). The day-time data of CPUE of *E.affinis* revealed a positive correlation with SST as catch tended to increase with sea surface temperature in NEM monsoon ($r = 0.87$, $p = 0.0007$) and decreased with temperature in SEM season SEM ($r = 0.98$, $p = 0.02$). Also sea surface temperature and CPUE revealed a positive correlation as catch tended to increase as temperature increased during the night in NEM monsoon NEM ($r = 0.81$, $p = 0.001$) and decreased with water temperature during SEM monsoon season ($r = 0.83$, $p = 0.002$).

For *S. commerson*, fishing took place only during the night and the number of fish caught was 167 and 555 for NEM and SEM, respectively. The highest catch was recorded in July while the lowest catch was observed in January (Fig. 2b). Higher CPUE of *S. commerson* was observed during NEM than in SEM ($DF = 13$, $t = 2.666$, $p = 0.004$). SST and CPUE showed negative correlation as catch decreased with increase in temperature during NEM ($r = - 0.79$, $p = 0.003$) and increased with decrease in temperature during SEM ($r = - 0.58$, $p = 0.045$).

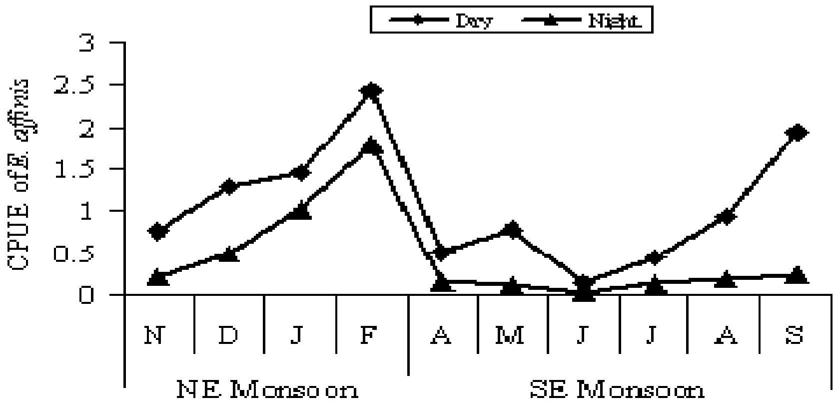

Fig 2a: Catch per Unit Effort of *Euthynnus affinis*

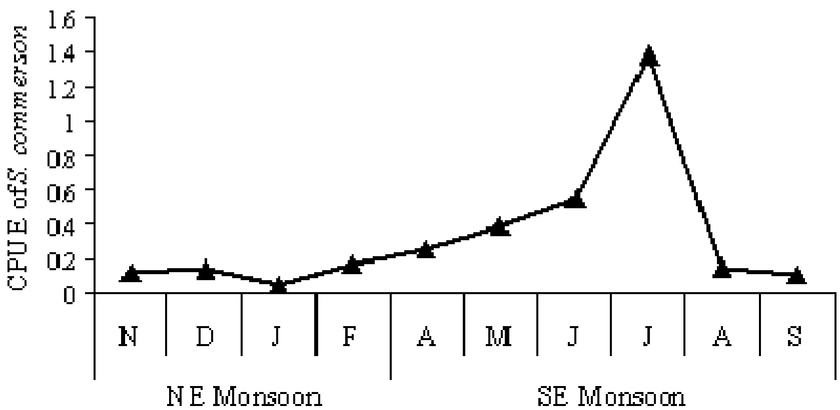

Fig 2b: Catch per Unit Effort of *Scomberomorus commerson*

Food Composition

Fishes: Diet analysis indicated that *E. affinis* feed on fish, crustaceans and gastropods. Fish were found to be the dominant food item for both *E. affinis* and *S. commerson* during southeast and northeast monsoon seasons (Table 1 and 2). Fishes identified in the stomach of *E. affinis* includes; *Atherina brevicepts*, *Apogon* spp, *Eutrumes teres*, *Atherinomonus spp*, *Engraulis japonicas*, *Atherina afra*, *S.ocelatus* and other unidentified fish. However, sea grass and worms were also identified in the stomach of *E. affinis* at different proportion. Among the seven species of fishes identified in the gut of *E. affinis*, *Atherina breviceps* was dominant. It was also found that the food fishes observed in the stomach of *E. affinis* varied from 4 cm to 18 cm total length. Largest fish (18 cm) found in the gut was *S. ocelatus* while the smallest fish observed in the stomach was *Atherina* *breviceps*. The most frequent food item in the diet of *E. affinis* was *A. breviceps* for both seasons. In comparison to the prey composition by number and weight, unidentified fish remains was the most important prey for *E. affinis* by weight while the *A. breviceps* was the most important food item by percentage by number. Based on the value of IRI, the prey items of *E. affinis*, the main food items were identified to be *A. breviceps*, *Engraulis spp,* unidentified small fish and *E.teres* (Table. 1).

In the stomach of *S. commerson*, identified fish species includes; *A. brevicepts, Silago spp*, *Eutrumes teres*, *Atherinomonus spp*, *Atherina. Lacunosus*, *S. ocelatus*, unidentified fish species, *Sardinella albella*, *S. barracuda*, *Thyrissa spp* and *Saurida spp* (Table 2). Among of the ten species of fishes identified in the gut of *S. commerson*, *Eutrumes teres* was the dominant prey species. Size of food fishes in the stomach of *S. commerson* ranged from 5 cm to 25 cm total length. Largest fish (25 cm) encountered in the stomach of *S. commerson* was *S. barracuda* while the smallest fish (5 cm) was *Atherina breviceps*. The most frequent prey in the stomachs of *S. commerson* during SEM was *S. ocelatus* followed by unidentified fish remains while during NEM, *E. teres* was the most frequent food item followed by *S. ocelatus* (Table. 2). The most important food by weight was unidentified fish while *A. breviceps* was identified as the most important food item in terms of number. Also the value of IRI identified *S. ocelatus*, *A. breviceps*, unidentified small fish and *E. teres* as the most important prey in the diet of *S.commerson* (Table. 2). The most frequent species found in the stomachs of *S. commerson* during SEM was *S. ocelatus* followed by unidentified fish remains while during NEM, *E. teres* was the most frequent food item followed by *S. ocelatus*. In comparison to the prey composition by number and weight, unidentified fish remains was the most important prey for *E. affinis* by weight while the *A. breviceps* was the most important food item by number. For *S. commerson*, the most important food prey by weight was unidentified fish while *A. breviceps* was identified as the most important food item in terms of number (Table 2).

Crustaceans: Crustaceans such as **s**hrimps were found to be the second dominant prey species in the diet of *E. affinis*. Shrimps contributed 5.3% during northeast monsoon and 14.9% during southeast monsoon to the diet of *E. affinis*. In terms of weight, shrimps contributed 2.4% during NEM and 1.3% during SEM season. It was also found that shrimps were important food in the diet of *E. affinis* during NEM (88.5) than during SEM (70.9) seasons (Table 1). For *S. commerson*, shrimps were found to be the second dominant food item during SEM (7.47) and the third dominant prey item during NEM (1.24) seasons (Table 2).

Mollusks: During this study mollusks were represented by squids and octopuses. Mollusks formed the third most dominant group in the diet of *E. affinis* over the study period. In terms of percentage by weight, mollusks contributed 2.1% during NEM and 0.9% during SEM season. Mollusks were the most important food items during NEM (22.7%) as compared to SEM where index of relative importance was found equal to 14.5% (Table 1). For *S. commerson*, mollusks formed the second dominant prey (1.26%) in the stomach during northeast monsoon while it was the third (2.49%) dominant food during SEM season (Table 2). On the other hand, mollusks were the third most important food item in the diet of *S. commerson* during the study period (Table 2).

Gastropoda and others: Gastropods formed the forth most dominant food items in the diet of *E. affinis* and it was observed only during northeast monsoon. In the group of 'others' sea grass and worms were observed in the stomach content of *E. affinis* during NEM season. Gastropods, sea grass and worms were not observed in the diet of *S. commerson*.

Month-wise Feeding Intensity of *Euthynnus affinis*

During this study highest percentage of empty stomach for female fishes was found in August (22.3%) and the lowest in May (5%) (Table 3). About 22% of females appeared to have not fed during August followed by 20.76% in January and 18.01% in July. Percentage of high feeding (full stomach) varied considerably from 0% in May to 65.32%

in February. Similarly highest feeding (gorged stomachs) was observed in the month of August (17.28%) while the lowest feeding (0.0%) was recorded in June, July, August and September (Table 3).

Table 2: Percentage Indices of Food Items of *Euthynnus affinis*

NORTHEAST MONSOON						**SOUTHEAST MONSOON**					
Organism group		**Feeding habits**				**Organism group**		**Feeding habits**			
FISH	Taxonomic category	**%N**	**%F**	**%W**	**IRI**	**FISH**	Taxonomic category	**%N**	**%F**	**%W**	**IRI**
	A.. breviceps	42.9	25.4	19.8	1591		*A.breviceps*	37.2	49.2	22.2	2918
	E. japonicas	18.6	19.4	14.8	647		Unidentified fish	7.34	18	35.9	778
	Atherina afra	11.2	5.8	5.1	97.5		*E. japonicus*	15.6	10.8	14.7	327
	S. ocelatus	0.6	5.56	11.8	92.3		*Etrumens teres*	15.8	5.7	8.5	138
	Atherinomonus spp	7.0	5.9	5.9	76.9		*S. ocelatus*	5.2	4.7	14.8	94.2
	Etrumens teres	2.7	5.9	2.4	30.3		*Apogon* spp	0.8	2.8	1.7	6.92
	Unidentified fish	3.7	20.9	25.8	615	**CRUSTACEANS**	Shrimps/prawns	14.9	4.4	1.3	70.9
CRUSTACEANS	Shrimps/prawns	5.3	11.4	2.4	88.5	**CEPHALOPODS**	Squids/octopuses	3.2	3.5	0.9	14.5
CEPHALOPODS	Squids/octopuses	0.98	7.5	2.1	22.7	**GASTROPODA**	x	x	x	x	x
GASTROPODA	Gastropods	0.2	2.9	0.3	1.6	**OTHERS**	x	x	x	x	x
OTHERS	Worms	3.2	2.9	0.3	10.6						
	Seagrass	0.7	2.9	0.3	1.6						

Table 2: Percentage Indices of Food Items of *Scomberomorus commerson*

NORTHEAST MONSOON						**SOUTHEAST MONSOON**					
Organism group		**Feeding habits**				**Organism group**		**Feeding habits**			
FISH	**Taxonomic category**	**%N**	**%F**	**%W**	**IRI**	**FISH**	Taxonomic category	**%N**	**%F**	**%W**	**IRI**
	Unidentified fish	41.1	15.6	49.9	1421		Unidentified fish	6.41	26	28.6	910
	Eutrumes teres	16.5	38.4	3.68	776.4		*S. ocelatus*	10.3	36	38.1	1740
	S. ocelatus	13.7	23.2	16.7	706.8		*A. breviceps*	57.2	14	20.7	1091
	A. breviceps	15.1	10.1	12.1	285.1		*A. lacunosus*	9.96	5	2.92	64.4
	Pelates spp	0.6	4.99	2.85	17.2		Silago *spp*	1.5	2	4.45	11.9
	Sardinella albella	3.31	1.18	4.93	9.72		*Engraulis spp*	0.36	2	0.44	4
	S. baracuda	3.16	0.67	4.12	4.88	**CRUSTACEANS**	Shrimps/prawns	7.47	8.1	1.76	70
	Saurida spp	1.17	0.41	2.25	1.4	**CEPHALOPODS**	Squids/octopuses	2.49	4	3	21.2
	M.vaniolensis	1.12	0.46	0.97	0.96	**GASTROPODA**	x	x	x	x	x
	Squilidae spp	0.56	0.08	1.89	0.19	**OTHERS**	x	x	x	x	x
	Thyssa spp	0.42	0.08	0.31	0.06						
CRUSTACEANS	Shrimps/prawns	1.24	4.2	0.54	7.48						
CEPHALOPODS	Squids/octopuses	1.26	0.19	0.08	0.25						
GASTROPODA	Gastropods	0.62	0.03	0.1	0.02						
OTHERS	x	x	x	x	x						

Male fishes revealed low feeding intensity as high percentage of empty stomachs was observed during various months of the study (35.6% in July, 30.78% in June, and 30.26% in August, 24.06% in September and 22.71% in April) (Table 4). Percentage of high feeding (full stomach) was highest in December (43.37%) and lowest in moths of June (10.66%). Highest feeding intensity (gorged stomachs-19.04%) was found in January, followed by 13.09% in June, 10.42% in December.

Table 3: Month - wise Feeding Intensity in Females of *Euthynnus affinis*

	Year									
	2008								**2009**	
Fullness of stomach	Apr	May	Jun	July	Aug	Sep	Nov	Dec	Jan	Feb
Empty	10	5	8	18.01	22.3	17.37	10.21	4.88	20.76	12
Trace	0	15	0	21.63	17.08	22.66	16.29	20.55	11.25	0
¼	10	15.7	15.28	10.83	11.23	10.54	0	0	0	6.78
½	20	29.07	18.5	20.74	27.71	25.27	8.4	17.19	12.91	15.9
¾	0	20	14.9	8	18.24	0	0	0	5.56	0
Full	40	0	43.32	20.79	1.76	24.16	49	40.1	49.52	65.32
Gorged	20	15.23	0	0	0	*0*	16.1	17.28	0	0

Table 4: Month - wise Feeding Intensity in Males of *Euthynnus affinis*

	Year									
	2008								**2009**	
Fullness of stomach	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Nov**	**Dec**	**Jan**	**Feb**
Empty	22.71	8.27	30.78	35.6	30.26	24.06	11.43	19.67	11.34	6.25
Trace	0	0	21.95	4.26	3.22	12.01	4.27	0	7.4	0
¼	16.6	17.74	11.29	14.1	12.28	17.6	7.3	5.2	10.7	14.52
½	20.27	34.5	12.23	10.5	22.05	7.47	28.31	21.34	20.5	23.18
¾	13.31	0	0	6.12	10.11	12	6.51	0	0	13.81
Full	20.2	29.06	10.66	20.1	20.88	22.15	39.03	43.37	31.02	36.48
Gorged	6.91	10.43	13.09	9.24	1.2	4.71	3.15	10.42	19.04	5.76

Month-wise Feeding Intensity of *Scomberomorus commerson*

During this study, highest percentage of empty stomach for female fishes was found in August (39.5%) (Table 5). Percentage of low feeding (quarter full stomachs) varied from 0.0% in the month of May, July and November and January to 15.7% in December.

Percentage of high feeding (full stomach) varied greatly from 0% in December to 61.1% in May while highest feeding (gorged stomachs) was revealed in the month of January (27%). Male fishes revealed low feeding intensity as high percentage of empty stomachs was observed during various months (27.63% in September and 23.22% in August, 21.39% in January (Table 6). Percentage of high feeding (full stomach) varied from 12.16% in August to 46.41% in June. Highest feeding intensity (gorged stomachs-20.1%) was found in January, followed by 19.2% in February and 17.98% in November (Table 6).

Table 5: Month - wise Feeding Intensity in Females of *Scomberomorus commerson*

	Year									
	2008								**2009**	
Fullness of stomach	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Nov**	**Dec**	**Jan**	**Feb**
Empty	10	3.66	23	11.6	39.5	29	7.21	0	10.3	5.7
Trace	8.64	0	17.18	21.63	0	18.4	14.6	20	0	0
¼	1.88	0	12.7	0	13.4	7.11	0	15.7	0	9
½	24.6	25.12	32.7	24	26	29.76	27.29	29.07	21.7	21
¾	5.56	8	0		3	7.12	6	20	3	0
Full	45.66	61.1	14.42	32.77	18.1	4.55	32.8	0	38	55.3
Gorged	3.66	2.12	0	10	0	*4.06*	12.1	15.23	27	9

Table 6: Month - wise Feeding Intensity in Males of *Scomberomorus commerson*

	Year									
	2008								**2009**	
Fullness of stomach	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Nov**	**Dec**	**Jan**	**Feb**
Empty	12.27	7.26	0	11.76	23.22	27.63	16.21	13.28	21.39	16.8
Trace	0	0	10.43	15.19	24	4.39	0	8.9	0	7.66
¼	16.71	18.56	12.16	17.26	11.08	14.22	17.17	12.33	18.23	11.51
½	24.79	35.1	31	22.88	10.11	18.08	0	27	0	23.28
¾	6.15	0	0	0	7.4	8.44	10.11	10.36	19.5	0
Full	28	33.08	46.41	32.91	12.16	22.61	38.53	28.13	20.78	21.55
Gorged	12.08	6	0	0	12.03	4.63	17.98	0	20.1	19.2

Diet Overlap

It was observed that prey items in the diet of *E. affinis* were also found in the stomach of *S. commerson* at different proportions. The results of the Morisita–Horn index (C_{mh}) showed a significantly higher overlap indices in the diet of *E. affinis* and *S. commerson*

(C_{mh} = 0.99 for crustaceans, 0.97 for fish and 0.86 for cephalopods). The diet overlap was not significant for gastropods between the two fish species (C_{mh} = 0.58).

DISCUSSION

Fishery and Fishing Season

Fisheries of *E. affinis* and *S. commerson* are restricted to the shallow waters (< 50 m deep) due to the poor technology used by artisan fishermen. The present study suggests that *E. affinis* increased with temperature during NEM and the reverse did occur in SEM season. In marine environment water temperature is one of the important factor in determining abundance and migration of nearly all marine fish species (Henderson and Holmes, 1990). This is because abundances of many species are limited by temperature dependent resources such as salinity, food quality and quantity. Therefore, temperature changes might for example, enhanced marine productivity and enabling this species to respond rapidly by changing their distribution to encompass our sampling sites or by enhancing their local population abundance directly. These results suggest that increase in water temperature could probably trigger migration of *E. affinis* to the coastal waters of Tanzania. Similar results were reported by Rose et al. (2000) where by sea temperature changes have been linked to fluctuations in cod (*Gadus morhua*) abundance, recruitment and habitat shifts off Labrador and Newfoundland. Likewise, alterations in ocean temperatures, and the food chains in the ocean have been reported to affect the location and abundance of tuna species (Lehodey et al. 1997, 2003, Loukos et al, 2003).

On the other hand, catch per unit effort of *S. commerson* increased with decrease in water temperature during SEM season. This is an indication that distribution and abundance of this species is not only affected by water temperature but also other factors such as food quality and quantity, spawning aggregation and turbid waters. MacPheron (1985) reported higher abundance of *S. commerson* in the coastal water of Queensland Australia where low water temperature and salinity and high turbidity prevails. Differences in the catch for the two pelagic species could be attributed by the effects of sea surface temperature on stock-recruitment, catchability coefficient and exploitation as reported to other fish species by Kawasaki (1994). This is due to their effects on the growth rate via their metabolic activity thus determining the number of individuals entering fishery (Begg, 1998). The present study was of interest simply because despite of the well known length shore migration, *E. affinis* and *S. commerson* were caught by artisanal fishers throughout the year. This result suggests the likelihood of having permanent resident and migratory individuals of both species in the coastal waters of Tanzania. Similar results were reported by (McPheron, 1992; Collette and Nauen, 2001) in the coastal waters of Queensland Australia.

Food Composition

The identification of food items consumed by fish is necessary to understand food availability in their natural habitat, which in turn has a potential in fisheries yield as fish grow. Availability of different types of food may perhaps influence the abundance and distribution of these fishes and consequently its migration. The presence of a wide variety of preys such as fish, crustaceans, cephalopods and gastropods in the stomach indicates carnivores feeding habits of *S. commeroson* and *E. affinis*. Present study showed that fish is the most preferred food item *E. affinis* and *S. commerson*, followed by crustaceans and cephalopods. On the other hand, having almost the same prey species in the diet of *E. affinis* and *S. commeroson* for both seasons suggests that they are more selective in their diets and specialize on particular food items. Also high degree of diet overlap between the two pelagic fish indicated that they feed mainly on the same kind of food. The occurrences of these prey items in both species could probably be attributed to the seasonal availability of prey items in the study area.

These fish species were observed to consume the food which was readily available in the fishing grounds where they live in. Although previous studies showed that *E. affinis* are carnivores (Takashi, 1983), the present findings revealed that despite of the small sized individuals feeding on small – sized pelagic crustaceans and fishes a filter feeding behavior was also suspected due to the presence of sea grass and worms in their stomach. This study is similar to that of Blaber et al. (1990) and Chiou and Lee (2004) around Solomon Islands and Taiwan which found *E. affinis* food to constitute 90% fish prey of the overall prey biomass. Tropical tuna of similar size to *E. affinis* that frequent oceanic habitats beyond continental shelf have been shown to feed primarily on epipelagic fish, crustaceans, and cephalopods (Bertrand et al. 2002 and Potier et al. 2004). The present findings have also noted that despite the varied diet of these species, selectivity in terms of size does exist simply because *S. commerson* feed on large fish while *E. affinis* feed on small fishes. This is an indication that *S. commerson* prefer bigger optimal prey size as compared to *E. affinis*. However, it is important to recognize the actual complexity of the situation when implementing management initiatives because species may feed at different levels in the food chain at different stages of their life cycle.

In the present study, percentage by number was observed to overemphasize the importance of smaller prey since they weigh so much less than larger prey. On the other hand, percentage by weight overemphasized the importance of large prey. This is because small sized prey (*A. breviceps*, *Engraulis* spp *and E. teres*) revealed higher %N and IRI values but small values of %W. However, by considering the contribution of a prey to the predator's nutrition, then higher %W for small sized fish (*S. ocelatus*, small unidentified fish, *S. barracuda*, *Sardinella albella, S*, *tumbil*) contributes much in the nutrition value of these large pelagic fishes. This is because the contribution of large sized prey items in terms of nutrition value is higher than for small prey species. Despite the fact that some prey species are having the small values of *IRI*, %N and %F they are still important in the diet of *E. affinis* and *S. commerson* as their total nutritional value depends primary on the combination of all prey items. The same results were observed in other studies of marine fish species by Hyslop (1980).

Feeding intensity of *E. affinis* changed with months whereas low percentage of stomach fullness in both sex was noticed from April to September probably due to the decline in water temperature. Highest percentage of stomach fullness in November (49%), December (40.1%), January (49.52%) and February (65.32%) could be attributed by increased water temperature. On the other hand, the highest percentage of stomach fullness to the female and female *S. commerson* were recorded in May (61.1%) and June (46.41%) when water temperature was at a lowest point. Variations in the prey items in the diet of these species can be associated with the characteristics of prey species which mediate predations such as absolute and relative abundance, conspicuousness, size, palatability, defensive morphology and behavior, spatial distribution including microhabitat and aggregation and nutritional value. These factors are limited or mediated by various elements of the environment including water temperature, turbidity, dissolved oxygen, solar radiation, water motion and structural aspects of the habitat (Smith, 2000).

Conclusion and Recommendations

Catch per unit effort of *E. affinis* and *S. commerson* was higher during NEM and SEM seasons, respectively. Changes in water temperature have showed impacts on the fisheries of these two large pelagic fish species. The presence of a wide variety of preys such as fish, crustaceans, cephalopods and gastropods in the stomach indicates carnivores feeding habits of *S. commeroson* and *E. affinis*. Index of relative importance revealed *Atherina breviceps*, *Engraulis* spp*,* small unidentified fish, *Eutrumes teres* as the main food items for *E. affinis*. Also *Sardinops ocelatus*, *Atherina breviceps*, small unidentified fish, *Eutrumes teres* were the most important prey of *S. commerson*. *E. affinis* and *S. commerson* were observed to feed on the same prey species. A long term study is recommended on the impacts of *E. affinis* and *S. commerson* fishery to the population dynamics of prey species in the WIO region.

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REFERENCES

Bakhoum, S.A (2007), 'Diet overlap of immigrant narrow–barred Spanish mackerel Scomberomorus commerson (Lac., 1802) and the largehead hairtail ribbonfish Trichiurus lepturus (L., 1758) in the Egyptian Mediterranean coast', *Animal Biodiversity and Conservation*, 30.2: 147 - 160

Begg G. A (1998), 'Reproductive Biology of Spanish mackerel *Scomberomorus commerson* and Spotted mackerel *Scomberomorus munroi* in Queensland East-coast waters', *Journal of Marine and Freshwater Research,* 49: 261−270

Bertrand A; Bard F. X and Josse E (2002), Tuna Food Habits Related to the Micronekton Distribution in French Polynesia', *Marine Biology*, 140: 1023–1037

Bianchi G (1985), *Field Guide to the Commercial Marine and Brackish – Water Species of Tanzania*: FAO Species Identification Sheets for Fishery Purposes, pp 89

Blaber S. J. M; Milton D.A; Rawlinson N.J.F; Tiroba G and Nichols P. V (1990), 'Diets of Lagoon Fishes of the Solomon Islands: Predators of Tuna baitfish and Trophic Effects of Bait Fishing on the Subsistence Fishery', *Fish Research*, 8: 263–286

Brill R. W (1987), 'On the Standard Metabolic Rates of Tropical Tunas, Including the Effect of Body Size and Acute Temperature Change', *Fishery Bulletin US,* 85: 25–35

Chiou W. D and Lee L. K (2004), Migration of Kawakawa *Euthynnus affinis* in the Waters near Taiwan', *Fisheries Science,* 70: 746–757

Collette B. B and Nauen C. E (2001), Scombrids of the World: An Annotated and Illustrated Catalogue of Tunas, Mackerels, Bonitos, and Related Species known to date, FAO Species Catalogue, United Nations Development Programme, Rome, 125(2), 137 pp

Cox S.P; Essington T.E; Kitchell J.F; Martell S.J.D; Walters C.J; Boggs C and Kaplan I (2002), Reconstructing Ecosystem Dynamics in the Central Pacific Ocean, 1952 1998. II. A Preliminary Assessment of the Trophic Impacts of Fishing and Effects on Tuna Dynamics', *Canadian Journal of Fish and Aquatic Sciences*, 59: 1736–1747

Dudley R.G; Prabhakar A and Brothers E (1992), 'Management of the Indo-Pacific Spanish mackerel *Scomberomorus commerson* in Oman', *Journal of Fisheries Research,* 15: 17-43

Duffy J.M and Hay M.E (2001), The Ecology and Evolution of Marine Consumer Prey Interaction: *In* Marine Community Ecology, Eds., Bertness, M.D., S.D. Gaines and M.E. Hay. Sinauer Associates, Inc., Sunderland, pp 131-157

Essington T.E; Schindler D.E; Olson R.J; Kitchell J.F; Boggs C and Hilborn R (2002), 'Alternative Fisheries and the Predation rate of Yellowfin tuna in the Eastern Pacific Ocean', *Ecology and Applications,* 12: 724–734

Francis J (1992), 'Physical Processes in the Rufiji Delta: Their Implications on the Mangrove Ecosystems', *Journal of Hydrobiology,* 247: 179 – 184

Griffiths, S.P; Petra M; Kuhnert, Gary F. Fry, and Fiona J. Manson (2007), 'Temporal and size-related variation in the diet, consumption rate, and daily ration of mackerel tuna (*Euthynnus affinis*) in neritic waters of eastern Australia', *ICES Journal of Marine Science,* 66: 720–73

Henderson P. A and Holmes R. H. A (1990), 'Population Stability Over a Ten-year Period in the Short-lived Fish *Liparis liparis* (L.)', *Journal of Fish Biology*, 37: 605–616

Horn H. S (1966), 'Measurement of 'Overlap' in Comparative Ecological Studies', *The American Naturalist,* 100: 419–424

Hyslop E.J (1980), 'Stomach Content Analysis: A Review of Methods and Their Application', *Journal of Fish Biology,* 17: 411-422

Keast A (1978), 'Trophic and Spatial Interrelationships in the Fish Species of Lake Ontario', *Journal of Environmental Biology and Fishes,* 3 (1), 7–31

Kimaro P.N (1993), Review of Tuna Fishery in Tanzania Mainland from 1989 to 1993. Tanzania Fishery Cooperation, Dar es Salaam. pp 1 - 2

Kingfish Task Force (1996), Kingfish Resource and Fisheries in the Sultanate of Oman, Indo-Pacific Tuna Development and Management Programme (IPTP/96/WP/27), Colombo, pp 55

Kitchell J.F; Eby L.A; Schindler D.E and Wright R.A (1999), 'Predator-prey Dynamics in an Ecosystem Context', *Journal of Fish Biology*, 45:209-226

Langton R. W (1982), 'Diet Overlap between the Atlantic cod *Gadus morhua*, Silver hake, *Merluccius bilinearis* and fifteen other Northwest Atlantic finfish', *Bulletin of United States,* 80: 745–759

Lehodey P.M; Bertignac J; Hampton A and Picaut J (1997), 'El niño Southern Oscillation and Tuna in the Western Pacific Ocean', *Nature* 389: 715-718

Lehodey P; Chai F and Hampton J (2003), 'Modelling Climate-related Variability of Tuna Populations from a Coupled Ocean Biogeochemical-Populations Dynamics Model', *Fisheries and Oceanography* 12: 483–494

McPherson G. R (1985), 'The Torres strait Spanish mackerel fishery: A review of Australian Development, Production and Research, *In* Haines A.K, Williams G.C, Coates D (Eds) The Torres Strait Fisheries Seminar, Port Moresby, Australian Government Publishing Service: Canberra, 11-14 February 1985

Pillai P.P and Pillai N.G.K (1998), Tuna Fisheries of India, *In* K.K. Balachandran, T.S.G. Iyer, P.Madhavan, J.Joeseph, P.A.Perigreen, M.R.Raghunath and M.D.Verghese (Eds.), Proceedings of Symposium on Advances and Priorities in Fisheries Technology, Society of Fisheries Technologist (India), Cochin, pp 18-23

Potier M; Marsac F; Lucas V; Sabatie R; Hallier J. P and Menard F (2004), Feeding Partitioning among Tuna taken in Surface and Mid-water Layers: the Case of Yellowfin (*Thunnus albacares*) and bigeye (*T. obesus*) in the Western Tropical Indian Ocean', *Western Indian Ocean Journal of Marine Science,* 3: 51–62

Prathibha R and Ramomohan K (2009), 'Fishery and Biological Aspects of Yellowfin Tuna *Thunnus albacares* along Andhra Coast, India', *Asian Fisheries Science* 22: 235-244

Rose G.A; deYoung B; Kulka D.W; Goddard S.V; Fletcher G.L (2000), 'Distribution Shifts and Overfishing the Northern cod (*Gadus morhua*): A View from the Ocean', *Canadian Journal of Fish and Aquatic Sciences* 57: 663-664

Rudy V. E (1993), *A Guide to the Common Sea Fishes of Southern Africa*, Cape Town, South Africa. pp 382

Schindler D.E; Essington T.E; Kitchell J.F; Boggs C and Hilborn R (2002), 'Sharks and Tunas: Fisheries Impacts on Predators with Contrasting Life Histories', *Ecological Applications,* 12**:** 735–74

Smith S (2000), 'Indian Ocean Expedition: Oceanic Response to Monsoon Forcing', *Journal of Science,* 1147: 1177 – 1677

Takahashi S (1974), An Account of the Ripe Ovaries of some Indian Tunas: Proceedings on the Symposium of Marine Biology, India, pp 733-743

Varghese S; Bhargava A.K and Somvanshi V.S (2002), 'Biological Aspects of Yellowfin Tuna (*Thunnus albacares*) from the Indian EEZ, *In* Pillai N.G.K; Menon N.G; Pillai P.P and Ganga U (Eds.), Management of Scombroid Fisheries. Central Marine Fisheries Research Institute, Kochi, p 74-81

Watters G.M; Olson, R.J; Francis R.C; Fiedler P.C; Polovina J.J; Reilly S.B; Aydin K.Y; Boggs C.H; Essington T.E; Walters C.J and Kitchell J.F (2003), Physical Forcing and the Dynamics of the Pelagic Ecosystem in the Eastern Tropical Pacific: Simulations with ENSO-scale and Global-Warming Climate Drivers', *Canadian Journal of Fisheries and Aquatic Sciences,* 60: 1161–1175

Windell J and Bowen S (1978), *Methods for Study of Fish Diets Based on Analysis of Stomach Contents*, *In* Methods for Assessment of Fish Production in Marine Waters, Eds, Bagenal, T. Blackwell Scientific Productions, Oxford, pp 219 – 227

Zamorov V.V; Spiridinov V.A and Napadovsky (1992), On the Role of Swimming Crab *Charybdis smithii* (Mc Leay 1938) in the Feeding Habit of Yellowfin Tuna *Thunnus alabacares* (Bonnaterre), Workshop of Stock Assessment of the Yellowfin Tuna in the Indian Ocean, Colombo Sri Lanka, IPTP Coll. Vol. Work Doc.6, pp 70-75

Zaret M.R and Rand A.S (1971), 'Competition in Tropical Stream Fishes: Support for the Competitive Exclusion Principle', *Journal of Ecology*, 52 (2): 336–342