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Fishery and Biological Aspects of Yellowfin Tuna *Thunnus albacares* along Andhra Coast, India

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Abstract

A potentially rich fishing ground for yellowfin tuna *Thunnus albacares* discovered off northern Andhra Pradesh along the east coast of India at depths of 200m and more is being gainfully exploited by the local fishers since 2002. Hooks and lines as well as trolls operated mostly from non-mechanized crafts (*catamaran*) are the major exploitation methods used. The mechanized sector ventured into oceanic tuna fishing during 2006 with the conversion of a few existing mechanized trawlers into long liners and for large scale commercial exploitation of yellowfin tuna in this region. The average annual (2004-2006) landing of tuna by the catamaran at Visakhapatnam was 1,515t. A wide size group represented the fishery with the fork length of *T.albacares* measuring from 25 cm to 190 cm with major modes at 90 and 130 cm. Fishes above 80 cm were found to be mature and the size at first maturity was estimated to be between 90-95 cm. Males were dominant with a male: female ratio of 1: 0.58. The length weight relationship is given by the formula $W= 0.008634L^{3.12}$. Food contents consisted of a variety of prey animals. Fishes (bony pelagic fishes), crustaceans (crabs and shrimps) and molluscs (squids) were the major prey groups. The fishery is still in its infancy and more research has to be carried out to understand its biology and formulate proper management measures to sustainably harvest this stock.

Introduction

Yellowfin tuna (*Thunnus albacares*) is fished in a vast area of the Indian Ocean north of 30°S latitude. The distribution of the fish ranges from temperate to tropical waters in this area. *T.albacares* is one of the most sought after oceanic tuna species in the world and there exists a targeted fishing for this species in several countries. In India, especially in the mainland, tuna fishing on a commercial scale has been mainly confined to the exploitation of coastal species such as *Euthynnus affinis*, *Auxis thazard* and *Katsuwonus pelamis* (Silas and Pillai, 1982; Silas et al., 1986; James et al., 1992, 1993; James and Pillai, 1993; Yohannan et al., 1993; Yohannan and Pillai, 1994 and Pillai and Pillai, 1998). Andhra Pradesh, located centrally along the west coast of India with a coastline of 974 km is well known for it rich and diverse fishery resources. With

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annual average landings of 185,948 t (2002-2006) it stands 5th among the maritime states of India. The pelagic resources with a contribution of 56.2 % during 2006 formed the dominant group of the total marine fish landings of the state. Smaller pelagics were constituted by the *Sardinella* spp., *Rastrelliger* spp. and *Stolephorus* spp., whereas the tunas, *Scomberomorus* spp, *Acanthocybium solandri*, *Makaira indica* and *Istiophorus platypterus* were the major groups contributing to the catch of large pelagics of this region. Several species of tunas contributed to the fishery of the region with the yellowfin tuna *Thunnus albacares* forming the major group. This species formed 50-60 % of the total tuna catch of the region and fishing for this species is carried out in several villages located in and around Visakhapatnam District, an important fishing centre of Andhra Pradesh. Though a number of publications on the fishery of tuna from Indian waters are available most of them pertain to the smaller coastal tunas such as *Euthynnus affinis*, *Auxis thazard* and *Katsuwonus pelamis* (Silas and Pillai, 1982; Silas et al., 1986; James et al., 1992,1993; James and Pillai, 1993; Yohannan et al., 1993; Yohannan and Pillai, 1994 and Pillai and Pillai, 1998).

Survey and training cruises conducted in Indian waters by different fishery organizations (Fishery survey of India, Central Institute of Fisheries Nautical and Engineering Training) have indicated the occurrence of yellowfin tuna and big eye tuna in Indian waters. The fishery status and some biological aspects of these tunas have been reported by Silas et al. (1985), John and Reddy (1989), Sudarshan et al. (1991), Vijaykumaran et al. (1992), Pillai et al. (1993), John and Sudarshan (1993), Sudarshan and John (1994), Somvanshi and John (1996), John (1995, 1998), Somvanshi et al. (1999). Govindraj et al. (2000), and Varghese et al. (2002).

Fishing for yellowfin tunas along the Andhra Pradesh Coast especially by the traditional fishers has been going on since 2002. It has however gained importance during the past couple of years and the catch contributes significantly to the marine fish landings as well as the export market of this State. This is the first study made on yellowfin tuna landed by the traditional fishers along Andhra Pradesh. The paper gives a firsthand account of the fishery, fishing season, details of crafts and gears used, length range contributing to he fishery as well as the length weight relationship. The study carried out on the important biological parameters (gonad maturity stages, size at first maturity, sex ratio, major food items in the stomach) of *Thunnus alabacares* landed along Andhra Pradesh coast during 2004-2006 is also included in this paper.

Material and methods

Weekly observations were made during 2004, 2005 and 2006 at Lawsons Bay, Visakhapatnam Outer Harbour and Pudimadaka Beach, the important tuna landing centres of Andhra Pradesh to collect statistics on crafts, gears and species composition of tunas

landed. The catch of yellowfin landed on the observation days was noted. Yellowfin tuna landing estimates on observation days were then raised to the months catch using a raising factor obtained by dividing the number of observation days in a month by the number of actual fishing days in that month. The catch estimated for the different months was then pooled to get the annual yellowfin catch for the centre. Fork lengths in cm and wet weight in kg of yellowfin tuna were taken at the field during the weekly visits. The collected lengths were then distributed into 2 cm length groups to get the length frequency distribution of the day. The frequency then was raised using a raising factor (days catch/ by sample weight* sample number) to get the length frequency of the distribution for the day. The weekly samples thus got were pooled and it was then raised similarly to get the monthly frequency distribution. Stomach condition and stage of gonad maturity were also collected whenever possible. Gonads were classified into four stages of maturity based on visual appearance; Stage I – immature, Stage II – maturing, Stage III- mature and stage IV- Partially spent. The different stages of gonad maturity observed were distributed into different length groups and the minimum length at which 50% of the fishes were found to be mature was fixed as the minimum length at first maturity. The stomachs were grouped as full, three-fourth full, half-full, one fourth full and empty based on visual examination. The data were analysed and length-weight relationship, sex ratio, lenght at first maturity and feeding condition were estimated.

Results

Craft and gear

Traditional non-mechanized crafts are used for tuna fishing in Andhra Pradesh. The crafts used are wooden catamarans (known locally as *teppalu*) or fibre canoes which resemble the *teppalu* in shape (Sreekrishna, 2002). Traditional wooden crafts are made of two or more logs which are strapped together with thick ropes before setting off for fishing. When the crafts reach back after fishing activity, the logs are unleashed and beach dried till the next day's fishing activity commences. The fibre boats are similarly carried ashore and kept ready for the next day's fishing. The crafts are driven by huge sails and on good windy days, these crafts get a speed of more than 10 knots per hour. A few crafts are now equipped with outboard engines (upto 10 hp). The outboard engines supplement the sails and are used sparingly when wind conditions are unfavourable. Part of the narrow deck space available is efficiently used to keep the neatly rolled up gear, a small ice box that serves to store the bait fishes and a day's ration of the crew. The rest of the deck space is used to operate the lines and store the fish catch. The sail when not in use is rolled up and kept along side the craft.

Trolling as well as hook and line operations are carried out from similar crafts. Crafts engaged in trolling take 2-6 lines. Each line is attached with a round bent barbed

hook (no.1 or 2). A long line unit consists of the main line and branch lines. The length of the main line ranges from 8000 - 10000 m with branch lines of 8-10 m. A distance of 15-20 m is maintained between the branch lines. Around 600 to 900 branch lines are operated at a time. Each branch line is attached with a round bent barbed hook (no.1, 2 or 4). Sardines (*Sardinella longiceps, S.gibbosa, S.fimbriata* or *Dussumeri acuta*) are the most popular baits used. In the absence of sardines; mackerel (*Rastrelliger kanagurta*) or small sized flying fish (*Hirundichthys* spp.) are used. Baits are usually iced and taken separately in insulated boxes. On nearing the fishing grounds the lines are unrolled and baits attached to the hooks and are either dragged by the craft (trolling) or are allowed to drift alongside the craft (long lining). In long line operation the lines with baited hooks are released and the crafts continue to move to deeper waters for some time. The lines are then allowed to drift for an hour after which they are hauled up. Lines are generally set after they reach a depth of 150 m and more.

The availability of yellowfin tuna grounds off Andhra coast and the ease with which the traditional fishers capture these species has encouraged some fishing entrepreneurs to convert some of the existing large trawlers into longliners. These are well equipped to locate the fishing grounds, have large deck space for operating the long lines and storage facilities to preserve the catch in chilled condition. Presently six such trawlers have been converted into longliners and a few more are likely to be converted by the end of 2006.

Fishery

Thunnus albacares is caught only beyond a depth of 200 m. The other fishes caught along with yellowfin tuna, include king seer (*Scomberomorus commerson*), marlin (*Makaira indica*), sailfish (*Istiophorus platypterus*), dolphinfish (*Corynemus* spp.) and Wahoo (*Acanthocybium solandri*). *Sarda orinetalis* and at times, *Euthynnus affinis* too are occasionally landed.

Fishing hours are not fixed. When the weather is conducive, fishermen take 3-4 hours to reach the ground and an equal time to return. If the crafts are not equipped with an outboard engine and if poor wind conditions prevail, then the duration taken for the fishing activity is doubled. The fishermen engaged in hooks and line fishing start early in the morning around 4.00 am and return after fishing around 6.00 pm or they start around 5.00 pm and return early in the morning the next day by 4.00 am. The operations are completely suspended when wind conditions are not conducive. On the other hand during the peak fishing season, the units operate both during the day and night.

An estimated 1500 *teppalu* are engaged in oceanic tuna fishing along Andhra coast. As the fishing hours are long and uncertain, around 600-700 crafts operate per day. The total tuna landings include both coastal (*E.affinis*, *Auxis* spp.) and oceanic

tunas. The yellowfin tuna (*Thunnus albacares*) however forms the dominant species and contributes to more than 60% of the total tuna catch of the region. On an average each craft lands two to three yellowfin tunas, 1 to 2 billfishes, 3 to 4 dolphinfish and a couple of smaller species of tunas. The annual landing of tunas by these small crafts at Visakhapatnam outer harbour fluctuated over the years (Fig. 1).

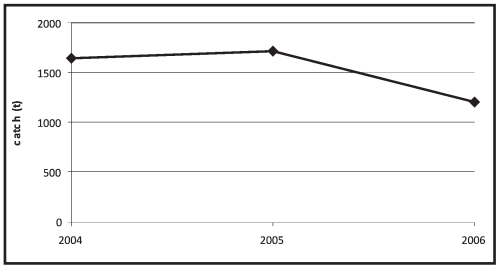

Figure 1. Annual landing of *T. albacares* at Visakhapatnam

The total catch ranged from 1,199 t to 1,709 t (2004 to 2006) with an average annual catch of 1,515 t at this centre. During the study period (2004-2006) the highest catch of yellowfin tuna was observed in 2005 and the lowest in 2006.

Fishing season

Tuna fishing is carried out throughout the year. However peak landings were observed during October – January. A second peak was observed during May-July (Fig.2). The annual catch per unit at Visakhapatnam was 41 kg and during the peak fishing season it increased to 58 kg per unit.

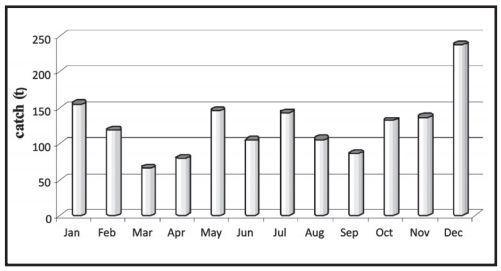

Figure 2. Monthwise landing of *T. albacares* at Visakhapatnam (2004-2006 pooled)

Biology

***Length frequency distribution*:**

The fork length of *T.albacares* during the study period ranged from 30-190 cm with mode at 130 cm (Fig. 3).

The mean length was at 106 cm. Monthwise analysis of length frequency distribution indicated that smaller sized yellowfin tunas (30-70 cm) were more abundant during June- July and bigger fishes (>100cm) during November-January.

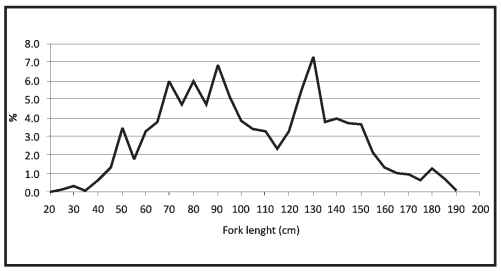

Figure 3. Length frequency distribution of *T. albacares* landed at Visakhapatnam

Length-weight relationship

The fork length and wet weight of yellowfin tunas landed at Visakhapatnam ranged from 30-190 cm and 0.423 kg to 103 kg. The length weight relationship of the yellowfin tuna landed along the Andhra coast was calculated using the equation $W= aL^b$ where, W= weight in grams. L= Fork length in cm; and a and b are constants. The length weight relationship is given by the formula $W= 0.008634L^{3.12}$

Sex ratio and maturity

Distribution of males and females in the catch was uneven with a dominance of males. The sex ratio (male: Females) observed was 1:0.58. Yellowfin tunas in all stages of maturity were observed in the fishery. The immature, maturing, mature and spent fishes formed 15%, 6%, 15% and 64. % respectively (Fig.4).

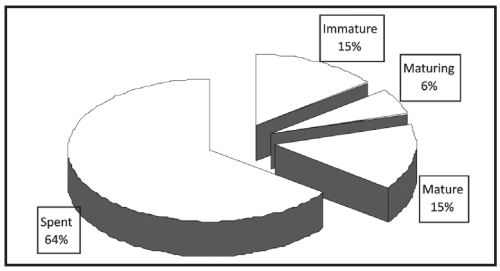

Figure 4. Gonad maturity stages in *T. albacares* landed at Visakhapatnam

Size at first maturity

Male and female gonads in yellowfin tunas could be differentiated at a fork length of 40 cm. Mature gonads (Stage III and above) were observed from a fork length of 75-80 cm. However, 50% of fishes reached maturity at a fork length of 85-90 cm (Fig.5).

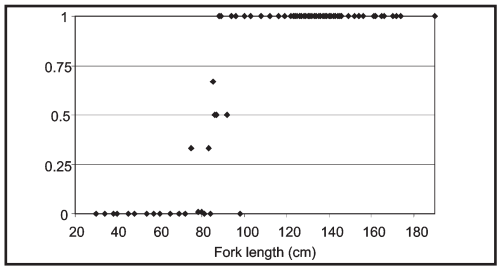

Figure 5. Length at first maturity estimated for *T. albacares* at Visakhapatnam

Food and feeding:

Of the 110 stomachs analyzed for food and feeding studies, 14.7% were found to be empty, 33.3%, one-fourth full, 24.5% half full, 6.9% three-fourth full and 20.6% full (Fig.6).

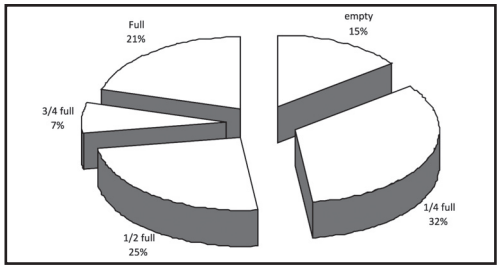

Figure 6. Feeding condition of *T. albacares* at Visakhapatnam

Food contents mainly consisted of crustaceans (42.5%), fishes (34.7%), and cephalopods (15.5%). Fully digested matter comprised 7.3 % of the food analyzed (Fig.7). Many of the stomachs, though found empty, had squid beaks in the stomach. Presence of foreign bodies like nylon twine,

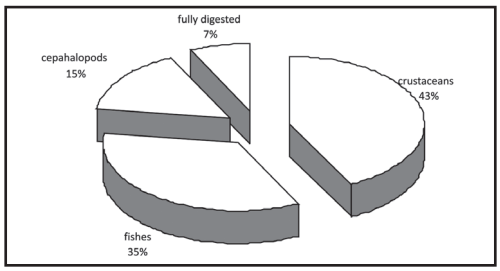

Figure 7. Major prey items found in the stomach of *T. albacares* at Visakhapatnam

small pieces of wood, and plastic were observed occasionally.

Discussion

The tuna landings estimated in the coastal states of India mainly take into account smaller coastal tuna species. The fishery and biology of these tunas have been reported by several earlier workers (Madhu et al., 2002; Pillai et al., 1996, 2002; Sivadas, 2002 and Nasser et al., 2002). The yellowfin tuna comprising the major tuna species among the oceanic tunas occurring along the Indian coast has not been studied in great depth; most of the study being restricted to catches made by research and exploratory cruises except for some studies carried out at Minicoy (Madan Mohan & Kunhikoya, 1985; Pillai et al., 1993 and Sivadas, 2002). The large longliners exploiting the yellowfin resources in Indian waters, process the fish on board and it is directly exported. Actual estimations of catch made by these large vessels are thus not known. Further the non-availability of the species in the general commercial fish landings may be some of the few reasons for the absence of detailed studies on yellowfin tunas. The annual average estimated catch of 1,515 t at Visakhapatnam outer harbour and 6,500 t for Andhra coast is very encouraging. The increasing trends noticed in motorization of country crafts and conversions of some of the existing trawlers to long liners, the effort and consequently the catch is bound to increase.

The yellowfin tunas landed at Visakhapatnam had a wide length range of 30-190 cm. Pillai et al. (1993) had reported a length range of 32-128 cm whereas John and Sudarshan (1993) recorded a length range of 60-180cm. The 'b' value obtained in the length weight relationship is close to 3 and comparable to the values obtained by earlier researchers (Silas et al., 1985; Sudarshan et al., 1991; John and Sudarshan, 1993; and Pillai et al., 1993).

Uneven distribution of males and females with a dominance of males as observed in the present study has been earlier reported (Sudarshan et al., 1991 and John and Sudarshan, 1993). The reason (differences between growth rates of males and females, difference in mortality rates, reduced catchability of females) and implications if any on the population, of such uneven distributions is yet to be determined (IPTP, 1992).

Maturity and reproduction in yellowfin tunas occurring in Indian waters has hardly been studied. The occurrence of yellowfin tunas in all stages of gonad maturity has been observed off Visakhapatnam. Fishes with mature gonads were more during

November-December and Juveniles were more during April-May. The size at first maturity (85-90 cm) observed in the present study is less compared to the size reported for the same species occurring in other regions (Itano, 2000, Sun et at 2005).

Yellowfin tunas feed on a variety of organisms. Earlier studies by Silas et al. (1985), Pon Siraimeetan (1985) and John and Sudarshan (1993) have also shown that crustaceans especially pelagic crabs form the major component of the diet. Fishes and cephalopods form the next important component of the food item in the stomachs. The present study also revealed a similar trend in food items observed in the stomach, with crustaceans forming the dominant food component.

Tuna fishing at Visakhapatnam is poised to take great leaps, both in production and export, in the near future. Fishermen from several villages around Visakhapatnam are totally engaged the exploitation of these oceanic tunas. Long lining and troll fishing are eco-friendly gears and known to be efficient in trapping the targeted fish, this activity may be encouraged. However, fishing for yellowfin tuna using motorized and mechanized crafts along this coast is a recent trend. The fishery therefore has to be continuously monitored and steps taken to see that the effort as well as catch is optimized. So far, fishing for yellowfin tunas off Visakhapatnam is being done mostly by the traditional fishermen using the small crafts. Though motorization and mechanization will help in reaching the fishing grounds faster as well as to hook more fishes, there is possibility of conflicts occurring between different groups as observed in other fishing activities. The fishermen also should be given some advice on maintaining the quality of the fishes caught so that they can fetch a better price for their catch.

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