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# Marine fisheries of Andhra Pradesh: a decadal analysis

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## ABSTRACT

The average annual marine fish landing of Andhra Pradesh during 2000-2010 was 1.99 lakh t. Fishing effort declined by 33% and 9% in terms of fishing units and fishing hours respectively. Pelagic finfishes contributed 55.6% to the total marine catch, followed by demersal finfishes (27%), crustaceans (14.4%) and molluscs (1.1%). Trawl nets contributed 44.24% to the total catch, followed by gillnets (23.95%). Oilsardine landings fluctuated between a maximum of 19125 t in 2000 and a minimum of 1068 t in 2002. Mackerel landings fluctuated between a maximum of 22763 t in 2009 and a minimum of 6418 t in 2007. Carangids and tunas registered continuous increase in catch over the years; the former from 9964 t in 2000 to 13268 t in 2010 and the latter from 2899 t in 2000 to 10515 t in 2010. Around one third of the tuna landing was contributed by the yellowfin tuna, *Thunnus albacares*, caught mainly by hooks and lines. Their landing increased on an average at Visakhapatnam from a meager 395 t during 2001-2005 to 2918 t during 2006-2010. Landings of some of the demersal resources namely, threadfin breams, croakers, lizardfishes and goatfishes increased substantially during the period. Threadfin bream increased by 348.9% from 1209 t in 2000 to 5427 t in 2010, croakers by 50.8% from 8054 t in 2000 to 12142 t in 2010, lizard fish by 297.7% from 1062 t in 2000 to 4224 t in 2010 and goat fish by 129.3% from 3501 t in 2000 to 8027 t in 2010. Among crustacean resources crabs showed the highest increase in landings by 125.4% from 2791 t in 2000 to 6292 t in 2010. The landing of penaeid prawns increased by 21% from 22657 t in 2000 to 27408 t in 2010, while non-penaeid prawn landings decreased by 12.3% from 2685 t in 2000 to 2354 t in 2010. Cephalopod resources have also shown a substantial increase of 282% during the period ranging from 1011 t in 2000 to 3862 t in 2010. The assessment of trawl fishery at Visakhapatnam from 2007 to 2010 with reference to yield/recruit indicated that two (*Metapenaeus monoceros* and *Portunus sanguinolentus*) out of the twelve commercially important resources are currently overexploited and one resource (*Pennahia macrophthalmus*) is optimally exploited.

Keywords: Andhra Pradesh, Crustacean resources, Demersal resources, East coast of India, Marine Fisheries, Molluscanresources, Pelagic resources

## Introduction

Andhra Pradesh, with a coastline of about 974 km spread over nine coastal districts, ranks fifth in contribution to the marine fish landings of the country. The annual average catch shows an increasing trend over the years. The fishery is contributed by mechanised, motorised and traditional sectors. However, the motorised and mechanised sectors are slowly and steadily replacing the traditional sectors. Hence, there is a perceptible increase in the landings of demersal fishes as well as crustacean and molluscan resources over the years. Pelagic finfishes continue to be the dominant group, constituted chiefly by clupeids, mackerels, ribbonfishes, carangids and tunas. Exploitation of oceanic resources is being actively carried out and targeted fishing for yellowfin tuna, *Thunnus albacares* is done by traditional and mechanised units. Intensive fishing pressure in the coastal waters of the state has necessitated the investigation of the resource characteristics of all major resources contributing to the fishery of the state over a period of eleven years for their judicious exploitation, management and conservation.

## Materials and methods

Data on catch of major resources and effort expended were collected weekly from all the major and minor landing centres of Andhra Pradesh for the eleven year study period from 2000 to 2010. The monthly and annual estimates of catches were made following the Stratified Multistage Random Sampling Design (Srinath *et al*., 2005). For estimating von Bertalanffy growth parameters (asymptotic length, $L_\infty$ and growth coefficient, K) for resources caught in trawls, the monthwise length composition data for four years from 2007 - 2010 were pooled and grouped with appropriate class intervals and analysed using the ELEFAN I module of FiSAT software version 1.2.0 (Gayanilo *et al*., 1996). Natural mortality (M) was calculated by Pauly's

empirical formula (Pauly, 1980), taking the mean sea surface temperature as 28 $^0$C and total mortality (Z) calculated from length converted catch curve (Pauly, 1983) using FiSAT software. Fishing mortality (F) in trawl nets was estimated using the formula, F = Z - M. Exploitation rate of finfishes and shellfishes in trawl nets was estimated from the equation, E = F/Z and exploitation ratio from U = F/Z (1-exp$^{-z}$) where, F is the fishing mortality rate. The probability of capture and size at first capture (Lc) were estimated as described by Pauly (1984). Total stock (P) and biomass (B) were estimated from the ratios Y/U and Y/F respectively; where Y is the annual average yield in tonnes. The yield per recruit (Y/R) and biomass per recruit (B/R) at different levels of F in trawl nets for all resources was estimated from Beverton and Holt Yield per Recruit Model.

## Results and discussion

*Gearwise production*

The average annual marine fish production in Andhra Pradesh during 2000-2010 was 1.99 lakh t. The mechanised sector contributed 72.7% to the annual landings while the non- mechanised sector contributed 27.3%. Trawlers landed 44.24% of the annual landings, followed by gillnetters (23.95%), purse seiners (6.56%) and hooks and lines (3.1%). The total catch and catch rate for multiday trawlers increased from 74185 t and 17.92 kg h$^{-1}$ in 2000 to 128088 t and 26 kg h$^{-1}$ in 2010. Rajkumar *et al*. (2004a) observed similar increase in catch rates from 7 kg h$^{-1}$ in 1999 to 33 kg h$^{-1}$ in 2003, for multiday trawlers, operating from Visakhapatnam. The total landing by gillnets decreased from 36962 t in 2000 to 31872 t in 2010. However, the catch rate increased from 61.2 kg unit$^{-1}$ to 77.02 kg unit$^{-1}$ because of reduction in effort from 603968 units in 2000 to 413840 units in 2010.

The major groups that contributed to the fishery were clupeids, prawns, Indian mackerel, ribbonfishes, carangids, croakers, elasmobranchs, threadfin breams, tunas and cephalopods. Trawlers contributed substantially to the catch of penaeid and nonpenaeid prawns, ribbonfishes, Indian mackerel, croakers, threadfin breams, carangids and cephalopods. The catch and catch rates of these resources by trawlers increased over the eleven year study period. Gillnets also recorded considerable increase in catch and catch rates of Indian mackerel, tuna, seerfish and sardines. The gillnet catch during 1985-'89 was dominated by sardines, mackerel, carangids and seerfishes (Rao, 1993). The catch of lesser sardines has increased in seines over the years in place of oilsardine.

*Resourcewise production*

Pelagic finfishes formed 55.6% of the annual marine finfish production in the state while demersal finfishes, crustaceans and cephalopods contributed 27, 14.4 and 1.1% respectively. Clupeids formed 48.4% of the pelagic fnfish landings, followed by mackerel (13.84%), ribbonfishes (11.1%) and carangids (10.14%). The contribution of clupeids and ribbonfishes decreased marginally from 62375 t and 13844 t in 2000 to 60638 t and 9357 t in 2010. On the contrary, landings of mackerel and carangids increased from 9834 t and 9964 t in 2000 to 19206 t and 13268 t in 2010 respectively. Seer fishes and tunas were the other commercially significant and highly valuable pelagic resources which showed increasing trends in landings over the period (Fig. 1 and 2. Among the demersal finfishes, croakers formed 17.12% followed by perches (15.72%), elasmobranchs (13%) and pomfrets (12.82%) (Fig. 3 and 4). Penaeid prawns formed on an average 70% of the total crustacean landings in the state. Crabs constituted 18.2% and nonpenaeid prawns formed 8.5% of the crustacean landings. The landing of penaeid prawns increased over the years by 21% from 22657 t in 2000 to 27408 t in 2010, while nonpenaeid prawn landings decreased by 12.3% from 2685 t in 2000 to 2354 t in 2010. The catches of crabs increased by 125.4% from 2791 t in 2000 to 6292 t in 2010 (Fig. 5). The total cephalopod production in the state increased from 975 t in 2000 to 3731 t in 2010 (Fig. 5) and was constituted mainly by *Sepia aculeata* (33.6%), *S. pharaonis* (32.7%) and *Loligo duvauceli* (27.1%).

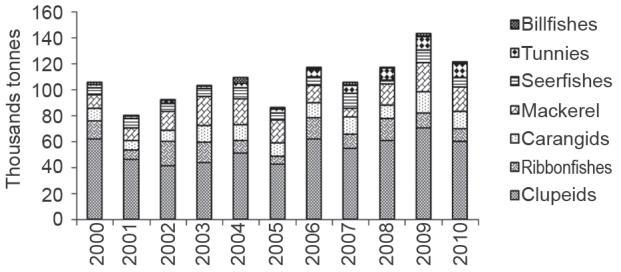


Fig. 1. Groupwise landings of pelagic resources in Andhra Pradesh during 2000-2010

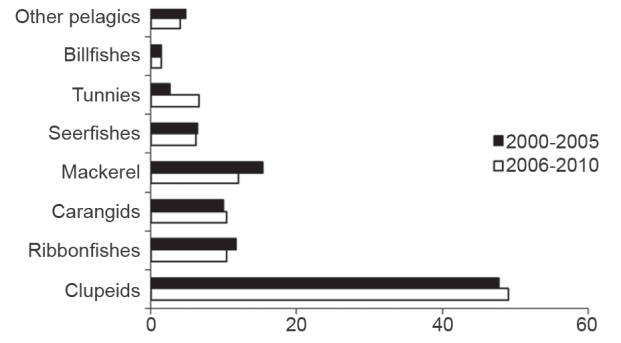


Fig. 2. Comparison of the contribution (%) of major groups to the pelagic landings during 2000 -2005 and 2006 - 2010

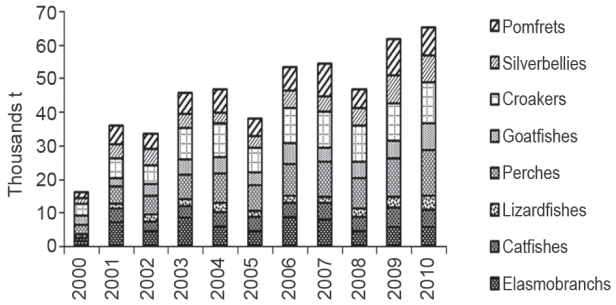


Fig. 3. Groupwise landings of demersal resources in Andhra Pradesh during 2000-2010

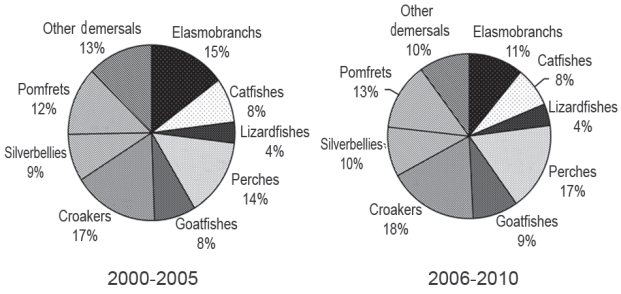


Fig. 4. Resourcewise contribution to demersal fish landings of Andhra Pradesh during 2000-2005 and 2006-2010

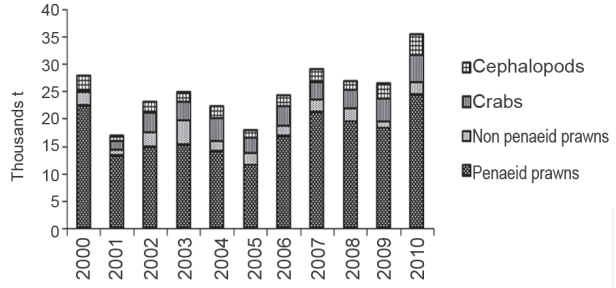


Fig. 5. Groupwise landings of shellfishes in Andhra Pradesh during 2000-2010

*Clupeids* : Clupeids, forming 27.3% of the total marine fish landings in the state, were represented by lesser sardines (39.05%), oilsardine (16.2%) and *Stolephorus* sp. (13.06%) (Fig. 6). The catch of lesser sardines increased over the years from 20230 t in 2000 to 23250 t in 2010, at the expense of the oilsardine catch which decreased from 19125 t in 2000 to 10463 t in 2010. The catch of both these resources exhibited wide fluctuations. The maximum catch of 29948 t for lesser sardines was observed in 2009. Luther *et al*. (1994) reported high catches of lesser sardines during1985-1992, with the average annual catch of 17130 t forming 6-23% of the total fish landings. The catch of oilsardines by seines decreased from 18084 t in 2000 to 9008 t in 2010, with the years from 2002 to 2007 recording very low average annual catch of 4825 t. The landings of *Stolephorus* sp. increased gradually over the years from 4043 t in 2000 to 14484 t in 2010. The catch of other clupeids remained more or less static over the years. The composition of clupeid landings showed some variations between 2000-2005 and 2006-2010 (Fig. 6).

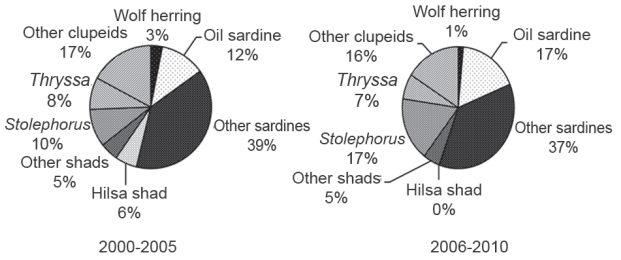


Fig. 6. Composition (%) of clupeid landings of Andhra Pradesh during 2000-2005 and 2006-2010

*Mackerel*

The contribution of Indian mackerel, *Rastrelliger kanagurta*, to the total marine catch during 2000 - 2010 was 7.8%, increasing from the 1- 3% reported during 1990 - 1994 by Luther (1995). The catch of mackerel increased two fold from 9834 t in 2000 to 19206 t in 2010 (Fig. 1). The highest landing of 22763 t was recorded in 2009. The landing of mackerel was contributed by both trawlers and gillnetters but the major catch comes from trawlers. Similar reports were published from Kakinada by Abdussamad *et al*. (2006) where 77% of the mackerel fishery was by trawls. In trawls the catch and catch rate increased from 2654 t and 0.64 kg $h^{-1}$ in 2000 to 8936 t and 1.81 kg $h^{-1}$ in 2010. In gillnetters the catch and catch rate increased from 1783 t and 3.62 kg $unit^{-1}$ in 2000 to 3639 t and 8.8 kg $unit^{-1}$ in 2010.

*Ribbonfish*

Ribbonfish landings increased from 13844 t in 2000 to a maximum of 18372 t in 2002 after which it gradually decreased to 9357 t in 2010 (Fig. 1). The bulk of the ribbonfish landing were by trawlers. Similar decreasing trend in catch and catch rates for ribbonfish in trawlers from Visakhapatnam waters during 1983 - 1991 was reported by Reuben *et al*. (1997). In sharp contrast to the total catch, the catch landed by trawlers increased from 7407 t in 2000 to 8167 t in 2010. However, the catch rate decreased over the same period from 1.79 kg $h^{-1}$ to 1.66 kg $h^{-1}$. This is because of the increase in fishing hours of trawlers from 4140397 in 2000 to 4924905 in 2010. The resource formed on an average 6.19% of the total marine landings.

*Carangids*

Carangids formed 5.75% of the total marine landings of Andhra Pradesh. This has increased from the 2.8% reported by Murty (1991) during 1980-1983. The catch was

contributed mainly by the scad, *Decapterus russelli* (30.8%), horse mackerel, *Megalaspis cordyla* (14.7%) and leather jackets, *Scomberoides* sp. (7.8%) (Fig. 7). Among carangids, *M. cordyla* dominated the gillnet catches while *D. russelli* dominated the trawl landings. According to Murty (1991), during 1980-1983, *D. russelli* formed 80-90% of the total carangid caught by trawlers. The catch of carangids increased from 9964 t in 2000 to 13268 t in 2010 (Fig. 1). The maximum catch of 16430 t was recorded in 2009. The catch and catch rate of scad in trawlers increased from 2232 t and 0.54 kg $h^{-1}$ in 2000 to 3314 t and 0.67 kg $h^{-1}$ in 2010.

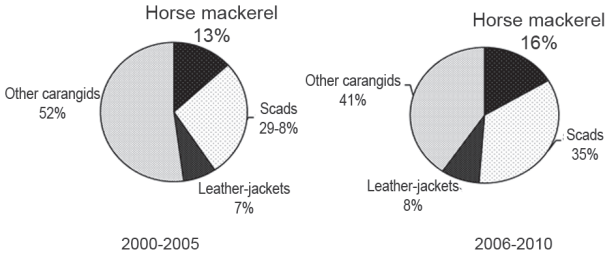


Fig. 7. Composition (%) of carangid landings of Andhra Pradesh during 2000-2005 and 2006-2010

*Seerfish*

Seerfishes formed on an average 3.52 % of the marine landings during 2000-2010. The landings of seerfish increased from 5437 t in 2000 to 7318 t in 2010 (Fig. 1). The highest catch of 11466 t was recorded in 2007. It contributed 6.3% to the average pelagic landings of the state. Two third (63.9 %) of the seerfish landings was contributed by *Scomberomorus commerson* and the rest one third (36.1 %) by *S. guttatus*. In gillnets the catch of seerfish increased from 2208 t in 2000 to 3054 t in 2010 with corresponding increase in catch rate from 4.49 kg $unit^{-1}$ in 2000 to 7.38 kg $unit^{-1}$ in 2010. During 2000-2005, *S. commerson* formed 59% of the seerfish catch and *S. guttatus* formed 41%. In 2006-2010, these species formed 70% and 30% of the seerfish catch, respectively.

*Tuna*

There was a substantial increase in catch of tunas from 2899 t in 2000 to 10515 t in 2010 (Fig. 1). Tunas formed on an average 2.64% of the total marine fish landings of the state. It contributed 4.42% to the average pelagic landings. The main species of tunas landed were *Euthynnus affinis* (49.2%), *Thunnus albacares* (37.98%), *Katsuwonus pelamis* (8.4%) and *Auxis thazard* (4.4%) There was heavy landing of yellowfin tuna to the tune of 4378 t in 2007, where in it contributed around 70% to the total tuna landings. Coastal tunas *viz*., *E. affinis* and *A. thazard* were landed mainly by gillnets and oceanic tunas *viz*., *T. albacares* and *K. pelamis* were caught mainly by hooks and lines. In gillnets their catch and catch rate increased from 1932 t and 3.93 kg $unit^{-1}$ in 2000 to 4212 t and 10.18 kg $unit^{-1}$ in 2010. The landing of yellowfin tuna by hooks and lines has increased at Visakhapatnam from a meager 395 t during 2001-2005 to 2918 t during 2006-2010. Rohit and Rammohan (2009) reported average annual landing of yellowfin tuna at Visakhapatnam to be 1515 t during 2004 - 2006. The perception of yellowfin tuna fishing changed with the advent of oil drilling at Kakinada and Visakhapatnam in which congregation of yellowfin tunas on the surface waters were observed in association with their favoured prey, squid attracted to the surface by huge lights used for the drilling activities. This has led to the commencement of night fishing where in fishermen venture out into the sea during night hours in their small sparsely equipped crafts and catch large size yellowfin tunas.

*Croakers*

The catch of croakers increased from 8054 t in 2000 to 12142 t in 2010 (Fig. 3). It contributed on an average 4.64% to the marine fish catch. The highest landing of 11121 t was recorded in 2009. Croakers were exploited by a multitude of gears but the major catch was from trawls. The catch and catch rate of croakers in trawls increased from 3561 t and 0.86 kg $h^{-1}$ in 2000 to 9264 t and 1.88 kg $h^{-1}$ in 2010. The contribution of croakers to trawl catch also increased similarly from 4.8% in 2000 to 7.23% in 2010. Rajkumar *et al*. (2004b) reported that croakers formed 5.76% of the total trawl landings during 1990-1999.

*Elasmobranchs*

Elasmobranchs contributed 3.4% to the total marine fish catch of the state and the fishery was supported by rays (57.9%), sharks (39.9%) and skates (2.2%). The landing of elasmobranchs in sharp contrast to other resources decreased during the eleven year period. The catch was 8907 t in 2000 which decreased to 5743 t in 2010 (Fig. 3). In 2000-2005, it formed 15% of the demersal landings while in 2006-2010 it formed only 11% (Fig. 4). Within elasmobranchs, the catch of sharks and skates drastically reduced from 4914 t and 562 t in 2000 to 1254 t and 99 t in 2010, respectively. The landing of rays however increased over the same period from 3431 t to 4390 t. Though elasmobranchs are caught by a variety of gears, rays are caught mainly in trawls. The catch and catch rate of rays in trawls increased from 1281 t and 0.31 kg $h^{-1}$ in 2000 to 3256 t and 0.66 kg $h^{-1}$ in 2010. Their contribution to trawl catch also increased from 1.73% to 2.54%.

*Pomfrets*

The increase in catch of pomfrets from 5864 t in 2000 to 8201 t in 2010 is encouraging for the marine fisherfolk of Andhra Pradesh (Fig. 3). The maximum landing of 10727 t

was recorded in 2009. Pomfrets contributed on an average 3.5% to the total marine fish landings. Black pomfret, *Parastromateus niger* was the major contributor to the pomfret fishery with 48.6%, followed by the silver pomfret, *Pampus argenteus* with 46.9% and Chinese pomfret, *Pampus chinensis* with 4.5%. The catch of silver pomfret has remained more or less stagnant over the years, while the catch of black pomfret exhibited sudden rise in 2009 and 2010. This can be attributed to the targeted fishing for black pomfret by trawlers in the recent past. The catch of black pomfrets and silver pomfrets in trawlers increased from 630 t and 1285 t in 2000 to 3064 t and 2122 t in 2010. Similar trends were observed in catch rates which increased for black pomfret from 0.15 kg $h^{-1}$ to 0.62 kg $h^{-1}$ and for silver pomfrets from 0.31 kg $h^{-1}$ to 0.43 kg $h^{-1}$.

*Threadfin breams*

The landing of threadfin breams increased gradually over the years from 1209 t in 2000 to 5427 t in 2010 (Fig. 3). Threadfin breams formed about 1.55% of the total marine fish catch. The catch and catch rate of this resource in trawls have increased from 1099 t and 0.27 kg $h^{-1}$ in 2000 to 5336 t and 1.08 kg $h^{-1}$ in 2010 (Fig. 8). Their contribution in trawl catch also increased from 1.48% to 4.17%. However, Rajkumar *et al*. (2003a) reported that during 1990-1999, threadfin breams formed 9% of the total trawl catches at Visakhapatnam.

*Silverbellies*

The silverbelly landing registered impressive increase from 3583 t in 2000 to 8091 t in 2010 (Fig. 3). Silverbellies accounted for 2.47% of the total marine fish landings. Its contribution to the demersal fishery was 9.15%. The catch and catch rates of silverbellies in trawls increased over the years from 1762 t and 0.43 kg $h^{-1}$ in 2000 to 3746 t and 0.76 kg $h^{-1}$ in 2010 (Fig. 8). Its contribution to the demersal finfish landings increased from 9% during 2000-2005 to 10% during 2006-2010 (Fig. 4). However, Rajkumar (2006) reported from Visakhapatnam that the contribution of silverbellies to trawl catches during 1990-2001 was 4.2%.

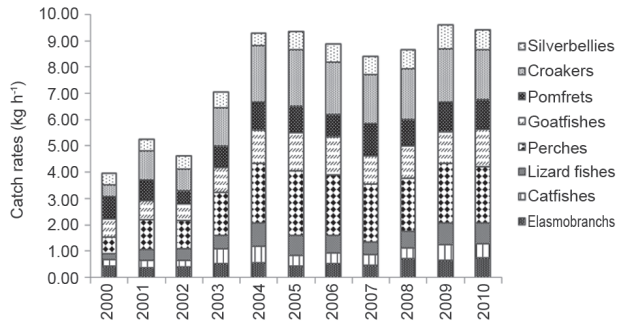


Fig. 8. Catch rates (kg $h^{-1}$) in of demersal resources in trawl landings of Andhra Pradesh during 2000 -2010

*Goatfishes*

Goatfishes contributed on an average 2.32% to the marine fish catch of the state. Their catch increased steadily from 3501 t in 2000 to 8027 t in 2010 (Fig. 3). Goatfishes formed 8.47% of the total demersal catch (Fig. 4). In trawls, the catch and catch rates of goatfishes increased over the years from 2807 t and 0.68 kg $h^{-1}$ in 2000 to 7047 t and 1.43 kg $h^{-1}$ in 2010 (Fig. 8). Their contribution to the trawl fishery also increased from 3.78% in 2000 to 5.5% in 2010. The average contribution of goatfishes to the trawl fishery reported by Hamsa and Rao (1997) during 1994-1996 was 4.5%, indicating a substantial increase in the landing of this resource.

*Lizardfishes*

The landing of lizardfishes increased from 1062 t in 2000 to 4224 t in 2010 (Fig. 3). Lizardfishes formed 1.1% of the total marine fish landings. Its contribution to the demersal fishery was 4.04%. Lizardfishes exhibited increase in catch and catch rates in trawls over the years from 949 t and 0.23 kg $h^{-1}$ in 2000 to 3970 t and 0.81 kg $h^{-1}$ in 2010 (Fig. 8). The contribution to trawl landings also increased during the same period from 1.28% to 3.1%. In sharp contrast, Rajkumar *et al*. (2003b) reported from Visakhapatnam that during 1990-2001, the contribution of lizardfishes to the trawl catches was 5.3%.

*Penaeid prawns*

The catch of penaeid prawns increased from 22657 t in 2000 to 27408 t in 2010 (Fig. 5). The contribution was 10.25% on an average to the total marine fish catch. Penaeid prawns were exploited mainly by trawls. Their catch and catch rate in trawls increased from 20446 t and 4.94 kg $h^{-1}$ in 2000 to 24660 t and 5.01 kg $h^{-1}$ in 2010. The catch rate increased in this decade as compared to 1.7 kg $h^{-1}$ to 2.96 kg $h^{-1}$ recorded by Rao (1999) during 1994 -1997. However, contrary to the increase in catch and catch rates, their contribution to the trawl catch decreased from 27.56% in 2000 to 19.25% in 2010.

*Nonpenaeid prawns*

The nonpenaeid prawn landings increased from 2685 t in 2000 to a maximum of 4445 t in 2003 after which it gradually decreased to 2354 t in 2010 (Fig. 5). The bulk of the landing was by trawlers. Similar to the total catch, the catch landed by trawlers also decreased from 2613 t in 2000 to 2154 t in 2010. The catch rate and their contribution to trawl catch also decreased over the same period from 0.63 kg $h^{-1}$ and 3.52% to 0.44 kg $h^{-1}$ and 1.68%. The resource formed on an average 1.19% of the total marine landings.

*Crabs*

The landing of crabs increased gradually over the years from 2791 t in 2000 to 6292 t in 2010. The highest landing for crabs of 6877 t was recorded in 2004 (Fig. 5). Crabs formed about 2.61% of the total marine fish catch. The catch and catch rate of crabs in trawls increased from 1867 t and 0.45 kg $h^{-1}$ in 2000 to 5016 t and 1.02 kg $h^{-1}$ in 2010. Similarly their contribution to trawl catch has also increased over the same period from 2.52% to 3.92%.

*Cephalopods*

Cephalopods formed on an average 1.05% of the total marine landings of Andhra Pradesh. Cephalopods catch was contributed mainly by the squid, *Loligo duvaucelli* (27.1%) and the cuttlefish, *Sepia* sp. (71.3%). The cephalopod catch increased from 1011 t in 2000 to 3862 t in 2010 (Fig. 5). Their catch and catch rate in trawlers increased from 975 t and 0.24 kg $h^{-1}$ in 2000 to 3731 t and 0.76 kg $h^{-1}$ in 2010 and the contribution to trawl catch also increased similarly during the same period from 1.31% to 2.91%.

Table 1. Growth and mortality parameters of finfish and shellfish resources landed by trawlers at Visakhapatnam during 2007 - 2010

| Species | $L_\infty$ (cm) | k | Z | M | F | E | $E_{max}$ | Lc (cm) |
|---|---|---|---|---|---|---|---|---|
| *Rastrelliger kanagurta* | 27.4 | 0.47 | 1.89 | 1.1 | 0.79 | 0.42 | 1.0 | 17.62 |
| *Trichiurus lepturus* | 114.4 | 0.13 | 0.74 | 0.32 | 0.42 | 0.57 | 0.62 | 40.26 |
| *Nemipterus japonicus* | 34.5 | 0.3 | 1.87 | 0.77 | 1.1 | 0.59 | 0.70 | 13.72 |
| *Pennahia macrophthalmus* | 36.0 | 0.53 | 3.76 | 1.1 | 2.66 | 0.71 | 0.72 | 16.30 |
| *Upeneus vittatus* | 23.5 | 0.33 | 2.21 | 0.91 | 1.3 | 0.59 | 1.0 | 12.6 |
| *Saurida undosquamis* | 40.5 | 0.29 | 2.51 | 0.72 | 1.79 | 0.71 | 0.84 | 19.5 |
| *Metapenaeus monoceros* males | 19.0 | 2.2 | 13.81 | 1.79 | 12.02 | 0.87 | 0.61 | 7.98 |
| *Metapenaeus monoceros* females | 22.4 | 1.78 | 7.03 | 1.49 | 5.54 | 0.79 | 0.64 | 8.39 |
| *Metapenaeus dobsoni* males | 11.9 | 1.4 | 7.63 | 2.88 | 4.75 | 0.62 | 0.78 | 5.80 |
| *Metapenaeus dobsoni* females | 12.5 | 1.75 | 7.57 | 3.29 | 4.28 | 0.57 | 0.67 | 5.41 |
| *Portunus sanguinolentus* males | 23 | 1.4 | 6.53 | 1.26 | 5.27 | 0.81 | 0.53 | 7.35 |
| *Portunus sanguinolentus* females | 22 | 1.3 | 7.82 | 1.22 | 6.6 | 0.84 | 0.53 | 6.85 |
| *Sepia aculeata* | 24.2 | 0.4 | 1.61 | 0.55 | 1.06 | 0.66 | 1.0 | 8.09 |
| *Sepia pharaonis* | 28.99 | 0.87 | 2.86 | 1.19 | 1.67 | 0.58 | 1.0 | 21.17 |
| *Loligo duvauceli* | 17.5 | 0.3 | 1.20 | 0.22 | 0.96 | 0.8 | 1.0 | 6.08 |

Table 2. Yield, biomass and exploitation status of resources caught in trawls during 2007 - 2010

| Species | Stock (t) | Biomass (t) | Biomass per recruit (g) | Annual average yield (t) | Yield per recruit (g) | Fishing effort - multiplier at maximum Y and Y/R | Level of exploitation |
|---|---|---|---|---|---|---|---|
| *Rastrelliger kanagurta* | 17760 | 7977 | 22.43 | 6302 | 17.72 | 1.6 | Under exploited |
| *Trichiurus lepturus* | 34016 | 24036 | 100.40 | 10095 | 42.17 | 1.4 | Under exploited |
| *Nemipterus japonicus* | 6171.9 | 2791.8 | 20.39 | 3071.0 | 22.43 | 1.6 | Under exploited |
| *Pennahia macrophthalmus* | 1288.0 | 334.6 | 15.75 | 890.0 | 41.891 | 1.2 | Optimally exploited |
| *Upeneus vittatus* | 6472.2 | 2607.3 | 6.17 | 3389.5 | 8.02 | 3.0 | Under exploited |
| *Saurida undosquamis* | 2057.1 | 752.96 | 13.95 | 1347.8 | 24.96 | 2.2 | Under exploited |
| *Metapenaeus monoceros* males | 1619.9 | 117.2 | 0.6 | 1409.3 | 3.89 | 0.2 | Over exploited |
| *Metapenaeus monoceros* females | 2678.2 | 381.6 | 1.97 | 2113.9 | 6.71 | 0.4 | Over exploited |
| *Metapenaeus dobsoni* males | 601.7 | 78.7 | 0.2 | 481.1 | 1.01 | 2.2 | Under exploited |
| *Metapenaeus dobsoni* females | 818.7 | 107.9 | 0.12 | 630.1 | 1.15 | 1.6 | Under exploited |
| *Portunus sanguinolentus* males | 466.4 | 71.6 | 3.64 | 377.2 | 32.4 | 0.4 | Over exploited |
| *Portunus sanguinolentus* females | 739.3 | 94.1 | 2.24 | 620.8 | 23.5 | 0.2 | Over exploited |
| *Sepia aculeata* | 0.85 | 0.9 | 0.22 | 737.9 | 0.121 | 3.0 | Under exploited |
| *Sepia pharaonis* | 2.0 | 0.7 | 0.18 | 782.2 | 0.210 | 3.0 | Under exploited |
| *Loligo duvauceli* | 7.7 | 4.5 | 0.03 | 703.2 | 0.006 | 3.0 | Under exploited |

The estimated growth and mortality parameters of finfishes and shellfishes caught in trawl nets during 2007- 2010 are given in Table 1. The yield, biomass and yield/recruit values are given in Table 2. The multiplication factor for changing fishing effort in order to maximise yield/ recruit for each species is also given in Table 2. Based on the exploitation rate and the F multiplication factor, the level of exploitation of each stock has been denoted. It was observed that two out of the twelve commercially important resources were overexploited and one was optimally exploited. All the overexploited resource groups were crustaceans. Mechanised fishing with trawlers started at Visakhapatnam in 1964 (Rajkumar *et al*., 2004a) and since then shrimp trawls with cod end mesh size of 10-25 mm are being used for exploiting shrimps. The only management measure presently in vogue in the area is the seasonal fishing ban. Hence it is quite obvious that shrimps are overexploited. Other than *Pennahia macrophthalmus* all the other dominant fish stocks being exploited by trawls are yet to attain their optimum exploitation levels. Cephalopod resources are also underexploited. The findings of the study indicated the necessity to reduce effort targeted towards crustaceans while the effort towards fish and cephalopod resources can be increased. Modifying the shrimp trawls to fish trawls *viz*., pelagic trawls and semipelagic trawls coupled with increase in cod end mesh size need to be pursued as a management measures.

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