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Fishery and population dynamics of *Protonibea diacanthus* (Lacepede) and *Otolithoides biauritus* (Cantor) landed by trawlers at Vanakbara, Diu along the west coast of India

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ABSTRACT

The fishery and population characteristics of larger sciaenids *Protonibea diacanthus* (Lacepede) and *Otolithoides biauritus* (Cantor) landed by trawlers at Vanakbara, Diu were studied for the period 2003 – 2007. The average annual catch of *P. diacanthus* was 770.6 t and that of *O. biauritus* was 1018.6 t, together contributing 12% to the total trawl catch at Vanakbara. Majority of the larger sciaenids were landed during September - December. The von Bertalanffy growth equation was $L_t = 145.3\ [1 - e^{-0.14\ (t + 0.0738)}]$ for *P. diacanthus* and $L_t = 160\ [1 - e^{-0.19\ (t + 0.0638)}]$ for *O. biauritus*. The mortality rates M, F and Z computed for *P. diacanthus* were 1, 0.30 and 0.61 and for *O. biauritus* were 7, 0.33 and 0.70. The exploitation ratio (E) was 0.49 for *P. diacanthus* and 0.47 for *O. biauritus*. A maximum increase in relative yield by 2.7% for *P. diacanthus* could be realized by decreasing the present level of fishing by 20%, while for *O. biauritus* the present fishing effort is at optimum level.

Keywords: Fishery, *Otolithoides biauritus*, Population dynamics, *Protonibea diacanthus*, Stock assessment, Vanakbara

Introduction

Sciaenids are one of the major demersal resources, contributing around 30% to the demersal fish catch of the north-west region of India during 2002 – 2006. The landings of sciaenids has decreased over the years from 40,000 t in 2002 to 33,000 t in 2006 (Mohanraj *et al*., 2009). It is exploited by a variety of gears *viz.,* trawl, gillnet and dol net but the major catch comes from the trawls. The larger growing species, ghol (*Protonibea diacanthus*) and koth (*Otolithoides biauritus*) are commercially important and fetch high price. A major portion of larger sciaenids caught by trawlers is landed at Vanakbara, Diu. The multiday trawlers conduct fishing for 5-8 days at depths ranging from 18-45 m in the fishing grounds off Nawabunder to Vapi. The cod end mesh size for trawls vary from 20-25 mm and trawlers perform on an average 4-6 hauls per day.

The fishery and biology of ghol and koth from the waters of Bombay and Saurashtra were extensively studied a few decades back (Jayaraman *et al*., 1959; Rao, 1961; 1963; 1964; 1966; 1967; 1968; Kutty, 1967; Jayaprakash, 1976; Sarvaiya, 1991). Preliminary account on the population parameters of these two larger sciaenids of Bombay and Saurashtra waters has been provided by Mohanraj *et al*. (2003) and Chakraborty *et al*. (2005). There is no information available on the status of these two larger sciaenids off Diu. The present study attempts to assess the fishery and status of these two valuable resources based on the data collected from the trawl landings at Vanakbara, Diu.

Materials and methods

Data on catch and effort expended for catching *P. diacanthus* and *O. biauritus* were collected weekly from the trawl landing centre at Vanakbara, Diu, during January 2003 to December 2007. The monthly and annual estimates of catches were made following the stratified random sampling design as adopted by CMFRI. A total of 3,975 specimens of *P. diacanthus* (length range: 18.0 to 141.9 cm) and 2,275 specimens of *O. biauritus* (length range: 30.0 to 151.9 cm) were sampled weekly for recording total length (in cm) and body weight (in g). The length - weight relationship of *P. diacanthus* and *O. biauritus* was calculated following the formula $W = aL^b$ (Le Cren, 1951). There was no data available on catch, effort, length and weight of ghol and koth from middle of June to middle of August in all the years due to sensational ban on trawl fishery.

For estimating the von Bertalanffy growth parameters *viz,* asymptotic length (L_α) and growth co-efficient (K), the monthly data on length measurements during 2003 - 2007

were pooled and grouped into 2 cm class interval, and analyzed using the ELEFAN I module of FiSAT software (Gayanilo *et al*., 1996). The output of the growth curve was obtained and length based growth performance index (Ø) was calculated from the final estimates of L_α and K (Pauly and Munro, 1984). The size at first capture (Lc) was estimated as in Pauly (1984) and the age at zero length (t_0) from Pauly's (1979) empirical equation,

$$\text{Log } (-t_0) = - 0.392 - 0.275 \text{ Log } L_\alpha - 1.038K^{-1} \quad (1)$$

The growth and age were estimated using the von Bertalanffy growth equation,

$$L_t = L_\alpha \ (1-e^{-k(t- to)})^{-2} \quad (2)$$

The mid point of the smallest length group in the catch was taken as length at recruitment (L_r). The recruitment pattern was studied from recruitment curves using final estimated values of L_α, K and t_0. The value of asymptotic weight (W_α) was derived from the value of L_α and the estimated length - weight relationship.

Natural mortality (M) was estimated as in Pauly (1980), by taking the mean sea surface temperature as 27 ^{0}C and total mortality (Z) from length converted catch curve (Pauly, 1983) using FiSAT software. Fishing mortality (F) was estimated by F = Z - M. Length structured virtual population analysis (VPA) of FiSAT was used to obtain fishing mortalities per length class. Exploitation ratio (E) was estimated from the equation, E = F/Z and exploitation rate (U) from U = F/Z*(1-e^{-z}); where, F is the fishing mortality rate.

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. Maximum sustainable yield (MSY) was calculated by the equation (Gulland, 1979) for exploited fish stocks, MSY = Z x 0.5 x B. The relative yield per recruit (Y/R) and biomass per recruit (B/R) at different levels of F was estimated using LFSA package (Sparre, 1987).

Results

Fishery

The fishing effort by the trawlers recorded a gradual decrease from 9,93,704 fishing hours in 2003 to 5,50,507 fishing hours in 2007. The average annual catch of sciaenids during 2003 - 2007 was 2803.2 t forming 18.9% of the total trawl catches at Vanakbara. The catch of sciaenids was dominated by *P. diacanthus* and *O. biauritus*, which contributed on an average 27.5% and 36.4% to the total sciaenid catch (Fig. 1 and 2). The annual catch of ghol increased steadily from 315. 8 t in 2003 to 1342.8 t in 2005 and then decreased to 788 t in 2007 (Fig. 1). The catch of koth on the contrary exhibited an increasing trend over the years from 580.2 t in 2003 to 1816.4 t in 2007 (Fig. 2). The catch rates (CPUE) for ghol and koth were highest in 2005 (3.1 kg h^{-1}) and 2007 (3.3 kg h^{-1}), respectively and lowest in 2003 (0.3 kg h^{-1} for ghol and 0.6 kg h^{-1} for koth) (Fig.1 and 2). The average catch rate during the period was 1.1 kg h^{-1} for ghol and 1.5 kg h^{-1} for koth.

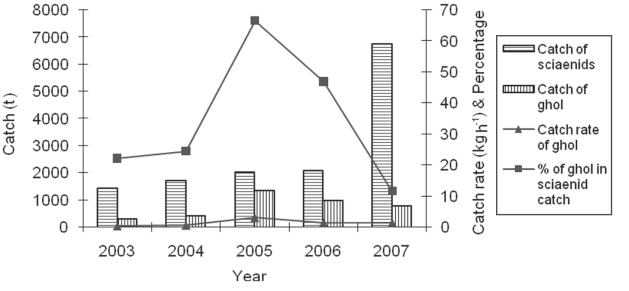

Fig. 1. Trend in fishery of ghol landed by trawlers at Vanakbara (2003 - 2007)

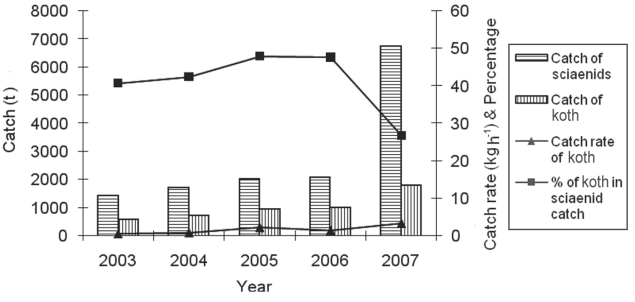

Fig. 2. Trend in fishery of koth landed by trawlers at Vanakbara (2003 - 2007)

Seasonal abundance

The studies on seasonal abundance revealed that the post-monsoon season (September to December) is the most productive in terms of catch and catch rate. The average monthly catch and catch rate for ghol was highest during November (166.1 t) and September (3.1 kg h^{-1}), respectively and the lowest during May (18.5 t) and April (0.4 kg h^{-1}) (Fig. 3). For koth, both the monthly catch and catch rate were high in October (271.98 t and 2.21 kg h^{-1}) and low in May (26.2 t) and April (0.75 kg h^{-1}) (Fig. 4). Similarly, the average month-wise proportion in the trawl landings was higher during September (12.7%) for ghol and October (11.0%) for koth (Fig. 3 and 4).

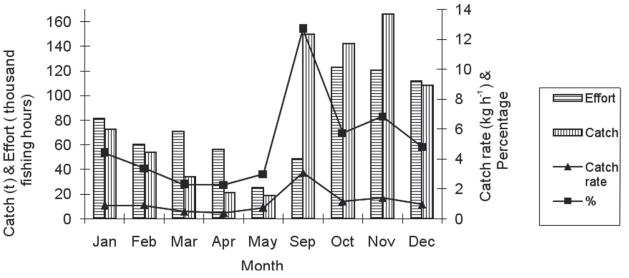

Fig. 3. Seasonal abundance of ghol at Vanakbara

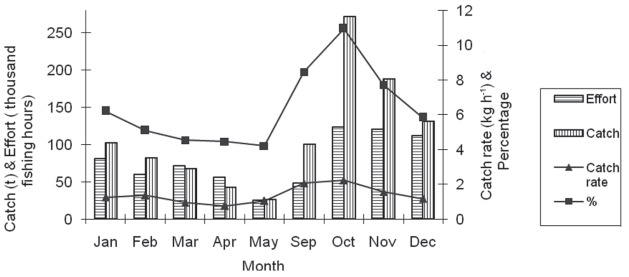

Fig. 4. Seasonal abundance of koth at Vanakbara

Length composition

The mean length of ghol exhibited fluctuating trends during the five year period with the highest mean length of 92.9 cm recorded in 2004 and the lowest mean length of 64.4 cm recorded in 2003. More number of juveniles was recruited into the fishery every alternate year starting from 2003 onwards which might account for lower mean lengths recorded in these years. Seasonally, the highest mean lengths were witnessed in the pre-monsoon months of April and May (101.7 cm – 104.3 cm) and the lowest in the post-monsoon months of September (61.2 cm) and November (60.2 cm). For koth, the mean length recorded was more or less similar in the five years with little variation from 103.6 cm to 105.9 cm. Similarly, the mean lengths of koth were also highest during March–May (113.3 cm – 123.6 cm) and lowest during September–October (83.5 cm – 89.6 cm).

Length-weight relationship

P. diacanthus

The estimated length-weight relationship for ghol is:

$\log W = -1.783 + 2.857 \log L$

O. biauritus

The estimated length-weight relationship for koth is:

$\log W = -1.427 + 2.539 \log L$

Growth

P. diacanthus

The growth parameters, L_α and K estimated using the ELEFAN I programme were 145.3 cm and 0.14year^{-1}, respectively at the highest Rn (goodness of fit index) value of 0.22. The length at first capture (L_c) was 22.2 cm and asymptotic weight (W_α) was 24822.87 g. The growth performance index (Ø) was 3.471 and t_0 was calculated as -0.0738 years. The von Bertalanffy growth equation was:

$$L_t = 145.3\ [1 - e^{-0.14\ (t + 0.0738)}]$$

O. biauritus

Using ELEFAN I programme, the estimated growth parameters L_α and K were 160 cm and 0.19 year^{-1} at the highest Rn value of 0.232. The growth performance index (Ø), t_0 and asymptotic weight (W_α) calculated were 3.687, -0.0638 years and 14751.67 g, respectively. Length at first capture (L_c) was 32.65 cm and the von Bertalanffy growth equation was:

$$L_t = 160\ [1 - e^{-0.19\ (t + 0.0638)}]$$

Recruitment pattern

The smallest length at recruitment for ghol and koth were 18.95 cm and 30.95 cm, respectively. A unimodal recruitment pattern was observed in ghol with fishes being recruited into the fishery throughout the year. The peak recruitment was in the months of April - August and this pulse on an average produced 77.2 % of the recruits. Koth was also recruited throughout the year with two major peaks in July and September. The peak pulse from May to November, on an average produced 92.06% of the recruits.

Mortality, exploitation and VPA

The mortality rates M, F and Z computed for ghol and koth were 0.31 and 0.37, 0.30 and 0.33 and 0.61 and 0.70 respectively. The rate of exploitation (U) for ghol and koth were 0.225 and 0.240 respectively. The exploitation ratio (E) for ghol and koth were 0.49 and 0.47 respectively. An astonishing feature of the ghol fishery is that at no length range the fishing mortality exceeded the natural mortality

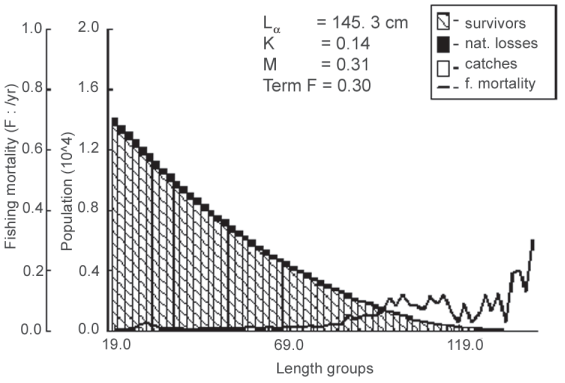

Fig. 5. Length structured VPA for ghol for the years 2003 - 2007

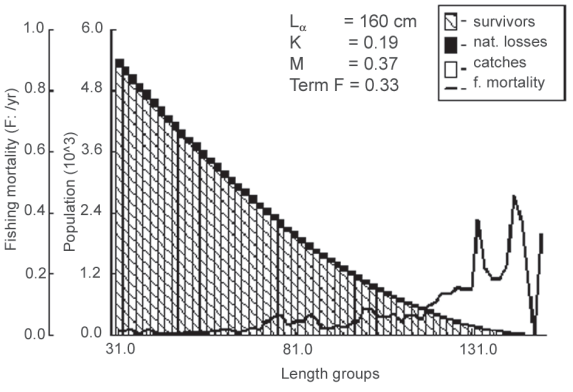

Fig. 6. Length structured VPA for koth for the years 2003 - 2007

(Fig. 5), whereas for koth, the fishing mortality exceeded natural mortality only at lengths of 132.95, 142.95 and 144.95 cm (Fig. 6). The maximum fishing mortality of 0.456 for koth was recorded at the size of 142.95 cm and for ghol the maximum fishing mortality of 0.3 was recorded at the size of 140.95 cm. The mean values of fishing mortality and exploitation ratio were 0.047 and 0.080 for ghol and 0.077 and 0.114 for koth.

Estimation of stock and MSY

For *P. diacanthus*, the annual total stock, biomass and MSY estimated were 3431 t, 2569 t and 783 t; and for *O. biauritus*, the annual total stock, biomass and MSY were 4250 t, 3087 t and 1080 t, respectively.

Yield/recruit

P. diacanthus

The yield/recruit and yield curves showed that the maximum yield and yield/recruit could be achieved by decreasing the present level of fishing by 20% (Fig. 7 and 8). The maximum yield and yield per recruit that can be obtained at 80% of the present fishing effort is 791.16 t and 574.573 g, respectively. At the present level of fishing, it is 770.64 t and 559.67 g. At the reduced effort, the relative yield would be 102.66 %. To get optimum yield of ghol, the present fishing effort has to be reduced by 20 %.

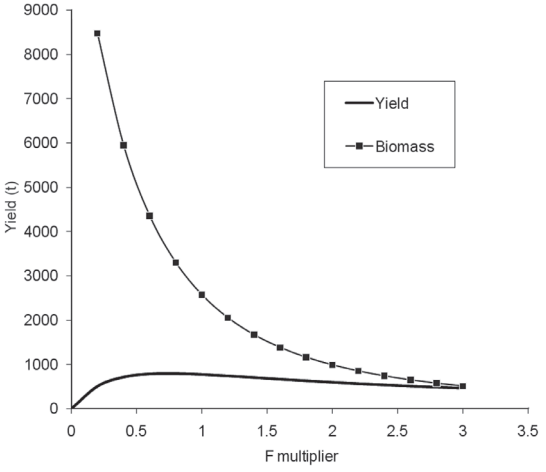

Fig. 7. Yield and biomass of ghol for different multiples of F

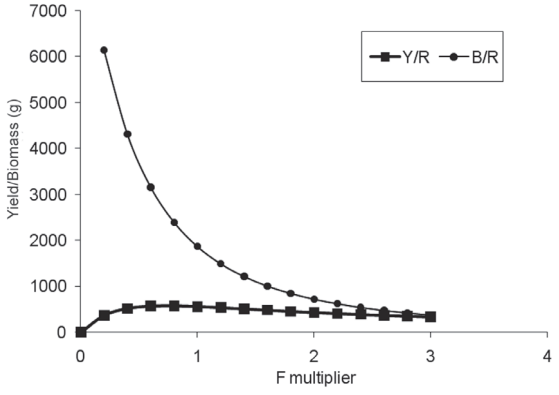

Fig. 8. Yield per recruit and biomass per recruit of ghol for different multiples of F

O. biauritus

A maximum yield of 1018.56 t and yield per recruit of 514.47 g was obtained at the present level of fishing (Fig. 9 and 10). Hence the present fishing effort is the optimum to get maximum yield for koth.

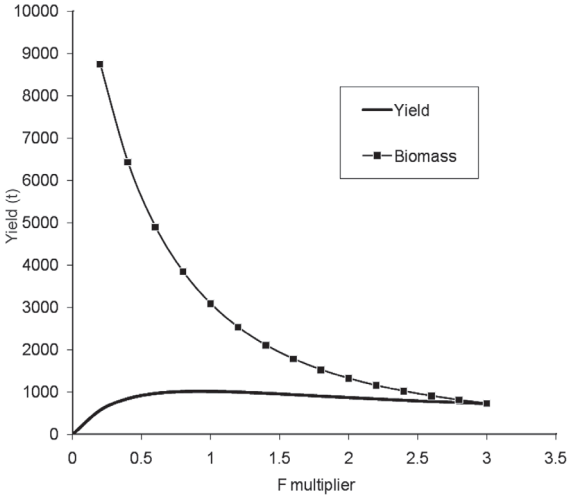

Fig. 9. Yield and biomass of koth for different multiples of F

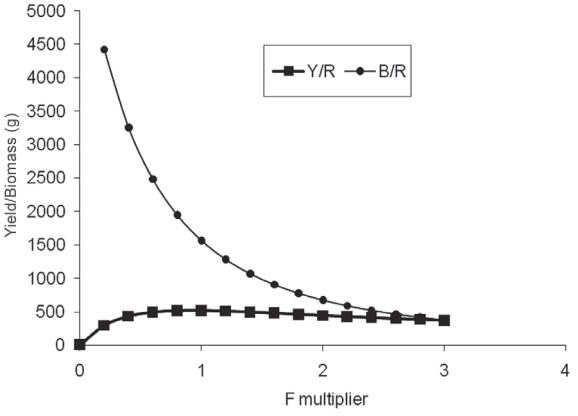

Fig. 10. Yield per recruit and biomass per recruit of koth for different multiples of F

Discussion

The targeted fishing for larger sciaenids coupled with improvement in the operational efficiency of trawls has resulted in higher catches and catch rates of ghol and koth in recent years. The multiday trawlers conduct fishing of

5-8 days duration for ghol and koth at a distance of 90–100 km off Vanakbara coast towards Vapi where there is an excellent fishing ground of 15 – 20 square km area for ghol and koth at the latitude between 20^0 03' N to 20^0 20' N and longitude between 71^0 30 E to 71^0 34 E at depth ranging from 18 - 30 m (Global Positioning System, Garmin, USA). The bulk of the catch was from about the 36.5 m line with koth showing relatively greater abundance on the landward side of this line, while ghol occurred in quantities a little to the seaward side of this line (Jayaraman *et al*., 1959). Similar observations on high catch and catch rate of ghol from the same area were reported by Rao (1964) and he associated this high yield with low and moderate bottom temperature characteristic of this area. In the recent past, specially designed nets of 60 m length and 12 m mouth opening were used to catch ghol and koth. The decrease in effort of trawl over the years is mainly due to the switching over to target fishing for larger sciaenids, ribbonfishes and cephalopods coupled with several other socio-economic factors like labour problem, hike in fuel price, *etc.* The seasonal peak of abundance in catch and catch rate during September – December coincided with increased fishing activity during this period. At Vanakbara, Diu fishing is suspended during the monsoon months (June – August), which has contributed to the high catch and catch rates in the post-monsoon season.

Rao (1963) has stated that the ghol in Bombay waters has a single spawning period extending from June to August. The recruitment of juveniles into the fishery from September to November could possibly explain the lower mean lengths recorded during this period. Similar results on length-weight relationship of ghol were reported by Rao (1968) from Bombay. However, higher 'b' values for ghol (2.94) and koth (3.0139) were reported by Rao (1963) and Pauly (1978). This variation is possibly due to factors related to ecosystem and biological phenomena like maturity stages, feeding behaviour, competition for food, *etc.*

The present estimate of L_α for *P. diacanthus* (145.3 cm) is much higher than 122.1 cm recorded by Rao (1966) from Bombay and Saurashtra waters but is in close agreement with 144.7 cm reported from Bombay by Rao (1968). For *O. biauritus*, the present estimate of L_α(160 cm) matches very well with 160 cm reported by Pauly (1978) but is lower than 170.25 cm and 206 cm observed by Kutty (1961) and Jayaprakash (1976) from the coast of Bombay. The growth performance index recorded for ghol and koth conforms fully to earlierpublished reports of 3.64 – 3.70 by Rao (1961) and Rao (1966) for ghol and 3.73 – 3.77 by Kutty (1961) and Jayaprakash (1976) for koth. According to Rao (1963), the length at first maturity for ghol was 85 cm. The length at first capture (22.2 cm) was very low when compared to the size at first maturity indicating that majority of them were caught before they mature and spawn. This indicated stress on spawning stock and could be addressed by enhancing their size and age at exploitation through mesh size regulation to avoid exploitation of the young fishes.

The exploitation ratios observed for ghol and koth is an indication that the stocks are under optimum fishing pressure, which are further substantiated by the fact that their MSY is also in close proximity to their annual catch. A maximum increase in relative yield by 2.66% for *P. diacanthus* was realized by decreasing the present level of fishing by 20%, while for *O. biauritus,* the present level of fishing is optimum. However since these two closely related sciaenids are equally targeted by the trawlers and have common feeding and breeding grounds, it is difficult to differentiate between them and recommend different management measures for each one of them. The relative yield of *P. diacanthus* at 80% of the present effort would increase by 2.66% only while that of *O. biauritus* would marginally decrease by 0.37%. Hence decreasing the present fishing effort by 20% appears to be more realistic considering that the decrease in relative yield of koth is very marginal at the reduced effort. It is thus recommended that measures be taken to decrease the fishing hours of trawlers operating at Vanakbara to optimally exploit these two species together .

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