Stock Assessment of the Demersal Offshore Fishery Resources off the Karnataka Coast

R. S. BIRADAR

Central Institute of Fisheries Education, Versova, Bombay - 400 061

The total biomass of the demersal stocks in the depth range of 30–200 m between 12° 40′ and 15°N latitudes in the Indian Exclusive Economic Zone is estimated to be around 1,23,000 metric tonnes (t). There is scope for doubling the present catch of about 40,000 t from demersal resources by extending exploitation to 50–200 m depth zone. About 78% of this increase is expected to come from four species, namely, *Nemipterus japonicus, Priacanthus macracanthus, Saurida tumbil* and *Arius* spp.

Standard errors to ascertain reliability of the estimates are presented along with the number of hauls required to achieve the desired accuracy.

The Karnataka state with a coast line of 270 km, ranks fifth in marine fish production in India with average annual landings of 1,35,418 t during 1980–83. For the rational exploitation of fish stocks, accurate information on the biomass and potential yield is of paramount importance. However such estimates are available only for the Indian waters as a whole. Therefore, the offshore waters off Karnataka beyond 30 m depth was surveyed and collected information on the composition, distribution and magnitude of the fishery resources.

Materials and Methods

The data collected in two cruises during May-June, 1984 off the Karnataka coast formed the basis for the study. During these cruises the area between 12°30′ – 15°N latitude in the depth range of 30 to 250 m was surveyed off the west coast of India. The surveyed area was divided into 4 depth strata, 30–49 m, 50–99 m, 100–199 m and above 200 m. Bottom trawling using fish and shrimp trawls was carried out in 38 stations with one haul at each station. The data were collected at 35 stations between 12°40′ and 15°N latitudes, corresponding roughly to the offshore waters off Karnataka coast (12°44′ to 14°53′N latitudes) (Fig. 1).

At each station, the fishing depth, total catch, species composition of catch and length frequency of selected species were recorded besides hydrographic data on temperature, dissolved oxygen, salinity and pH at depth intervals.

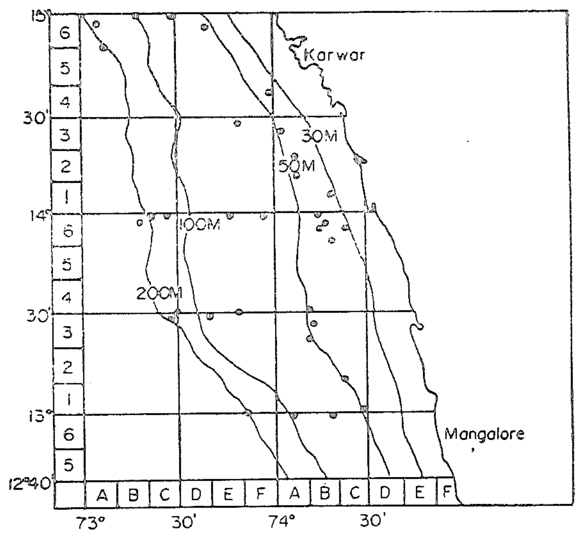

Fig. 1. Sampling area and location of stations

The area swept by the trawl a, was estimated from the expression

$$a = v.t.h.x_2 \quad (1)$$

where v is the velocity of the trawler over ground when trawling, t the time spend on trawling, h the length of the head rope and x_2 the fraction of the head rope which is equal to the width of the path swept by the trawl and $h.x_2$ the wing spread. In Southeast Asian waters, values for x_2 ranging from 0.4 (Shindo, 1973) to 0.66 (Anon, 1978) have been used. In the present study, $x_2 = 0.5$ as suggested by Pauly (1979) as the best compromise has been used.

Catch per unit area was obtained by dividing the catch per hour by the area swept per hour by the trawl. Based on these, the average catch per unit area was worked out separately for each stratum and for some important species. Average catch per unit area was also obtained by transforming the data to logarithmic scale, using the method given by Pennington (1983). These were compared with the estimates obtained for untransformed data.

Biomass of demersal stocks in each stratum was estimated from the relationship.

$$B = \frac{\overline{X}\, A}{x_1} \qquad (2)$$

where $\overline{X}$ is the mean catch per unit area (square nautical mile), A the area of the stratum and x_1, the proportion of the fish in the path of the gear that are actually retained by the net. In Southeast Asian waters a value of $x_1 = 0.5$ is commonly used (Isarankhura, 1971; Seager *et al.*, 1976; Anon, 1978) and there is some evidence that this value might in fact, be very realistic (Pauly, 1979). In the present study also $x_1 = 0.5$ is used.

The potential yield (P_y) from the demersal resources in 50–200 m depth was computed using Gulland's (1971) formula

$$P_y = 0.5\,M.Bv \qquad (3)$$

where Bv is the virgin standing stock and M. the coefficient of natural mortality. In Southeast Asian demersal trawl fisheries M in formula (3) is set equal to 1, as fishes of this region are relatively small and short lived (Pauly, 1983).

The standard error (SE) of the mean catch per unit area (mean density) was worked out using the formula

$$SE = \frac{S}{\sqrt{n}} \qquad (4)$$

where S is the root of the variance of catch per unit area in the sample and n the number of hauls. The maximum relative error 'e' was estimated using the formula.

$$e = \frac{t\ S}{\overline{X}\sqrt{n}} \times 100$$

where t stands for the Student's t with n-1 d.f. at 5% level of significance. The relation between the maximum relative error and the number of hauls was depicted graphically.

Neyman allocation (Cochran, 1963) was used to computs the number of hauls to be allocated for each stratum.

Results and Discussion

Overall catch composition

Nemipterus japonicus contributed maximum (17%) followed by *Pomatomidae* spp. (13.3%), *Arius* spp. (11.1%), and *Priacanthus macracanthus* (8.5%). The *Pomatomidae* spp. was found in only two hauls, one of the hauls contributing 1100 kg to the total catch of 1105 kg. *N. japonicus, P. macracanthus* and *Saurida tumbil* were found in catches of most of the hauls. *Therapon jarbua* was dominant between 14°10′ and 14°30′ N latitude at a depth of 44 to 46 m and in 13°50′–13°60′ at a depth of 34 m.

Catch composition by depth strata

Arius spp. was dominant (20%) in the first stratum (30–49 m), followed by *Therapon jarbua* (11.9%) and *N. japonicus* (10.1%). In the second stratum (50–99 m), 53% of the catch was contributed by *N. japonicus,* followed by *Arius* spp. (13.3%) and *S. tumbil* (8.9%). The dominant species in the third stratum (100–199 m) was *P. macracanthus* which contributed 37% followed by *N. japonicus* with 26% share in the total catch of the stratum. In the fourth stratum (above 200 m) only two hauls were taken. In one of the hauls, *Pomatomidae* spp. contributed 90% to the total catch. In the other *P. macracanthus* was dominant.

As only two hauls were available in stratum IV, resources in this stratum have not been further quantified.

Table 1. *Mean catch, tonnes per sq. nautical mile*

Species	Stratum I	Stratum II	Stratum III
N. japonicus	1.65 ± 0.50	3.41 ± 2.26	1.57 ± 0.97
	(2.05 ± 0.95)*	(2.64 ± 2.73)	(2.29 ± 1.92)
Arius spp.	2.54 ± 1.23	0.83 ± 0.80	—
	(2.83 ± 1.66)	(0.83 ± 0.83)	—
P. macracanthus	1.04 ± 0.84	0.44 ± 0.30	2.19 ± 0.71
	(0.68 ± 0.44)	(0.34 ± 0.17)	(2.66 ± 1.39)
S. tumbil	0.35 ± 0.13	0.57 ± 0.13	0.35 ± 0.22
	(0.36 ± 0.30)	(0.62 ± 0.20)	(0.36 ± 0.24)
All demersal spp.	13.40 ± 2.85	6.31 ± 2.43	6.26 ± 1.18
	(15.96 ± 5.50)	(6.30 ± 2.60)	(6.28 ± 1.29)

*Figures in brackets refer to the catch rates for logarithmically transformed data

Table 2. *Estimates of biomass ('000 t) by depth strata*

Species	Stratum I	Stratum II	Stratum III	Total
N. japonicus	6.29 ± 1.90	27.96 ± 18.53	5.02 ± 3.10	39.25 ± 18.89
Arius spp.	9.65 ± 4.67	6.81 ± 6.56	—	16.46 ± 8.05
P. macracanthus	3.95 ± 3.19	3.61 ± 2.46	7.01 ± 2.27	14.57 ± 4.63
S. tumbil	1.33 ± 0.49	4.67 ± 1.07	1.12 ± 0.70	7.12 ± 1.27
All demersal spp.	50.92 ± 10.83	51.74 ± 19.93	20.03 ± 3.78	122.69 ± 22.99

Catch rate by strata

Two gears, fish trawl and shrimp trawl, were operated during the cruise. As a first step, catch rates in each stratum were worked out separately for each gear. As there was no significant difference in the catch rates, the data of both gears were combined to compute the mean catch rate.

The catch rate varied from 8.2 to 569.4 kg in stratum I, from 9 to 526 kg in stratum II and 50.2 to 192 kg in stratum III.

The comparison of the standard errors of mean catch rates for log-transformed and untransformed data indicated that the transformation of data was not beneficial in most of the cases (Table 1). Whether transformation other than logarithmic will be efficient needs to be studied, but has not been attempted in the present study. The mean catch per square nautical mile of the untransformed data has been taken as the estimates of biomass density in further discussion.

The catch per unit area per haul varied from 0.41 to 28.33 t in stratum I, 0.48 to 28.28 t in stratum II and 2.7 to 10.3 t in stratum III. There was significant difference between the catch rates of strata. The mean catch per square nautical mile was 13.4 t in stratum I, 6.3 t each in strata II and III. The mean catch per square nautical mile of dominant species, *N. japonicus, Arius* spp., *P. macracanthus* and *S. tumbil* is furnished in Table 1.

Arius spp. had the highest mean catch per square nautical mile (2.5 t) in stratum I, followed by *N. japonicus* (1.7 t). In stratum II, *N. japonicus* had the highest mean density (3.4 t), folowed by *Arius* spp. (0.8 t). In stratum III, it was *P. macracanthus* which had the highest mean catch per square nautical mile (2.2 t), followed by *N. japonicus* (1.6 t).

Estimates of biomass

The total biomass of all demersal stocks together with the biomass estimates for some major demersal stocks is given in Table 2. The total biomass of demersal fish resources off the Karnataka coast has been estimated to be around 1,23,000 t between 30 and 200m depth. *N. japonicus* is the dominant species with estimated biomass of 39,000 t followed by *Arius* species (16,500 t), *P. macracanthus* (14,600 t) and *S. tumbil* (7,100 t). The estimated biomass in the 50-200 m depth zone, which is almost unfished, was 71,800 t.

Strata I and II contributed about 84% to the total demersal biomass with almost equal share. 71% of the biomass of *N. japonicus* came fom stratum II. *Arius* species was distributed only in strata I and II. Almost 50% of the biomass of *P. macracanthus* came from stratum III alone, whereas, 66 % biomass of *S. tumbil* came from stratum II

Potential yield

The potential yield from 50-200 m depth is estimated to be around 36,000 t per annum (Table 3). About 46% of this yield is expected to come from a single species *N. japonicus.*

Precision

The relationship between the maximum relative error and the number of hauls is depicated in Fig. 2. Less the relative error, greater is the precision of the estimated mean density. The precision of the estimate increased with the increase in number of hauls. The rate of increase in precision became marginal as the number of hauls increased beyond 100.

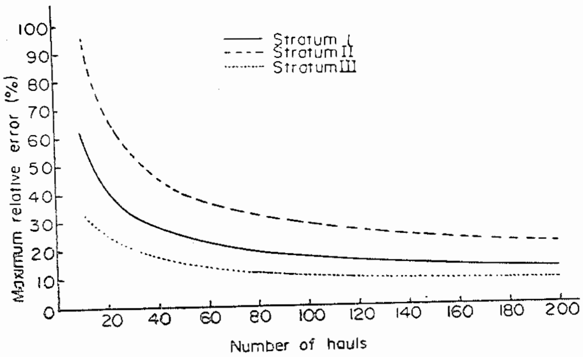

Fig. 2. The relation between the maximum relative error and the number of hauls

Table 3. *Potential yield of demersal stocks off the Karnataka coast (between 50-200 m depth)*

Species	Potential yield ('ooo t)
N. japonicus	16.49
Arius spp.	3.41
P. macracanthus	5.31
S. tumbil	2.90
All demersal spp.	35.89

This study provides a preliminary estimate of the total off shore demersal biomass off the Karnataka coast which works out to 1,23,000 t. Strata I and II are more productive contributing 41.5 and 42.2% respectively to the total offshore biomass. As the present area of exploitation does not usually extend beyond the 50 m depth, the biomass of demersal stocks beyond this depth is almost unexploited. Using formula (3), the potential yield for 50-200 m depth is estimated to be around 36,000 t. The average annual catch of demersal fishery from the present area of exploitation (up to 50 m depth) is around 40,000 t. Thus by extending the area of exploitation upto the 200 m depth, there is scope for almost doubling the catch from demersal resources.

Nemiterus japonicus, Priacanthus macracanthus, Saurida tumbil and *Arius* spp. are expected to contribute very significantly to this increase as 78% of the biomass in the 50-200 m depth comes from these 4 species.

The number of sample hauls required to estimate the mean catch per unit area (stock density) with the maximum relative error not exceeding 20%, 65 hauls were required in stratum I, 170 hauls in stratum II and 26 hauls in stratum III (Fig. 2). In order to

Table 4. *Percentage allocation of hauls among strata by the Neyman allocation*

Strata	Percentage of hauls
I	34.0
II	58.0
III	8.0
Total	100.0

achieve the higher precision with the maximum relative error 10%, as preferred in statistical decision making in experimental biology, the number of sample hauls required will be very high. As exploratory fishing involves very high costs and is done by few vessels, only a limited number of hauls can be taken for the purpose of assessing resources. The problem is therefore to allocate these limited number of hauls to different strata such that the precision of the estimates are maximal. Following Neyman allocation, hauls are assigned to a given stratum in proportion to the product of the areas of the stratum and standard deviation of the mean density in that stratum. Table 4 gives the Neyman allocation of hauls to different strata. If 100 hauls can be made in a resource assessment survey, 34 should be in stratum I, 58 in stratum II and 8 in stratum III to attain the maximum precision for a given number of hauls.

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