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Estimates on potential yield and maximum sustainable fleet size for marine fisheries in Kerala

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Abstract

Time series data on marine fish landings and effort in units and hours of operation along Kerala during 1997-2007 were used to arrive at estimates on potential yield (PY) and maximum sustainable fleet size (MSFS). The PY was estimated as a simple high pass filter of the landings after classifying the resources into three categories, *viz*., demersals, large pelagics and small pelagics. The total PY was estimated as 6.99 lakh tonnes and the annual average landings during 1997-2007 was 5.81 lakh tonnes. The MSFS estimates were made from the data on fishing units and hours of operations of important craft and gear combinations, and compared with the existing fleet size. It was found that the number of trawlers and outboard ringseiners in operation are in excess of the recommended MSFS.

Keywords: Potential yield, maximum sustainable fleet size, marine fish landings, simple high pass filter

Introduction

Estimation of marine fishery resources potential and maximum fleet size that could be deployed to exploit the resources at the potential and sustainable level are essential for proper planning and development of the marine fisheries sector. On different occasions, working groups have estimated the potential yield of marine fisheries resources in the Indian Exclusive Economic Zone (EEZ). Based on primary production and fish production trends, Prasad *et al*. (1970), Jones and Banerji (1973) and Mitra (1973) have attempted to assess the fishery potential of the Indian Ocean and the seas around India. Kalawar *et al*. (1985), in the report of the expert committee on marine fisheries in Kerala, have recommended the maximum limits for the number of mechanized trawlers operating between 20 and 50 m depth and motorized canoes in the traditional fishing grounds. Based on values of secondary production, Mathew *et al*. (1990) estimated the potential yield of the Indian EEZ as 3.74 million tonnes. The working group constituted by the Government of India estimated the potential yield in the Indian EEZ as 3.9 million tonnes in 1991 (Anon, 1991). According to their estimate, the annual catchable potential in the 0-50 m depth zone off Kerala is 0.57 million tonnes. In 2000, another working group revalidated the estimate of potential yield in the Indian EEZ as 3.93 million tonnes, of which 2.02 million tonnes are from demersal resources, 1.67 million tonnes from pelagic resources and 0.24 million tonnes from oceanic resources (Anon, 2000). State-level break up is not available in the revalidated estimates.

Estimation of harvestable potential and the maximum sustainable fleet size, which can safeguard the interest of the fisherfolk as well as the conservationists, have always been a challenging task. The most comprehensive attempts to estimate the potential have been rooted on the estimates of primary productivity, which when properly apportioned, may yield the composition of various fish resources. Organic production, average annual growth rate and fish yield per unit area are reliable inputs for such an exercise. Though this seems to be a method with more biological footing, the main drawback is the data intensiveness. Moreover, multi-gear and multiple resource targeting by the fishing fleet impact the trophic levels in the ecosystems (Vivekanandan *et al.*, 2005), thereby leading to a total misinterpretation of the potential yield estimates based on primary productivity. Further, time series data on primary productivity are not available.

To tide over these data intense issues, resource assessors resorted to more output dependent methods. One such method is the Maximum Contribution Approach propounded by Alagaraja (1984). According to that concept, the peak landings realized under each resource in a period of time are added to arrive at a potential estimate. His method was inspired by the greatest annual average yield over a period or under average condition concept floated by Gulland (1969). Though this method was easily amenable to criticism for its naivety, it gave a ready-to-use solution as a reasonably good approximation.

Kurup and Devaraj (2000) tried to approach the whole issue at a macro-level. Their method was rooted on the argument that catch-per-unit effort (CPUE) or catch-per-hour (CPH) does not necessarily indicate abundance of resources nor do they indicate efficiency. They put forth a weighted CPUE/CPH wherein the CPUEs were weighted against the catch of the target resources. The standard effort was then calculated as the ratio of actual landings and weighted CPUE. From the response, a quadratic curve was fitted and the MSY was estimated. From the expected values of MSY, the optimum fleet for different resources was calculated.

As regards computation of maximum sustainable fleet size, the reference point happens to be the potential yield estimates. With the estimated potential, the fleet size can be back calculated using the efficiency historically recorded against them.

Here, an attempt is made to estimate the catchable potential from the present fishing grounds off Kerala based on the data for 1997-2007. Attempt is also made to calculate the maximum sustainable fleet size that could be employed to catch the potential.

The state of Kerala, in the southwest coast of India, has a coastal length of 590 km, and contributes the maximum (about 25%) to the marine fish landings in the country. During 1997-2007, the marine fish landings along Kerala fluctuated between 5.14 lakh tonnes in 2001 and 6.23 lakh tonnes in 2003 and the estimate for 2007 was 6.19 lakh tonnes (CMFRI, 2000). Important resources based on their average contribution to the total landings are the oil sardine (*Sardinella longiceps*), Indian mackerel (*Rastrelliger kanagurta*), penaeid prawns, carangids, perches, anchovies, cephalopods, ribbonfishes, tunas and flatfishes. The contribution by the mechanized, motorized and non-mechanized fleet were 45.2%, 51.3% and 3.5% respectively. Within the sectors, the average contribution by mechanized multi-day trawlers was 16.5% and by the mechanized single-day trawlers was 19.5%. The contribution by outboard ringseiners was 33.4% and by outboard gillneters was 6.9%.

Material and methods

Around 800 species are landed along the Kerala coast of which about 200 are commercially important. They are grouped into 60 groups/species for reporting and ease of presentation. For analyzing the trend and estimation of potential yield, time series data on estimated landings of 60 species/groups of marine fishery resources along the Kerala coast from 1997 to 2007 and the fishing effort expended in terms of unit and hours of operation of different craft were obtained from the National Marine Living Resources Data Centre (NMLRDC) of the Central Marine Fisheries Research Institute, Cochin.

For the trend analysis, a five point moving average (simple high pass filter) was calculated for the landings of each of the 60 species/group, and the maximum of the moving average series was noted down for each species/group. The species/groups were then classified into three categories, namely, demersals, large pelagics and small pelagics as shown in Table 1. For each of the three categories, the potential yield was estimated by adding the maximum of the moving averages of the groups identified for that category (Alagaraja, 1984). The total potential yield for Kerala was obtained as the total of the potential yields of the three categories.

From the landings during 2005-2007, it was observed that the fleet exploiting demersal resources are mainly (i) mechanized multi-day trawlers, (ii) mechanized single-day trawlers, (iii) outboard trawlers and (iv) mechanized hooks and lines. The last fleet type was found to exploit both demersals and large pelagics in almost equal proportion. The fleet that catch large pelagics are the (i) mechanized gillnetters, (ii) mechanized driftnetters, (iii) mechanized hooks and lines and (iv) outboard hooks and lines. Small pelagics are caught mainly by (i) mechanized purseseiners, (ii) mechanized ringseiners, (iii) outboard ringseiners, (iv) outboard gillnetters, (v) outboard boatseiners, (vi) outboard hooks and lines and (vii) non-mechanized craft.

To determine the maximum sustainable fleet size (MSFS) corresponding to the potential yield, the data on gearwise landings and effort for the last three years (2005 - 2007) were used. For each year, the landings of demersals, large pelagics and small pelagics by each fleet was found out. The miscellaneous group consisting of species which were not included in the list of 60 species/groups was proportionately distributed among the three categories. For estimating the MSFS, two different sets of data on fishing effort were used. As the trawlers are engaged in single-day and multi-day operations, the data on actual time (hours) spent in trawling was used. In the case of gillnetters, driftnetters, hooks and lines and other mechanized gears, the relationship between catch and hours of operation is not very strong as movement of fish towards the gear is necessary for them to be caught. Also, ringseines and purseines operate after locating the shoal. Hence, it was considered that the estimate of MSFS based on unit operation is more appropriate for all fleets other than trawlers. One unit operation refers to every operation of a craft from its departure from the landing centre/harbour to its return.

Based on the percentage of catch, the MSFS for the three categories were estimated. The fleet contributing maximum to the catch of each category was identified. The maximum effort for a category was estimated by adding the effort of those fleet identified for that category. When there was equal contribution by a fleet to two categories, that fleet was identified for both the categories with equal contribution. In this manner, for the demersals, large pelagics and small pelagics, the total catch, effort in unit and hours, and catch per unit effort in terms of hours of operation (CPH, for trawlers) and unit operations (CPU, for other fleet) were calculated.

Results and Discussion

Potential Yield Estimation: During 1997-2007, the annual average landings of the demersals, large pelagics and small pelagics were 1,85,876 tonnes, 31,601 tonnes and 3,52,512 tonnes respectively (Table 1).

Table 1. Annual average landings (1997-2007) and the potential yield estimates for demersals, large pelagics and small pelagics along the Kerala coast

Species / Groups	Potential yield (t)	Annual average landings (t)
Demersals		
Sharks	2301	1983
Skates	510	395
Rays	1522	1314
Eels	216	209
Catfishes	263	228
Lizardfishes	9575	8497
Rock cods	6119	5139
Snappers	1873	1387
Pig-face breams	725	493
Threadfin breams	34555	30750
Other perches	10659	8837
Goatfishes	136	124
Threadfins	126	96
Croakers	9389	8191
Silverbellies	5765	5349
Big-jawed jumper	1762	1131

Black pomfret	1146	810
Silver pomfret	1030	600
Chinese pomfret	54	29
Halibut	56	53
Flounders	36	32
Soles	19798	18804
Penaeid prawns	51823	44209
Non-penaeid prawns	9132	6384
Lobsters	419	274
Crabs	6471	5486
Stomatopods	12968	8426
Bivalves	82	71
Gastropods	890	740
Cephalopods	32207	25835
Total	**221608**	**185876**
Large pelagics		
Scomberomorus commerson	9797	6697
S. guttatus	154	122
S. lineolatus	3	2
Acanthocybium spp.	43	22
Euthynnus affinis	11143	9184
Auxis spp	6847	5801
Katsuwonus pelamis	689	483
Thunnus tonggol	842	667
Other tunas	3139	2890
Billfishes	1235	1003
Barracudas	5164	4730
Total	**39056**	**31601**
Small pelagics		
Wolf herring	745	616
Oil sardine	236922	192492
Other sardines	14641	12117
Hilsa shad	1	1
Other shads	245	127
Coilia spp	100	69
Stolephorus spp.	24559	22485
Thryssa spp.	4991	4847
Other clupeids	7913	5325
Half beaks & full beaks	1088	828
Flyingfishes	27	14
Ribbonfishes	21678	19931
Horse mackerel	4780	4026
Scads	25021	23523
Leather-jackets	745	519
Other carangids	15795	14785
Indian mackerel	56209	50650
Mullets	171	157
Total	**415631**	**352512**
Others (*)	**22775**	**11240**
Grand total	**699070**	**581229**

(*others include marine turtles, marine mammals and miscellaneous)

The potential yield estimates were 2,21,608 tonnes for the demersals (Fig. 1), 39,056 tonnes for large pelagics 4,15,631 tonnes for small pelagics, and 22,775 tonnes for others. The total potential yield estimate for Kerala was 6.99 lakh tonnes against the average landings of 5.81 lakh tonnes.

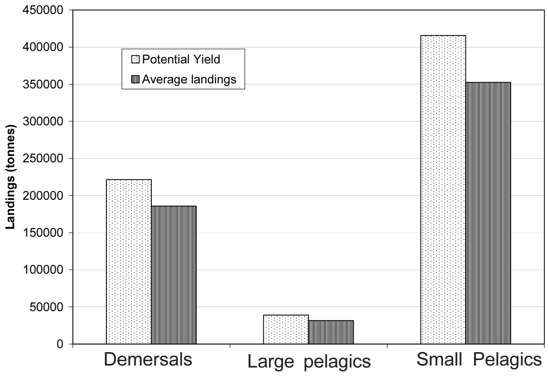

Fig 1. Estimated potential yield and average annual landings for three categories during 1997-2007

The annual average catch by different fleet for the three categories during 2005-2007 is given in Table 2 along with average catch rates both in terms of unit operation and hours of operation. It was estimated that for catching the potential of

Table 2. Annual average catch, catch per unit operation and catch per hour of operation for different fleet during 2005-2007

Fleet	Catch (t)	Catch / unit (kg)	Catch / hour (kg)
Mechanized multi-day trawlers (demersals)	89122	1154	44
Mechanized single-day trawlers (demersals)	65872	408	46
Outboard trawlers (demersals)	5453	65	15
Mechanized gillnetters/ driftnetters (large pelagics)	1754	1177	23
Outboard hooks and lines (large pelagics)	10826	67	21
Other mechanized craft (large pelagics)	432	1318	29
Mechanized purseseiners/ ringseiners (small pelagics)	101763	2716	1253
Outboard ringseiners (small pelagics)	163147	1082	625
Other outboard craft (small pelagics)	57726	126	32

demersals, about 63.3 lakh hours of operation of the fleet that exploit the demersals is necessary. Similarly, for the large pelagics, about 8.9 lakh hours of operation and for the small pelagics about 46.6 lakh hours of operation is needed to exploit their potential yield. The estimates of unit operations necessary to catch the potential of each category are 5.64 lakh for the demersals, 2.37 lakh for large pelagics and 15.27 lakh for small pelagics.

Maximum sustainable fleet size: The potential yield estimated for each category was distributed proportionately to the average catch among the fleet during 2005-2007. Using CPH (trawls) and CPU (other fleet) estimates, the total number of hours and units of operation necessary for each fleet to catch their portion of potential yield was calculated. The maximum hours and unit operations by each fleet for the potential yield was divided by the trips per year to get the fleet size based on the CPH and CPU. The estimate of fleet size based on CPH was obtained using average hours of operation per trip for the fleets, worked out from the CMFRI database and trips per year values by dividing the hours of operation necessary for the potential yield of the fleet with the product of trips per year and hours per trip (Table 3).

It is estimated that the maximum number of mechanized multi-day trawlers, mechanized single day trawlers and outboard trawlers may be 1614, 1215 and 549 respectively. The maximum number of outboard ringseiners may be 816 and the maximum number of other outboard craft may be 2480. Summary table showing the estimates of maximum fleet size for different categories along with the number of existing fleet sizes obtained from the marine fishermen census report 2005 (Anon, 2005) are given in Table 4.

Table 4. Number of existing vessels of different types in Kerala (Anon., 2005) and estimates of maximum sustainable fleet size

Fleet	Existing fleet size	Maximum fleet size
Mechanized multi-day trawlers	3982	1614
Mechanized single-day trawlers		1215
Outboard trawlers	NA	549
Mechanized gillnetters/driftneters	428*	79
Outboard hooks and lines	NA	2135
Other mechanized craft	NA	3
Mechanized purseseiners/ ringseiners	54	232
Outboard ringseiners	NA	816
Other outboard craft	NA	2480

*Combined value for all types of gillnetters; NA = not available)

As per the census report 2005 (Anon, 2005), there are 3982 trawlers in Kerala and the estimate of maximum sustainable fleet size for mechanized trawlers (single day and multi-day trawlers) is 2829. Thus the present trawler fleet size is in excess by 1153 boats.

Table 3. Estimate on Maximum Sustainable Fleet Size based on fishing hours (trawlers) and number of unit operations (other fleet)

Fleet	Maximum hours of operation	Maximum unit operations	Trips / year	Hours / trip	Number of boats
Mechanized multi-day trawlers	2905091		60	30	1614
Mechanized single-day trawlers	2041786		240	7	1215
Outboard trawlers	527344		240	4	549
Mechanized gillnetters/driftnetters		4697	60		79
Outboard hooks and lines		512474	240		2135
Other mechanized craft		769	240		3
Mechanized purseseiners / ringseiners		48657	225		232
Outboard ringseiners		195865	240		816
Other outboard craft		595276	240		2480

The Kalawar Committee (1985) recommended limiting the number of trawlers operating in 20 m to 50 m depth to about 1145 and the motorized canoes in the traditional fishing grounds to 2200 - 2700 in Kerala. The estimate of maximum fleet size for trawlers in the present study is 2829 in which 1614 are for multi-day trawlers and 1215 for single-day trawlers. The operation of multi-day trawlers is up to 200 m depth.

Though the potential yield may not be subjected to much debate *vis-à-vis* its connotation, the term optimum yield needs explanation. Optima can be biological, economic or conservational. As per the requirement of the investigation the optimum concept will vary. The information sought after by the policy makers is either based on the conservational or economic criteria. In this investigation, the MSFS has been estimated as the one which will ensure returns in terms of quantity caught. If the fishery is near fully exploited, these fleet sizes will necessarily mean the maximum permissible under the given circumstance. Hence in that scenario these may not necessarily mean maximum economic returns to the stakeholders.

Economics of fishing and value of catch are not considered here for estimating the MSFS. A linear programming inclusive of the most profitable allocations, and inclusion of data on the efficiency, power and other technical calibrations of the vessels would be useful. However, the data demand will be very high, and the results will lead to a very assorted report on the fleet size with various technicalities coming into play (Cruz-Trinidad and Garces, 1996).

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