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Economic Performance of Mechanised Trawlers in the State of Kerala, India

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ABSTRACT

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The rapid growth in the fleet of small mechanised shrimp trawlers in Kerala from 769 trawlers day^{-1} in 1973 to 3500 trawlers day^{-1} in 1980 resulted in considerable erosion in the estimated annual net profit $trawler^{-1}$ from a maximum of Rs 537.5×10^3 in 1976 to a minimum of Rs 5805 in 1982. This study proposes to optimise the fleet at 1460 trawlers day^{-1} at which the net profit day^{-1} for the trawler sector in Kerala would be Rs 2.127×10^6 (or Rs 457.305×10^6 $year^{-1}$ of 215 fishing days). At this economically optimum level of fishing effort, the yield from trawl fishery is estimated at 91 323 tons, comprising 44 931 tons of shrimps and 46 392 tons of finfish. The optimum number of trawlers may be chosen each year by about March or April by lot. The surplus vessels may be deployed in alternative fisheries such as for whitebait, rock perches, red snappers, breams, cephalopods, sharks and larger pelagics.

INTRODUCTION

The fishing industry is one of the major extractive industries in India. Marine fish production in India increased from 534×10^3 t in 1951 to 1583×10^3 t in 1983-84 at an average annual rate of 4.3% and contributed about 0.75% to the GNP in 1981-82 (Rs 1305×10^9). The quantity of marine products exported also grew substantially from 19 651 t (value Rs 24.6×10^6) in 1951-52 to 86 169 t (value Rs 3623×10^6) in 1983 when it accounted for about 4.18% of the total value of exports from India. In terms of the contribution by the various maritime states to the all-India marine fish landings and marine products exports, the state of Kerala stands first by virtue of its very rich shrimp grounds situated between 8°18′ and 12°48′ north and 74°52′ and 77°22′ east (Fig. 1). Kerala contributed 30.7% (296.8×10^3 tons) to the all-India average annual marine fish landings during 1951-83 (966.9×10^3 tons) and 53.71% (23.9×10^3 tons, worth Rs 569.3×10^6) to the all-India average annual export of marine products during 1963-83 (48×10^3 tons, worth Rs 1210.9×10^6).

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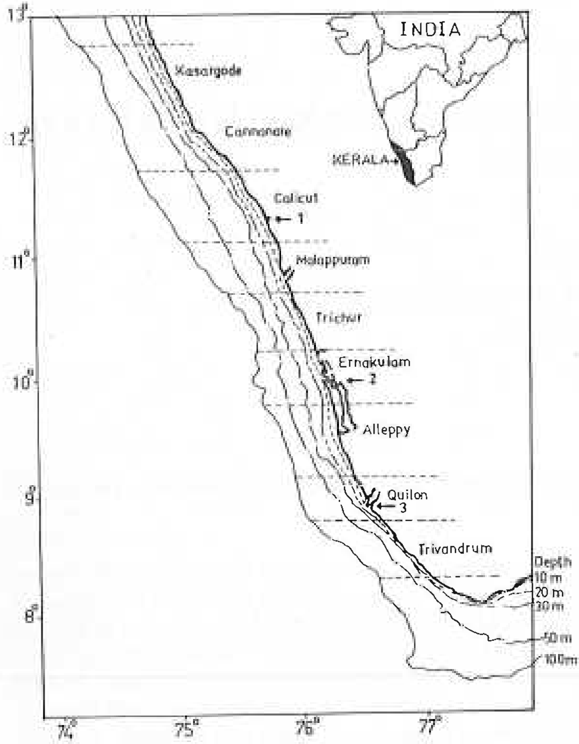

Fig. 1. Map of Kerala showing the coastal districts and the three important trawl landing centres: 1, Calicut; 2, Cochin; 3, Sakthikulangara-Neendakara.

Shrimp trawling in Kerala was lucrative until about 1979, but since 1980 most of the units have become uneconomic owing to fleet overcapacity, dwindling catch per unit effort and fuel oil price escalation (Kurien and Willman, 1982). This sector, therefore, is in urgent need of management and rehabilitation. The present study examines the problems by analysing economic performance over a decade from 1970 to 1980, and endeavours to prescribe the economically optimum yield and effort for the long term sustenance of the shrimp fishery.

BACKGROUND: THE PROBLEMS OUTLINED

In Kerala, mechanised fishing was first introduced in 1956 at Sakthikulangara-Neendakara which is by far the most important shrimp landing centre in this state. From 1956 to 1967, the trawling effort was low (about 200 trawlers per day (t.p.d.)) and the annual trawl catch in Kerala was about 1300 t in 1956. In 1968 a marginal increase in the effort to about 250–300 t.p.d. increased the catch to about 3200 t. Thereafter, the trawl fishery developed very rapidly, with the production increasing progressively to 180×10^3 t in 1975 when the effort was 1086 t.p.d. for an average of 215 fishing days per trawler. The increasing economic returns from 1968 to 1972 led to a substantial rise in the number of trawlers from about 300 in 1968 to 807 in 1972. However, the trend in the growth of the fleet diminished in 1973 owing to the first major rise in the price of diesel fuel, forcing about 556 trawlers to remain idle (Bhaskaran Pillai, 1980). As a result, the annual shrimp catch per trawler increased from 40.025 t in 1972 (effort=807 t.p.d.) to 98.47 t in 1973 (effort=769 t.p.d.); this increase triggered fleet growth by about 7% per year during 1974–77 (effort=885–1243 t.p.d.) followed by 16–20% in 1978 and 1979 (effort=1971 t.p.d.) and an exceptional 78% in 1980 (effort=3500 t.p.d.). The rapid increase in effort resulted in the stagnation in production at an annual average of 50×10^3 t and export at an annual average of 30×10^3 t during 1975–80.

The relatively moderate fleet growth from 1974 to 1979 ensured a steady increase in the annual net profits from Rs 580.9×10^3 in 1976 to Rs 635.1×10^3 per trawler in 1979, but there was a drop to Rs 294.6×10^3 per trawler in 1980 owing to: (i) the sudden growth of the fleet to 3500 t.p.d.; (ii) abrupt and sharp increase in diesel price by 65 paise l^{-1} plus a 22% rise in the sales tax (as a result of which the annual expenditure on account of diesel alone increased from Rs 50×10^3 in 1979 to Rs 100×10^3 in 1980); (iii) failure of fish prices to keep pace with the increase in the production costs. Although, the disincentive from the serious erosion of net profit reduced the effort to 1607 t.p.d. in 1981 and 2434 t.p.d. in 1982, the net profit continued to decline reaching the relatively low level of Rs 158.7×10^3 in 1982. Kurien and Willman (1982) reported that, owing to very poor catches in 1981–82, the gross annual profit per trawler was so poor (only Rs 3562) that it resulted in negative net returns (−9.25%). This situation led to a decline in the contribution towards depreciation of the capital assets from 20 to 18% of gross earnings and also to defaults in the payment of insurance (at 4% of the gross earnings). These observations lend credibility to the contention that boat owners were eating into their capital (Bhaskaran Pillai, 1980).

THE ECONOMIC MODEL: OBJECTIVES, SPECIFICATIONS AND RESULTS

Objectives

Restoration of the profitability of the mechanised sector to its pre-1980 levels through the economic optimisation of the trawl fishery and rehabilitation of the surplus trawlers is one of the major problems confronting marine fisheries development and management in Kerala. The economic model dealt with here aims to provide estimates of economically optimum catch and effort which could be used as the basis for the management of the fishery.

Specifications

The basis for the estimation of the economically optimum catch and effort was the time series data for the small mechanised trawlers (28–32′ overall length) for the three important landing centres in Kerala (Fig. 1), viz., Sakthikulangara-Neendakara (Quilon), Cochin (Ernakulam) and Calicut (George et al., 1980; Silas et al., 1984) for the period 1970–80 and the all-Kerala mechanised trawler landings (finfish, shrimps and cephalopods) for the period 1971–82 together with cost and price data.

The annual trawler effort in boat hours (b.h.) for all-Kerala was computed by dividing the all-Kerala shrimp catch by the average shrimp catch per unit trawler effort in boat hours for all-Kerala estimated from the data for Sakthikulangara-Neendakara, Cochin and Calicut. The total annual effort in boat hours was divided by the average trawling hours per day (8 h) to convert effort into boat days (b.d.) which was then divided by the average number of fishing days per year (215 days) for expressing effort in trawlers per day (t.p.d.).

In recent years, e.g. 1979, 1981 and 1982, shrimp export data from Kerala exceeded its catch owing to the inclusion of shrimps from some neighbouring states. In such cases, Kerala's likely contribution to the export has been computed from an eye-fitted relation between the quantity of shrimp landed and the quantity exported during the period 1971–78 and 1980.

The price per unit weight of shrimp in the export and the domestic markets, the price per unit weight of the bycatch in the domestic market and operational cost per trawler per day (C) for the years 1971, 1976, 1979, 1981 and 1982 (Swaminath, 1983; Bhaskaran Pillai, 1980), together with the production data, formed the basis for evaluating the unit economics.

A second degree curve was fitted to the operational cost trawler^{-1} day^{-1} (C) as a function of time in years (t) for 1971, 1976, 1979, 1981 and 1982 (eqn. (1))

$$C = at^2 + bt + c \tag{1}$$

This equation, generally used to describe fishery production functions, also fits well cost and revenue functions in fisheries (as subsequently shown). In order to make the cost and revenue functions compatible with each other, the same second degree curve was fitted to the total revenue per trawler per day (R) as a function of time in years (t) for the period 1971–82 (eqn. (2)).

$$R = at^2 + bt + c \tag{2}$$

The value of C for the years 1972 to 1975, 1977, 1978 and 1980 were computed from the cost curve fitted for the data for 1971, 1976, 1979, 1981 and 1982 (eqn. (1)).

Average operational cost (C) and revenue (R) per trawler per day for individual years, plotted as a function of fishing effort (f) in t.p.d. (the annual effort = t.p.d. × 215 fishing days) were fitted by the following equations, respectively

$$C = af^b \quad (3)$$

$$R = af^b \quad (4)$$

The net profit per day earned by the entire fleet of trawlers was estimated by multiplying the differences between R and C for 1 trawler per day by the total number of trawlers per day for the various levels of effort, and fitted in the form of a profit curve. The economically-optimum fleet strength (f_{MEY}) is that which shows the maximum net profit in the profit curve while the catch giving the maximum net profit is the maximum economic yield (MEY). The MEY was estimated by means of eqns. (5) and (6) which express price in rupees per kg of catch (p_k) as a function of effort (f) in t.p.d. and price in rupees ton^{-1} of catch (p_t) as a function of catch in t (Y), respectively.

$$p_k = af^b \quad (5)$$

$$p_t = aY^b \quad (6)$$

RESULTS

During the period 1970–82, the effort was at its minimum in 1973 ($f = 1.321 \times 10^6$ b.h. or 769 t.p.d.) when the total catch (finfish, shrimps and cephalopods) was 93 659 t of which shrimps accounted for 75 725 t (80.9%). The maximum effort of 6.02×10^6 b.h. (3500 t.p.d.) was expended in the year 1980 when the catch was 135 305 t including 46 170 t of shrimps (Tables I and II). The annual shrimp catch by one mechanised trawler ranged from 8.967 t in 1982 for an effort of 2434 t.p.d. to 98.472 t in 1973 when the effort was 769 t.p.d. (Table III). Figure 2 shows the relation between the quantity of shrimps landed in Kerala and the quantity exported therefrom.

The cost curve according to eqn. (1) is fitted to be

$$C = 7.64429t^2 + 5.1543t + 300.8439 \quad (7)$$

The coefficient of determination, $r^2 = 0.8953$, indicates that 89.53% of the variation in C is explained by t. Equation (7) shows that the cost of production has been constantly rising from the estimated Rs 314 (observed = Rs 322) per day in 1971 to Rs 1463 (observed = Rs 1450) per day in 1982 (Fig. 3).

The revenue curve according to eqn. (2) is fitted to be

$$R = -57.2758t^2 + 761.5058t + 599.4706 \quad (8)$$

The value of $r^2 = 0.1218$ shows that only 12.18% of the variation in R is explained by t. Equation (8) shows R to be increasing rather gently from the

TABLE I

Observed annual shrimp catch (Y), effort (f) and catch bh^{-1} (Y/f) for Sakthikulangara-Neendakara (Quilon), Cochin (Ernakulam) and Calicut centres

Year	Sakthikulangara-Neendakara			Cochin			Calicut			Total		
	Effort (bh) ($\times 10^3$)	Catch (t)	Catch h^{-1} (kg)	Effort (bh) ($\times 10^3$)	Catch (t)	Catch h^{-1} (kg)	Effort (bh) ($\times 10^3$)	Catch (t)	Catch h^{-1} (kg)	Effort (bh) ($\times 10^3$)	Catch (t)	Catch h^{-1} (kg)
1970	146	1845	12.6	100	2200	22.0	72	1300	18.1	318	5345	16.8
1971	276	11 004	39.8	632	3850	6.1	91	1050	11.5	1000	15 904	15.9
1972	383	11 267	29.4	184	2150	11.7	18	200	11.4	585	13 617	23.3
1973	550	45 477	82.6	284	6000	21.1	75	625	8.3	910	52 102	57.3
1974	824	27 764	33.7	336	3900	11.6	60	420	7.0	1220	32 084	26.3
1975	1332	56 750	42.6	344	7200	20.9	74	570	7.7	1750	64 520	36.9
1976	537	14 993	27.9	280	2800	10.0	83	235	2.8	900	18 028	20.0
1977	1337	24 121	18.0	376	5300	14.0	82	340	4.1	1795	29 761	16.6
1978	2413	33 143	13.7	536	2160	4.0	53	230	4.4	3002	35 533	11.8
1979	724	14 582	20.1	356	3350	9.4	68	330	4.9	1148	18 262	15.9
1980	4843	36 559	7.55	360	3500	9.7	70	380	5.5	5273	40 439	7.7
1981	–	–	–	–	–	–	–	–	–	2764	16 309	5.9
1982–83	–	–	–	–	–	–	–	–	–	5256	27 403	5.2

TABLE II

Observed annual shrimp and bycatch and effort for the mechanised sector in Kerala (about 90% trawlers and 10% gillnetters)

Year	Shrimp catch (t)	Bycatch (t)	Total catch (t)	Effort in bh (a)	Effort (bd) ($b = a/8$)	No. of mechanised boats year^{-1} ($c = b/215$)
1971	28 977	18 314	47 291	1 821 372	227 672	1059
1972	32 300	6348	38 648	1 387 252	173 406	807
1973	75 725	17 934	93 659	1 321 972	165 246	769
1974	53 717	47 695	101 412	2 042 130	255 266	1187
1975	68 847	111 264	180 111	1 867 494	233 437	1086
1976	30 495	28 222	58 717	1 522 566	190 321	885
1977	35 456	71 968	107 424	2 138 632	267 329	1243
1978	40 117	77 239	117 356	3 389 548	423 694	1971
1979	26 567	68 209	94 776	1 669 683	208 710	971
1980	46 170	89 135	135 305	6 020 342	752 543	3500
1981	16 309	80 012	96 321	2 764 284	345 536	1607
1982	21 826	126 414	148 240	4 186 038	523 255	2434

estimated Rs 1304 (observed = Rs 1070) per day in 1971 to Rs 3123 (observed = Rs 2857) per day in 1977. This was followed by a drop, with the revenue (R) curve intersecting the cost (C) curve in 1982 when the total revenue per day (estimated = Rs 1490; observed = Rs 2188) was nearly the same as the cost per day (estimated = Rs 1463; observed = Rs 1450), and the net profit per

TABLE III

Average annual catch, effort and catch per unit effort for one mechanised trawler unit in Kerala

Year	Effort per boat (bh)	Total catch			Shrimp catch			Bycatch		
		year^{-1} (tons)	day^{-1} (kg)	h^{-1} (kg)	year^{-1} (tons)	day^{-1} (kg)	h^{-1} (kg)	year^{-1} (tons)	day^{-1} (kg)	h^{-1} (kg)
1971	1720	44.7	208	26.0	27.2	126	15.8	17.3	80	10.1
1972	1719	47.9	223	27.9	40.0	186	23.3	7.9	37	4.6
1973	1719	121.8	567	70.9	98.5	458	57.3	23.3	109	13.6
1974	1720	85.4	397	49.7	45.3	210	26.3	40.2	187	23.4
1975	1720	165.8	771	96.5	63.4	295	36.9	102.5	477	59.6
1976	1720	66.3	309	38.6	34.5	160	20.0	31.9	148	18.5
1977	1721	86.4	402	50.2	28.5	133	16.6	57.9	269	33.7
1978	1720	59.5	277	34.6	20.4	95	11.8	39.2	182	22.8
1979	1720	97.6	454	56.8	27.4	127	15.9	70.2	327	40.8
1980	1720	38.7	180	22.5	13.2	61	7.7	25.5	118	14.8
1981	1720	59.9	279	34.9	10.2	47	5.9	49.8	232	29.0
1982	1720	60.9	283	34.4	9.0	42	5.2	51.9	242	30.2

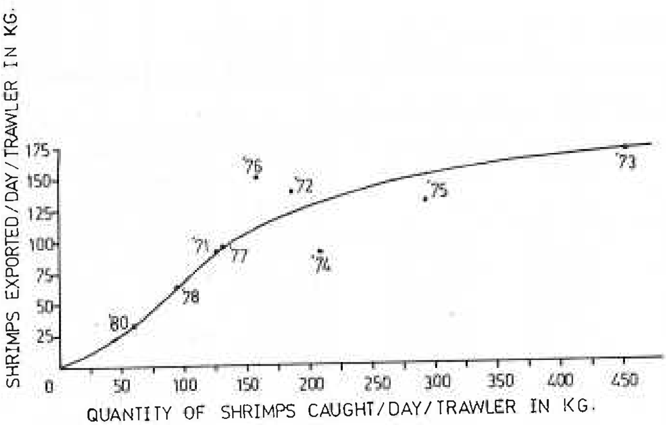

Fig. 2. Eye-fitted curve showing the relation between the quantity of shrimps exported from Kerala and the quantity of shrimps landed at Kerala by the mechanised sector on a daily basis.

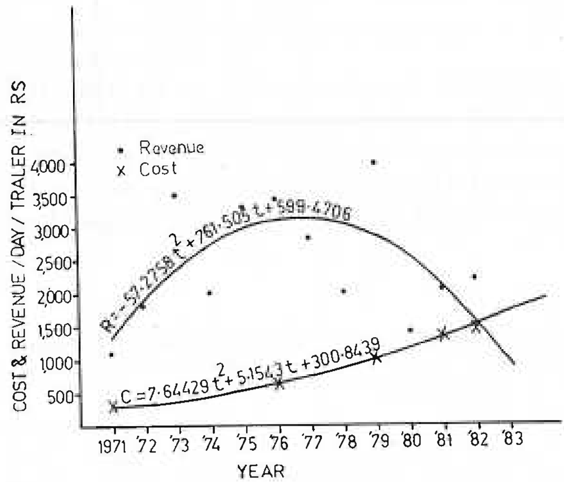

Fig. 3. Second degree curve fitted for the income and expenditure per day per mechanised trawler in Kerala.

was negligible (estimated = Rs 27; observed = Rs 738). This implied net losses since 1983, although according to Bhaskaran Pillai (1980), the trawlers had been incurring a net daily loss of Rs 241 per unit even in 1979 (Tables IV–VI).

The average cost and revenue curves fitted in Fig. 4 for eqns. (3) and (4) are

$$C = 1.72 f^{0.8294} \tag{9}$$

$$R = 38141.695 f^{-0.3927} \tag{10}$$

The values of r^2 for eqn. (9) is 0.5460 and for eqn. (10) is 0.2085, indicating thereby that 54.6% of the variation in C is explained by f while only 20.85% of the variation in R is explained by f. The profit curve (Fig. 4) shows that at the economically-optimum level (f_{MEY}) the fleet has 1460 trawlers per day operating for an average of 215 fishing days a year, and earns the highest profit of 2.127×10^6 rupees a day or 457.305×10^6 rupees a year. The price functions fitted for eqns. (5) and (6) are,

$$p_k = 5.4853 f^{0.0314} \quad (11)$$

$$p_t = 34276\, Y^{-0.1404} \quad (12)$$

TABLE IV

The break-even point (for fixed and operational costs on a day^{-1} basis) in respect of a Neendakara-based 32-footer wooden mechanised trawler (with a 65 HP engine; total investment 160 000 rupees; 215 days of operations $year^{-1}$) for the year 1979

	Nature of expense	Expenses in rupees	
		Annual	Daily
Fixed costs	Insurance	9000	42
	Bank interest on loan of Rs 125 000	15 000	70
	Registration	200	1
	Depreciation at 20%	32 000	149
Maintenance and repairs	Cost of spares, repairs and maintenance	9850	46
	Stores purchases (e.g. nets)	19 350	90
	Rent for berthing place, harbour tools and watch and ward	2690	13
	Travelling, boarding and lodging	6050	28
	Supervision	4250	20
Daily expenses	Diesel, 150 l (average)		264
	Lube oil, grease and rope compound		26
	Diesel transportation, ferry, etc.		10
	Batta for crew		30
	Miscellaneous and unforeseen		7
Subtotal			796
Crew share	at one-quarter of average daily income of Rs 750		195
All total			991 (Break-even point)
	Income		750
Net daily loss			241

TABLE V

Unit economics indicating the shrimp and bycatch day^{-1} mechanised boat^{-1}, the total revenue realised through the export and domestic markets, the total cost and the net revenue in Kerala (NA = not available)

Year	Shrimp							Bycatch			Total income (Rs)	Total expenditure[a] (Rs)	Net profit (Rs)
	Quantity landed (kg)	Export market			Domestic market			Domestic market					
		Quantity exported (kg)	First sale price kg^{-1} (export price kg^{-1} between brackets)[1,4] (Rs)	Value realised at first sale (Rs)	Quantity sold (kg)	Prices[5] kg^{-1} (Rs)	Value realised (Rs)	Landed and sold (kg)	Price/ k[2,3] (Rs)	Value realised (Rs)			
1971	127	89	9 (14)	801	38	3.5	133	80	1.7	136	1070	322	748
1972	186	137	11 (17)	1507	49	4.2	206	37	2.1	78	1791	NA	NA
1973	458	169	12 (18)	2028	289	4.5	1301	109	2.2	240	3569	NA	NA
1974	211	89	12 (18)	1068	122	4.4	537	187	2.2	411	2016	NA	NA
1975	295	131	12 (18)	1572	164	4.5	738	477	2.2	1049	3359	NA	NA
1976	160	150	18 (29)	2700	10	7.1	71	148	3.5	518	3289	587	2702
1977	133	93	18 (27)	1674	40	6.7	268	269	3.4	915	2857	NA	NA
1978	95	63	18 (28)	1134	32	6.9	221	182	3.5	637	1992	NA	NA
1979[b]	127	95 (129)	23 (36)	2185	32	9.0	288	327	4.5	1472	3945	991	2954
1980	61	31	21 (32)	651	30	8.0	240	118	4.0	472	1363	NA	NA
1981[b]	47	23 (78)	26 (41)	598	24	10.1	242	232	5.1	1183	2023	1283	740
1982[b]	42	20 (52)	29 (45)	580	22	11.2	253	242	5.6	1355	2188	1450	738

[1]The first sale price of Rs 9.2 kg^{-1} for shrimp for 1970–71 has been taken from Kuthalingum et al. (1978).
[2]The first sale price of Rs 1.73 kg^{-1} for finfish bycatch for 1970–71 has been taken from Kuthalingam et al. (1978).
[3]The first sale price for finfish for the subsequent years was calculated from the first sale price of shrimp assuming the relation between the first sale price of shrimp (Rs 9.02 kg^{-1}) and first sale price of bycatch (Rs 1.73 kg^{-1}) for 1970 to be true for all subsequent years.
[4]The first sale price of shrimp kg^{-1} for the subsequent years was worked out from the export price assuming the relation between the first sale price (Rs 9.02 kg^{-1}) and export price (Rs 13.99 kg^{-1}) for 1970 to hold for all the subsequent years.
[5]The value of shrimp in the domestic market was considered to be double that of fish in the domestic market.
[a]Total expenditure boat^{-1} day^{-1} was taken from Swaminath (1983).
[b]The exported quantity of shrimp from Kerala exceeded the actual landing in Kerala due to shrimps being transported to Kerala from the adjacent states before export. Therefore, the portion of Kerala's catch likely to have been exported has been graphically read from the relation between the actual catch and export for the other years indicated in Fig. 1.

TABLE VI

Total revenue, cost and net profit for one mechanised boat day^{-1} and year^{-1} in Kerala (NA = not available)

Year	Total revenue day^{-1} (Rs)		Total cost day^{-1} (Rs)		Net profit (Rs)			
					day^{-1}		year^{-1}	
	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated
1971	1070	1304	322	314	748	990	161 710	212 850
1972	1791	1893	NA	342	NA	1551	NA	333 465
1973	3569	2369	NA	385	NA	1984	NA	426 560
1974	2016	2729	NA	444	NA	2285	NA	491 275
1975	3359	2975	NA	518	NA	2457	NA	528 255
1976	3289	3107	587	607	2702	2500	580 930	537 500
1977	2857	3123	NA	711	NA	2412	NA	518 580
1978	1992	3026	NA	831	NA	2195	NA	471 925
1979	3945	2814	991	966	2954	1848	635 110	397 320
1980	1363	2487	NA	1117	NA	1370	NA	294 550
1981	2023	2046	1283	1282	740	764	159 100	164 260
1982	2188	1490	1450	1463	738	27	158 670	5805

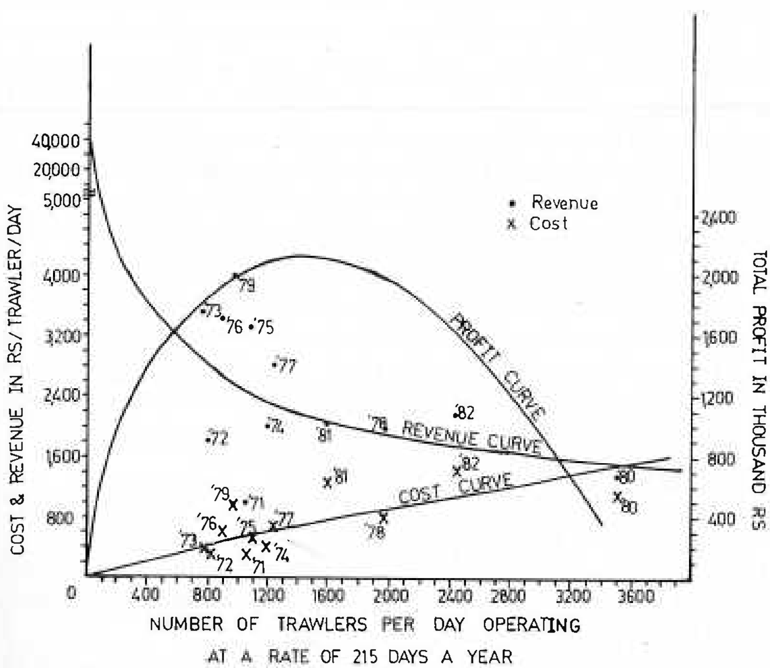

Fig. 4. The revenue, the cost and the profit curves showing the economic performance of the trawler sector in Kerala and the economically optimum number of t.p.d. (f_{MEY}).

The price per ton of catch (all categories) at $f_{\mathrm{MEY}} = 1460$ t.p.d. for 215 fishing days, estimated from eqn. (11), is Rs 6895 which when substituted for p in eqn. (12), gives MEY to be 91 323 t comprising 44 931 t of shrimps and 46 392 t of finfish.

The maximum sustainable yield (MSY) of 96 830 t from the demersal stocks exploited by the trawlers and the biologically optimum effort (f_{MSY}) of 1503 trawlers per day for 215 fishing days a year required for attaining the MSY agree very significantly with the MEY (91 323 t) and f_{MEY} (1460 trawlers), respectively.

IMPLICATIONS FOR FISHERIES MANAGEMENT

Various measures have been suggested to help remedy the ills of the trawler sector in Kerala. George (1977) suggests: (1) 50–100% subsidy on the price of engines as has been extended by the government of other maritime states in India in the initial stages of mechanisation; (2) reduction in the rate of interest on loans availed for the purchase of boats; (3) insuring the boats free of cost; (4) extension of crop insurance scheme to the fishing industry to provide insurance in times of fish famines; (5) tax holiday in years of fish famine as an alternative to crop insurance. Bhaskaran Pillai (1980) proposes: (1) extension of special grants, subsidies and other forms of relief; (2) free supply of nets to mechanised boat owners at least for some years; (3) waiving the sales tax on spare parts of marine engines, which is comparatively high in Kerala state, for five years; (4) a minimum of 50% subsidy on diesel price, as was considered by the government of India for several years, to bring about a saving of Rs 1321 a day per unit on the daily expense of Rs 991 at 1980 rates, and exempting the mechanised sector from paying any future increase in the diesel price.

These measures could bring about a permanent economic recovery of the mechanised sector only if the international oil prices are not subjected to frequent increases. Even if the international prices decrease substantially as in 1985–86, there is no guarantee that the government will pass on the benefit to the local industry by reducing domestic oil prices. Subsidies to mechanised fishing would subject the other tax-paying sectors of the state economy, which are already under considerable strain, to further strains. Suggestions for waiving sales tax alone sound logical and merit consideration.

Since nearly all these suggestions seem rather unrealistic and suffer from one limitation or other, it may be best to resort to fleet optimisation and rehabilitation of the surplus vessels, as indicated by the economic analysis. Out of the present fleet of about 3500 shrimp trawlers, only about 1500 vessels should be permitted to participate in the shrimp fishery.

One possible means of regulating the fleet is to choose the optimum number of trawlers by a lot system by about March or April just before the onset of the peak fishing season in June so that every trawler will have an opportunity to participate in the shrimp fishery one year or the other.

The remaining 2000 vessels could be deployed in alternative fisheries (e.g.

whitebaits, perches, cephalopods, sharks, pelagics, etc., all beyond the 20 m depth to avoid conflicts with the inshore artisanal fishermen) as outlined below.

The whitebait fishery

About 200 vessels in 100 pairs for pair trawling (high-opening midwater trawling) for 6 h during daytime at the rate of 25 vessels for each coastal district except the Trivandrum district where there is already a well-developed artisanal fishery for whitebaits. The whitebait catch potential along the southwest coast of India from 8°N to 16°N comprising the states of Goa, Karnataka, Kerala and the west coast of Tamil Nadu, is estimated to be 160×10^3 t year^{-1} (George et al., 1977). The average annual yield of whitebaits during 1969–83 was 15 713 t (average annual for 1979–83 was 16 575 t) indicating a production gap of about 144 287 t. At the rate of about 5 t day^{-1} unit^{-1} of a pair of vessels (Davidas Menon and George, 1975), the 100 units can land about 107.5×10^3 t year^{-1} of about 215 fishing days.

Perch fishery

About 300 vessels for a hook and line fishery at the rate of 50 vessels each for the Trivandrum and Quilon districts, 30 vessels each for the Alleppy and Ernakulam districts and 20 each for the other districts in 70–115-m-deep grounds of hard substratum where perches abound.

One hundred vessels for dory fishing (at the rate of 15 each for the Trivandrum and Quilon districts and 10 each for the other districts), where each vessel acting as a mothership will not only tow about 4 catamarans for a hook and line fishery, but will also engage itself in this fishery in the 70–115-m-deep grounds.

The perch fishery potential along the southwest coast has been estimated to be 120×10^3 t year^{-1} (George et al., 1977) of which about one-third to one-half ($40–60\times10^3$ t) is likely to be of the rock perches (*Epinephelus* spp.), red snappers (*Lutjanus* spp.) and breams (*Lethrinus* spp.) in the 70–115-m-deep grounds alone. The average annual yield of perches during 1969–83 was 12 198 t (average annual for 1979–83 was 15 371 t), and the production gap is about 107 802 t. At the rate of 6.26 kg catch line^{-1} (120–150-m-long with hooks at 0.6-m intervals) h^{-1}, a vessel operating 4 lines would catch 25.04 kg h^{-1} or 300.5 kg per 12 h (6.00 p.m. to 6.00 a.m.) of fishing per day (Joseph et al., 1976). At this rate the 400 catamarans could land about 24 040 t of rock perches, red snappers and breams per year in about 100 fishing trips of 3 days each involving 2 days of sailing and 1 day of fishing.

Cephalopod fishery

About 100 vessels at the rate of 25 each for Trivandrum and Quilon districts and 10 each for the others for squid jigging, for which, however, there is no information on the catch per unit of effort. The annual potential of this fishery along the southwest coast of India is estimated at 35 000 t (George et al., 1977), whereas the average annual production during 1969–83 was only about 2724 t (annual average for 1979–83 was 3066 t) indicating a production gap of about 32 276 t. Since preliminary experiments by the Fisheries Survey of India show squid jigging to be a successful proposition, the present gap in production could be narrowed by popularising this technique by initially introducing about 100 vessels and then increasing them progressively.

Shark fishery

Three hundred vessels distributed in equal number for each district for a longline fishery in the 100–200 m grounds. The total elasmobranch potential along the southwest coast of India has been estimated to be 44 000 t year^{-1} (George et al., 1977) of which about 75% (33 750 t) is sharks. The average annual catch during 1969–83 was 7842 t (compared with 7233 t for 1979–83), which shows the gap to be about 25 908 t. The longline fishery for sharks can operate all through the year except during the southwest monsoon season from June to August. Each vessel could undertake about 70 fishing trips of 3 days each involving 2 days of cruising to and from the fishing grounds at 100–200 m depth, and about 12 h of longlining. Preliminary observations indicate that at the rate of about 20 kg of sharks per h of longlining, 300 vessels operating 70 trips a year would be able to land only about 5040 t which is far less than the potential.

Larger surface pelagics (seerfishes, tunas and carangids)

About 100 vessels at the rate of about 12 for each district for a troll-line fishery. Troll-line operation is practised for only 5 months (September–January) a year. The catch day^{-1} vessel^{-1} operating 4–7 lines ranged from 39 kg (king seer = 92%, tuna = 5.8% and others = 2.3%) during October 1961 to February 1962 at Cochin (Dashpande and Sivan, 1969) to 91 kg (king seer = 84%, *Caranx* spp. and *Chorinemus lysan* = 14.6%, tuna = 1.1% comprising *Euthynnus affinis* and *Thunnus tonggol*, and others = 1.2% comprising *Rachycentron canadus* and *Chironcentrus dorab*) for Goa (Dhawan et al., 1969).

The annual potential for the seerfishes, tunas and carangids along the southwest coast of India is estimated to be 10 000, 60 000 and 110 000 t, respectively (George et al., 1977). Out of the annual potential of 7000 tons for the king seer (70% of the total seerfish potential) along the southwest coast, about 93% is comprised of 2-year-old fish, and thus the annual potential of the king seer for the troll-line fishery is about 6519 t. The *E. affinis* and *T. tonggol* part of the total tuna potential is about 43 560 t (about 72.6% of the total tuna potential along the southwest coast), and thus, about 40 511 t (93% formed by 2-year-old fish) can be taken to be the tuna potential available for the troll-line fishery. The *C. lysan* and *Caranx* spp. part of the total carangid potential available for the troll-line fishery is only 2871 t (about 2.61% of the total carangid potential). The observed average annual catch of king seer (4144 t), *E. affinis* and *T. tonggol* (5218 t) and *Caranx* and *C. lysan* (265 t) during 1969–83 indicates a production gap of about 2375, 38 342 and 2606 t, respectively, i.e. a total of 43 323 t. At the average rate of about 65 kg day^{-1} (39 kg for Goa and 91 kg for Cochin), 100 vessels would land only about 988 t per season. The remaining potential, which is still substantial, could be exploited by further increasing the trolling operation as well as by strengthening the existing drift-gillnet fishery. Since the catch per day per boat for trolling is nearly the same as that for drift gillnetting, the returns for the latter must hold for trolling as well. In fact, since as much as 84% of the troll catch is of the king seer which fetches very high prices (Rs 30–45 kg^{-1}), the returns must be much higher.

Larger surface and midwater pelagic (seerfishes, tunas, carangids, sharks and catfishes)

About 500 vessels distributed in equal number for each district in areas beyond a depth of 50 m for a drift gillnet fishery. Assuming the catch per boat day to be about 96 kg (tunas and billfishes=48%, seerfishes=10.2%, catfishes=13.8%, sharks=13.2% and carangids=5.3%) as for the 20–50-m-deep grounds (Silas et al., 1984) the total catch by the 500 vessels for 280 fishing days a year (Silas et al., 1984) would be 13 440 t, which is nominal compared to the potential of 333 750 t comprising catfishes (120 000 t), shark (33 750 t), seerfishes (10 000 t), tunas and billfishes (60 000 t) and carangids (110 000 t). The average annual catch of these fishes was about 53 338 t during 1969–83 (average annual for 1979–83 was 51 417 t) thereby indicating a production gap of about 280 412 t and considerable development prospects. The drift gillnet fishery by mechanised boats (25–30′) at Cochin in 1981–82 showed that the annual catch per boat per year was 26 740 kg worth Rs 96 246 (approx. Rs 3.6 kg^{-1}), and the rate of return on investment was 28.5% (Silas et al., 1984).

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