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Resource characteristics and stock assessment of whitebaits

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ABSTRACT

The fishery of whitebait for 1979-88 was studied. The southern maritime states accounted for 97% of the country's whitebait landings. The quarterwise whitebait landings, gearwise catch and catch per unit effort for 1985-88 were studied and discussed. *Encrasicholina devisi* and *Stolephorus waitei* were the dominant species in the whitebait fishery. The fishery and biological characteristics of these two species at Visakhapatnam, Madras, Vizhinjam, Cochin and Mangalore are presented. Whitebait are short-lived fish, the longevity of *E. devisi* being 1.9 years and that of *S. waitei* about 2.3 years. Both the species get recruited into the fishing ground at about 30-35 mm total length when 2-3 months old. The fish from 40-55 mm length onwards (3-5 months old) are caught in greater abundance. The major bulk of the annual landings is constituted by 6-15 months old fish. The growth parameters, mortality rates and exploitation ratios of the two species were estimated for both the coasts. Critical evaluation of the maximum sustainable yield (MSY) estimates in relation to biomass at MSY level indicated the possible increase in production of *E. devisi* by about 20% over the current yield with higher effort input along the west coast. For *E. devisi* in the east coast and *S. waitei* in both the coasts, the expected increase was only marginal.

Whitebait or the whitebait anchovy is the common name applied to the fishes of the genera *Stolephorus* Lacepede 1803 and *Encrasicholina* Fowler, 1938. This group has wide distribution in the Indo-Pacific region. Our knowledge on the resource potential and some aspects of biology of the whitebaits of India is largely due to the investigations of the UNDP/FAO Pelagic Fishery Project (1971-75) along the southwest coast of India extending from Ratnagiri on the west coast (17° N) to Tuticorin (8° 48' N) on the east coast (Anon 1974 a, b; 1976 a, b ; Menon and George 1975). Luther (1990) gives an account of the biology of whitebait anchovies of the Indian waters. Other works relate to certain selected centres, namely, Vizhinjam (Luther 1972, 1979; Luther *et al.* 1984) and Mangalore-Cochin (Rao *et al.* 1982 and Rao 1988 a, b). This study is on the fishery, biology and stock assessment of the whitebaits with special reference to the two dominant species, *Encrasicholina devisi* and *Stolephorus waitei*, along the Indian coast.

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MATERIALS AND METHODS

The all-India and statewise data on whitebait landings for 1979–88, obtained from the records of the Fishery Resources Assessment Division of the CMFRI, were used to describe the whitebait fishery along the Indian coast. Catch, effort and biological data collected on the whitebaits at the observation centres Mangalore, Cochin and Vizhinjam on the west coast, and Madras and Visakhapatnam on the east coast, during 1985–88, were utilized for studies on the biology and population dynamics. The unit of fishing effort in this study was taken as one day's fishing in case of daily fishing, or eight hours fishing in case of voyage fishing. Sampling frequency for biological investigations varied from 4–8 days in a month. The estimated length frequency (total length) at the observation centres were raised to the catches of the concerned state and then to the east and west coasts.

The length frequencies grouped into 5 mm class intervals were used to estimate L_∞ and K, the parameters of von Betalanffy growth equation. The ELEFAN I programme of Pauly and David (1981) was used to estimate the growth parameters L_∞ and K by restructuring length frequency data and selecting the growth curve which has the best fit. Length-weight relationship was found by the method of least squares on the log transforms. The length converted cohort analysis (Jones 1984) was employed for estimating stock size of the species and fishing mortality coefficient. The natural mortality M was estimated by using Pauly's empirical equation (Pauly 1980):

$$\ln (M) = -0.152-0.279 \times \ln (L_\infty) + 0.6543 \times \ln (k) + 0.463 \times \ln (T).$$

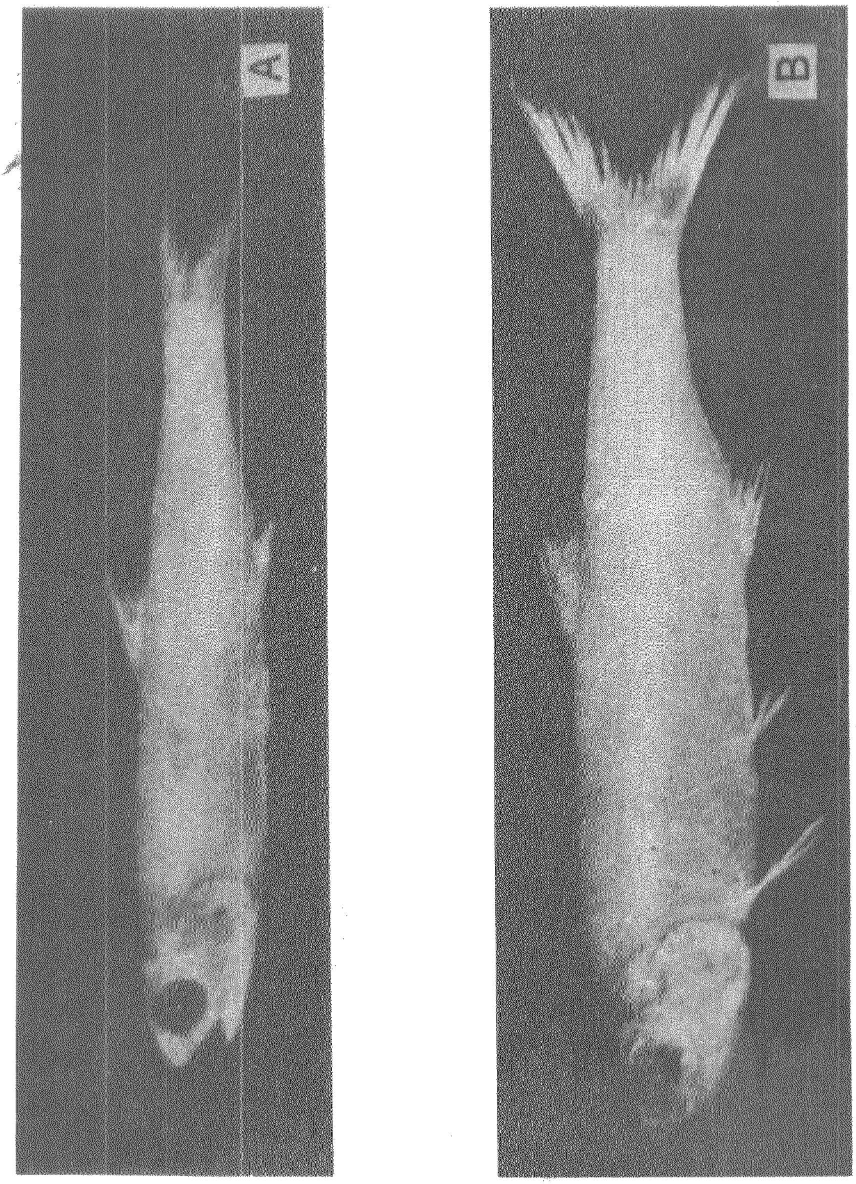
M was also estimated by the method of Sekharan (1974) and Rikhter and Efanov (1976) for comparison. The exploitation ratio E was computed as E = F/Z, where F, instantaneous fishing mortality coefficient and Z, instantaneous total mortality coefficient. Recruitment pattern was obtained by ELEFAN II programme assuming the value of t_0 as –0.01 for both the species. Thomson and Bell (1934) method was used to assess the maximum sustainable yield (MSY) and the biomass at MSY and also to forecast long-term yields (Sparre 1987). Relative yield per recruit analysis given by Beverton and Holt (1957) was also performed for comparison. The analysis of data was accomplished with the help of LFSA package (Sparre 1987).

RESULTS

Fishery

The whitebait anchovy was the dominant component of the anchovy landings in India. It formed 60–90% of the total anchovy landings in the four southern states, namely, Andhra Pradesh, Tamil Nadu-Pondicherry, Kerala and Karnataka. On the other hand, one or more of the other anchovies (genera *Thryssa, Setipinna, Coilia* and *Thryssina*) formed 70–98% of the anchovy catch in the other maritime states of India. Whitebait was highly variable in occurrence in time and space. It formed 46–74% of the anchovy catch in different quarters in Andhra Pradesh, 37–74% in Tamil Nadu-Pondicherry (hereafter merely referred to as Tamil Nadu), 75–93% in Kerala and 25–94% in Karnataka.

The annual whitebait landings in the country during 1979–88 ranged between 26 588 tonnes (1979) and 101 168 tonnes (1988) with the average at 57 541 tonnes (Fig. 1). This formed 3.7% of the total fish production of the country. However, during 1984–88, due to improvement in landings, this fish accounted for 4.2% of the total fish production. About 97% of the country's whitebait catch was produced by the southern states, namely, Kerala (44%), Tamil Nadu (23%), Karnataka



A. *Encrasicholina devisi*, B. *Stolephorus waitei*

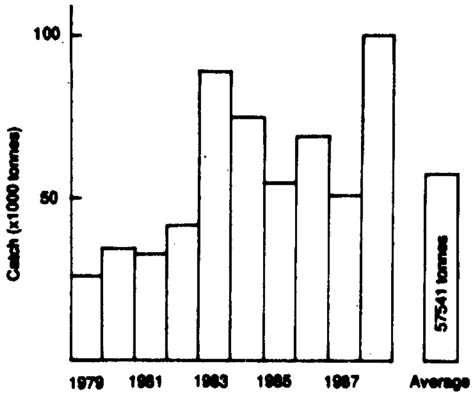


Fig. 1. Annual whitebait landings in India during 1979-88.

(16%) and Andhra Pradesh (14%). In the total fish landings in these states, the whitebait accounted for 7,5,6 and 6% respectively. The annual whitebait landings of these states during 1979–88 as also the quarterwise catch trends from 1984–88 are given in Figs 2–5.

Along the east coast the main fishery season differed between Andhra Pradesh and Tamil Nadu. In Andhra Pradesh (Fig. 2) the catches during October–March accounted for 75% of the annual catch. In Tamil Nadu (Fig.3) the main season was protracted extending from April to December (92%) with the peak period during July–September (40%). Nearly 50% of the whitebait catch of this state came from its west coast (Kanyakumari district) where the main fishery season was during April–June. The main fishery season off Madras was during July–December.

Along the west coast, the main fishery season in Karnataka (Fig.4) occurred during October–March (82%). In Kerala (Fig. 5), on the other hand, the main season was from July–December accounting for 85% of the annual catch. Thus, except in Tamil Nadu, the whitebait fishery in most states was seasonal lasting for six months, the main fishery season accounting for 75–85% of the annual catch.

Craft and gear: In Andhra Pradesh, Tamil Nadu and Kerala the most common gears catching whitebaits were the boat seines (cod end mesh size, 10 mm) and shore seines (cod end mesh size, 10–20 mm). On the west coast, south of Quilon, gill net, known as *netholivala* (mesh size, 15 mm), was specially employed for catching whitebaits in their main fishery season. All these gears were mainly operated from catamarans and small plank built boats, many of them fitted with outboard motors (OBM) in Kerala. In Andhra Pradesh, however, large plank built boats known as *masula* boats were employed for operating large shore seines. In shrimp trawls (cod end mesh size, 15 mm), whitebaits formed a small fraction of the catch. They were operated from medium-sized boats with in-

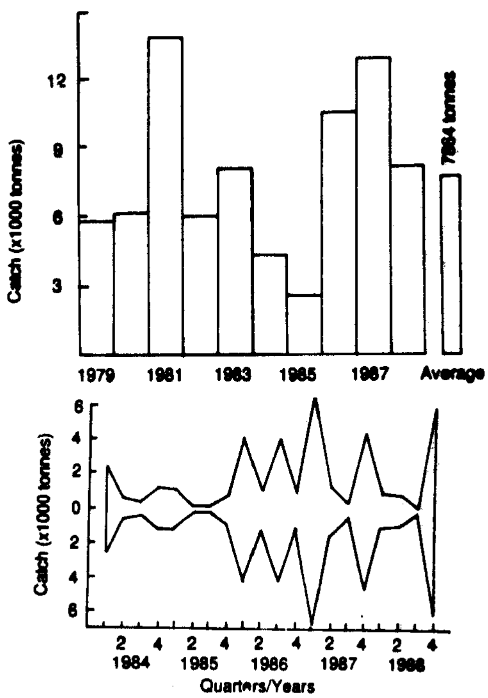


Fig. 2. Annual whitebait landings (1979-88) and quarterwise catch trends (1984-88) in Andhra Pradesh.

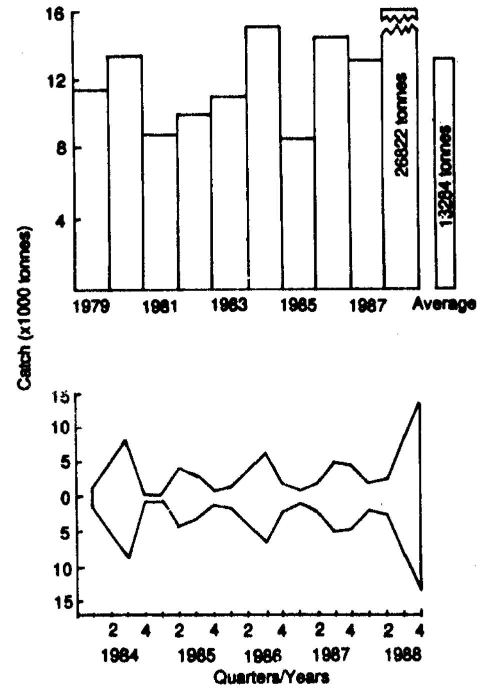


Fig. 3. Annual whitebait landings (1979-88) and quarterwise catch trends (1984-88) in Tamil Nadu-Pondicherry.

board engines. Purse seines (common mesh size, 14–18 mm) are in operation from mechanized boats since seventies in Karnataka and Kerala coasts. Ring seines (mini purse seine with mesh size 8 mm) which are of recent origin, operated from plank-built boats, and dugout canoes fitted with outboard motors were employed along the central and northern coasts of Kerala and off southern Karnataka. The operational depth of the above gears ranged generally from 15 to 50 metres.

Gearwise contribution to the fishery: In Andhra Pradesh, 82% of the whitebait catch was obtained by shore seine, followed by trawl net (13%), boat seine (4%) and gill net (1%). In Tamil Nadu, gill net, boat seine and shore seine combinedly accounted for 83% of the annual catch followed by trawl net (17%). In Karnataka, purse seine contributed the highest (93%) followed by trawl net (6%) and others (1%). In Kerala, on the other hand, boat seines landed the bulk (65%) of the whitebait catch followed by gill net (11%), trawl net (11%), shore seine (9%), ring seine (OBM units) (3%) and others (1%).

The seasonal contributions by these gears varied in different states. In Andhra Pradesh, bulk of the catch by shore seines (80%) was obtained during October–March with catch per unit effort (CPUE) ranging between 50 and 120 kg, by trawl net during April–June with a CPUE of 11 kg and by boat seine during April–September with a CPUE of 3 kg. In Tamil Nadu the fishery season was July–December with the CPUE around 7–10 kg in trawl net. In Kerala, good catches were

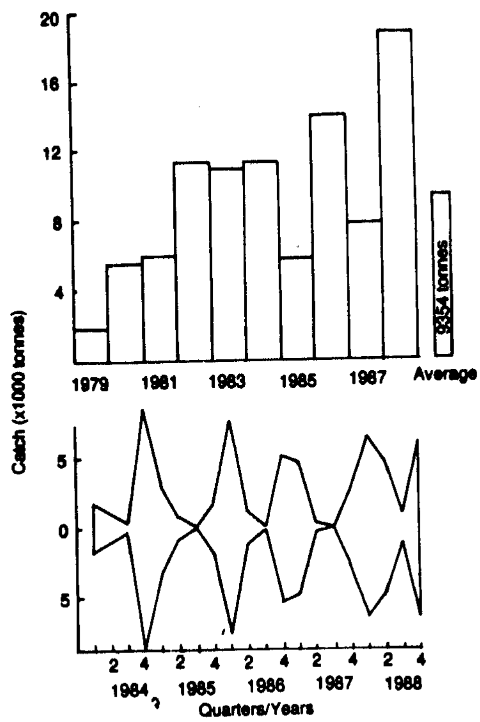


Fig. 4. Annual whitebait landings (1979-88) and quarterwise catch trends (1984-88) in Karnataka.

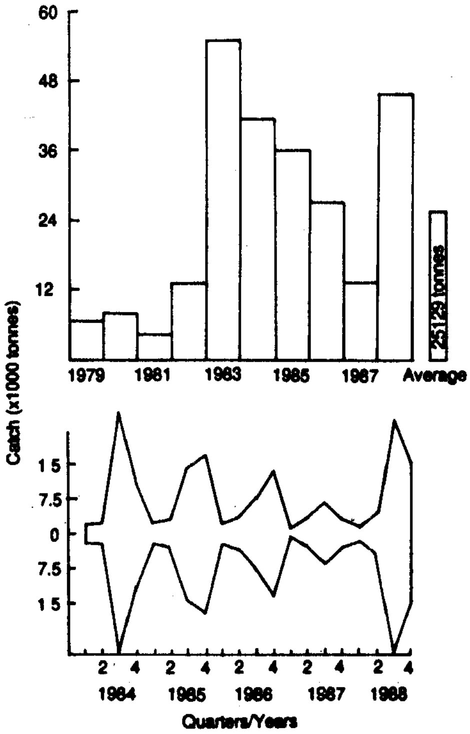


Fig. 5. Annual whitebait landings (1979-88) and quarterwise catch trends (1984-88) in Kerala.

obtained by boat seine during July–December with CPUE ranging between 87 and 129 kg by OBM units, and between 9 and 23 kg by non-mechanized (NM) units; by trawl net during October–December and April–June with CPUE of 12 and 9 kg respectively; by gill net during April–December with CPUE at 5–6 kg (NM units); by shore seine during October-June with CPUE at 21–43 kg; and by ring seine (OB units) during July–September with CPUE at 40 kg. In Karnataka, the fishery season was during October–March with a CPUE at 176–350 kg for purse seine, and during April–June and October–December with CPUE of 5 and 6 kg respectively, for trawl net.

Species composition: According to Whitehead *et al.* (1988), ten species of white-bait occur in the Indian seas. They are : *E. devisi, E. heteroloba, E. punctifer (= S. buccaneeri), S. andhraensis, S. baganensis (= S. macrops), S. commersonii, S. dubiosus, S. indicus, S. insularis* and *S. waitei (= S. bataviensis)*. Of these, *E. devisi* and *S. waitei* are the two dominant species in most parts of the côast. *E. punctifer* and *S. indicus* are the other important species in the fishery.

The variations in the species composition in different gears at the five observation centres were as follows. At Visakhapatnam, *E. devisi* and *S. waitei* accounted for 36% and 57% respectively of the whitebait catch (Fig. 6). However, their relative percentage composition varied in different gears; shrimp trawl 23: 74, shore seine 54:8 and boat seine 49:22. The rest of the catch was formed by six other species, namely *S. indicus, S. commersonii, S. andhraensis, E. heteroloba, S. baganensis* and *E. punctifer*, in that order. At Madras, *E. devisi* and *S. waitei* occurred in the ratio 27 : 73 in shrimp trawl (Fig. 7). However, *E. heteroloba* was also reported to occur occasionally. At Mangalore, *E. devisi* and

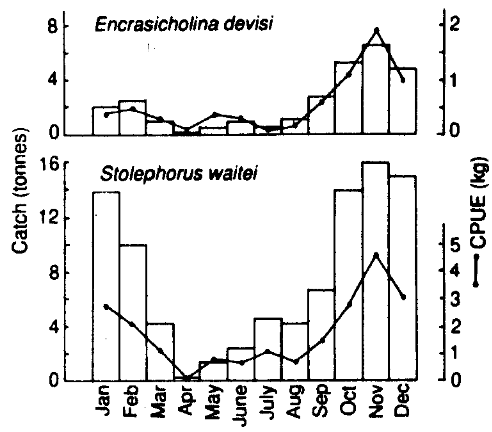


Fig. 6. Monthly catch and CPUE for *Encrasicholina devisi* and *Stolephorus waitei* at Visakhapatnam in trawl net.

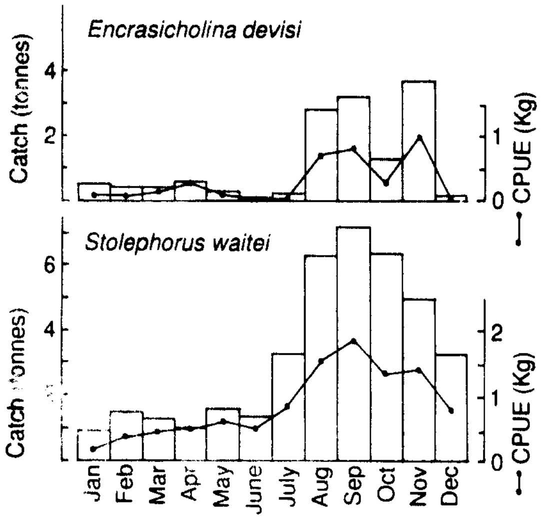


Fig. 7. Monthly catch and CPUE for *Encrasicholina devisi* and *Stolephorus waitei* at Madras in trawl net.

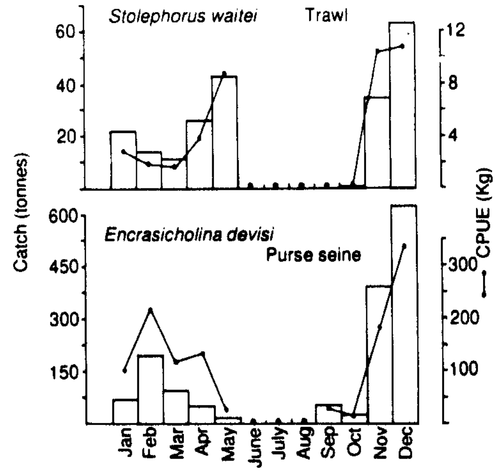


Fig. 8. Monthly catch and CPUE for *Stolephorus waitei* in trawl net and *Encrasicholina devisi* in purse seine at Mangalore.

S. waitei occurred in the ratio 73:20 in whitebait catch. However, in the purse seine catch, their relative composition was 77:17, the composition of the other species being *E. punctifer* 5.5% and *S. baganensis* 0.5%. In shrimp trawl, *S. waitei* formed the dominant catch (64.5%) followed by *E. devisi*(27.7%) and *S. baganensis* (7.7%) while *S. commersonii* and *S. indicus* formed negligible amounts (Fig. 8). At Cochin, *E.devisi* and *S. waitei* occurred in the ratio of 50:39 in shrimp trawl, and 79:1 in the purse seine and ring seine (Fig. 9). The rest of the catch was formed by *E. punctifer, S. commersonii, S. indicus* and *S. baganensis.* At Vizhinjam, *E. devisi* (40%), *S.waitei* (34%) and *E. punctifer* (22%) were the most important whitebaits met with in the fishery. The others comprised *S. andhraensis, S. indicus, S. commersonii* and *S. baganensis.* In boat seine, *S. waitei* (36.7%), *E. devisi* (33.8%) and *E. punctifer* (24.5%) formed the dominant catch whereas in gill net *E. devisi* was the dominant whitebait (84.8%) followed by *S. waitei* (15.1%) (Fig. 10). In shore seine, *E. devisi* formed the dominant catch (70.7%) followed by *S. indicus* (12.4%), *S. waitei* (10.4%) and *E. punctifer* (6.2%).

Biology

Fishery season, size range of fish and dominant size groups in the fishery, size at first maturity, spawning season and season of young fish abundance for *E. devisi* and *S. waitei* at the different centres have been studied (Table 1).

The main fishery seasons for the two dominant species more or less coincided with each other at each centre. The total length range of *E. devisi* in the fishery was 20–105 mm, the dominant size being 60–85 mm along the east and west coasts. For *S. waitei*, the total length range was 30–133 mm, but the dominant size was 60–90 mm along both the coasts. Sexes were equally distributed. The size at first maturity for *E. devisi* was 64.5

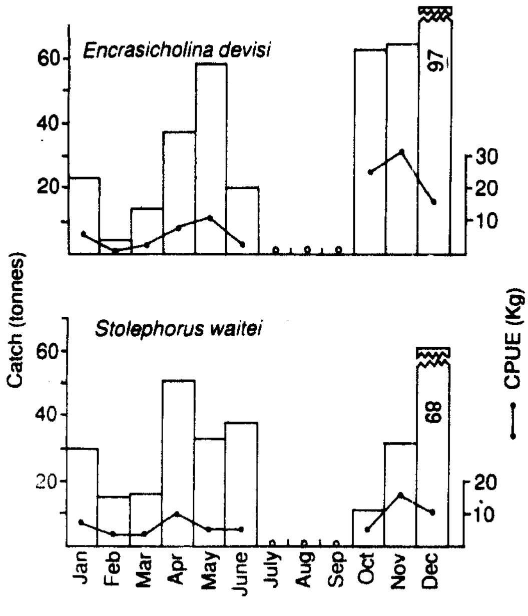


Fig. 9. Monthly catch and CPUE in trawl net for *Encrasicholina devisi* and *Stolephorus waitei* at Cochin.

mm on the east coast, but varied between 64.5 mm and 67.0 mm along the west coast; for *S. waitei* it was 77.5 mm on the east coast and 75 mm on the west coast. The percentage of spawners among adult fish varied among localities for both the species (Fig.11). *E. devisi* at Visakhapatnam spawned almost throughout the year with periods of intensity during February–March and July; at Madras it spawned during April–September with intensity during April–June; at Vizhinjam almost throughout the year with peaks during March–May and November–December; at Cochin during October–June with peaks in October, February–March and May; and at Mangalore it spawned during September–May with intensity during November–February and May. For *S. waitei* the spawning season lasted for almost throughout the year at Visakhapatnam with peak periods during February–March and June–July; at Madras it was during April–September with peaks in April and June–August. At Vizhinjam, mature fish of *S. waitei* occurred very rarely with no clear indication of any season of abundance; at Cochin it was during November–May with peak in February; and at Mangalore it was from October to May with peaks during November–February and May.

Spawning frequency and fecundity : An individual fish appeared to shed three batches of eggs in quick succession followed by a second set after a period of about three and four months in *E. devisi* and *S. waitei*, respectively (Luther 1990). Taking into consideration the size at first maturity as 64.5 mm for *E. devisi* and 77.5 mm for *S. waitei* and the growth rates for these two species as obtained in this study, the second set of multiple spawning would take place when *E. devisi* is around 85 mm length along both the coasts and when

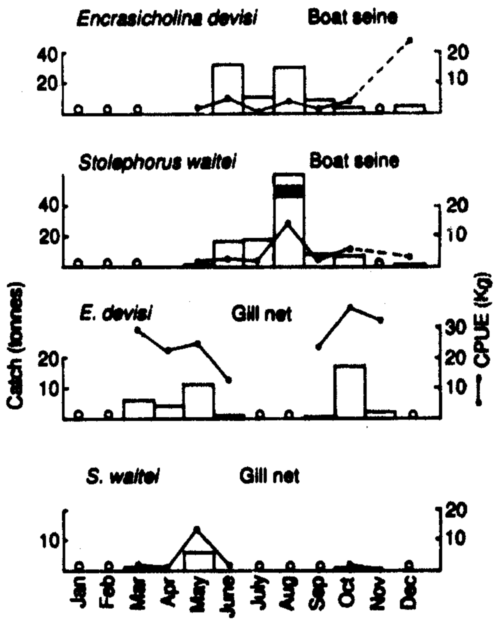


Fig. 10. Monthly catch and CPUE for *Encrasicholina devisi* and *Stolephorus waitei* in boat seine and in gill net at Vizhinjam.

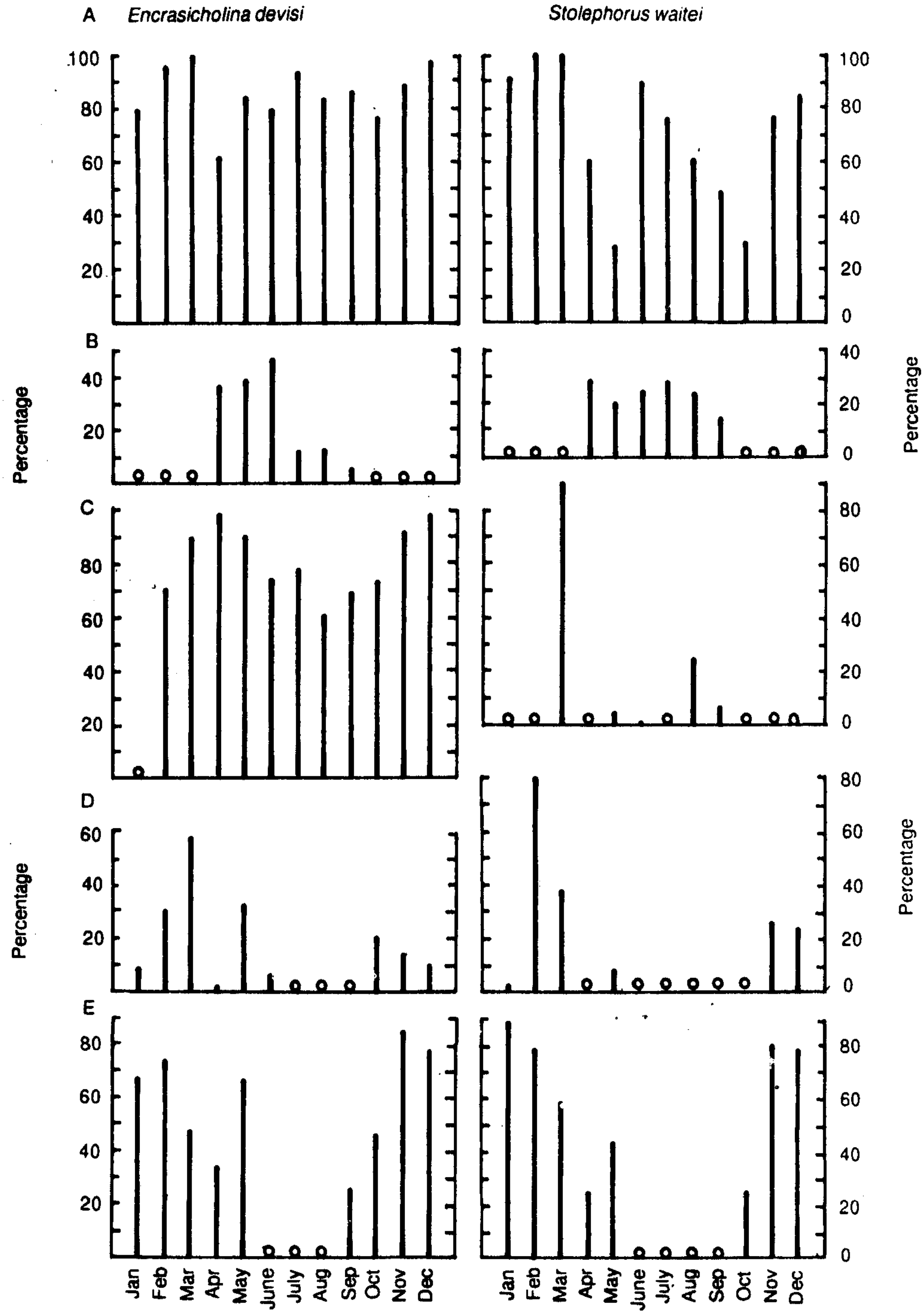


Fig. 11. Percentage of fish in advanced stages of maturity among adult fish in different months (1984-88) for *Encrasicholina devisi* and *Stolephorus waitei* at Visakhapatnam (A), Madras (B), Vizhinjam (C), Cochin (D) and Mangalore (E).

Table 1. Synopsis of biological information on *Encrasicholina devisi and Stolephorus waitei* from different centres

Centre	Peak fishery season	Size range (mm)	Model size (mm)	Size at first maturity (mm)	Season of abundance of mature fish	Peak spawning period	Season of abundance of young fish
Encrasicholina devisi							
Visakhapatnam	September-February	30-100	60-85	64.5	Throughout the year	February-March and July	February-April September and November
Madras	August-November	50-100	60-90	—	April-September	April-June	October-April
Mangalore	November-December	45-105	65-90	67	September-May	November-February and May	—
Cochin	April-May and October-December	45-95	60-80	66.5	October-June	October, February-March and May	May-June
Vizhinjam	May-August and October	20-100	30-85	64.5	February-December	March-May and November-December	January-July
Stolephorus waitei							
Visakhapatnam	October-February	35-133	60-125	77.5	Throughout the year	February-March and June-July	August-December and February
Madras	July-December	40-115	60-100	—	April-September	April and June-August	January-March, May and September-October
Mangalore	April-May and November-January	50-105	60-90	75	October-May	November-February and May	March-May
Cochin	April-June November-January	30-105	65-90	75	November-May	February	March-May
Vizhinjam	May-August	35-100	45-100	88	Occurrence of mature fish scarce and erratic	—	May-July

S. waitei is around 92 mm length in the east coast and around 95 mm length in the west coast. Fecundity, as per Luther (1990), ranged from 1 698 to 6 785 eggs for *E. devisi* of 60–95 mm length, and from 303 to 4 812 eggs for *S. waitei* of 80–120 mm length during one multiple spawning at Vizhinjam.

Food and feeding: Luther (1972) reported the food of *E. devisi* and *S. waitei* as mainly copepods and other small crustaceans besides small bivalves. Generally, larger food items were found in *S. waitei* than in *E. devisi*. Rao (1988 a and b) confirming the above observations stated that phytoplankton comprising *Coscinodiscus* was also found occasionally in the stomach contents.

Stock assessment

Growth parameters: The growth parameters (L_∞ and K) of von Bertalanffy equation, $L_t = L_\infty (1-e^{-k(t-t_0)})$, estimated by ELEFAN I programme were as follows (Fig. 12. A to D).

	L_∞ (mm)	K (annual)
Encrasicholina devisi		
East coast	103.5	1.6
West coast	103.5	1.6
Stolephorus waitei		
East coast	134.5	1.2
West coast	130.0	1.4

t_0 was taken as –0.01 per year.

Length-weight relationships: The length-weight relationships were estimated to be:

Encrasicholina devisi

East coast $W = 0.000001143\ L^{3.4136}$

West coast $W = 0.000003483\ L^{3.147341}$

Stolephorus waitei

East coast $W = 0.00000455\ L^{3.106561}$

West coast $W = 0.000007287\ L^{2.978259}$

Recruitment pattern: The recruitment patterns of *E. devisi* and *S. waitei* for east coast (based on Visakhapatnam data) and west coast (based on Vizhinjam data) are given in Fig.13. Two pulses of recruitment, the major one around March and the minor one around December, are evident from the pattern, in both *E. devisi* and *S. waitei* at Visakhapatnam. In the west coast, at Vizhinjam, two pulses of recruitment are evident in *S. waitei*, the major one around February and the minor one around November. For *E. devisi*, however, one recruitment pulse around January was discernible at Vizhinjam. However, from the spawning periodicity more than one recruitment pulse is evident even though it is not reflected in the recruitment pattern due to inadequate sampling. The interval between the major and minor pulses of recruitment was three to four months for both the species in this study. This is in agreement with the findings of Luther (1990).

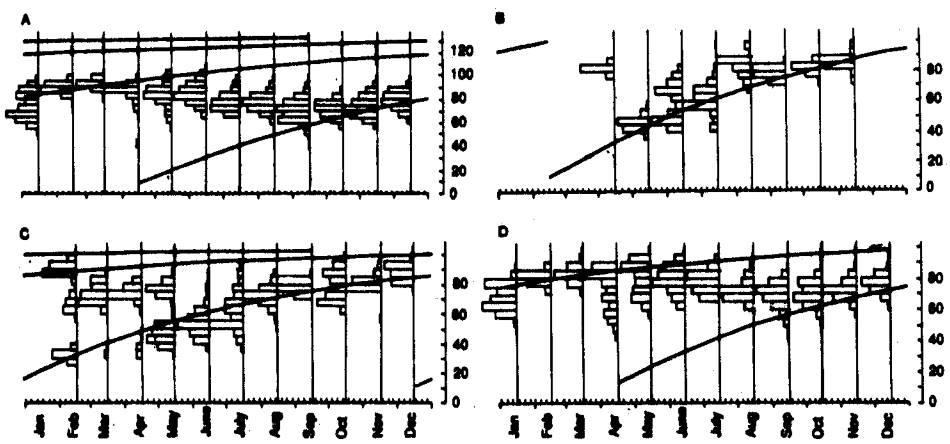


Fig. 12. E LEFAN I generated von Bertalanffy growth curves for **A.** *Stolephorus waitei:* East coast (Visakhapatnam) (L_∞, 134.50 in; K, 1.200; C, 0.000; WP, 0.000; SS, 3; SL 92.500 in; Rn, 0.203), **B.** *S. waitei:* West coast (Pooled) (L_∞, 130.00 in; K, 1.400; C, 0.000; WP, 0.000; SS, 7; SL, 82.500 in; Rn, 0.30), **C.** *Encrasicholina devisi:* West coast (Pooled monthly boat seine-shore seine) (L_∞, 103.50 in; K, 1.600; C, 0.000; WP, 0.000; SS, 1; SL, 32.500 in; Rn, 0.1600) and **D.** *E. devisi:* East coast (Visakhapatnam) (L_∞, 103.50 in; K, 1.600; C. 0.000; WP, 0.000; SS, 3; SL, 82.500 in; Rn, 0.273).

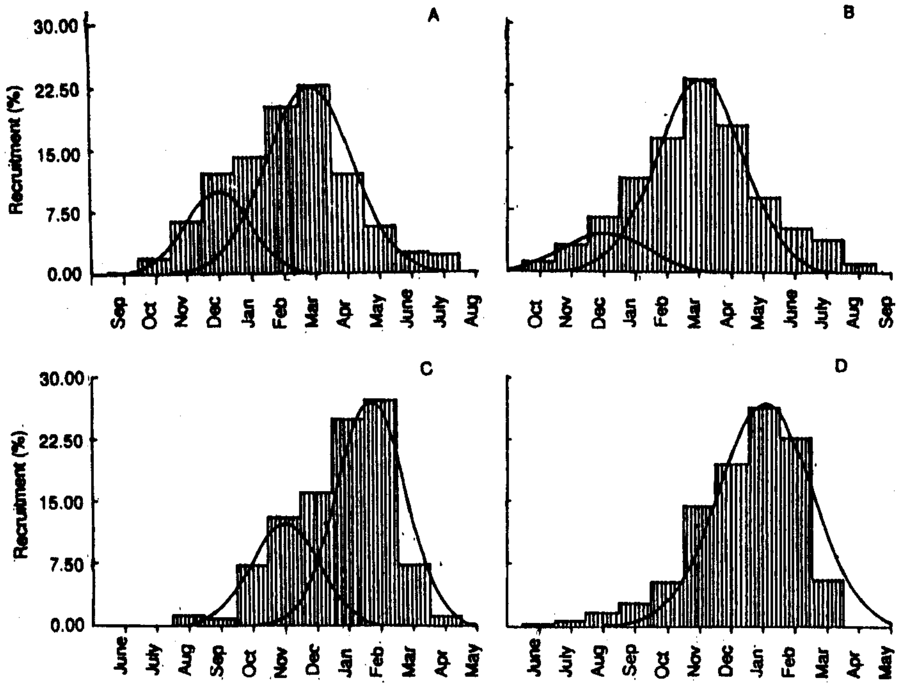


Fig. 13. ELEFAN II generated recruitment patterns for (A) *Encrasicholina devisi:* East coast, (B) *Stolephorus waitei:* East coast, (C) *S. waitei:* West coast, (D) *E. devisi:* West coast.

Age at first maturity (T_m) and longevity (T_{max}): The age at first maturity (T_m), as derived from von Bertalanffy growth equation corresponding to the size at first maturity of *S. waitei* (77.5 mm), was 0.71 year for east coast and 0.64 year for west coast. The same was 0.64 year for *E. devisi* (64.5 mm) in both the coasts. The longevity was estimated as 2.49 years for east coast and 2.13 years for west coast for *S. waitei* and 1.9 years for *E. devisi* in both the coasts.

Mortality: The instantaneous natural mortality coefficient (M) estimated by Pauly's method and corrected for the shoaling behaviour, as suggested by its author against an annual average temperature of 29° C for the east coast and 28° C for the west coast, as well as the size at first capture (L_c) and the corresponding mean instantaneous fishing mortality (F), the instantaneous total mortality (Z) and the exploitation ratio (F/Z) obtained are given in Table 2.

The table shows that exploitation ratio for *E. devisi* is the lowest indicating scope for further exploitation.

Stock size: The results of Thompson and Bell analysis are given in Tables 3 and 4. The results of Beverton and Holt relative yield per

Table 2. Length at first capture (L_c), mortality parameters and exploitation ratio of *Encrasicholina devisi* and *Stolephorus waitei*

	L_c	M	F	Z	F/Z
Encrasicholina. devisi					
East coast	45	2.66	1.11	3.77	0.29
West coast	40	2.61	0.46	3.07	0.15
Stolephorus waitei					
East coast	55	2.04	1.91	3.95	0.48
West coast	45	2.25	1.35	3.60	0.38

Table 3. Thompson and Bell long-term forecast for *Encrasicholina devisi* in east and west coasts

X	Yield	Mean biomass
East coast		
0.0000	0.00	12 971.56
0.2000	5 939.94	9 759.11
0.4000	8 709.94	8 004.29
0.6000	10 154.96	6 924.19
0.8000	10 970.72	6 201.32
1.0000	11 459.05	5 686.24
1.2000	11 764.43	5 300.93
1.4000	11 961.45	5 001.34
1.6000	12 091.10	4 761.06
1.8000	12 177.08	4 563.40
2.0000	12 233.76	4 397.35
MSY = 12 306.65, X = 3.015625		
Biomass MSY = 3 825.555		
West coast		
0.0000	0.00	29 435.75
0.2000	7 197.23	25 830.91
0.4000	11 912.47	23 286.19
0.6000	15 140.58	21 399.61
0.8000	17 429.34	19 945.19
1.0000	19 099.63	18 787.35
1.2000	20 348.64	17 840.53
1.4000	21 302.38	17 048.54
1.6000	22 043.92	16 373.11
1.8000	22 629.54	15 787.50
2.0000	23 098.31	15 272.52
MSY = 25 188.36, X = 6.015625		
Biomass MSY = 10 308.8		

Table 4. Thompson and Bell long-term forecast for *Stolephorus waitei* in east and west coasts

X	Yield	Mean biomass
East coast		
0.0000	0.00	15 251.34
0.2000	4 086.51	11 347.85
0.4000	6 542.82	8 753.34
0.6000	8 017.65	6 993.98
0.8000	8 894.02	5 776.75
1.0000	9 402.14	4 917.06
1.2000	9 682.38	4 296.68
1.4000	9 821.35	3 838.82
1.6000	9 872.98	3 492.97
1.8000	9 871.06	3 225.47
2.0000	9 836.87	3 013.67
MSY = 9 877.181, X = 1.6875		
Biomass MSY = 3 371.231		
West coast		
0.0000	0.00	15 410.40
0.2000	9 260.59	10 193.16
0.4000	12 254.46	8 020.24
0.6000	13 418.19	6 840.93
0.8000	13 888.90	6 097.88
1.0000	14 060.35	5 581.12
1.2000	14 092.51	5 195.54
1.4000	14 057.09	4 892.48
1.6000	13 988.35	4 644.78
1.8000	13 903.43	4 436.18
2.0000	13 811.16	4 256.42
MSY = 14 090.84, X = 1.2125		
Biomass MSY = 5 137.512		

recruit are given in Tables 5 and 6. The present yield, biomass at present yield, maximum sustainable yield (MSY) and biomass at MSY for the two species by Thompson and Bell forecast are given in Table 7.

Species	F_{max}		
	Beverton & Holt Model	Thompson & Bell Model	Current F
S. waitei			
East coast	3.90	3.46	1.91
West coast	2.98	2.89	1.35
E. devisi			
East coast	8.32	4.91	1.11
West coast	2.76	3.95	0.46

The estimates of F_{max} obtained by Thompson and Bell long-term forecast and Beverton and Holt relative yield per recruit analysis were as given in previous column:

The results indicated that there was scope for increasing the exploitation rate, especially in *E. devisi* on the west coast.

DISCUSSION

One of the most important limitations in the stock assessment of tropical fishes is the inadequacy of methods of ageing the fish. In the present case, the estimates of L_∞ and K of von Bertalanffy growth equation estimated by

Table 5. Relative yield/recruit for *Encrasicholina devisi* in east and west coasts

E	Y'/R	B'/R	E	Y'/R	B'/R
East coast					
0.05	0.0058752	0.918577	0.55	0.0399324	0.268853
0.10	0.0113393	0.839786	0.60	0.0406558	0.223034
0.15	0.0163787	0.763742	0.65	0.0408844	0.181156
0.20	0.0209798	0.690560	0.70	0.0406326	0.143297
0.25	0.0251295	0.620362	0.75	0.0399236	0.109508
0.30	0.0288152	0.553271	0.80	0.0387920	0.079803
0.35	0.0320252	0.489414	0.85	0.0372865	0.054146
0.40	0.0347491	0.428919	0.90	0.0354720	0.032433
0.45	0.0369785	0.371911	0.95	0.0334327	0.014480
0.50	0.0387072	0.318516	1.00	0.0312726	0.000000
L_c/L_∞ = 0.43, M/K = 1.66, E_{max} = 0.649, E at 0.1 = 0.607, E at 0.5 = 0.306					
West coast.					
0.05	0.0061814	0.915410	0.55	0.0395512	0.252224
0.10	0.0118855	0.833753	0.60	0.0398478	0.207057
0.15	0.0170973	0.755151	0.65	0.0396005	0.166201
0.20	0.0218023	0.679735	0.70	0.0388329	0.129718
0.25	0.0259863	0.607635	0.75	0.0375811	0.097639
0.30	0.0296363	0.538987	0.80	0.0358954	0.069945
0.35	0.0327406	0.473924	0.85	0.033844	0.046552
0.40	0.0352895	0.412585	0.90	0.0315169	0.027295
0.45	0.0372759	0.355104	0.95	0.0290249	0.011907
0.05	0.0386961	0.301609	1.00	0.0265027	0.000000
L_c/L_∞ = 0.39, M/K = 1.63, E_{max} = 0.62, E at 0.1 = 0.562, E at 0.5 = 0.320					

length frequency analysis gave identical values for *E. devisi* in east coast as well as west coast, but slightly different values for *S. waitei* for east and west coasts. The estimates of L_∞ were the same as obtained by Luther (1990) but the present estimates of K were lower. The L_∞ and K obtained by Rao (1988a, b) for *S. waitei* varied much from the present estimates. The L_∞ and K for *E. devisi* obtained by Tiroba *et al.* (1990) and for both *E. devisi* and *S. waitei* by Dalzell (1990) were comparatively lower than the present estimates.

The natural mortality coefficient (M) estimated by Pauly's empirical formula was compared with the values obtained by the methods of Sekharan (1974) and Rikhter and Efanov (1976), as given follows:

Species	Natural mortality coefficient (M)		
	Sekharan's method	Rikhter and Efanov's method	Pauly's Method
Stolephorus waitei			
East coast	1.85	1.79	2.04
West coast	2.16	1.94	2.25
Encrasicholina devisi			
East coast	2.42	2.04	2.66
West coast	2.42	2.04	2.66

The estimates obtained by Pauly's method in all the occasions were high. This is expected for a short-lived fish such as whitebait. It forms prey to many carnivorous species and as the large-sized fish is poorly represented in the fishery, the whitebait species are expected to be subjected to higher rates of natural mortality and, therefore, the estimates arrived

Table 6. Relative yield/recruit for *Stolephorus waitei* in east and west coasts

E	Y'/R	B'/R	E	Y'/R	B'/R
East coast					
0.05	0.0057283	0.916880	0.55	0.0378610	0.260961
0.10	0.0110340	0.836584	0.60	0.0383836	0.215570
0.15	0.0159041	0.759229	0.65	0.0384209	0.174284
0.20	0.0203261	0.684933	0.70	0.0379913	0.137165
0.25	0.0242876	0.613820	0.75	0.0371224	0.104244
0.30	0.0277774	0.546014	0.80	0.0358537	0.075511
0.35	0.0307853	0.481641	0.85	0.0342387	0.050901
0.40	0.0333026	0.420827	0.90	0.0323474	0.030278
0.45	0.0353228	0.363697	0.95	0.0302677	0.013420
0.50	0.0368423	0.310371	1.00	0.0281064	0.000000
L_c/L_∞ = 0.41, M/K = 1.7, E_{max} = 0.629, E at 0.1 = 0.556, E at 0.5 = 0.311.					
West coast					
0.05	0.0064540	0.912207	0.55	0.0387329	0.235743
0.10	0.0123623	0.827657	0.60	0.0385714	0.191286
0.15	0.0177086	0.746484	0.65	0.0378236	0.151505
0.20	0.0224774	0.668828	0.70	0.0365255	0.116447
0.25	0.0266541	0.594833	0.75	0.0347284	0.086114
0.30	0.0302257	0.524642	0.80	0.0325021	0.060445
0.35	0.0331810	0.458400	0.85	0.0299386	0.039302
0.40	0.0355117	0.396253	0.90	0.0271548	0.022445
0.45	0.0372130	0.338341	0.95	0.0242939	0.009512
0.50	0.0382847	0.284797	1.00	0.0215217	0.000000
L_c/L_∞ = 0.35, M/K = 1.6, E_{max} = 0.562, E at 0.1 = 0.518, E at 0.5 = 0.318					

by employing Pauly's method seem to be reasonable. The earlier estimates of Luther (1990), Dalzell (1990) and Tiroba *et al.* (1990) also gave higher values of M.

The moderate fishing mortality (Table 1) in the west and the east coasts for *E. devisi* and *S. waitei* indicates the possibility of increasing whitebait production by increasing fishing effort as exploitation ratios obtained are in the low to medium range.

Table 7. Present yield, maximum sustainable yield (MSY) and corresponding biomass of *Stolephorus waitei* and *Encrasicholina devisi*

Species	Present yield (tonnes)	Biomass at present yield (tonnes)	MSY (tonnes)	Biomass at MSY
Stolephorus waitei				
East coast	9402	4917	9877	3371
West coast	14060	5581	14091	5138
Encrasicholina devisi				
East coast	11459	5686	12307	3826
West coast	19099	18787	25188	10309

The results of the Thompson and Bell long-term forecast, and estimates of F_{max} obtained by Thompson and Bell analysis as well as Beverton and Holt relative yield per recruit analysis indicate some scope of increasing the whitebait production by increasing exploitation. But it can be observed that in respect of *S. waitei* in west coast to achieve an MSY of 14 091 tonnes an increase of 21% in effort is required which would result in a gain of mere 30 tonnes in the yield. It means, the present yield is almost at MSY level and any further increase in effort would not result in appreciable increase in the yield. In respect of *S. waitei* in east coast, the yield can be increased by 5%

through increasing the effort by 69% which evidently is not a tenable proposition because at the MSY level it is expected that the catch per unit effort or the biomass will reduce by 42%. Here again it is advisable to maintain the *status quo*.

E. devisi is poorly exploited in both the coasts. But it is observed that a three-fold increase in effort along the east coast and a six-fold increase along the west coast is necessary to realize the corresponding MSYs with a concomitant increase in the landings by 7.4% and 31.9%, respectively. In the east coast, with a three-fold increase in effort, the resulting 7.4% increase in the catch is only marginal. Similarly, the increase of 31.9% in the estimated yield for the west coast for a six-fold increase in effort is also not tenable. However, the effort may be doubled in the west coast to obtain an increase of 21% in the current yield against a reduction of 19% in the CPUE.

The results of Thompson and Bell analysis though show the need for a high increase in the effort level to realize the maximum sustainable yields, with a consequent reduction in the CPUE at MSY level, in the multispecies/multigear context, as in the present case, such advice can never be implemented as the whitebaits are not the target group of the concerned gear. The results obtained in this study may thus be interpreted to indicate only a relative picture of the maximum sustainable yield and the effort to obtain the same (MSY) could be decided only in consideration with the stock position of the other resources caught in the gears along with the whitebaits.

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