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Population Characteristics of the Tuna Baitfish *Spratelloides delicatulus* (Clupeidae) from Lakshadweep, India

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Abstract

The blue sprat, *Spratelloides delicatulus* is the dominant species of bait used in the pole-and-line tuna fishery of Lakshadweep. Length-frequency data were collected on a monthly basis during 1988-89 and 1989-90 fishing seasons from Minicoy and Agatti. Analyses were performed using the compleat ELEFAN suite of programmes. The results indicate that L_∞ is between 65 and 66 mm and K values range from 4.9 to 5.0 per year. Total mortality estimates with L_∞ as 66 and K = 5 varied widely in the three methods employed and between sites. Natural mortality at the sites was similar while fishing mortality and exploitation rate was maximum at Bangaram. Recruitment patterns showed high percentage during August and December at Bangaram while at Perumal Par it showed a delayed pulsing with maximum mode in January. The exploitation rate (E) values obtained for the bait fishery suggests fishing to be near optimum with marginal increase especially at Bangaram. Therefore, the bait fishery at Agatti require close monitoring and further expansion in effort must be viewed with extreme caution.

Key words: Population characteristics, tuna, baitfish

Introduction

Population dynamics of baitfish species was studied with the major objective of rational management and conservation of the resource. Effective management of any fishery requires considerable knowledge regarding population parameters such as age and growth, mortality and recruitment patterns of the exploited stock. Biology of baitfish includes those of Dalzell (1990) from Papua New Guinea, Tiroba *et al.* (1990) and Milton *et al.* (1990) from Solomon Islands and Somerton (1990) at Hawaii. Previous studies on baitfishes of Lakshadweep have been mostly restricted to length-weight relationships (Madan Mohan and Kunhikoya, 1985; Gopakumar *et al.*, 1991). Baitfishery of Minicoy has been described by Jones (1958) and the present status of the fishery at Minicoy and Agatti is reported by Nasser and James (1999). The present study concentrates on the baitfish *Spratelloides delicatulus* from the pole-and-line fishing areas of Minicoy, Agatti, Bangaram and Perumal Par in Lakshadweep.

Material and Methods

Baitfish samples were collected from pole-and-line fishing boats every month during the 1988-89 and 1989-90 fishing seasons. The boats set out for baitfishing in the we hours of the morning and on its completion proceed to open sea for tuna fishing. At Minicoy, a lift net and encircling net are employed to catch the baitfish while at Agatti only the encircling net is used for catching sprats. Information such as the time spent on baitfishing, species caught, number of hauls, quantity of bait caught and used, area of fishing and the relative abundance of bait was collected. Effort represented in numbers is the total number of baitfishing trips made by the boats in a month while catch (in kg) is the total amount of bait caught for the respective effort. Catch divided by the effort gives the catch per unit effort (CPUE). Fish lengths (TL, mm), weight (±0.001 g) and sex were recorded from random sub-samples. Length-frequency time series data for *S. delicatulus* from Bangaram and Perumal Par for five months (October-February) were analysed separately and by combining the data of the two areas. The length-frequency profile was raised to the month's catch. The data were analysed using the compleat ELEFAN suite of computer programs (Gayanilo *et al.*, 1988).

Results and Discussion

The size range of *S. delicatulus* in the fishery at the various locations were: Minicoy-15.5 to 65.5 mm, Agatti-25.5 to 65.5 mm, Bangaram-20.5 to 60.5 mm and Perumal Par-25.5 to 65.5 mm. Results of analysis are presented in Table 1. The preliminary estimate of L_∞ using ELEFAN II indicated that it varies from 62-75 mm. Further refinement of this value by ELEFAN I for the three data sets of data showed that L_∞ is between 65 and 66 mm. The K values ranged form 4.9 to 5.0/yr. Growth curves generated by 'able 1. **Number of specimens of *S. delicatulus* collected at Bangaram and Perumal Par and summary of results obtained from ELEFAN**

'alues of L_∞ and Z/K obtained from ELEFAN I

,ocation	L_∞	Z/K
1inicoy	66.6	2.03
,gatti	65.7	2.33
;angaram	75.3	6.70
'erumal Par	61.9	2.70

;rowth parameters from ELEFAN I and Ø'

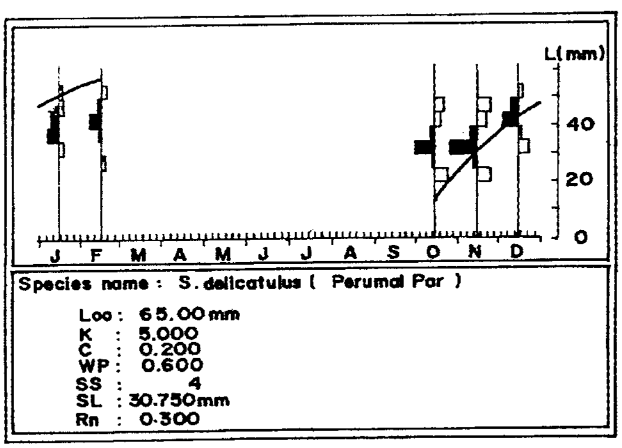
,ocation	L_∞	K	C	WP	Rn	Ø'
;angaram	66.0	4.9	0.2	0.6	0.228	4.33
'erumal Par	65.0	5.0	0.2	0.6	0.300	4.32
:ombined	66.0	5.0	0.2	0.6	0.238	4.32

1ortality parameters from ELEFAN II

,ocation	Z (1)	Z (2)	Z (3)	M	F	E
1inicoy	10.15	10.46	10.10	7.94	2.16	0.21
,gatti	11.65	14.13	12.25	7.94	4.31	0.35
;angaram	33.50	16.50	21.13	7.94	13.38	0.63
'erumal Par	13.50	15.93	16.64	7.94	8.70	0.52

; (1) Value obtained by multiplying Z/K of ELEFAN II by K of ELEFAN I
; (2) Total mortality from mean length (ELEFAN II)
; (3) Catch curve value (ELEFAN II)

:LEFAN I for *S. delicatulus* from Perumal Par is presented ı Fig. 1. Total mortality estimates with L_∞ as 66 and K = 5 aried widely in the three methods employed and between ites. Natural mortality at the sites was similar while fishing ıortality and exploitation rate was maximum at Bangaram Fig. 2). Recruitment pattern showed a higher percentage uring August and December at Bangaram. At Perumal Par ıe recruitment showed a delayed pulsing with maximum ıode in January (Fig. 3).



'ig. 1. **Von Bertalanffy growth curves generated by ELEFAN I for *S. delicatulus* from Perumal Par**

The estimates of fishing mortality (F) was used to ompute the standing stocks in each location using the ormula:

Standing stock = Total catch/F

The estimated annual standing stock biomass were 7404, 989, 2811 and 3269 at Minicoy, Agatti, Bangaram and Perumal Par, respectively.

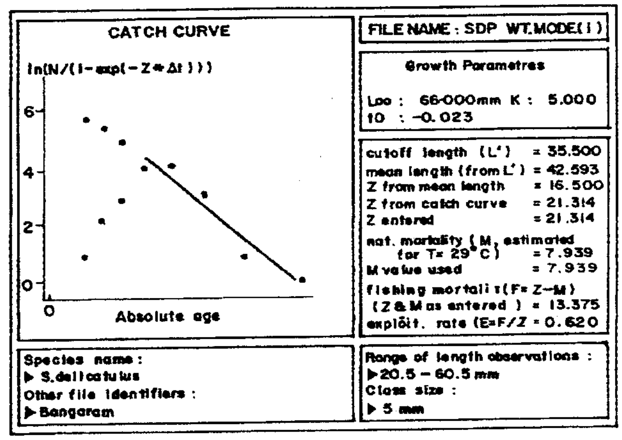


Fig. 2. **Length-converted catch curves generated by ELEFAN II for *S. delicatulus* from Bangaram**

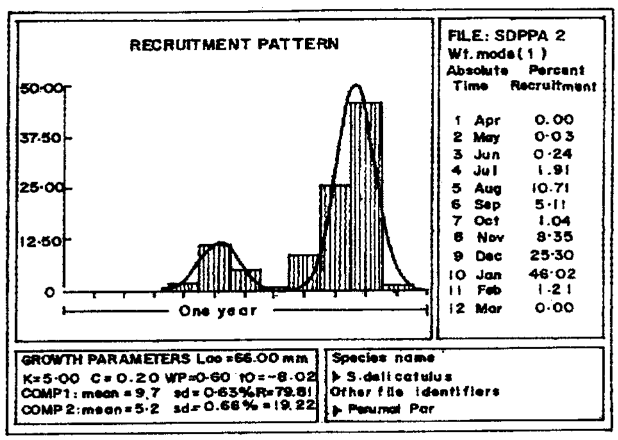


Fig. 3. **Recruitment patterns obtained from ELEFAN II for *S. delicatulus* from Perumal Par**

The natural mortality (M) was also independently computed based on the effort data for Bangaram and Perumal Par. Fishing mortality (F) is related to fishing effort (f) by the catchability coefficient (q) as F = qf. The total mortality (Z) is the sum of F+M or Z = qf+M. Using simultaneous equation, q and M are solved giving the values of Z from the catch curves and the effort data for Bangaram (4325 trips) and Perumal Par (3361 trips). The estimate of natural mortality from the above is 4.4, which is considerably lower than that of the Pauly (1980) value of 7.9, but is within the confidence limits of Pauly's equation.

The results of *S. delicatulus* presented are based only on five months of data, involving length of only about a thousand specimens from each site. However, the growth parameter estimates of *S.delicatulus* are in broad agreement with published values for this and related species (Dalzell *et al.*, 1987; Tiroba *et al.*, 1990; Milton *et al.*, 1991, 1993). Milton *et al.* (1991) concluded that *Spratelloides* spp. has an extremely flexible growth pattern and the biological variations within a site can be as great as variations between sites. The sprats are a fast growing, short-lived group of fishes. For example, the life expectancy of *S. delicatulus* is around 6 months (Dalzell *et al.*, 1987) and it is generally less than 4 months for the genus *Spratelloides* (Milton *et al.*, 1991). Bait fisheries in the northern group of islands of Lakshadweep, unlike Minicoy, depends only on *S. delicatulus* and this to an extent may explain the high mortalities observed. On the basis of life cycle strategies, sprats are classified as type 1 (Lewis, 1990). They are species with short life cycle, are relatively small in size, grow rapidly, attain sexual maturity in 3-4 months, spawn over an extended period and have batch fecundities of 500-1500 oocytes per gram of fish. Lewis (1990) also explains that recovery from periods of heavy exploitation of such species are rapid because of the fast population turnover, existence of unfished buffer zones and division of stocks into discrete but spatially overlapping units. The fishery to a large extent is self-regulatory due to the availability of a large number of alternative baiting sites. There have been instances when concentration of bait fishing at Perumal Par alone resulted in complete depletion of the stock. The resumption of fishing was possible only after a delay of few months. The complete suspension of pole-and-line fishing during the southwest monsoon also helps in recovery of the stock.

The mortality values were comparable with those reported for the Solomon Islands fishery (Tiroba *et al.*, 1990). As might be expected from such short-lived fishes the mortality rates are very high and are probably best expressed on a monthly rather than annual basis (Dalzell, 1990). The high values of total mortalities observed for *S. delicatulus* in the study indicate that monthly survival rate may be only 20 per cent. Thus, the entire recruited population will turn over in only two or three months. It is to be expected that environmental influences on survival, particularly nutrient cycles in relatively nutrient-poor coral reef environments, will be considerable, and successful recruitment may only occur at particularly favourable times (Lewis, 1990). The total mortality rate of adults, an important factor influencing population fluctuations, is the sum total of both natural and fishing mortalities. The natural mortality rates were similar at the four sites studied but fishing mortality varied greatly. Somerton (1990) noted that in the Hawaiian baitfishery in Pearl Harbour for *Encrasicholina purpurea*, upto 80% of the adult population biomass is removed in a single month by fishing. He attributed the variation in fishing mortality to two responses in the baitfishery. First, when bait abundance increases, the bait catch of individual vessels tend to increase, at least until capacity is reached. Second, more vessels fish in a particular area when the catch rates are high compared to other baitfishing grounds.

The ratio of fishing mortality to total mortality or exploitation rate (E) can be used as a measure of the exploitation of a fish stock. Gulland (1971) suggested that in a stock that is optimally exploited, fishing mortality should be about equal to natural mortality or $F_{opt} = M$ and $E_{opt} = 0.5$. Pauly (1984) proposed a more conservative definition of optimum fishing mortality where $F_{opt} = 0.4$ M and $E_{opt} = 0.3$. The E values obtained for the bait fishery at Bangaram and Perumal Par suggest that fishing at these sites are near optimum with marginal increase over optimal values especially at Bangaram. The island of Agatti in recent times emerged as an important contributor to the total tuna catch of Lakshadweep (Varghese and Shanmugham, 1983). The results of this study, therefore, indicate that the fishery of this area require close monitoring and further expansion in terms of increased effort must be viewed with extreme caution.

The peak of recruitment observed during August-September at Bangaram and Perumal Par tallies with the major recruitment months of *S. delicatulus* at Solomon Islands (Tiroba *et al.*, 1990). Milton and Blaber (1991) found that spawning of six species of baitfish correlated with particular environmental conditions, especially moon phase and less importantly, rainfall and temperature. They also point out that the lack of clear proximate stimuli for spawning makes it difficult to predict the timing of major spawning events. Lewis (1990) opined that the highly fecund sprats appear to spawn year round, with recruitment occurring on a much less predictable basis and the probability of success determined by stochastic processes. Milton *et al.* (1990a) established that a significant proportion of the baitfish population at Solomon Islands is spawning at any given time. This means that even if there is heavy fishing during peak spawning, it will not seriously affect the overall fishery, as there will be some recruitment to the fishery from fish spawning at other sites. A similar mechanism may be operating at Bangaram and Perumal Par as is evident from the protracted recruitment and continued availability of *S.delicatulus* in spite of tremendous fishing pressure.

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