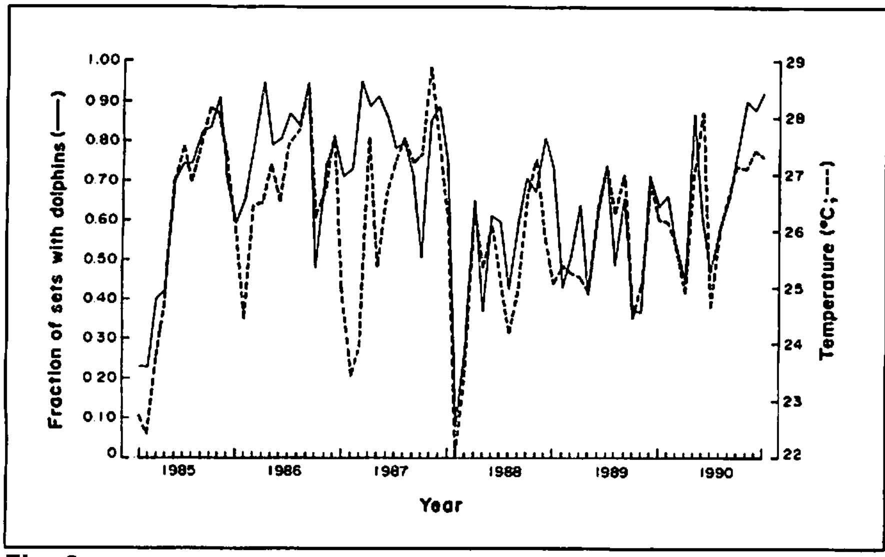

Fig. 2. *Relationship in the Mexican (eastern Pacific) tuna fleet betweeen SST and the proportion of sets with tuna.*

also found that, apart from the common dolphin (*Delphinus delphis*), other species were sighted mostly at 27-28°C irrespective of area or season. *Stenella attenuata* and the spinner dolphin *Stenella longirostris*, have been encountered mainly off southern Mexico, where the relatively deep 20°C isotherm indicates a large surface lens of warm water. The warmest surface waters in the Eastern Tropical Pacific normally occur in this area (Au and Perryman 1985).

Results and Discussions

The correlation between monthly mean SST and the proportion of dolphin sets was significant ($P<0.01$) for the time period considered here, i.e., 1985-1990 (Fig. 2). Dividing the time series into individual years leaves the correlation still significant ($P<0.05$), except for the 1987, an El Niño year when these variables had opposite trends during February-June and November.

The data presented here suggest that the tuna-dolphin association depends on the gradient and depth of the thermocline, and that SST is a good indicator of this situation.

References

Anon. 1983. Annual Report 1982. Inter-Am. Trop. Tuna Comm., La Jolla, California, 294 p.

Au, D.W.K., W.L. Perryman and W.F. Perrin. 1979. Dolphin distribution and the relationship to environmental features in the eastern tropical Pacific. NOAA SWFC Admin. Rep. No. LJ-79-43, 59 p.

Au, D.W.K. and W.L. Perryman. 1985. Dolphin habitats in the eastern tropical Pacific. Fish. Bull. 83(4):623-643.

Blackburn, M. 1965. Oceanography and the ecology of tunas. Oceanogr. Mar. Biol. Ann. Rev. 3:299-322.

Nakamura, H. 1969. Tuna distribution and migration. Fishing News Books, Farnham, Surrey, 76 p.

Perrin, W.F., G.J. Walker, F.M. Ralston and D.W.K. Au. 1983. Distribution of four dolphins (*Stenella* spp. and *Delphinus delphis*) in the eastern tropical Pacific with an annotated catalog of data sources. U.S. Dep. Commer., NOAA Tech. Memo. MNFS-SWFC-38, 65 p.

Ortega-García, S. 1989. Análisis y normalización de la flota atunera mexicana de cerco y vara que opera en el Pacífico Oriental. Instituto Politécnico Nacional, México. 103 p. M.Sc. thesis.

Reilly, S.B. 1990. Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific. Mar. Ecol. (Prog. Ser.) 66:1-11.

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Population Parameters of *Sardinella* Species in the Coastal Waters of Dar es Salaam, Tanzania

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Abstract

Population parameters of *Sardinella* species from the artisanal purse seine and ring net fisheries of the Dar es Salaam area, Tanzania, were investigated based on length-frequency data, analyzed with FAO's LFSA and ICLARM's Compleat ELEFAN packages. The results for *S. gibbosa* and *S. albella* were $L_\infty = 18.6$ cm and $K = 1.8$ year^{-1}, respectively, $L_\infty = 16.8$ cm and $K = 1.15$ year^{-1}. Preliminary estimates on mortalities and exploitation rates are also presented.

Introduction

Small pelagic fishes are the main target of the light-assisted purse seine and ring net fishery off Dar es Salaam, Tanzania. The important species caught are the goldstripe sardinella (*Sardinella gibbosa*), the white sardinella (*Sardinella albella*) and the spotted sardinella (*Amblygaster sirm*), which form more than 60% of the catches (Nhwani and Makwaia 1988). The small pelagic fishes caught along the coast of Tanzania were increased from 5,400 t or 11.6% of the total marine catch in 1977 to 9,200 t or 19.8% of the catch in 1986. Although these catches are quite modest compared to the estimated potential yield of between 20,000 t (FAO 1979) and 40,000 t (Iversen et al. 1984), the doubling of catch within ten years indicates the increasing intensity of fishing on these species. Since the estimates of potential yield are not very precise, also in view of the year to year fluctuations in recruitment known to occur in populations of pelagic species (Garcia and Josse 1988), it was considered to study the population dynamics of these fishes.

Materials and Methods

Fish samples for length-frequency measurements were obtained randomly from landings of the artisanal purse seine and ring net fishery at Banda Beach Fish Landing Centre, within Dar es Salaam City. Some of the fishing grounds for small pelagic fishes near Dar es Salaam are shown in Fig. 1.

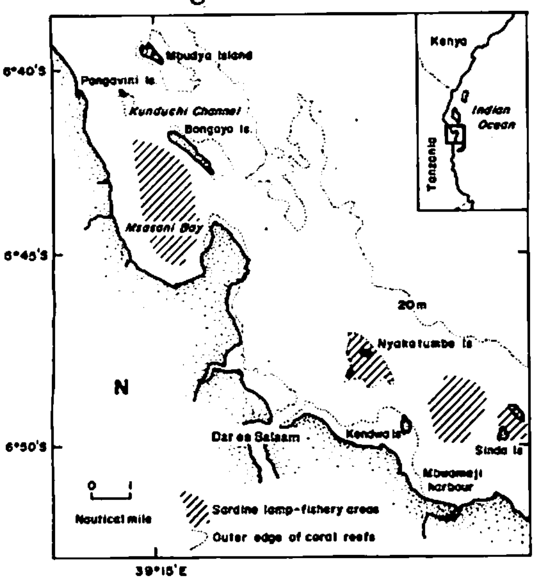

Fig. 1. *Map of area around Dar es Salaam showing fishing grounds of fishery discussed in text.*

The fishing gears used were of an average length of 140 m and average stretched mesh size in the bag (bunt) of 8.6 mm (Nhwani and Makwaia 1988). The frequency of sampling in January to December 1987 was three to four times a month at weekly intervals; sample sizes varied from 2 to 14 kg. The samples were sorted according to species and length was measured to the millimeter below from the tip of the snout, mouth closed, to the tip of the longest caudal fin, i.e., total length.

The length-frequency data were aggregated into bimonthly intervals; then those for *S. gibbosa* were split into their component normal distributions applying the Bhattacharya method incorporated in the LFSA computer programs of Sparre (1987). Where a temporal progression of the means was visible, the von Bertalanffy growth parameters L_∞ and K were estimated using the Gulland and Holt plot of the LFSA package. In the case of *S. albella*, for which modal separation and progression were not clear, the growth parameters were estimated from the bimonthly data using the ELEFAN package of Brey and Pauly (1986).

The parameters obtained were used as input to length-converted catch curves to obtain estimates of total mortality (Z), following Pauly (1983). Natural mortality (M) was estimated using the empirical formula of Pauly (1980), with T set at 28°C (Harvey 1977).

The values of M obtained were multiplied by a correction factor of 0.8 to account for the effect of schooling on M, as suggested by Pauly (1980). Fishing mortality (F) was estimated from Z = F + M and the exploitation rate (E) was obtained from E = F/Z.

Results and Discussion

Length-frequency distributions for *Sardinella gibbosa* and *S. albella* from the artisanal purse seine and ring net fishery of Dar es Salaam area are presented in Table 1 and 2.

Table 1. Length-frequency distributions of *Sardinella gibbosa* from the artisanal purse seine and ring net fishery of Dar es Salaam, in 1987.

Mid-length (cm)	J/F	M/A	M/J	J/A	S/O	N/D
4.5	1	0	0	21	24	0
5.5	10	1	0	28	37	0
6.5	8	6	0	20	56	0
7.5	3	22	0	9	42	1
8.5	0	57	0	5	46	10
9.5	0	50	1	6	36	19
10.5	2	24	17	15	19	34
11.5	5	8	101	10	5	6
12.5	8	13	20	25	3	0
13.5	3	4	4	27	0	0
14.5	6	14	18	19	0	0
15.5	8	49	16	29	0	0
16.5	2	7	12	10	0	0
17.5	0	1	0	1	0	0
Total	56	256	189	225	268	70

Table 2. Length-frequency distributions of *Sardinella albella* from the artisanal purse seine and ring net fishery of Dar es Salaam, in 1987.

Mid-length (cm)	J/F	M/A	M/J	J/A	S/O	N/D
7.5	0	0	1	0	0	1
8.5	0	1	4	0	0	10
9.5	0	3	6	1	0	34
10.5	2	4	19	0	0	13
11.5	2	64	14	17	0	2
12.5	14	60	21	97	6	0
13.5	5	39	4	99	2	0
14.5	7	9	27	29	2	0
15.5	1	4	2	8	0	0
Total	31	184	98	251	10	60

Fig. 2, respective Fig. 3, document the growth and catch curves that were derived. These led to the following growth and mortality parameter estimates for *S. gibbosa*, i.e., L_∞ = 18.6 cm, K = 1.8, Z = 3.2, M = 2.4, F = 0.8 year^{-1} and E = 0.25.

The steps taken in obtaining our growth and mortality estimates for *S. albella*, i.e., L_∞ = 16.8 cm, K g = 1.15, Z = 3.7, M = 1.8, F = 1.9 year^{-1} and E = 0.51, are documented in Figs. 4A-C.

The growth parameter estimates are compatible with those obtained elsewhere for *S. albella* and *S. gibbosa* (Table 3, see p. 28). This is especially true for *S. albella* for which the growth performance index ϕ' of Pauly and Munro (1984) is very close to the ϕ' values from India.

The estimate of E = F/Z suggests, for *S. albella*, that the stock is now subjected to a strong fishing pressure; the low value of E = 0.25 for *S. gibbosa* is probably an artifact, due to K and hence M having been overestimated.

However, detailed suggestions for managing this stock will have to await more detailed studies, based on catch and effort data and a longer time series of length-frequency data than presented and analyzed here.

In the meantime, we conclude by pointing out the two length-based approaches we have used here, i.e., LFSA and ELEFAN, provided useful results, and hence we commend the effort presently undertaken to merge these packages into a single, even more powerful software, as described in Pauly and Sparre (1991).

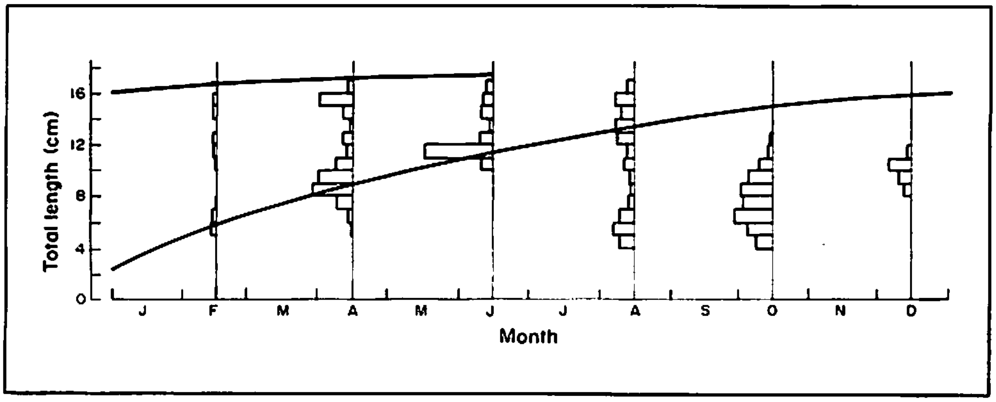

Fig. 2. *Length-frequency data of Table 1, for* **Sardinella gibbosa** *from the Dar es Salaam area, with superimposed growth curve, as estimated using LFSA routines for analysis of mixtures of distributions ("Bhattacharya method") and a "Gulland and Holt plot" for estimation of L_∞=18.6 cm and K=1.8 year^{-1}.*

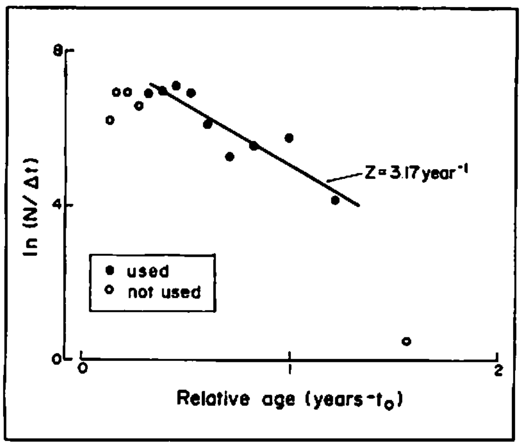

Fig. 3. *Catch curve for* **Sardinella gibbosa**, *based on the data of Table 1 (weighed by the square root of sample size before cumulating by length class), and the parameters L_∞=18.6 cm and K=1.8 year^{-1}.*

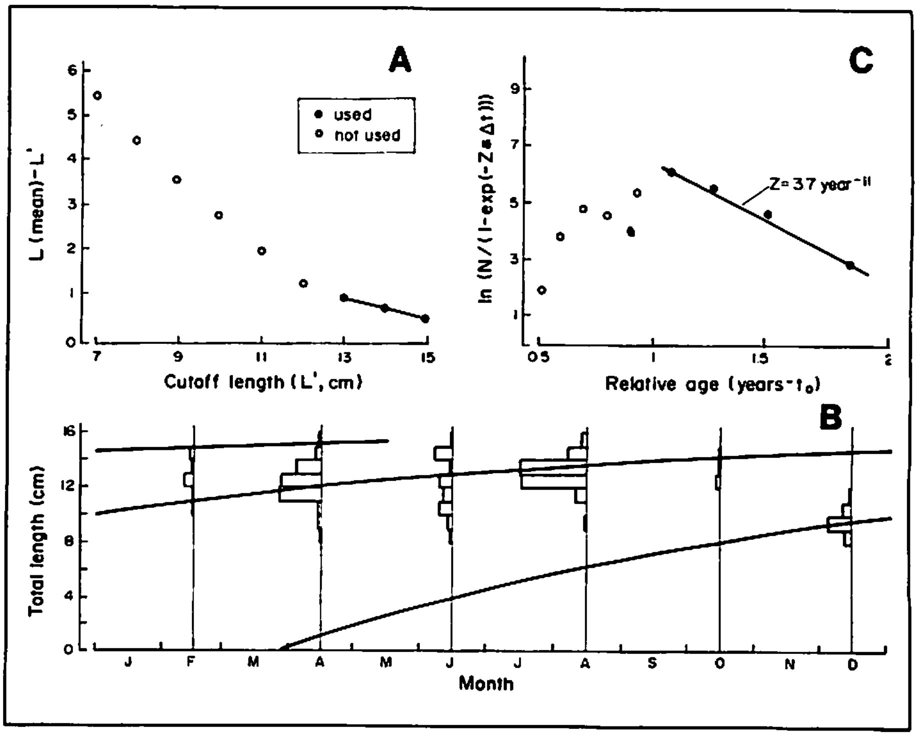

Fig. 4. *Steps in estimating the growth and mortality of* **S. abella** *from the Dar es Salaam area using the Compleat ELEFAN software package: (A) Wetherall plot for estimation of L_∞=16.8 cm; (B) Estimation of K=1.15 year^{-1} using ELEFAN software package, (C) Length-converted catch curve, with estimation of Z=3.7 year^{-1} (data on Table 1, cumulated by length class).*

Table 3. Comparison of growth parameter estimates for *S. gibbosa* and *S. albella*.

Species and Location	TL_∞ (cm)	K (year^{-1})	ϕ'[a]	Source
Sardinella gibbosa				
Tanzania (Dar es Salaam)	16.1	1.59	2.61	Nhwani and Makwaia (1988)
Tanzania (Zanzibar)	17.0	0.58	2.22	Nhwani and Bianchi (1987)
India (Palk Bay)	≈17	≈1.1	2.50	Holt (1960) based on Nair (1960) and Sekharan (1955)
Tanzania (Dar es Salaam)	18.6	1.79	2.79	This study
Sardinella albella				
India (Gulf of Manaar)	13.0	1.65	2.45	Pauly (1978), based on Bennett (1961)
India (Palk Bay, Gulf of Manaar)	≈17.0	≈1.1	2.50	Holt (1960), based on Nair (1960) and Sekharan (1955)
India (Mandapam area)[b]	13.3	1.44	2.41	Pauly (1978) based on Sekharan (1955)
Tanzania (Dar es Salaam)	16.5	1.15	2.51	This study

[a] $\phi' = \log_{10}K + 2\log_{10}L_\infty$ (Pauly and Munro 1984).

[b] another entry for this species and area (same sources) is L_∞=13.3 and K=1.3; the K value is probably too low.

References

Bennett, S. 1961. Further observations on the fishery of biology of "chooday" (*Sardinella* spp.) of Mandapan area. Indian J. Biol. 8(1): 152-168.

Brey, T. and D. Pauly. 1986. A user's guide to ELEFAN 0, I. II. Revised and expanded CP/M version. Ber. Inst. Meereskd. Christian-Albrechts-Univ. Kiel 149, 77 p.

FAO. 1979. Report of the workshop on the Fishery resources of the Western Indian Ocean South of the Equator. Dev. Rep. Indian Ocean Programme 45, 102 p.

Garcia, S. and E. Josse. 1988. Notes on the assessment of the stocks of small pelagic species on the basis of length-frequency analysis and converted catch curves. Fishbyte 6(1):16-18.

Harvey, J. 1977. Some aspects of the hydrobiology of the waters off the coast of Tanzania. A contribution to CINCWIO. Univ. Sci. J. (Univ. of Dar) 3 (1/2): 53-92.

Holt, S.J. 1960. A preliminary comparative study of the growth, maturity and mortality of sardines. Proc. World Scient. Meeting on the Biology of Sardine and Related Species. Synopsis No. 2:553-561.

Iversen, S.A., S. Myklevoll, K. Lwiza and J. Yonazi. 1984. Tanzania marine fish resources in the depth region 10-500 m investigated by R.V. Dr. Fridtjof Nansen, p. 43-83. *In* S.A. Iversen, and S. Myklevoll (eds.) The proceedings of the NORAD-Tanzania Seminar to Review the Marine Stocks in Tanzania. NORAD/Institute of Marine Research, Bergen.

Nair, R.A. 1960. Synopsis on the biology and fishery of the Indian sardines. Proc. World Scient. Meeting on the Biology of Sardine and Related Species. Synopsis No. 16:329-371.

Nhwani, L.B. and G. Bianchi. 1987. Preliminary assessment of *Sardinella gibbosa* in Zanzibar waters, p. 231-236. *In* M.J., Sanders, P. Sparre and S.C. Venema. Proceedings of the Workshop on the Assessment of the Fishery Resources in the Southwest Indian Ocean, Mauritius, 1987. FAO/UNDP: RAF/79/065/WP/41/88/E.

Nhwani, L.B. and E.D. Makwaia, 1988. Aspects of the fishery and biology of small pelagic fishes at Dar-es-Salaam, Tanzania. Fishbyte 6(3):7-10.

Pauly, D. 1978. A preliminary compilation of fish length growth parameters. Ber. Inst. Meereskd. Christian-Albrechts-Univ. Kiel 55, 200 p.

Pauly, D. 1980. On the interrelationship between natural mortality, growth parameters and mean environmental temperatures in 175 fish stocks. J. Cons. CIEM 39 (3) 175-192.

Pauly, D. 1983. Length-converted catch curves: a powerful tool for fisheries research in the tropics (Part II). Fishbyte 2(1):17-19.

Pauly, D. and J.L. Munro. 1984. Once more on growth comparison in fish and invertebrates. Fishbyte 2(1):21.

Pauly, D. and P. Sparre. 1991. A note on the development of a new software package, the FAO-ICLARM Stock Assessment Tools (FISAT). Fishbyte 9(1): 47-49.

Sekharan, K.V. 1955. Observations on the choodai fishery of Madapam area. Indian J. Fish. 2:113-132.

Sparre, P. 1987. Computer programs for fish stock assessment. Length based fish stock assessment for Apple II computers FAO Fish Tech. Pap. 101. Suppl. 2.

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