Asian Fisheries Science 1(1988):157-164.
Asian Fisheries Society, Manila, Philippines

Stock Assessment and Dynamics of the *Coilia dussumieri* (Engraulidae) Resource in the Indian Exclusive Economic Zone along the Northwestern Coast of India

IRENE FERNANDEZ

P.O. Box 3550, Ruwi
Muscat, Sultanate of Oman

M. DEVARAJ

Central Institute of Fisheries Education, Versova,
Bombay 400 061, India

Abstract

Coilia dussumieri (Cuv. and Val.) ranks second in the total catch of marine fish landed around Bombay throughout the year. The stock is concentrated along the northwestern coast of India between latitudes 19°N and 21°N and longitudes 71°E and 73°E and is mainly landed by bag net and trawl.

The analytical model of R.J.H. Beverton and S.J. Holt was used for the 1982-1983 stock after evaluating the three sets of basic population parameters, namely, growth (L_∞ = 28.5 cm, t_0 = 0.07 year and K = 0.8 year^{-1} for length growth; W_∞ = 30.1 g, t_0 = 0.15 year and K = 1.2 year^{-1} for weight growth); mortality (Z = 2.7; M = 1.3 and F = 1.4 year^{-1}) and selection (length at first capture, L_c = 8.8 cm and t_c = 0.4 year). J.G. Pope's cohort analysis was used for obtaining estimates of instantaneous rates of fishing mortality and population surviving at each age of a year class.

The pattern of recruitment into the commercial stock showed that recruitment in 1983 was continuous with a peak in June. Also estimated was the 1982-1983 annual total stock (P = 29,162 t), the absolute number of recruits at the age of first capture t_c (R_c = 5.2·10^9), the mean number of fish in the exploited stock (PN = 1.8·10^9) and the standing stock ($\bar{P}$ = 10,144 t). The study showed that the *C. dussumieri* stock could be fished to its maximum sustainable yield stabilizing the fishing mortality between 2.5 and 3.0 and the length at first capture at 8.8 cm when the fish is 0.4 year old.

Introduction

Anchovies of the family Engraulidae assume a very important place in world fisheries. They are represented in the Maharashtra-

Gujarat waters along the northwestern coast of India by eight species, of which the most important is the gold spotted grenadier anchovy *Coilia dussumieri* (Cuvier and Valenciennes), known locally as "mandeli". It is caught along with a variety of other fish in bag nets as well as trawls and ranks second in the catches landed in and around Bombay throughout the year. It contributed 8,509 t (3.18%) and 5,483 t (2.79%) to the total marine fish landings in Maharashtra and Gujarat states, respectively.

Knowledge of the population biology of *C. dussumieri* pertaining to the management of its resource is very limited, although some basic aspects of its taxonomy, anatomy and biology have been studied by earlier workers. For example, Jones and Menon (1952) gave an account of the systematics and development of the genus *Coilia* Gray; Joshi and Bal (1953a, 1953b) studied the osteology of *C. dussumieri;* Palekar and Karandikar (1953) dealt with the temporal distribution of maturity stages of *C. dussumieri* in Bombay waters while Bal and Joshi (1956) and Gadgil (1965) gave a general account of its biology for the same area.

The present study deals with aspects of the population dynamics of *C. dussumieri* along the northwestern coast of India. The population of this species in the study area (Fig. 1) is treated as a unit stock because the individuals exhibit no significant differences in biological or anatomical characteristics.

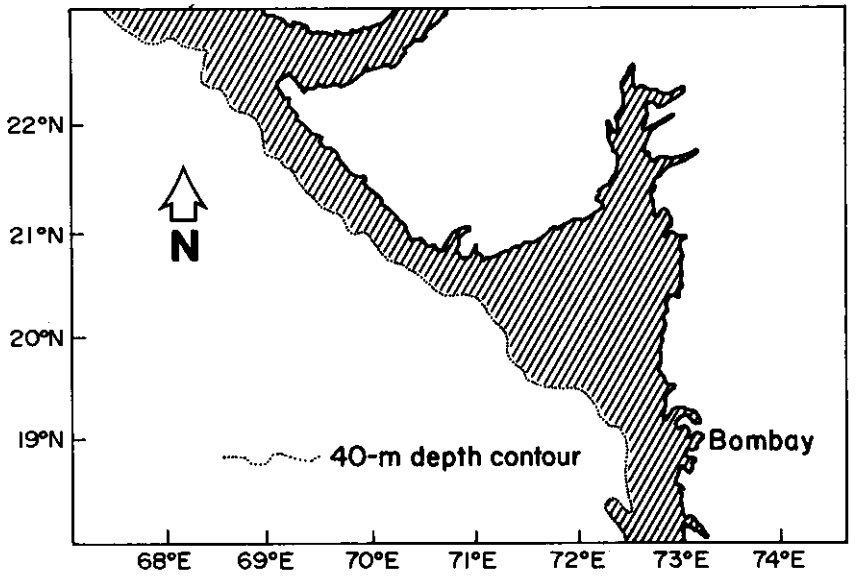

Fig. 1. The northwestern coast of India, showing the study area.

Materials and Methods

A total of 5,514 specimens was collected randomly during 1982-1983 at weekly intervals from three major landing centers in Bombay viz., the Ferry Wharf, the Sassoon Docks and Versova fishing village. Sporadic samples taken during the above period at Dakti Dahanu, 80 km north of Bombay, and from the catches by the research vessels, MFV Saraswati and MFV Narmada of the Central Institute of Fisheries Education (CIFE), Bombay, were also used for the study.

The growth, mortality and gear selection parameters were estimated for incorporation in the Beverton and Holt (1957) analytical model, and therefrom to assess the status of the stock and yield for the 1963-1964, 1980-1981 and 1982-1983 periods.

The modal values in the percentage length-frequency distribution for successive months were plotted in the form of a scatter diagram. Relative ages were determined by eye-fitted lines tracing the progression of the modal points in the scatter diagram (Devaraj 1983). Estimations of L_∞, W_∞ and K were performed using Ford's (1933) and Walford's (1946) method of plotting $L_t + 1$ against L_t for length and with subsequent conversion of L_∞ to W_∞. The age structure of the population was derived from the length-frequency data using the age-length key.

Instantaneous total mortality (Z) was estimated from the age composition data (Table 1) using Jackson's (1939) method. Instantaneous rate of natural mortality (M) was estimated using Pauly's (1980) method for instantaneous fishing mortality (F) by subtracting M from Z.

Trawl selectivity was determined from the ratio of catch in numbers for the larger mesh (40 mm) to that for the smaller mesh (20 mm) as given by Beverton and Holt (1957). The length at first capture (L_c) for 20-mm mesh was calculated from the relation $L_c = SF \cdot m$, where SF is the selection factor and m the mesh size. The length at recruitment (L_r) was taken arbitrarily as the minimum length in the length-frequency distribution.

Yield as a function of both age at first capture (t_c) and F was calculated for 1982-1983 using the worksheets of Beverton and Holt (1957) and for 1963-1964 from the incomplete beta function tables (Willimovsky and Wicklund 1963), with M/K = 1.75. The potential yield per recruit was estimated using the model developed by Krishnankutty and Qasim (1968).

Pope's (1972) cohort analysis was carried out only for the 1982-1983 period because catch statistics for the period 1963-1964 were not available. This analysis starts with a value of terminal fishing mortality (F_t) considered to apply to the oldest age group (N_t) and works backwards to the youngest age group. The results of this analysis can also be used to estimate the average biomass of the respective age groups.

The seasonal pattern of recruitment was determined as shown in Pauly (1982) by projecting the length-frequency distribution backwards onto the time axis.

Mean annual standing stock (biomass, $\overline{B}$) was estimated by applying the equation $\overline{B} = Y/F$, while the total annual stock (P) was estimated by applying the equation $P = Y/E$ where $E = F/Z$ and Y is the annual catch (CMFRI 1983).

Catch per hour of trawling was estimated: (1) from the random samples observed at the commercial landing centers; (2) from information obtained through weekly interviews with skippers of vessels and local fishermen; and (3) from the logbooks of the research vessels MFV Narmada and MFV Saraswati of CIFE, Bombay. The depthwise distribution of the population along the northwestern coast was studied based on the catch and effort data of MFV Narmada and MFV Saraswati.

Results and Discussion

The modal class progression analysis revealed that the broods comprising the 1963 year class were released in February, May, July and October. The length-frequency data for 1964 showed the origin of one brood in February while the 1983 data indicated one brood in January and another in March. The growth curves for 1963-1964 and 1982-1983 differed from each other and were treated separately (Fig. 2). While one-year old *C. dussumieri* measured 18.5 cm in 1963-1964, they were only 16.3 cm in 1982-1983 (Table 1). Table 1 also shows differences in all the parameters derived in the analyses between the two sampling periods.

Based on the yield-per-recruit analyses optimum age at entry into the fishery was found to be 0.9 year and the potential yield per recruit (Y/R), 3.9 g.

Cohort analyses show that for 1982-1983 the numbers attaining 0+ age (0-5 months) were 4-6 x 10^9; 0.5+ (6-11 months) 2-3 x 10^9; 1+ (12-17 months) 3-4 x 10^6; and 1.5+ (12-18 months) 1-2 x 10^6.

Table 1. Estimated population parameters of *C. dussumieri*.

Parameter description	Estimated parameters	Year	Values and remarks
Growth	Length (L, cm)	1963-1964	L_{max} = 18.5 cm; L_∞ = 27.2 cm; K = 1.08 $year^{-1}$; t_0 = 0.001 year
		1982-1983	L_{max} = 20.5 cm; L_∞ = 28.5 cm; K = 0.84 $year^{-1}$; t_0 = −0.07 year
	Weight (W, g)	1963-1964	W_{max} = 18.5 g; W_∞ = 26.83 g; K = 0.96 $year^{-1}$; t_0 = 0.01 year
		1982-1983	W_{max} = 20.5 g; W_∞ = 30.1 g; K = 1.2 $year^{-1}$; t_0 = 0.15 year
	Length-weight rel.	1982-1983	$W = 0.0454\ L^{2.0231}$
	Age composition (half year groups)	1963-1964	0+ = upto 10.6 cm = 12.4%; 1/2+ = 10.7 to 17.0 cm = 80.2%; 1+ = 17.1 to 19.5 cm = 7.3%.
		1982-1983	0+ = upto 9.1 cm = 6.6%; 1/2+ = 9.2 to 16.0 cm = 68.9%; 1+ = 16.1 to 19.8 cm = 24.3%; 1 1/2+ = 19.9 to 20.5 cm = 0.12%.
Mortality	Total mortality (Z)	1963-1964	4.78
		1982-1983	2.68
	Natural mortality (M)	1963-1964	1.68
		1982-1983	1.30
	Fishing mortality (F)	1963-1964	3.10
		1982-1983	1.37
Selection	Length at first capture (L_c, cm)	1963-1964	11.05 cm
		1982-1983	for 20 mm codend mesh of the commercial trawlers = 8.75 cm
	Length at recruitment (L_r, cm)	1963-1964	3.55 cm
		1982-1983	3.50 cm
	Age at first capture (t_c, months)	1963-1964	6 months
		1982-1983	for 20 mm codend mesh of the commercial trawlers = 5 months
	Age at recruitment (t_r, months)	1963-1964	1.5 months
		1982-1983	1 month

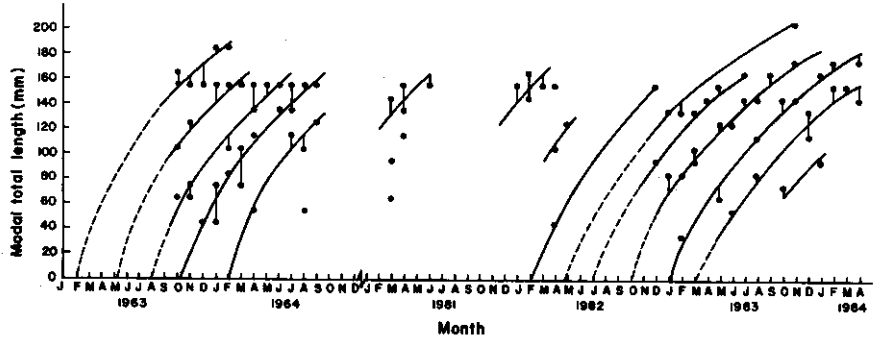

Fig. 2. Scatter diagram of modal lengths by month for *C. dussumieri* for various years.

The recruitment pattern for 1982 showed recruitment to have a peak in May-June (Fig. 3).

Mean annual standing stock ($\bar{P}$) for 1982-1983 was estimated to be 10,144 t and the annual stock (P) to be 29,162 t. The absolute number of recruits was estimated to be 5.2×10^9. The mean number of fish in the stock was 1.8×10^9.

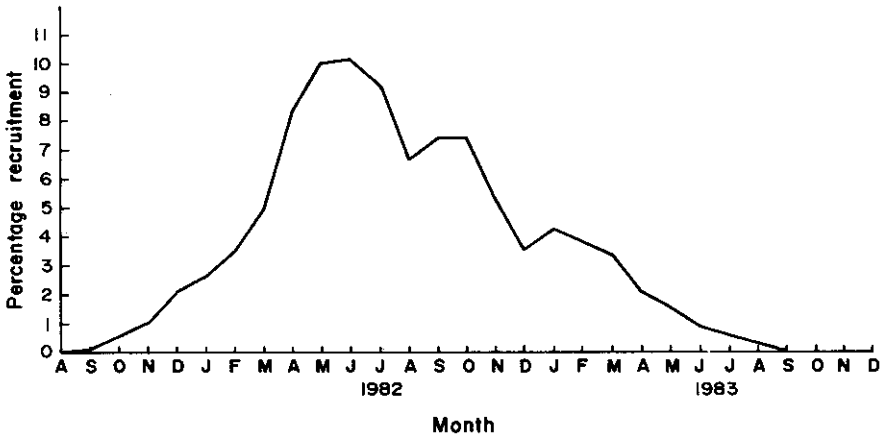

Fig. 3. Recruitment pattern for *C. dussumieri.*

Bag-net landings in the monsoon season at the Sassoon Docks comprised fish less than 12 cm, indicating migration of adults to deeper (about 40 m) waters within the inshore grounds for spawning. The trawls operating about 36-64 km offshore in waters deeper than 40 m brought in fish up to 20.5 cm long, confirming migration of adults to deeper grounds. Studies conducted by the research vessels indicated concentrations of *C. dussumieri* between latitudes 19°N and 21°N and longitudes 71°E and 73°E along the Maharashtra-Gujarat coast of the northwestern coast of India.

Fig. 4 suggests that by 1963-1964, fishing mortality (F = 3.10) was excessive and produced, at high levels of effort, a yield per recruit less than would have been obtained with a reduction of effort of about 50%.

The fishing mortality estimated for 1982-1983 (F = 1.37) appears to be below optimum. Therefore, yield per recruit would increase if F were increased to 2.5-3.0. The apparent decrease in fishing mortality may be due to mechanized fishing effort having switched from pelagics to demersal trawling (because of penaeid shrimps), where engraulids form only a very small bycatch.

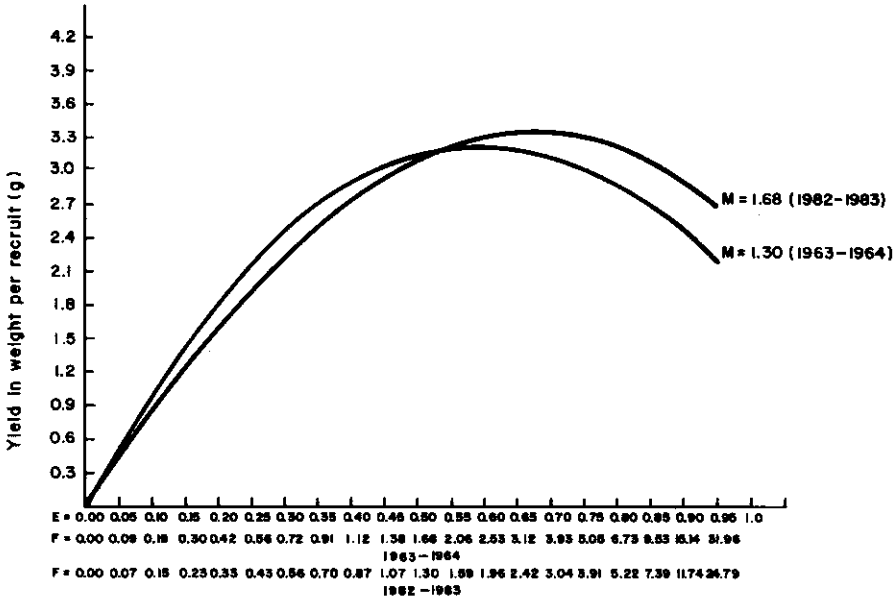

Fig. 4. Yield curves for *C. dussumieri*.

Acknowledgements

We acknowledge Dr. S.N. Dwivedi, Director, Central Institute of Fisheries Education, Bombay, for his kind permission to use the data obtained from the Institute's research vessels, MFV Saraswati and MFV Narmada, and the facilities at the Institute.

References

Bal, D.V. and M.S. Joshi. 1956. Studies on the biology of *Coilia dussumieri* (Cuv. & Val.). Indian J. Fish. 3(1):9-100.

Beverton, R.J.H. and S.J. Holt. 1957. On dynamics of exploited fish populations. Ministry of Agriculture, Fisheries and Food. Fishery Investigations, II(XI). Her Majesty's Stationery Office, London. 533 p.

CMFRI. 1983. Composition of marine fish landing from mechanised boats at major landing centres (tonnes). Marine Fisheries Information Service, Technical and Extension Series No. 52. Central Marine Fisheries Research Institute, Cochin, India.

Devaraj, M. 1983. Fish populations dynamics - Course Manual. CIFE (Central Institute of Fisheries Education) Bull. 3(10). 98 p.

Ford, E. 1933. An account of the herring investigations conducted at Plymouth during the years from 1924-1933. J. Mar. Biol. Assoc. U.K. 19:305-384.

Gadgil, M.D. 1965. On some aspects of the biology of *Coilia dussumieri* (Cuv. & Val.). University of Bombay. M.Sc. thesis.

Jackson, C.H.N. 1939. The analysis of an animal population. J. Anim. Ecol. 8(2):238-246.

Jones, S. and P.M.G. Menon. 1952. Observation on the development and systematics of *Coilia*, Gray. J. Zool. Soc. India 4:17.

Joshi, M.S. and D.V. Bal. 1953a. The skeleton of *Coilia dussumieri*. I. The skull. J. Univ. Bombay 21:93.

Joshi, M.S. and D.V. Bal. 1953b. The skeleton of *Coilia dussumieri*. II. The vertebral column and appendicular skeleton. J. Univ. Bombay 22:53.

Krishnankutty, M. and S.Z. Qasim. 1968. The estimation of optimum age of exploitation and potential yield in fish populations. J. Cons., Cons. Int. Explor. Mer 32(2):249-255.

Palekar, V.C. and K.R. Karandikar. 1953. Maturity of *Coilia dussumieri* (Cuv. & Val.) in Bombay during different months of the year. J. Zool. Soc. India 5(2):217.

Pauly, D. 1980. A selection of simple methods for the assessment of tropical fish stocks. FAO Fish. Circ. 729. 54 p.

Pauly, D. 1982. Studying single-species dynamics in a tropical multispecies context, p. 33-70. *In* D. Pauly and G.I. Murphy (eds.) Theory and management of tropical fisheries. ICLARM Conf. Proc. 9, 360 p. International Center for Living Aquatic Resources Management, Philippines and Commonwealth Scientific & Industrial Research Organisation, Australia.

Pauly, D. and G.I. Murphy, editors. 1982. Theory and management of tropical fisheries. ICLARM Conf. Proc. 9, 360 p. International Center for Living Aquatic Resources Management, Philippines and Commonwealth Scientific & Industrial Research Organisation, Australia.

Pope, J.G. 1972. An investigation of the accuracy of the virtual population analysis using cohort analysis. ICNAF Res. Bull. 9:65-74.

Walford, L.A. 1946. A new graphic method of describing the growth of animals. Biol. Bull. 90:141-147.

Willimovsky, N.J. and E.C. Wicklund. 1963. Tables of incomplete beta function for the calculation of fish population yield. Institute of Fisheries, University of British Columbia, Vancouver, Canada. 291 p.

Manuscript received 9 March 1987; accepted 21 April 1988