Journal of the Indian Fisheries Association
25, 1995 (Proc.Nat.Symp. Aquacrops), 15-24

STOCK ASSESSMENT AND BIOLOGY OF *JOHNIUS GLAUCUS* (DAY) OFF THE NORTHWEST COAST OF INDIA

S. S. KAMAT AND M. DEVARAJ*

Central Institute of Fisheries Education, Versova, Mumbai-400 061.

ABSTRACT

The stock size and biology of *Johnius glaucus* (Day) resource off the northwest coast of India were studied for 1982-83 and 1983-84. The total length at the end of 6, 12, 18, 24 and 26 months was 121 mm, 183 mm, 237 mm, 261 mm and 264 mm respectively. The length growth parameters were : $L\infty$ = 300 mm, K = 0.0807 (monthly) and t_o = -0.51 month. The weight growth parameters were : $W\infty$ = 317g, K = 0.0762 (monthly) and t_o = -0.41 month. The exploited stock mainly composed of 1/2 + and 1+ age groups. The annual Z, M and F were 2.34, 1.49 and 0.85 respectively. The l_b, t_b, l_r, t_r and selection factor K were 155 mm, 0.75 year, 65 mm, 0.25 year and 3.875 respectively. The Yw/R was optimum at the exploitation rate (E) of 0.75 and codend mesh size of 37 mm. The total stock for 1982-83 and 1983-84 was 14,624 and 26,190 tons respectively. The standing stock of 1982-83 and 1983-84 was 5,645 and 10,110 tons respectively. The MSY for 1982-83 and 1983-84 was 6,623 and 11,788 tons respectively. The F and Z was lowest in O+ age group and highest in 1+ age group.

INTRODUCTION

The smaller sciaenids, commonly called as dhoma, form one of the important constituent of the shrimp trawler bycatch off the Mumbai Coast. Although considerable work has been done on various aspects of the sciaenids, which comprised of 16 genera in the Indian waters, till the present study, work on the dynamics of the Indian sciaenids was limited to some studies on the dynamics of *Otolithoides biauritus* by Jayaprakash (1976) and of *Protonibea diacanthus* by Rao (1970). The analytical model used for the stock estimation in the present study is a single species model and can be ideally applied only to the single species stocks of the temperate countries, but it is a milestone for the studies using multispecies stock estimation model incorporating the interspecies relations. Till the present study, the stock estimation studies on sciaenids in India using the analytical model were limited to those by Rao (1971) on *Protonibea diacanthus;* by Chakraborty (1980) on *Otolithus cuvieri, Johnieops macrorhynus* and

* Central Marine Fisheries Research Institute. Dr. Salim Ali Road, Tatapuram P.O. Ernakulam, Kochi-682 018.

Johnieops vogleri; by Murthy (1986) on *Johnius carutta* and by Gulati (1987) on *Otolithus cuvieri*. The present study was undertaken to know the dynamics and status of the *Johnius glaucus* stock off the northwest coast of India.

MATERIAL AND METHODS

The length frequency data collected from the New Ferry Wharf and Versova landing centres along with the data from the catches of the trawlers M.F.V. *Saraswati* and M.F.V. *Narmada,* when operated off the Gujarat and Maharashtra (15°30'N to 23°40'N Lat) coast, during January 1983 to March 1984 formed the basis of the study.

Estimation of growth parameters

For the age and origin of brood estimates the Scatter diagram technique of length mode analysis (Devaraj, 1977; 1981; 1983) was used. The length weight relation was used for converting the length-at-age to weight-at-age.

Estimation of mortality parameters

The total mortality coefficient (Z) was calculated from the age composition data in half year age groups for the year 1983 using Jackson's (1939) method.

$$S = \frac{N1 + N2 + N3 + ...}{N0 + N1 + N2 + ...}$$

Only fully recruited age groups were included for the estimation of S.

From the S calculated above, the Z was calculated using equation;

$$Z = -\log_e S$$

As the Z calculated above was on half yearly basis, it was converted to annual form by multiplying with 2.

The natural mortality coefficient M was calculated using the equation given by Pauly (1980);

$$\log M = 0.1228 - 0.1912 \log L\infty + 0.7485 \log K + 0.2391 \log T$$

The fishing mortality coefficient F was calculated by substracting M from Z.

Estimation of selection parameters

The minimum length of fish from the length frequency data was taken as the length at recruitment (l_r), while the length on the x-axis corresponding to 0.5 selection ratio on the y-axis of the codend selection curve for the 40 mm codend mesh trawl net was taken as the length at first capture (l_c). The age at recruitment (t_r) and the age at first capture (t_c) were estimated using the age-length key. The selection factor *K* was estimated using equation;

$$K = lc/m$$

where, lc = length at first capture and m = stretched codend mesh size of the trawl net.

Mechanism of fitting the analytical model

Derivation of yield using the work sheets :- The analytical model expresses yield as a function of growth,

mortality and gear selection parameters, according to equation;

$$Y/R = Fe^{-M(t_c - t_r)} W\infty \sum_{n=o}^{3} \frac{U_n e^{-nk}(t_c - t_o)}{F+M+nK}$$

where, t_c = age at first capture (age at l_c, the 50% selection length), t_r = age recruitment, U_n = Summation variable.

Yield as function of F, keeping t_c constant :

Worksheet-A (Devaraj, 1983) was used for this purpose. F values for E ranging from 0 to 1 were first calculated from the following relation between M and E ;

$$E = \frac{F}{Z} = \frac{F}{F+M}$$

Yield as a function of t_c. keeping F constant :

Worksheet B.1 and B.2 were used for this purpose. 1_C values in cm. (column B in worksheet B.1) for *C* ranging from 0.98 to 0.02 were estimated by;

$$C = 1_C/L_\infty$$

Mesh size (column A in worksheet B.1) was calculated by;

$$(A) = 1_C/K$$

where, K = Selector factor and 1_C= length at first capture in cm.

The optimum age of exploitation (t_y) is defined as the age when the brood attains its maximum weight (Beverton and Holt, 1957) and the potential yield (Y^1) is the quantity corresponding to this weight as a function of infinite fishing mortality. The Y^1 was estimated from the equation given by Kutty and Qasim (1978).

$$Y^1 = a e^{-M(ty-tr)} \{L\infty - (L\infty - 1o) e^{-Kty}\}^b$$

For the conversion of *YW/R* in grams to total yield in tons, Corten's graphic method (1974) was used. The annual yield in tons for 1982-83 and 1983-84 was superimposed on the *YW/R* in gram curve, against the E value for the year 1982-83 and 1983-84. A vertical scale indicating yield in tons was fitted on the extreme right of the figure, and was caliberated at regular intervals starting from zero, using the position of 1982-83 and 1983-84 yield in tons as the guideline.

The total stock $\underline{P}$, was estimated from the equation;

$$\underline{P} = Y/U$$

where Y = annual yield in tons and U = exploitation rate.

The standing stock $\overline{P}$, was estimated from the equation;

$$\overline{P} = Y/F$$

where Y = annual yield in tons and F = annual fishing mortality coefficient.

Pope's (1972) Cohort analysis was carried out by the stepwise treatment

of the catch in numbers (C_t) according to the half year groups from 0+ to 2+ using the age composition data.

RESULTS

Growth parameters

The modal progression analysis by the Scattogram technique indicated *Johnius glaucus* to be a protracted spawner, annually releasing 4 major broods in the month of January, April, July and October (Fig.1). The species was found to be fast growing attaining the length of 121 mm, 183 mm, 237 mm and 261 mm at the end of 6 months, 12 months, 18 months and 24 months respectively.

The von Bertalanffy Growth Function (VBGF) parameters for length growth were estimated to be $L\infty$ = 300 mm; K = 0.0807 (monthly) and t_0 = -0.51 month. The VBGF parameters for weight growth were found to be : $W\infty$ = 317 g.; K = 0.0762 (monthly) and t_0 = -0.41 month.

Mortality parameters

The age composition analysis for 1983 showed the exploited *Johnius glaucus* stock to be mainly composed of $^1/_2$+ and 1 + age groups. For 1983, $^1/_2$ + year class was the fully recruited age group.

Hence, survival rate

$$S\ 1/2 = \frac{27.63 + 1.30 + 0.05}{64.50 + 27.63 + 1.30} = 0.3102$$

$\therefore$ Z 1/2 = -loge 0.3102 = 1.1706

$\therefore$ Annual Z = Z 1/2 x 2 = 1.1706 x 2 = 2.3412

The $L\infty$ was estimated to be 300 cm. and the annual length growth coefficient (K) was 0.9683. As the stock is limited to a depth of 50 meters along the northwest coast of India, mean temperature (T) was taken as 27.225°C. based on the observations made from M.F.V. Saraswati during the years 1982-87. The natural mortality coefficient was calculated as 1.489 and the fishing mortality coefficient was calculated as 0.8522.

Selection parameters

From the length frequency data the length at recruitment (1r) was taken as 65 mm. From the codend selection curve the length at first capture (1c) for the trawl of 40 mm codend mesh was found to be 155 mm. By replacing the value of 1c and M the selection factor K was estimated to be 155/40 = 3.875. Using the age-length key the t_c was estimated to be 0.75 year and t_r was estimated to be 0.25 year.

Yield as function of F keeping t_c constant and yield as function of t_c keeping F constant :

Results of the yield isopleth diagram are presented in Fig. 2. Maximum Y_W/R of 22.31 g. is obtained at F_{max} of 4.467 compared to Y_W/R of 16.13 g. at the present F of 0.8522. The eumetric fishing curve BB and MSY curve AA met vertically at $F\infty$ giving Y_W/R of 23.82 g. at the optimum age of exploitation of about 1 year.

The yield in weight per recruit (YW/R) was found to be maximum at the exploitation ratio (E) of 0.75, which was very much higher than the E of 0.364 for 1982-83, indicating the 49% underexploitation of the stock. The optimum mesh size for *Johnius glaucus* was estimated to be 37 mm to get optimum yield of 17.53g/recruit, which was higher than the mesh size of 20 mm by which the stock was exploited in 1982-83.

The optimum age of exploitation (t_y) was estimated to be 1.13 year, while the potential yield per recruit (Y^1) was estimated to be 23.82 g.

The coversion of YW/R in g to total yield in tons using Corten's graphic method (1974) for 1982-83 and 1983-84 is given in figures 3 and 4. The exploitation ratio E for 1982-83 was 0.364 and it was presumed that it remained constant for 1983-84. Hence based on the catch of 4,811 tons for 1982-83 and 8,616 tons for 1983-84 the MSY for 1982-83 and 1983-84 was estimated to be 6,623 tons and 11,788 tons respectively indicating 27% and 44% under exploitation during 1982-83 and 1983-84 respectively.

Estimation of stock and yield in absolute terms

The total stock P for 1982-83 and 1983-84 was estimated to be 14,624 tons and 26,191 tons respectively. The standing stock P for 1982-83 and 1983-84 was estimated to be 5,645 tons and 10,110 tons respectively.

Pope's (1972) age Cohort analysis

The results of the Pope's Cohort analysis are given in Table 1. The results indicate that the total and fishing mortality was lowest in the 0+age group and highest in the 1+age group.

DISCUSSION

Johnius glaucus was found to be a fast growing species with an annual K of 0.9684 compared to 0.52, 0.75 and 0.72 of *Otolithus cuvieri, Johnieops macrorhynus* and *Johnieops vogleri* respectively (Chakraborty, 1980) and 0.9303 of *Otolithus cuvieri* (Gulati, 1987).

The L_∞ for *Johnius glaucus* was found to be 30.0 cm compared to 39.8 cm, 35.0 cm and 34.5 of *O.cuvieri, J. macrorhynus* and *J. vogleri* respectively (Chakraborty, 1980) and 33.07 cm. of *O.cuvieri* (Gulati, 1987).

The annual total mortality coefficient Z of *J. glaucus* was found to be 2.34 compared to 3.125, 3.3931 and 3.4154 of *O.cuvieri, J. macrorhynus* and *J. vogleri* respectively (Chakraborty, 1980) and 1.55 (average) of *O.cuvieri,* (Gulati, 1987).

The annual fishing mortality coefficient F of *J. glaucus* was found to be 0.85 compared to 1.2982, 2.6431 and 2.6954 of *O.cuvieri, J.macrorhynus* and *J.vogleri* respectively (Chakraborty, 1980) and 0.25 of *O.cuvieri* (Gulati, 1987).

Table 1 : *Results of the Pope's Cohort analysis*

Year (Observed)	Weight of the sample (kg)	Numbers per year class					Mortality Estimates		
		0+	$^1/_2$+	1+	1$^1/_2$+	2+	$^1/_2$Z	$^1/_2$M	$^1/_2$F
1983	88.274	120	1188	509	24	1	1.1706	0.7445	0.4261

Calculated from pope's cohort Analysis

Year	Catch in ton	Age group (t)	Numbers caught (C_t)	Numbers attaining each age (N_t)	Average Nos in the sea ($\bar{N}_t$)	$S_t=e^{-zt}$	Z_t	F_t
		0+	6540091	406363000	283634000	0.4639	0.7681	0.1197
		$^1/_2$+	64746902	188503000	100105000	0.2383	1.4344	0.7820
1982-83	4811	1+	27740886	44911518	14184079	0.0493	3.0103	2.3579
		1 $^1/_2$+	1308018	2213184	766116	0.0677	2.6934	2.0410
		2+	54501	149727	-	-	-	-
		0+	11712622	727753000	507958600	0.4639	0.7681	0.1157
		$^1/_2$+	115954960	337590000	179279300	0.2383	1.4344	0.7820
1983-84	8616	1+	49681039	80431768	25402448	0.0493	3.0103	2.3579
		1 $^1/_2$+	2342524	3963542	1372035	0.0677	2.6934	2.0410
		2+	97605	268145	-	-	-	-

Calculation of Exploitation ratio E

Year	Age	Np	Nc	E=Nc/Np	Wp (tons)	Wc (tons)	E-Wc/Wp
	Upto t_r (0.25 year)	406363000	6540091	0.0161	2035.066	32.753	0.0161
1982-83	From t_r onwards	235777429	93850307	0.3980	11177.883	5116.045	0.4577
	Total	642140429	100390398	0.1563	13212.949	5148.798	0.3897
	Upto t_r (0.25 years)	727753000	11712622	0.0161	3644.587	58.657	0.0161
1983-84	From t_r onwards	422253455	168076128	0.3980	20018.436	9162.300	0.4577
	Total	1150006455	179788750	0.1563	23663.023	9220.957	0.3897

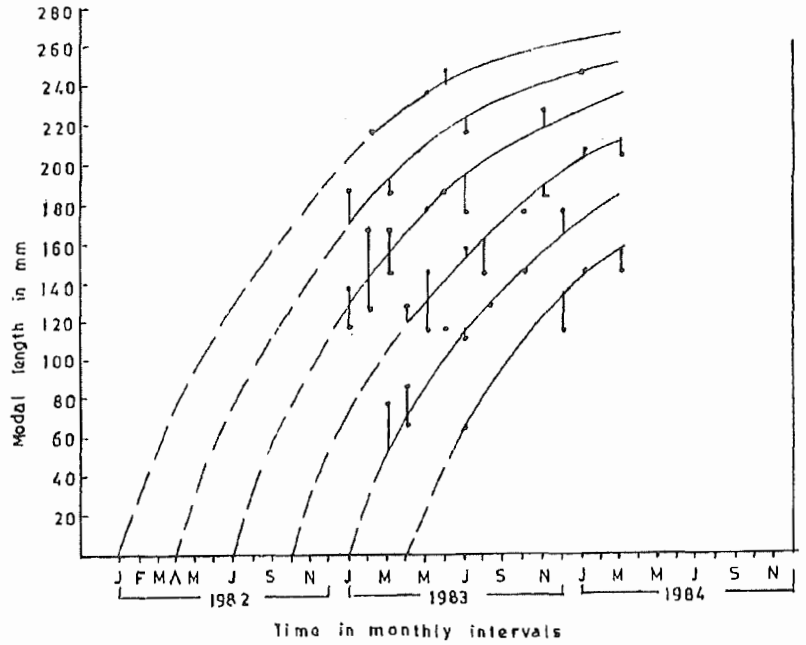

Fig. 1 : *Scatter diagram of modal length month for J.glaucus*

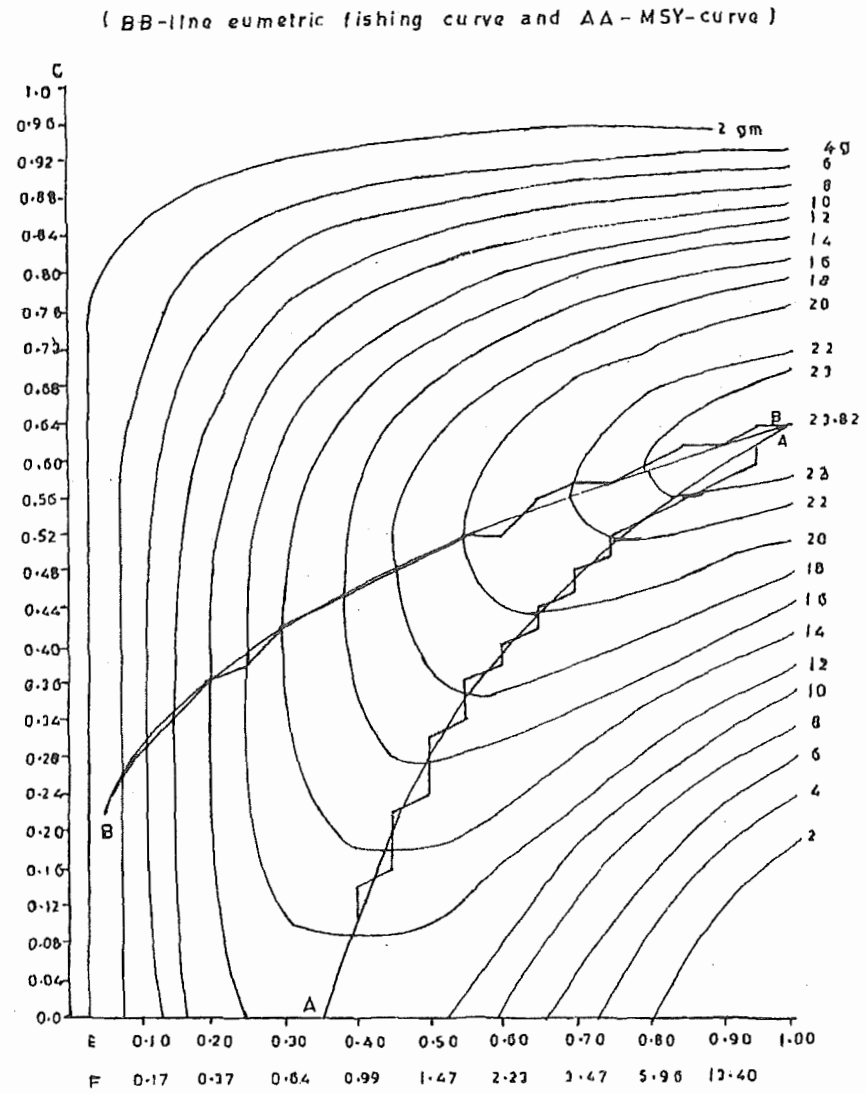

Fig. 2 : *Yield isopleth at 2g interval for J.glaucus in 1983-84*

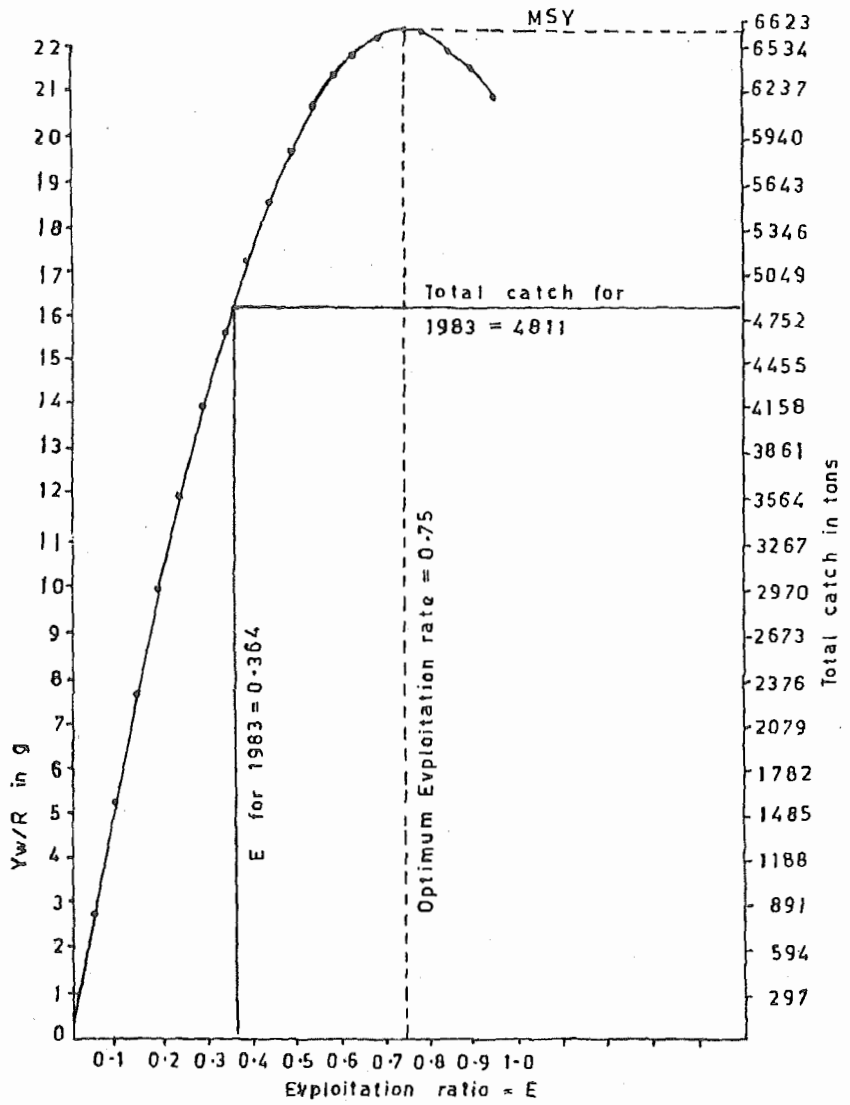

Fig. 3 : *Estimation of maximum sustainable yield (MSY) of J.glaucus for 1982-83 using Corten's method*

The studies indicated that *Johnius glaucus* (Day) stock off the northwest coast of India was grossly underexploited and to exploit the stock at optimum level the mesh size of the trawl net for *Johnius glaucus* exploitation is to be increased from 20 mm to 37 mm. As *Johnius glaucus* forms one of the major constituents of the bycatch of the shrimp trawlers operating off the northwest coast. majority of which was discarded at sea (during the period of study), underestimation of the species catch at the landing centres can not be ruled out. In order to encourage the fishermen to retain in their fishholds this and other species of the bycatch, development of new technologies for producing various value added products from this important low fat proteinacious food resource is suggested.

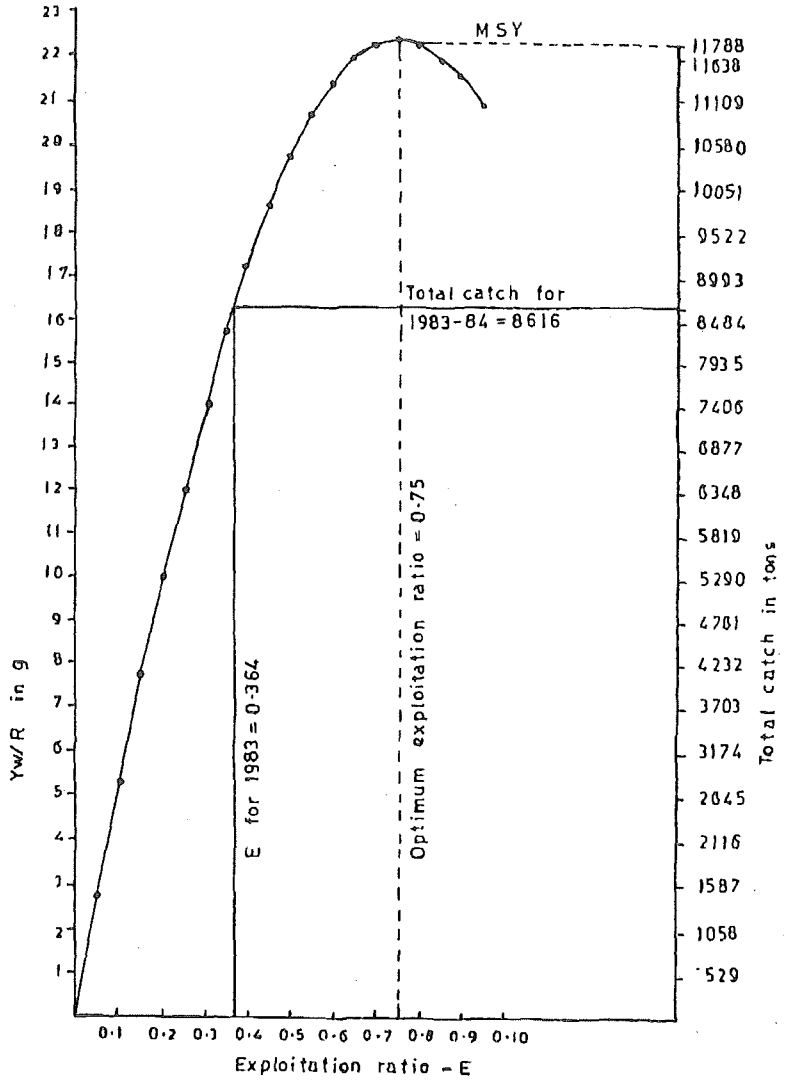

Fig 4 : *Estimation of maximum sustainable yield (MSY) of J.glaucus for 1983-84 using Corten's method*

ACKNOWLEDGEMENT

The authors are grateful to Dr.S.D. Tripathi, Director, CIFE, Mumbai for encouragement and the facilities provided.

REFERENCES

Beverton, R.J.H. and Holt, S.J. 1957. On the dynamics of exploited fish populations. *Fish. Invest. Lond. Ser.* (2) **19** : 533 pp.

Beverton, R.J.H. and Holt, S.J. 1966. Manual of Methods for Fish Stock Assessment. Part-2, Tables of Yield functions. *FAO Fish. Tech. Pap. Rev.* 1 : 1-67.

Chakraborty, Sushant. 1980. *A Study on the Sciaenids of Bombay Waters.* Ph.D. thesis. University of Bombay.

Corten, A. 1974. Recent changes in the stock of Celtic sea herring *(Clupea harengus L.). J. Cons.*

Perm. Int. Explor. Mer. **35** : 194-201.

Day, F. 1958. *The Fishes of India.* : William Dawson & Sons Ltd., London.

Devaraj, M. 1977. *The Biology of and Fishery for the Seerfishes of India.* Ph.D. Thesis. Madurai Kamaraj University, Madurai, India. 337 pp.

Devaraj, M. 1981. Age and growth of three species of seerfishes in India *(Scomberomorous commerson ; S. guttatus* and *S. lineolatus). Indian J. Fish.* **28** : 104-127.

Devaraj, M. 1993. Fish Population Dynamics. A course manual. *CIFE Bulletin,* **3**(10)83. Central Institute of Fisheries Education, Mumbai. India. 98 pp.

Gulati, Deepak. 1987. *Morphometry, Biology and Stock Assessment of Otolithus cuvieri (Trewavas, 1974) off the Bombay Coast.* M.Sc. Thesis. University of Bombay.

Gulland, J.A., 1969. Manual of Methods for Fish Stock Assessment. Part I. Fish population analysis. *FAO Fish. Tech. Paper.* **40** Rev.1.

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

Jayaprakash, A.A. 1978. Age and growth of juveniles of Koth *Otolithoides brunneus* (Day) in Bombay waters. *Indian J. Fish.* **23**: 86-96 (1976).

Krishnan Kutty, M. and Qasim, S.Z. 1968. The estimation of optimum age of exploitation and potential yield in fish populations. *J. Cons. Perm. Int. Expor. Mar.* **32** (2) : 249-255.

Murty, V.S. 1986. Growth and yield per recruit of *Johnius carutta* (Bloch) in the trawling grounds off Kakinada. *Indian J. Fish.* **33** : 163-170.

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

Pope, J.G. 1972. An Investigation of the accuracy of Virtual Population Analysis using Cohort analysis. *ICNAF Res. Bulletin.* **9** : 65-74.

Rao, K.V.S. 1970. Age and growth of "Ghol" *Pseudosciaena diacanthus* (Lacepede) in Bombay and Saurashtra waters. *Indian J. Fish.* **13** (1) : 251-292.

Rao, K.V.S. 1971. Estimates of mortality and yield per recruit of "Ghol" *Pseudosciaena diacanthus* (Lacepede). *Indian J. Fish.* **15**:88-98.