MULTI SPECIES ASSESSMENT OF FISH STOCKS OFF THE WESTERN SAHARA REGION WITH EMPHASIS ON THE FAMILY SPARIDAE

by
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Introduction

The Western Sahara region (21-26 °N) is well known for its intense upwelling and good fishing grounds. A large international fleet is operating in the area and the main target species are cephalopods. Large fish are taken as bycatch. About half of the fish caught belong to the family Sparidae.

Methods

In 1980, 1981 and 1982 the research vessel of the ISPM made a total of 8 cruises to the region (21-26° N, 0-100 meters depth), and this resulted in 434 trawling stations. The vessel has an overall length of 39 meters. A cephalopod trawl with a headline of 72 meters was used. The codend meshsize was 60 mm (stretched) and a 25 mm cover was always applied. Catches of net and cover have always been treated separately. Length/frequencies of Sparidae caught were always recorded.

The data of these cruises have been analyzed on the HP 9845B computer (56 Kbyte, Graphics ROM, Advanced Programming ROM) of which the peripherals were an 8 inch 500 Kbyte flexible disc (programs), a 10 Mbyte hard disc (files), a matrix printer and a plotter.

Data have been stored on disc with a package of programs, described in Mennes (1982).

For each cruise the captain's records, catch records and length/frequencies have been stored; Captain's records on CAPT files, each record (24 items) contains data such as date, depth, position, etc. Catch records are stored on BIOL files (4 items per record). A station always begins with one record with system information (station number, etc.) and thereafter a variable number of catch records follows: species code, total weight, total number and a number that indicates whether a length-frequency sample has been taken or not. Length-frequencies are stored on LEFR files (2 items per record). A station begins with 3 records that contain system information (station number, etc.) and a raising factor, to take into account any sub-sampling. Thereafter, a variable number of data pairs 'length, frequency' follows.

A fish codification system has been stored as a file, called FISHES and records contain a six digit code and a scientific name.

Some LINE files have been made, they contain digitalized map contours, such as the coastline and depthlines.

For each BIOL file a binary pointer table (POBI) has been made, and for each LEFR file one binary POLE pointer table and one pointer table in ordinary format (POLF). These pointers speed up data processing.

Data have been processed with programs, described in Mennes (1983).

Distribution of stations

Maps of the cruises have been prepared by program MAPSTA, which uses CAPT and LINE files.

Biomass estimate

For each species, the average catch per hour has been calculated, as well as the variance of the estimated

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mean catch per hour (Saville, 1977). The program BIOMAS, which works with the CAPT, BIOL and POBI files has been used. Depth stratification and stratification perpendicular to the coastline may be defined by the operator and various other selection criteria are implemented in the program. The results are presented on a printout and are summarized in Table 1. Combined with the towing speed, the wingspread of the net and the surface of the swept area, the Sparidae stock can be estimated at 217,000 tonnes, and all other fish at 245,000 tonnes.

Length/weight relationship

Programs LEWE01 (calculations) and LEWE02 (plot) have been used to obtain a optimal regression with a fixed power of 3. Length/weight data are entered manually and are log/log converted. The program calculates the correlation coefficient of two lines, one far above the cloud of dots, and one far below. Only the 'best' of the two lines is kept and the correlation coefficient of a new line, 'halfway' the first two lines, is calculated. The correlation coefficients of the two lines are compared. Through this 'binary search' a 'best' line with a fixed power of three can be found. The method has two advantages:

1) no 'tricks' are necessary later on, in the Beverton and Holt model,

2) only one parameter determines the curve, hence inter-species comparison is easy.

Selectivity

Program SELE01 (calculations) and SELE02 (plot) use the CAPT, BIOL and LEFR files, as well as the POBI, POLE and POLF pointers. Various selection criteria (cruises, depth limits, etc.) may be specified by the operator. Only stations that have length/frequencies in both the net and the cover are accepted. A length/total frequency array is built up in the memory and the frequencies are converted to 'logits'. The operator may define an upper and lower limit for linear regression, which is applied on the length/logit array and the result is re-converted to length/percentage retained. The method is described in Pope (1975). An example is given in Figure 1.

Growth

Program LFTIME has been used to prepare plots of length-frequency distributions, as shown in Figure 2. The program works with the CAPT, LEFR, POLE and POLF files and allows the operator to select on various parameters (which cruises, etc.). The subjectively estimated modes can be used to estimate growth. It is assumed that there has been constant growth in time, and thus modes of different years have been combined. Program vonBER uses the von Bertalanffy growth curve and allows the user to enter data pairs: time, length, where the time is the year in the decimal system, as given in Figure 2. The program requires the entry of the maximum length and estimates of t_0 and K, as start values. Both t_0 and K are varied and the sum of the differences between the calculated length minus the observed length is minimized. An example is given in Figure 3. The first version of vonBER varied the maximum length (L_∞) as well, but because of the intense fishing in the region no large specimens were available and the first estimates of growth resulted in non-realistic values for L_∞. It has been decided to adapt vonBER and to take L_∞ from the literature.

Mortality

The natural mortality has been estimated with the formula of Pauly (1983). Total mortality has been estimated with program CATCUR, which uses the CAPT, LEFR, POLE and POLF files. Again, various selection criteria may be specified by the operator. A total length-frequency array is built up in the memory and a length-to-age converted catch curve is prepared. The method is described by Pauly (1983). The program accepts two time limits for the linear regression. This in order to allow rejection of the left part (incomplete recruitment) and the right

Table 1. Stratified mean catch per hour and the 95% confidence limits, per species(-group).

Taxonomic group	kgs/hr	%
Dentex	1.484	108
Dentex dentex	0.215	86
Dentex gibbosus	1.768	44
Dentex canariensis	4.351	50
Dentex macrophthalmus	1.756	91
Dentex maroccanus	2.553	71
Spondyliosoma cantharus	1.809	31
Pagellus	0.001	0
Pagellus centrodontus	11.217	91
Pagellus erythrinus	15.403	38
Pagellus acarne	20.383	24
Pagellus bellottii	38.508	21
Lithognathus mormyrus	0.361	128
Lithognathus aureti	0.006	0
Pagrus	0.005	0
Pagrus pagrus	0.444	83
Sparus auriga	1.214	46
Sparus aurata	0.970	64
Sparus coeruleostictus	0.161	109
Boops boops	1.362	44
Sarpa salpa	0.082	76
Puntazzo puntazzo	0.111	56
Diplodus annularis	0.047	132
Diplodus bellottii	27.149	27
Diplodus vulgaris	6.457	49
Diplodus sargus	0.698	49
Diplodus cervinus	0.248	106
Oblada melanura	0.028	221
Sub-total (Sparidae)	138.791	
Sharks	13.716	34
Rays	7.209	28
Serranidae	0.673	58
Pomadasyidae (small)	8.630	38
Pomadasyidae (big)	14.928	83
Sciaenidae (small)	5.378	59
Sciaenidae (big)	2.403	54
Trachurus	31.791	38
Mullus	0.666	47
Trachinidae	5.169	18
Uranoscopus/Halobatrachus	1.943	68
Balistes	0.007	1252
Scomber	4.566	60
Lepidopus/Trichiurus	1.202	72
Triglidae	6.364	21
Tetraodon	3.844	72
Murene	0.351	53
Conger	5.488	50
Zeus faber	6.990	34
Flatfish	4.291	17
Sardine	16.048	42
Pelagic small mixed	0.405	94
Alosa	0.140	183
Anchois	1.285	141
Macrorhamphosus	1.102	167
Pelagic big mixed	0.326	85
Scorpaena	0.692	73
Demersal small mixed	0.498	65
Merlu	1.111	61
Lophius	0.871	72
Others	8.382	70
Sub-total (non-Sparidae)	157.169	
Total	295.960	

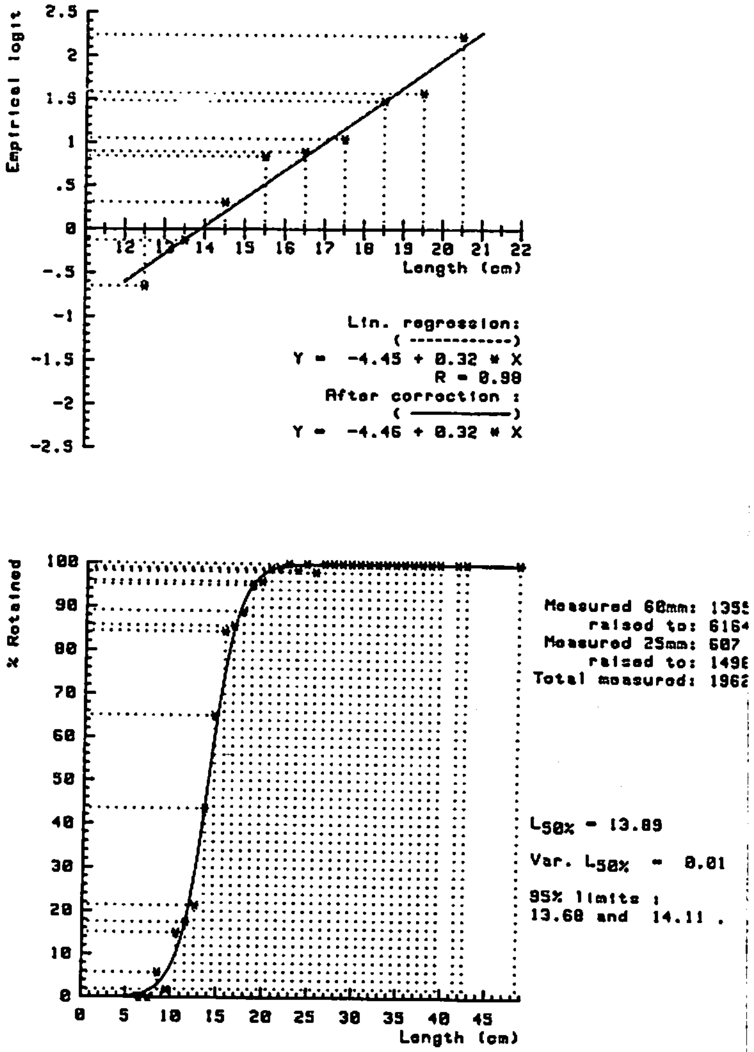

Fig. 1. Sample output of selectivity analysis.

Species: Pagellus erythrinus. Cruises: March 1980 till November 1982. Limits: 20 and 98 percent. Casablanca, 9.8.83.

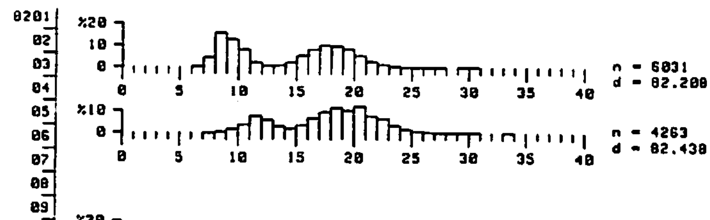

Fig. 2. Sample output of length-frequency data.

Species: Pagellus bellottii. Cruises: March 1982 till November 1982. Casablanca, 2.8.83.

part (low number of fish) of the plot. The result is given in Figure 4.

Beverton and Holt model

Programs YIELD1 (screen) and YIELD2 (plotter) have been used. The operator may define the scales of the fishing mortality axis and the age at first capture axis, and is requested to enter the natural mortality, the maximum weight, K, t_0 and the age at first recruitment (tr). The latter has been estimated using the lowest length observed in the plots of program LFTIME. The value of t_0 has always been assumed to be zero. Furthermore, the program needs as inputs various values of yield per recruit: these will be the isopleths which are to be drawn. The resolution may also be defined. For tryouts on the screen, low resolution is used, whilst the final result is prepared with high resolution. This is because a high resolution plot may take up to one hour processing time. An example of a plot is given in Figure 5, in which the resolution was 500.

Basically, in this method, the scaled area is divided into a number of intervals (this depends on the resolution). Then, for each isopleth, the program scans the sides of the plotting area and calculates for each interval two times the yield per recruit (Y/R). If a data pair is found with the first Y/R lower, and the second Y/R higher than the selected isopleth, the start point of the isopleth is found. Thereafter, the program follows the isopleth. For each interval, it calculates four times a Y/R value (for four points in a square), adjusts itself each time for the various values found and advances one interval step, until a side of the plotting area is reached.

Eleven plots were prepared, of which 10 showed 'overfishing'.

Multi-species Beverton and Holt model

To allow for 'addition' of several species, programs MULTI1/MULTI2 have as scales relative fishing effort (RFE percentage) and codend meshsize (MS, mm). A linear relationship between RFE and fishing mortality has been assumed. For each species F can be calculated corresponding to a certain level of RFE: F = AF x RFE / 100 where AF = the actual F of Table 2. Also a linear relationship has been assumed between MS and the length at which 50% of the fish are retained (L_c). For each species, L_c can be calculated corresponding to a certain level of MS: $L_c = AL_c \times MS / 60$ where AL_c = the actual L_c of Table 2. It is assumed that the actual codend meshsize used in the fishery also equals 60 mm. To account for various levels of recruitment, a relative index of recruitment has been included in the model, equal to the average number of fish caught per hour multiplied by the total mortality. This index was used as a weighting factor while summing the yield per recruit for each species. The results are isopleths similar to Figure 5, applicable to several species.

Conclusions

The Sparidae stock is 'overfished'. If the objective is to optimize the output of the system, expressed in weight of Sparidae, then a codend meshsize of 90 mm, a reduction of fishing effort by 60% to 40%, or a combination of these two should be advised.

And more ....

A Pella and Thomlinson production model has been applied on catch/effort data given in FAO (1979) and FAO (1982). Program GPM has been used. The result shows that a reduction of fishing effort by 70% to 30% corresponds to the MSY.

Length cohort analysis (Jones, 1981) has been undertaken, using program COHORT (iterative method, with plot). The results show that recruitment overfishing does not take place. Seasonal closure will probably not be the solution.

When population parameters of the main target species (*Octopus vulgaris*, *Sepia officinalis* and *Loligo vulgaris*) are included in the model, as well as market values for all species, the plot

Table 2. Some population-dynamic parameters. Symbols are as follows:

- a — factor in $W = a \cdot L^3$, used in calculation of maximum weight
- W_∞ — maximum weight in grams
- L_∞ — maximum fork length in centimeters
- K — growth coefficient of von Bertalanffy curve (annual basis)
- L_c — fork length (cm) at which 50% of the fish will be retained (net selectivity, 60 mm)
- t_c — relative age (years) of L_c
- M — natural mortality
- Z — total mortality
- F — fishing mortality
- E — exploitation rate
- L_r — fork length (cm) at first recruitment
- t_r — relative age (years) of L_r

Species	a	W_∞	L_∞	K	L_c	t_c	M	Z	F	E	L_r	t_r
Boops boops	0.0145	475	32	0.29	13.89	1.96	0.57	2.80	2.23	0.80	4.50	0.52
Dentex gibbosus	0.0173	11,004	86	0.19	11.55	0.76	0.32	1.15	0.83	0.72	5.50	0.35
Dentex macrophthalmus	0.0210	3,889	57	0.25	10.64	0.83	0.44	2.10	1.66	0.79	4.50	0.33
Dentex maroccanus	0.0211	1,252	39	0.23	12.08	1.61	0.46	2.33	1.87	0.80	4.50	0.53
Dentex canariensis	0.0223	13,695	85	0.15	14.04	1.20	0.28	2.58	2.30	0.89	7.50	0.62
Dipldus vulgaris	0.0240	1,424	39	0.40	11.28	0.85	0.66	2.11	1.15	0.69	7.50	0.53
Diplodus bellottii	0.0308	541	26	0.27	11.28	2.11	0.57	2.14	1.57	0.73	3.50	0.54
Pagellus erythrinus	0.0206	2,733	51	0.24	13.89	1.32	0.43	1.20	0.77	0.64	5.50	0.48
Pagellus acarne	0.0204	608	31	0.21	13.89	2.83	0.46	0.88	0.42	0.48	3.50	0.57
Pagellus bellottii	0.0192	896	36	0.38	13.39	1.22	0.65	2.18	1.53	0.70	3.50	0.27
Spondyliosoma cantharus	0.0211	2,967	52	0.30	12.79	0.94	0.50	2.38	1.88	0.79	3.50	0.23

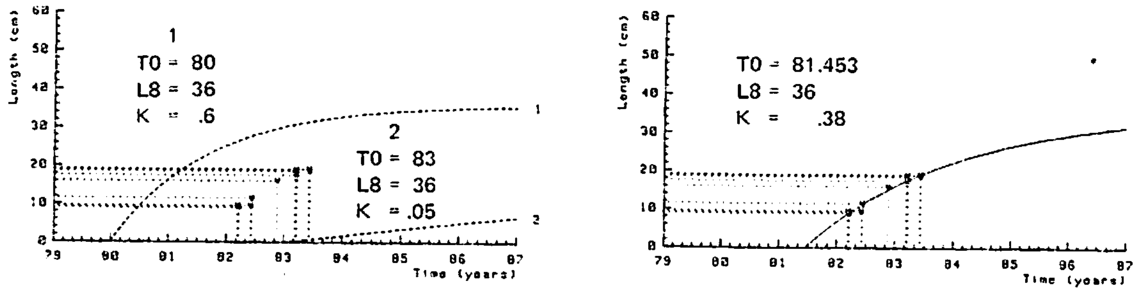

Fig. 3. Sample output of growth analysis program. Species: Pagellus bellottii. Data based on results of plot of program LFTIME for the cruises: March 1980 till November 1982. Casablanca, 5.10.83.

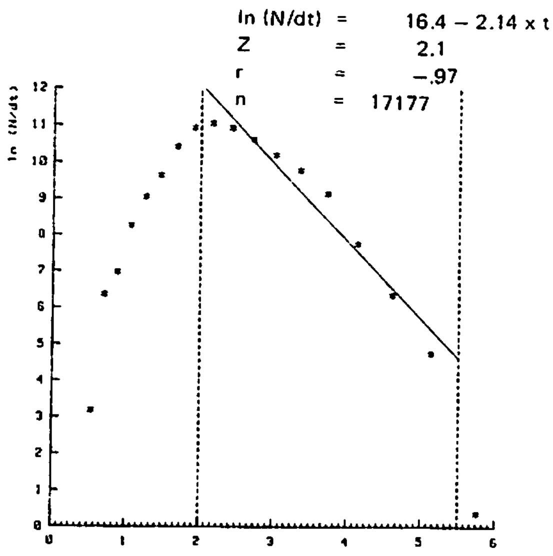

Fig. 4. Length-converted catch curve and mortality estimates generated by program CATCUA. Species: Diplodus bellottii. Cruises: March 1980 till November 1982. K = 0.27, infinitive length = 26 cm. Limits set to 2 and 5.5 years. Casablanca, 6.9.83.

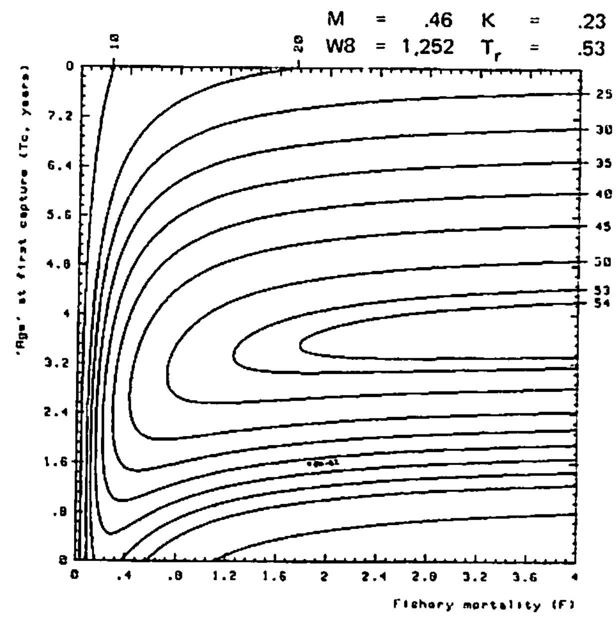

Fig. 5. Yield isopleth diagram for a single species. Species: Dentex maroccanus. Yield per recruit indicated at top or right side of the plot, in grams. Casablanca, 5.10.84. (plot revised)

shows that the yield per recruit, expressed in US dollars, will optimize at a mesh size of 125 mm or at 60% of the present effort.

The complete stock assessment has been repeated for the 1981-82-83 data. Comparison between 1980-81-82 and 1981-82-83 indicates that fishing effort appears to have increased, as well as 'overfishing'.

For the three main species, Diplodus bellottii, Pagellus bellottii and P. acarne the catch in numbers per hour decreases in time, whilst the total mortality increases.

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Note for programmers: Listings and users' instructions written by Mr. Mennes for all of the programs mentioned above can be obtained from ICLARM, by writing to the Network Secretary (address on p.1). Please use your judgement before making a request as the full set amounts to 231 pages. i.e. serious users only please!

PRELIMINARY LENGTH-BASED GROWTH PARAMETER ESTIMATES OF PERUVIAN SARDINE *(SARDINOPS SAGAX SAGAX)*

by

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Introduction

The Peruvian sardine (Sardinops sagax sagax) is one of the most important fish species caught off Peru. Its landings increased after the decline of the anchoveta (Engraulis ringens) landings (Fig. 1). With the increase of sardine landings interest about the state of the stock also increased.

Stock assessments of sardine until today have been based mainly on biomass estimations by means of acoustic surveys. Also, staff at IMARPE (Instituto del Mar del Perú) have attempted to apply Virtual Population Analysis for comparison of stock estimates with those obtained through acoustic methods and to obtain more information about the population structure of the sardine stock. Because growth is one of the most important aspects of fish biology population dynamics and because we observed differences between the estimates of growth parameters derived by several authors, we present here an attempt to obtain growth parameter estimates using the ELEFAN I program for the analysis of length frequency data.