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ASSESSMENT OF THE LIZARD FISH SAURIDA UNDOSQUAMIS (RICHARDSON) FISHERY IN THE GULF OF SUEZ, RED SEA.

BY

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ABSTRACT

This paper gives an overview of the lizard fish saurida undosquamis (Richardson) fishery in the Gulf of Suez. It highlights the results of the application of two surplus production models, to assess the state of the lizard fish fishery and to improve its management. A time series of catch and effort data set (1979- 2001) were analyzed according to the computer program PRODFIT (Fox 1975) and the non-equilibrium production model (Prager 1994) as implemented in the ASPIC computer program (Prager 1995). Estimates of maximum sustainable yield (MSY) from PRODFIT and ASPIC ranged between 1007.45 ton and 1391.00 ton, respectively. The estimated effort associated with maximum sustainable yield (f_{MSY}) from the two applied models ranged between 8716 and 9013 annual fishing days. Both methods of surplus production modeling agree that the stock of the lizard fish saurida undosquamis in the Gulf of Suez is overexploited.

INTRODUCTION

Lizard fishes are a group of fishes widely distributed in tropical waters. They represent one of the most economically and commercially important fish groups in the Gulf of Suez, Red Sea. *Saurida undosquamis* (Richardson) constitutes the principal species of the lizard fishes recorded in the Gulf of Suez, and contributes by about 40% of the annual total landings of the trawl fishery. The most frequented fishing grounds within the Gulf of Suez appear to be in the northern half of the Gulf where *S. undosquamis* are caught from all the fishing areas. *Saurida undosquamis* is an intermittent spawner with prolonged spawning season extending from January through June (El-Ganainy 1992). Although the lizard fishes are subject to an extensive trawl fishery in the Gulf of Suez, studies on the state of the lizard fish *S. undosquamis* fishery are scarce limited to some biological and dynamical aspects (Sanders and Kedidi 1984 and El-Ganainy 1992).

The purpose of this paper is to re-evaluate the status of the lizard fish *S. undosquamis* using biological reference values from surplus production models PRODFIT (Fox 1975) and ASPIC (Prager 1995) for the proper management of its resource in the Gulf of Suez.

MATERIALS AND METHODS

The data used (Table 1) are the annual lizard fish landings and annual fishing effort in units of average annual number of fishing days in the period from 1979/1980 through 2000/2001. The monthly catch statistics are obtained from the office of the Egyptian General Authority for Fish Resources Development, from the fishing season 1982/1983 to 2000/2001, while the data for fishing seasons 1979/1980 to 1981/1982 were taken after Sanders and Kedidi (1984a).

Production Models

Two varieties of surplus production models were used to analyze the data of lizard fishes in the Gulf of Suez. The computer program PRODFIT (Fox 1975), which attempts to account for non-equilibrium conditions through a smoothing process, was used to estimate the maximum sustainable yield (MSY) and its corresponding fishing effort (f_{opt}) for the Pella-Tomlinson generalized stock production model (Pella and Tomlinson 1969) by least squares and equilibrium approximation:

$$U = (a + bf)^{1/m-1} \qquad (1)$$

Where U is the catch per unit effort, f is the fishing effort, and a, b and m are constant parameters.

The management implications of the generalized stock production model are computed as:-

$$U_{opt} = (a/m)^{1/m-1}, \; f_{opt} = (a/b)\,(1/m-1) \text{ and } Y_{max} = (a/b)\,(1/m-1)\,(a/m)^{1/m-1}.$$

Where U_{opt} is the relative population density providing the MSY; f_{opt} is the amount of fishing effort to obtain the MSY; and Y_{max} is the MSY.

Since catch and effort data usually do not represent equilibrium conditions as required by equation (1), the fishing effort was adjusted to approximate equilibrium conditions by computing a weighted average of the fishing effort (Fox 1975). The equilibrium approximation method was firstly devised by Gulland (1969).

The second production modeling approach was the non-equilibrium surplus production model described by Prager (1994) and implemented in the ASPIC computer program (Prager 1995). This is an extension of the Schaefer (1954, 1957) model and uses a fitting procedure similar to that developed by Pella (1967), later used by Pella and Tomlinson (1969) in their GENPROD computer program, and recently termed the "time-series method" by Hilborn and Walters (1992). The basic model is derived by postulating that the time rate of surplus biomass production (the excess of growth and recruitment over natural mortality) can be represented by the differential equation

$$dB_t/dt = (r - F_t)B_t - r/K\, B_t^2$$

Where B_t is the population biomass at time t, F_t is the corresponding rate of fishing mortality, r is a constant model parameter often considered the population's intrinsic rate of increase, and K is a constant model parameter often considered the carrying capacity of the environment (maximum population size). Details of the model development are described in Prager (1994, 1995 and 1996). However, the management benchmarks derived from the model are computed as:

$$\text{MSY} = rK/4,\ B_{\text{MSY}} = K/2,\ F_{\text{MSY}} = r/2 \text{ and } f_{\text{MSY}} = r/2q$$

Where B_{MSY} is the stock biomass at MSY; F_{MSY} is the fishing mortality at MSY; f_{MSY} is the fishing effort at MSY and q is the catchability coefficient by fishery.

RESULTS

For fitting the surplus production models for lizard fish *S. undosquamis* in the Gulf of Suez the population abundance were represented by the catch per unit effort (CPUE) under the assumption that CPUE is proportional to abundance, where the fishing effort were measured by the annual average number of fishing days (Table 1). The lizard fish fishery in the Gulf of Suez showed a high catch rate in the fishing season 1982/1983 (Fig. 1). The catch relatively declined in 1989/1990 and 1990/1991, but has declined precipitously in the fishing season 1993/1994. However, the catch peaked in the fishing season 1986/1987 with 2721 t., while the fishing effort showed a general trend of increase during the period of investigation. Most recently the catch of lizard fishes fluctuated between 772.00 and 1110.66 t. in 1995/1996 through 2000/2001, with relatively high fishing effort fluctuated between 13923 and 15164 fishing days.

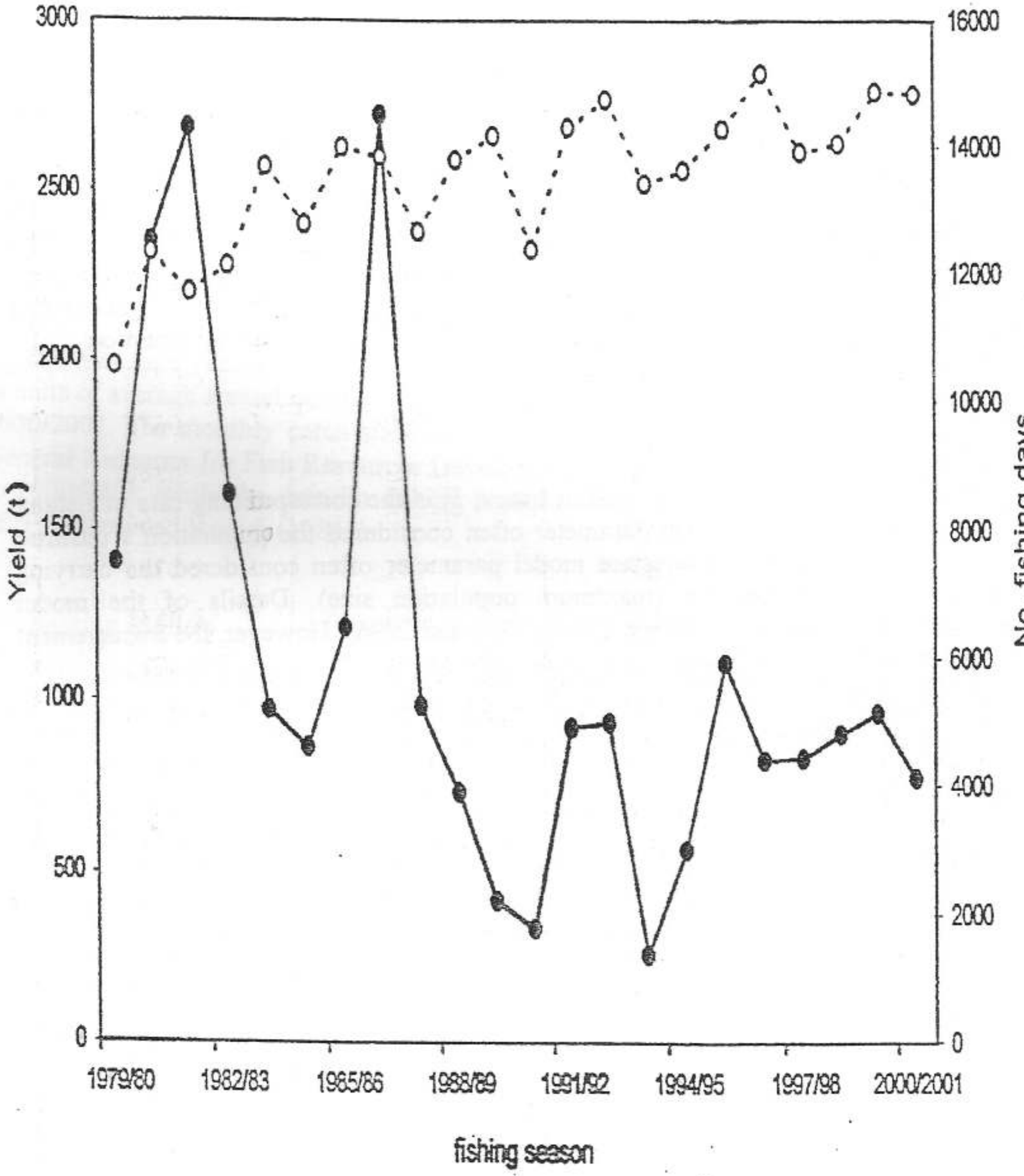


Fig. 1 : Catch and fishing effort data of *S. undosquamis* in the Gulf of Suez, used for fitting surplus production models.

Table 1 : Seasonal catch, effort (Number of fishing days) and catch per unit Effort of lizard fishes from the Gulf of Suez.

Fishing season	Total landings (ton)	Fishing effort (№. Fishing days)	Catch per fishing effort (CPUE)
1979/1980	1405.700	10563	0.1331
1980/1981	2349.700	12352	0.1903
1981/1982	2682.600	11733	0.2287
1982/1983	1601.950	12139	0.1320
1983/1984	972.032	13690	0.0710
1984/1985	863.820	12790	0.0675
1985/1986	1216.141	14003	0.0868
1986/1987	2720.792	13852	0.1964
1987/1988	984.200	12685	0.0775
1988/1989	731.850	13793	0.0531
1989/1990	414.090	14171	0.0921
1990/1991	333.061	12394	0.0269
1991/1992	922.500	14309	0.0644
1992/1993	936.290	14763	0.0634
1993/1994	259.460	13438	0.0193
1994/1995	563.920	13634	0.0414
1995/1996	1110.660	14280	0.0778
1996/1997	825.040	15164	0.0544
1997/1998	830.540	13923	0.0596
1998/1999	901.020	14051	0.0641
1999/2000	962.000	14866	0.0647
2000/2001	772.000	14832	0.0521

In using PRODFIT, the reported catch and effort were used. The estimated parameters and associated square root of the variability index (Fox 1975) are given in Table (2). The average number of fishing days (13519) exerted in the Gulf of Suez during the study period from 1979/1980 to 2000/2001 exceeded the estimated f_{opt} = 8716 fishing day/season by about 35.5 %, and the estimated maximum sustainable yield (MSY = 1007 t.) exceeded the recorded catch in the fishing seasons 1987/1988 to 2000/2001 (Fig. 2).

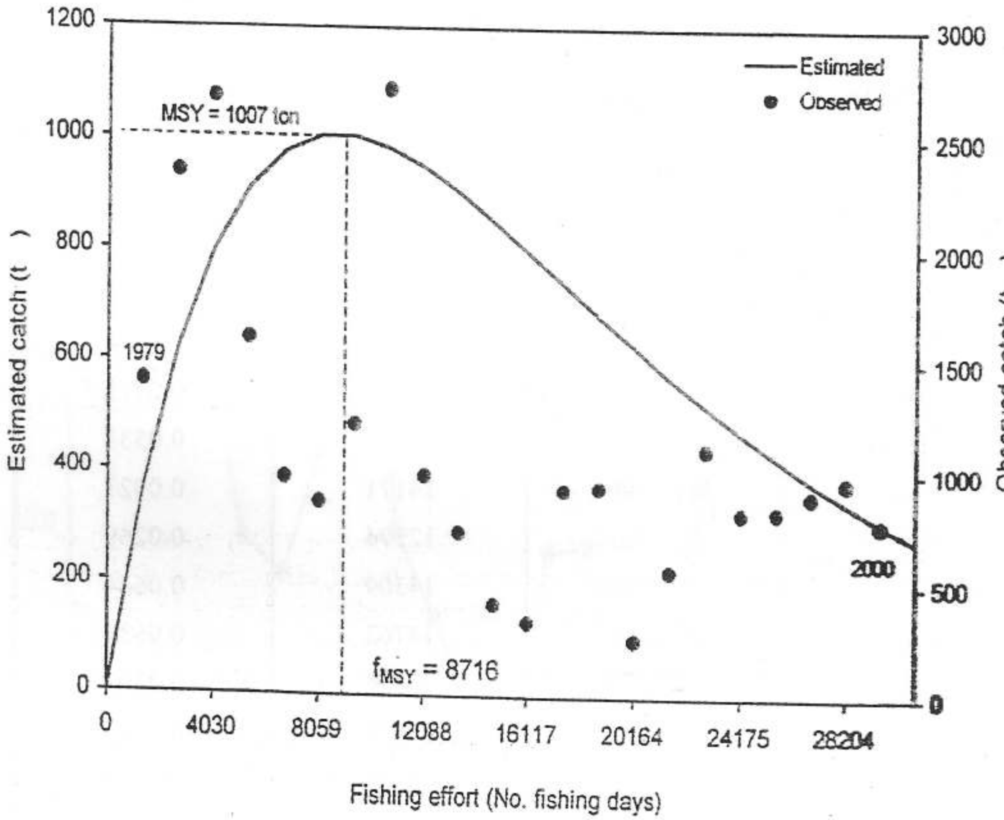


Fig. 2 : Generalized surplus production model (PRODFIT) for lizard fish *S. undosquamis* using catch and effort data for the period 1979/80 to 2000/2001.

Table 2 : Result of the generalized stock production model (PRODFIT)
For the lizard fish *S. undosquamis* in the Gulf of Suez.
The estimated parameters is θ.

Parameter estimated	θ	Variability index square root
a	0.9988420	0.002134
b	-0.0000014	0.000561
m	0.10010000	0.000000
C/f_{opt}	0.115590	0.060975
f_{opt}	8715.63	13495.63
MSY	1007.45	699.06
q	0.000152	
optimum population size*	7589.05	

*Arithmetic mean

In respect to the non-equilibrium production model (Prager 1994) the ASPIC run for lizard fishes in the Gulf of Suez used the same catch and effort series. A maximum sustainable yield of 1391 t. was estimated to be produced by a biomass (B_{MSY}) of 3750 t. at a fishing mortality (F_{MSY}) of 0.371. The results also indicate that the yield of the lizard fishes have been below the estimated surplus production since 1983/1984.

Bootstrap analysis indicate that MSY and f_{MSY} were estimated with relatively high precision (Table 3) where the relative interquartile range, IQR = 13.1% and 21.6% respectively, and B_{MSY} (IQR = 42.2%) and F_{MSY} (IQR = 28.6%) were estimated with moderate precision. Prager (1994) in applying the ASPIC for the North Atlantic swordfish indicated that the IQR was smallest in MSY and f_{MSY}, the benchmarks that do not depend on (q), while estimates of the quantities that depend on (q) and that thus involve absolute scaling, exhibited relative IQ range of about 50%. Table (3) shows that the bias-corrected estimates (θ_{BC}) are very close to the point estimates (θ), also the approximate 80% nonparametric confidence intervals derived from the bootstrap for all the estimated parameters are given. The reliability of the results were tested by the nearness and coverage indices (N and C) proposed by Prager (1996) where, the estimated N = 1.00 and C = 1.155 suggested a relatively reliable results.

Table 3 : Result of the bootstrapped production model analysis (ASPIC) for the For the lizard fish *S. undosquamis* in the Gulf.of Suez. Each convential parameter is θ, the corresponding biascorrected estimate is θ_{BC} with the 80% confidence intervals.

Estimated parameters	θ	θ_{BC}	80% lower CL	80% upper CL	Relative IQ range
Management benchmarks					
MSY	1391	1390	931	1525	13.10%
F_{MSY}	0.371	0.371	0.1901	0.4351	28.60%
f_{MSY}	9013	8963	7549	12540	21.60%
B_{MSY}	3750	3802	3322	30440	42.20%
$F_{0.1}$	0.3339	0.3339	0.1711	0.3916	28.60%
$Y_{0.1}$	1377	1376	921.6	1509	13.10%
$f_{0.1}$	8112	8066	6794	11290	21.60%
B_{2001}/B_{MSY}	0.3651	0.3489	0.1352	0.8071	24.00%
F_{2000}/F_{MSY}	1.546	1.601	0.8564	3.101	28.20%
Directly estimated parameters					
r	0.742	0.742	0.3802	0.8703	28.60%
q	0.00004116	0.00004149	0.00001914	0.00005083	31.90%
K	7500	7605	6644	60890	42.20%

The catchability coefficient for the fishery of the lizard fish *S. undosqumis* in the Gulf of Suez estimated from the generalized stock production model PRODFIT ($q = 0.000152$) is higher than that estimated from ASPIC ($q = 0.0000412$), while the maximum population size (K) estimated from the two models is in close agreement ($K = 7589$ and 7500 ton respectively).

The observed and estimated catch per unit effort (Fig. 3) show a trend of general decline. However, the estimated CPUE from ASPIC show a relatively high relative abundance in the fishing seasons 1979/1980 and 1985/1986, while the observed CPUE show relative increase in 1981/1982 and 1986/1987. However, the model fits the effort data reasonably well.

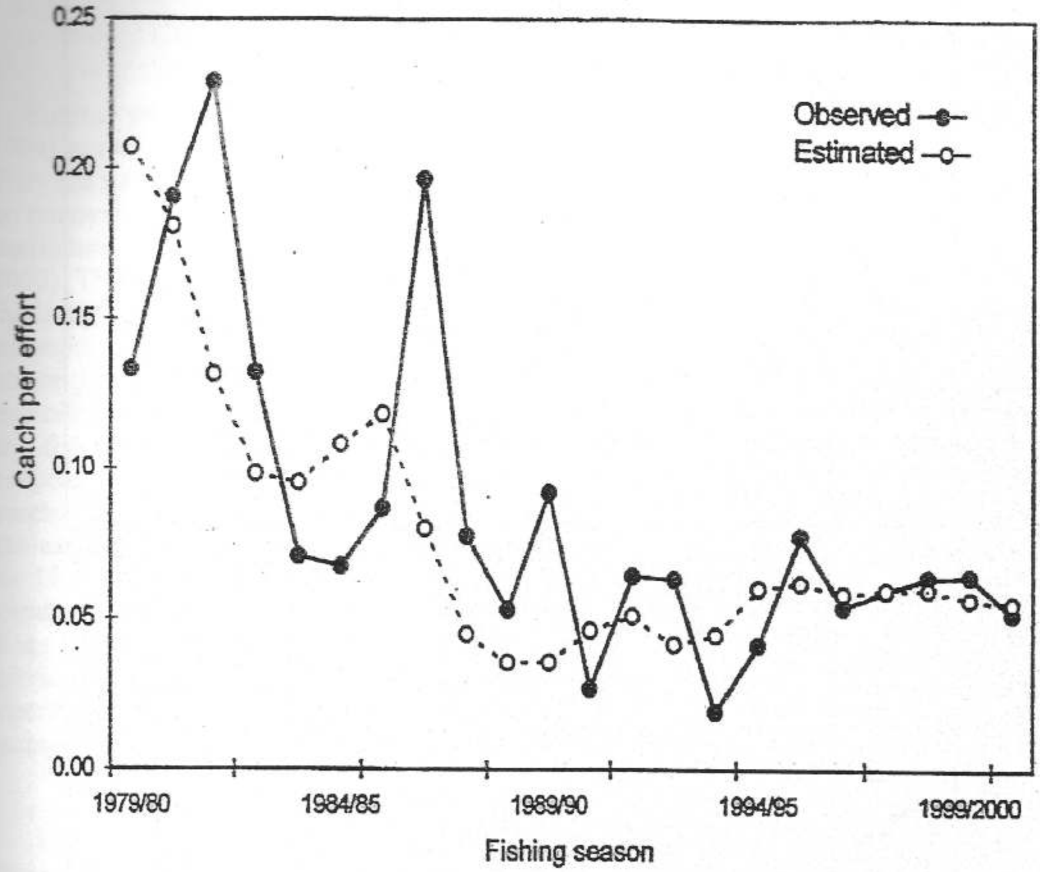
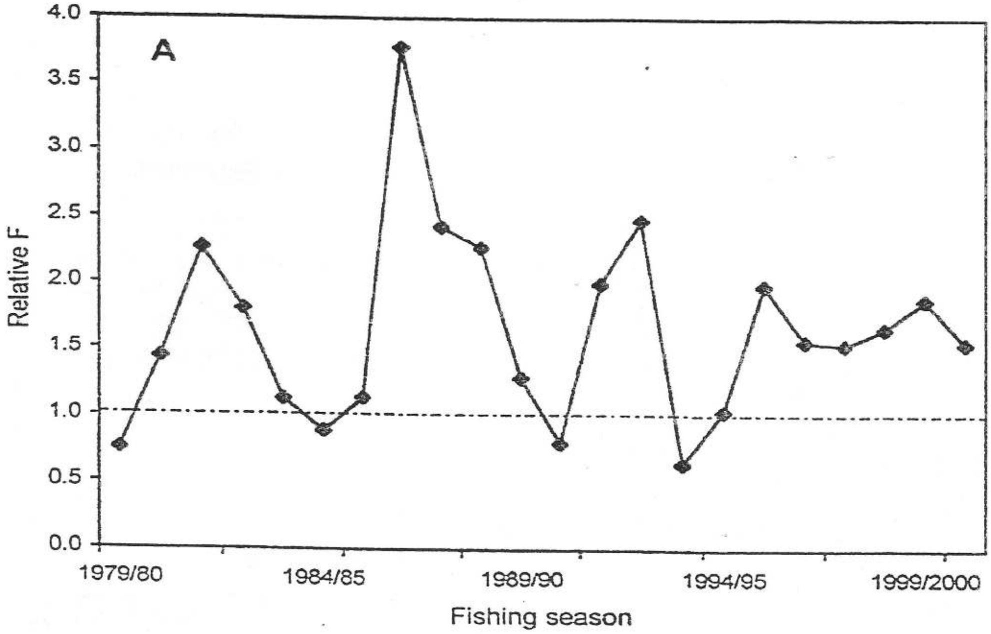


Fig. 3 : Observed and estimated catch per unit effort for *S. undosquamis* as estimated from ASPIC production model.

A plot of the annual fishing mortality rate relative to the fishing mortality rate that produces MSY when the stock is at B_{MSY} is shown in Figure 4A, while a plot of population biomass relative that population biomass producing MSY is shown in Figure 4B. If relative biomass (B/B_{MSY}) is below 1, the stock is depressed (whether from natural phenomena or over-fishing) and cannot provide MSY; if the relative F (F/F_{MSY}) is above 1, the rate of fishing mortality is above that which can provide MSY, and if continued through time will result in a stock size below B_{MSY} (Vaughan *et al* 2000). The relative F (Fig. 4A) was significantly above 1 in most of the fishing seasons, it was below 1 in 1979/1980, 1984/1985, 1990/1991 and 1993/1994, while the relative biomass was significantly below 1 in almost all the fishing seasons except the first three ones. This is an obvious indication of the serious depression of the lizard fish stock in the Gulf of Suez. The current level of the stock as represented by the ratio B_{2001}/B_{MSY} (Table 3) supports this indication. It also shows that the recent fishing mortality rate, as represented by the ratio $F_{2000}/F_{MSY} = 1.546$, is very high.



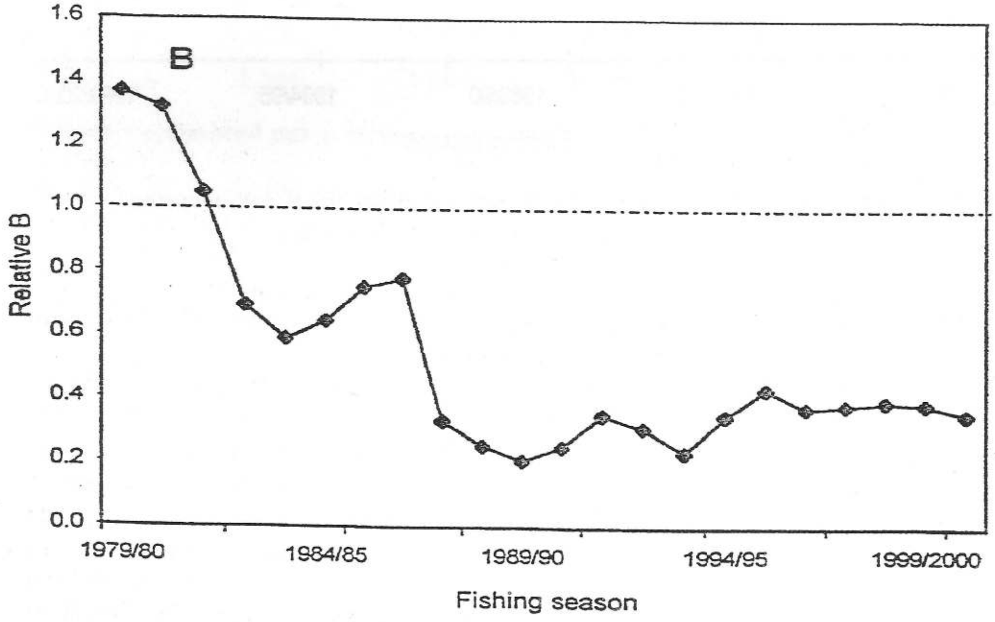


Fig. 4 : Plots of (A) relative fishing mortality (F/F_{MSY}) and (B) relative biomass (B/B_{MSY}) from ASPIC production model for *S. undosquamis* in the Gulf of Suez.

DISCUSSION

Surplus production models (Schaefer 1954, 1957; Pella 1967; Fox 1970; Prager 1994) are of great importance for fish stock assessments and fisheries management. They are simple and require relatively limited data. Surplus production models use data on removals from the stock and relative abundance through time to obtain estimates of maximum sustainable yield (MSY) and related benchmarks (Vaughan, Smith & Prager 2000). The results of the two applied surplus production models agree that the stock of the lizard fish *S. undosquamis* in the Gulf of Suez is overexploited and needs an urgent management regulation. Sanders and Kedidi (1984) in a study based on data for a single season (1981/1982) stated that the lizard fish stock within the Gulf of Suez is fully exploited, this is based on the yield per recruit analysis, which showed that increasing the fishing effort by 50% would generate only about 10% additional catch and a reduction of about 25% in fishing effort would result only an eight percent reduction in catch. El-Ganainy (1992) applied the surplus production model of Schaefer (1954) on the catch and effort data of the lizard fish in the Gulf of Suez, and estimated the MSY as 1822 ton corresponding to an optimum effort of 10501 fishing day. The average catch of lizard fishes during the period of that study from 1979/1980 to 1986/1987 have been 1726.6 ton while, the mean annual fishing effort have been 12640 fishing day. It is obvious that the present average annual catch (1107 ton) from 1979/1980 to 2000/2001 decreased while the average fishing effort (13519 fishing days) increased, and in consequence the current MSY and its associated f_{MSY} decreased.

In General, the results indicate that the stock of lizard fish within the Gulf of Suez is heavily exploited and the population appears to be in serious situation of over-fishing. The Annual production is below MSY while fishing effort, exceeded f_{MSY} by about 33 to 35% of its value. The fleet size is stable but the efficiency of vessels is in general increase, since the horsepower of the operating vessels during the 1980s ranged between 120 and 430 hp. with an average of 300 hp., during the 1990s it ranged between 120 to 520 hp with an average of 420 hp. and in 2000/ 2001 the mean horsepower of the trawl vessels reached 460 hp. (Table 4).

For improving and developing the production of lizard fish *S. undosquamis* in the Gulf of Suez some implications for the fishery management can be applied. The fishing effort measured in number of fishing days should be decreased by about 35% of its current value. This can be achieved by fixing the fishing trip duration to 7 days through all the fishing season. Meanwhile, the species should be protected during part of its life-cycle by the periodic prohibition of fishing in the spawning and nursery grounds. This may be achieved through the establishment of certain reserves in the Gulf of Suez to protect the spawning stock biomass, and then monitoring their effects as a management strategy. In this context, a map for the spawning and nursery grounds of lizard fishes in the Gulf of Suez should be prepared on the basis of sound biological research.

Unfortunately decreasing the number of fishing days and closing some fishing areas can have negative impacts on fishermen and vessel profitability. Thus, it is necessary to encounter the social problems of fishermen in order to develop and manage the fishery. Finally, no more fishing units should be licensed to operate within the Gulf of Suez and the increase in fishing efficiency (such as increasing the horsepower or changing the gear characteristics) should be forbidden.

Table 4 : Variations of the trawl vessels horsepower in the Gulf of Suez During the period from 1985 to 2002.

Range of hp.	1985 - 1990	1990 - 1999	2000 / 2001	2001 / 2002
	Number of vessels			
100 – 150	1	1	1	1
150 – 200	2	2	2	1
200 – 250	24	5	5	3
250 – 300	9	1	1	
300 – 400	27	9	9	5
400 – 500	15	53	53	62
500 - 600		7	7	6

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