Fishing Mortality and Abundance of the Silver croaker, *Otolithes argenteus* in the Kuwait's Waters

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The virtual population analysis technique was applied to the silver croaker, *Otolithes argenteus,* stock based on length frequency composition, age-length key and nominal catches taken by the trawl fleet and fixed-stake nets in the Kuwait's waters during 1981~1988.

One-year-old fish was dominant, whereas three-year-old and older fish were at a very low level. Fishing mortality was much higher in the age groups of 2 and 3 than in the others. A strong year-class occurred in 1980 and 1981. Population size of fishable stock markedly decreased from 1982 to 1985 and remained at a low level during 1986~1987. The effects of changes in fishing effort showed that an increase in fishing effort would not lead to benefits in yield and would comprise more young and fewer old fish, whereas a reduction in fishing effort to a certain level (by 20~40%) from the fishing effort level on the average during 1981~1988 could bring some small advantage to the fishery consisting of fewer young and older fish.

Introduction

The *Otolithes argenteus,* silver croaker (local name, newaiby) stock is exploited by trawlers, drift gillnet fishery, fixed-stake nets(locally known as hadra) and fish traps (known as gargoor) in the northern part of the Arabian Gulf. More than two-thirds of the total production (240 t/yr) on an average is taken by both trawl and fixed-stake net fisheries in the Kuwait's waters (Morgan, 1981; Hakim et al., 1989). Stock assessments of this species were carried out by Samuel and Morgan(1984), Mathews and Samuel(1985), and Lee and Al-Baz (1989) using the yield-per-recruit models of Beverton and Holt(1957) and Ricker(1975). According to a recent study (Lee and Al-Baz, 1989), this fish stock is presently overfished, and alternative measures to maintain yields are either to increase the size at entry into the fishery or to reduce the fishing effort from the current level. Earlier studies, however, did not consider the stock structure of the fish species, nor the variation in abundance and recruitment pattern.

As part of continuing work to assess the status of the silver croaker stock in Kuwait's waters, this paper aims to estimate the fishing mortality by age and stock size by year using the virtual population analysis of Gulland's (1965) technique.

Materials

The data used here to apply the virtual population analysis (VPA) method include the monthly length frequency, annual age-length key and age composition for 1981~1988, and nominal catches from the trawl fleet and fixed-stake nets in Kuwait's waters and its neighbouring areas for the

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same period (Fig. 1).

Randomly selected fish samples of approximately 300 to 600 individuals monthly from catches landed by trawl fishery and fixed-stake nets were measured to the nearest centimeter as total length (TL) at Kuwait's fish markets during 1981~1988, with the exception of a total of 560 fish samples in 1981. It was not possible, however, to obtain length data on this species for different segments of the fishery, because the catches landed at the fish markets were always mixed together for sale. In cases where the catches from fish trap and gillnet fisheries were mixed with the catches of trawl and stake net fisheries, length frequency data obtained from the catches were not used.

Any type of trawling is banned in the Kuwait's waters during the shrimp closed season that has been usually imposed for 3 to 5 months between February and August every year since 1980. During the closed season, most fish samples came from research vessels of the Kuwait Institute for Scientific Research. Yearly about 600 to 1700 fish were randomly sampled from the catches of the research vessels, which have carried out demersal fish surveys using the same size of trawl net (46 *mm* stretched mesh cod end), at intervals of nearly two months around the Kuwait's waters, except for 1987 and 1988 when the survey was conducted quarterly. The fish species collected were measured to the nearest centimeter as total length and weighed to the nearest gram, and were also sexed on board the research vessels. While measuring the fish, a secondary sampling was carried out to collect sagittal otoliths (usually 30 to 50 fish per month) for ageing. Although the materials used in stake nets differs from trawl nets, it was assumed that the probability of capture for each length group (1 *cm* interval in this study) from the two types of fishing nets would be similar for corresponding mesh sizes ranging from 40 to 50 *mm* stretched mesh.

Now that it was not possible to sample fish for several months due to sporadic landings and closed fishing seasons, the monthly length distributions sampled at the fish markets and on the research vessels were pooled into quarterly length composition.

Methods

To provide representative length composition of the catches, a weighting factor was estimated quarterly by dividing the total landings in weight recorded by both trawl and stake net fisheries in each quarter by the total weight of fish sampled during the corresponding quarter. The total weight of fish sampled was calculated by multiplying the number of fish in each length class by the mean weight in the respective length class obtained in accordance with the length-weight relationship (L, *cm*; W, g): $W=0.0106L^{2.9930}$ (Mathews and Samuel, 1985). The length composition estimated for each quarter were added to obain annual length compositions.

The age composition of catches was estimated in combination with the annual length composition of catches and annual age-length composition (age-length key) obtained from ageing fish. For ageing, the whole sagittal otoliths extracted from fish samples from 1981 to 1988 were broken through the nucleus and ground mildly on a wet grinder. Ageing was carried out on the ground surface with reflected light using a stereomicroscope (numbers of fish aged from 1981 to 1988 were 665, 1007, 502, 331, 392, 190, 301 and 137, respectively).

The VPA technique described by Gulland (1965), which is independent of effort data, was used to estimate fishing mortality rate (F) and stock size by age and year.

An estimate of instantaneous natural mortality rate, $M=0.53\ yr^{-1}$ suggested by Samuel and Morgan (1984) and Mathews and Samuel (1985), was used to obtain the terminal fishing mortality rate in the oldest age group, *via* $F=Z-M$ for each cohort.

In order to determine effects of changes in fishing effort on this stock as a whole, a yield from 10,000 recruits was analyzed with the age composition pooled for 1981~1988 and exploitation rate on the oldest age (E_{i+1}). In estimating the value of E_{i+1}, an average of Z from each cohort for the study period and three different values of M (0.40, 0.53 and 0.70 yr^{-1}) were employed. The two values of $M=0.40$ and 0.70 yr^{-1} were chosen subjectively, because the estimate of $M=0.53\ yr^{-1}$ used in this

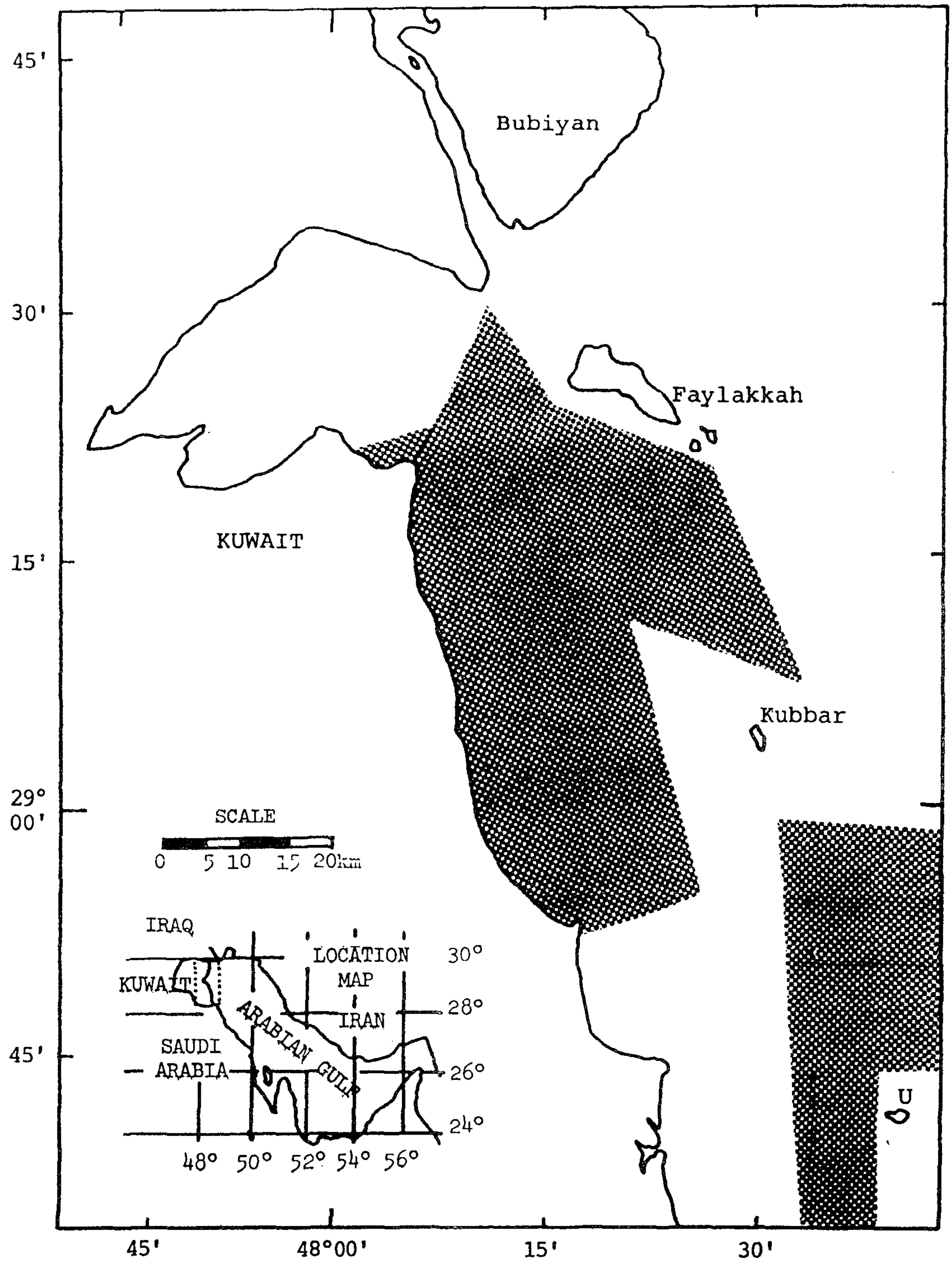

Fig. 1. Areas fished by trawlers and stake net fishery for the silver croaker in the Kuwait's waters.

study was predicted by using a statistical method, which is associated with growth parameters in the von Bertalanffy growth equation and water temperature based on the method of Pauly (1980).

For conversion of the yield in number obtained by age to the yield in weight, a length-growth equation (Mathews and Samuel, 1985) was employed to obtain mean length at age (l_t); $l_t=69.6(1-e^{-0.505(t+0.530)})$, then mean weight at each age was obtained from the length-weight relationship.

Results and Discussion

Stock Structure

The silver croaker stock distributed in the Kuwaits' waters was of a size range from 7 to 51 *cm* TL for 1981~1988 (Fig. 2). Yearly length distribution of this species showed that there have been no big fluctuations in each length class between years until 1987, with dominant size classes of 20 to 30 *cm* TL. In 1988, fish bigger than 30 *cm* TL in the composition appeared in a higher proportion, leading to a peak in the length classes from 30 to 40 *cm* TL. This implies that large silver croakers migrated into the Kuwait's waters during 1988. According to Euzen (1987) and Pauly and Palomares (1987), silver croaker distributed in the Kuwait's waters is a predator consuming large amount of small shrimps. In 1988, the extraordinarily high re-

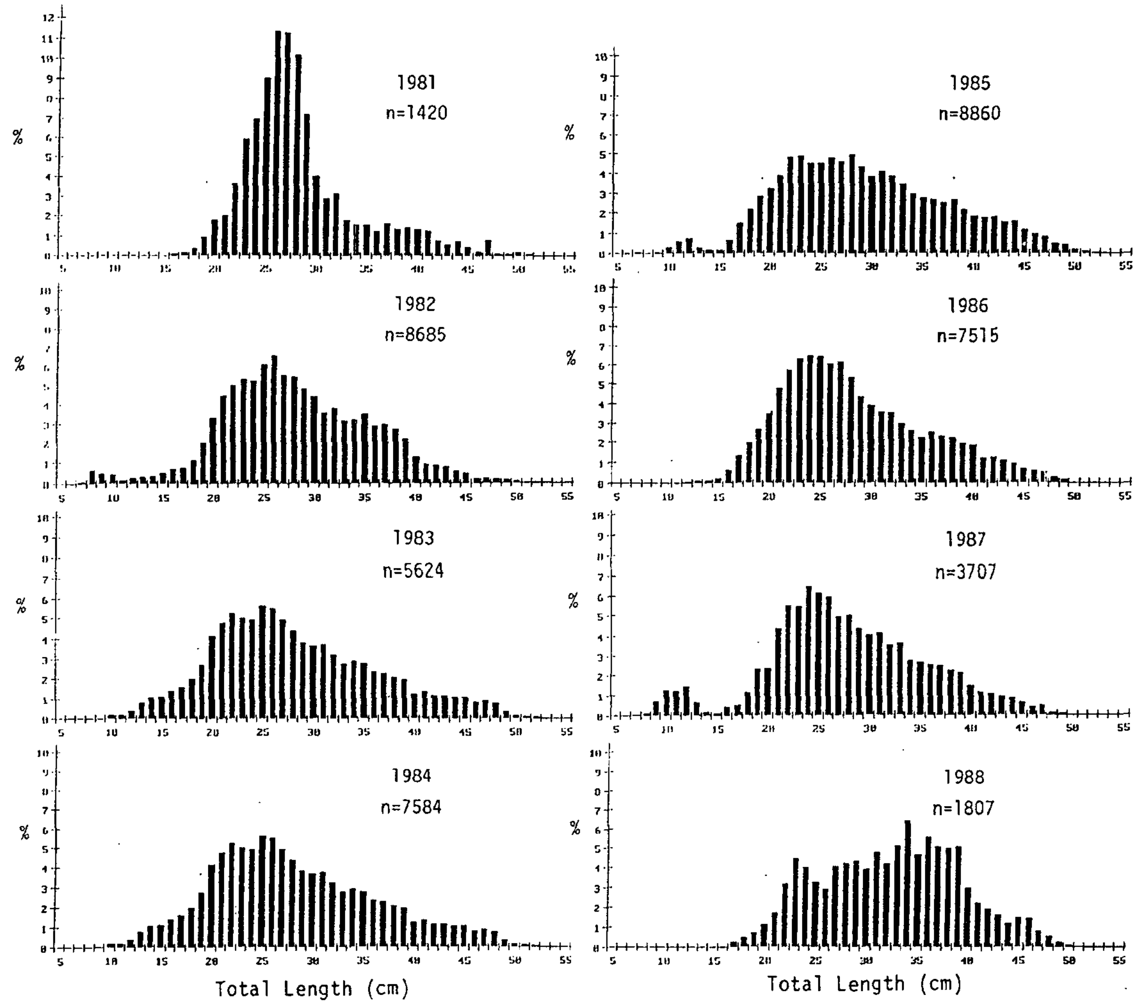

Fig. 2. Length composition of the silver croaker in the catch for 1981~1988.

cruitment of *Penaeus semisulcatus* (Siddeek, pers. comm.) might have attracted a large size group of silver croakers to the fishing grounds.

Age distribution of catches ranged from 0 to 5 years, and the dominant age group was one-year-old whose proportion accounted for about 58% of the total number of fish per year during the study period (Table 1). The age composition of three-year-old and older fish was a very low proportion throughout the whole study period compared with that in age groups of one and two, corresponding to the sizes of 20 to 30 *cm* TL shown in Fig. 2. The silver croaker stock in the Kuwait's waters is fully recruited into fishable stocks at age one. It should be mentioned that for the assessment of the silver croaker stock in this study, no adjustment was made from landings to catches because of the negligible amount of fish dumped into the sea. Accordingly, the numbers estimated in each length class are numbers landed rather than the numbers caught by both fisheries.

Mortality Estimate

The total mortality rate (Z) estimated for each cohort from the age composition in Table 1 showed that the 1978 and 1979 cohorts were 1.20 and 1.21 yr^{-1} (Table 2); the 1980 cohort experienced a very high total mortality rate, 2.10 yr^{-1}; the cohorts born between 1981 and 1983 had a high value of Z at a range of 1.81~1.97 yr^{-1}; and the 1984 and 1985 cohorts had 1.55 and 1.59 yr^{-1}, respectively.

Fishing mortality estimates fluctuated much between age groups for 1981~1988 resulting in higher values in age groups of two and three than the others (Table 3). An average fishing mortality rate for the ages 1~5 was higher in 1985 and 1987 (F=1.45 and 1.24 yr^{-1}) than in the other years (F=0.49~1.10 yr^{-1}). This was caused by high fishing mortality in ages two and three in these two years.

Fig. 3 represents yearly nominal fishing effort expended by shrimp trawlers and stake net fishery to catch fish during 1981~1988. Fishing effort of shrimp trawlers was at a very high level for 1983~1986 with a peak in 1984. Fishing effort by stake net fishery increased steadily until 1985 and afterwards it levelled off. When fishing increased, fishing mortality estimates were high (1980 to 1983 year-classes in Table 2). *e.g.*, both trawl and stake net fisheries in 1984, which showed a very high fishing effort level, operated to catch one-year-old fish of the 1983 year-class, two-year-olds of the 1982 year-class, three-year-olds of the 1981 year-class and four-year-olds of the 1980 year-class. He-

Table 1. Number of the silver croaker caught per year and by age in the Kuwait's waters for 1981~1988

Age	Year								Total
	1981	1982	1983	1984	1985	1986	1987	1988	
0	23745	51213	31614	41060	45861	99633	48479	18407	360012
1	184238	304789	262775	227003	127504	268276	274986	198083	1847654
2	20040	203028	145793	44177	153775	58740	113551	77963	817067
3	7708	16442	44566	13265	19090	5389	5759	11157	123376
4	0	2267	1768	3012	3038	855	4078	0	15018
5	0	0	705	0	0	0	732	0	1437

Table 2. Total mortality and fishing mortality estimates of the silver croaker for the 1978~1985 year-classes

	Year-class							
	1978	1979	1980	1981	1982	1983	1984	1985
Z	1.20	1.21	2.10	1.93	1.97	1.81	1.55	1.59
r^2	0.99	0.81	0.97	0.98	0.90	0.81	0.92	0.93
Age*	3~5	2~4	2~4	2~4	2~4	2~4	1~3	1~3

* Range of age used for estimating value of Z for each cohort.

nce, fishing effort would affect the fishing mortality rate.

Stock Size

The estimates of silver croaker abundance in the Kuwait's waters at the beginning of the year indicated that strong year-classes occurred in 1980 and 1981 (Table 4). These year-classes were of major importance, because they contributed to good production of this fish species in 1982 and 1983 (Table 1). The population size of the fishable stock

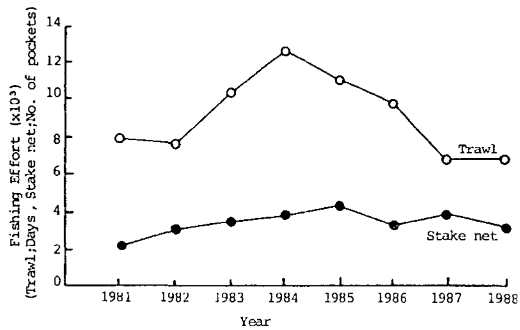

Fig. 3. Nominal fishing effort trends of trawl and stake net fisheries in the Kuwait's waters for 1981~1988.

(ages 1 to 5) of the silver croaker showed a big variation among years (Table 4). Numbers in the fishable stocks decreased markedly from about 1.13 million fish in 1982 to about 0.56 million fish in 1985. During 1986~1987, the numbers showed an increasing trend, but it was at a low level over the 1982 stock size.

It was impossible to establish the relationship between recruitment and parent stock of this fish stock because of the short time series of data(only 8 years). In general, however, it is very likely that recruitment in a particular year depends on the parent (fishable) stock size of the previous year.

Determination of Effects on Yield

Assessments were carried out to determine the effects of various percentage changes in fishing effort using the age composition for 1981~1988 (Table 1) combined with a set of values of exploitation rate, E_{i+1}=0.20, 0.27 and 0.36 for the oldest age when M=0.40, 0.53 and 0.70 yr^{-1}, respectively. For calculation of E_{i+1} for the oldest age, an average estimate of Z=1.67 yr^{-1} from the 1979~1985 cohorts (Table 2) was used for each selected value

Table 3. Fishing mortality estimates of the silver croaker by year and age group for 1981~1988

Age	Year							
	1981	1982	1983	1984	1985	1986	1987	1988
0	0.02	0.08	0.04	0.10	0.06	0.11	-	-
1	0.33	0.71	1.04	0.58	0.72	0.76	0.73	-
2	0.43	1.22	1.65	0.78	1.91	1.56	1.58	0.73
3	0.67	1.29	2.05	1.09	1.69	0.46	1.02	1.06
4	-	0.66	0.68	1.57	1.40	0.44	1.28	-
5	-	-	0.67	-	-	-	1.44	-
Weighted mean	0.49	0.93	1.09	1.10	1.45	0.69	1.24	0.92

Table 4. Number of the silver croaker in the stock at beginning of the year for 1981~1988

Age	Year							
	1981	1982	1983	1984	1985	1986	1987	1988
0	1318898	921757	1146356	582658	1122366	1250226	-	-
1	833034	750619	500196	650408	312200	627770	662193	-
2	72443	351975	217871	103601	215075	89831	172726	187863
3	19741	27675	60686	24701	28209	18562	11118	21011
4	-	5932	4487	4591	4900	3070	6900	-
5	-	-	1803	-	-	-	1164	-

of M. It was supposed that a given change in fishing effort would affect the finding mortality rate at each age by the same proportion, based on the findings obtained from relationship between fishing effort (Fig. 3) and fishing mortailty (Table 2).

Based on the above-mentioned data, overall percentage changes in the yield per 10,000 recruits in terms of various levels of fishing effort were given in Fig. 4. For $M=0.40\ yr^{-1}$, the yield shows an increase to a maximum of about 7% at which fishing effort is reduced to 40% of the current level (this is referred to as the mean value of F for 1981~1988, unless otherwise mentioned). When fishing effort intensifies, yield is reduced drastically from the current level of 1988. With $M=0.53\ yr^{-1}$, which is the current estimate for this fish stock, yield maintains the same trend as for $M=0.40\ yr^{-1}$, but there is less gain (maximum gain of 1.0% at reduction of 20% fishing effort), and any increase in fishing effort results in the reduction of the yield. When $M=0.70\ yr^{-1}$, any decrease in fishing effort from the current level causes a decrease in yield, while increasing fishing effort keeps the yield almost at the current level. Thus, it is clear that for any value of M, an increase in fishing effort would not lead to increase in yield. On the other hand, a reduction in fishing effort to a certain level (by 20~40%) could make some gains in catch for the fishery, except for $M=0.70\ yr^{-1}$.

Fig. 5 presents the results of fluctuation in age composition of the catches upon changes in fishing effort (a 40% increase and 40% decrease) with $M=0.53\ yr^{-1}$. When fishing effort increases, the catch comprises more young (particularly one-year-old fish) and fewer old fish. A decrease in fishing effort includes fewer young and more old fish (from age two onwards).

Since changes in fishing effort would be attributed to changes in the size of the stock, such changes could influence stock characteristics, especially for growth, recruitment or natural mortality. The effects of changes in those parameters could not be assessed in this study because of insufficient data. Moreover, the effects of changes in the present mesh size could not be studied, because there was no mesh selectivity study on trawl and stake nets in this area as yet. Therefore, more effort should be given to collect the basic data required for analyzing the long-term effects of changes in the silver croaker stock along with more time series of age composition data.

Considering overall results from the present assessment on this fish stock and from the earlier study (Lee and Al-Baz, 1989), the silver croaker should be fished at a reduced fishing effort. It can be concluded that the silver croaker stock in the Kuwait's waters has encountered high fishing mortality and poor abundance in fishable stock during

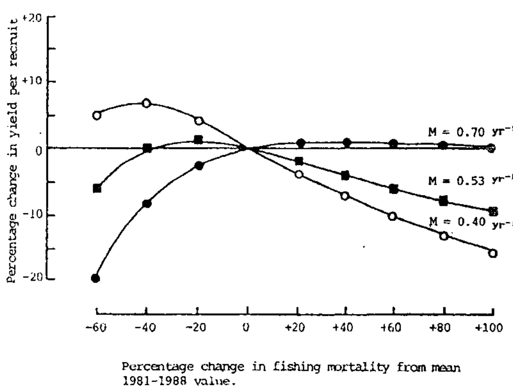

Fig. 4. Effects of change in fishing mortality on yield perrecruit for the silver croaker in the Kuwait's waters for different assumed values of natural mortality (M).

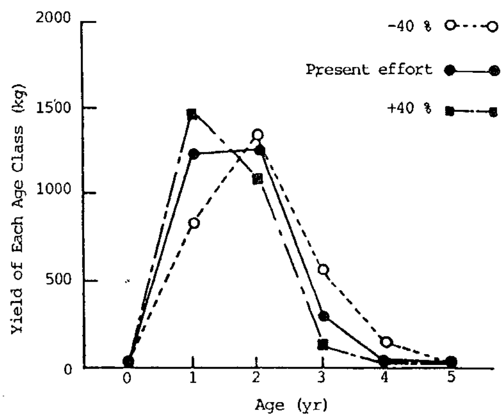

Fig. 5. Predicted yield in weight from a cohort of 10,000 recruits of the silver croaker in the Kuwait's waters given ± 40% changes in fishing mortality, $M=0.53\ yr^{-1}$.

the past 8 years. Thus, although reducing fishing effort to a certain level (by 20~40%) will only slightly increase the yield, this measure will be one of the appropriate ways to maximize recruitment of this fish stock in the Kuwait's waters.

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