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Fisheries exploitation pattern of narrow-barred Spanish mackerel, *Scomberomorus commerson*, in Oman and potential management options

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Summary

A data base including length frequency distributions and catches of the *Scomberomorus commerson* in Oman according to fleet (gear/technique) and region has been established to carry out length cohort analyses, determine yield per recruit and simulate changes in fishing effort and/or increase in minimum length limit in catches. The analyse of data showed that: (i) The average fishing mortality rate is moderate (0.5–0.6), but acts in part on the juvenile fraction of the stock. The exploitation pattern differs, however, among fleets with some fleet components targeting largely immature kingfish and others largely the adult stock. (ii) An increase in total fishing effort would lead to long-term losses in total catch; the losses would be highest for fleets that target the larger specimens. A reduction of the effort would, in the long term, lead to an increase in yield and spawning stock biomass. (iii) An increase of minimum length limit in catches would, in the long term, lead to a substantial increase in yield and spawning stock biomass; the gain in catch would be largest for fleet components that target the adult fraction of the stock and (iv) an increase in minimum length limit in catches combined with an increased selectivity of the fisheries (i.e. favorising fleets targeting the adult fraction of the stock) would lead to the highest gain in sustainable catch. In this case, the sustainable catch could be increased by more than 50%. Therefore, this option represents the optimal management strategy obtained in the present study.

Introduction

The narrow-barred Spanish mackerel, *Scomberomorus commerson*, is an important species in the Oman fisheries exceeding 99% of the total kingfish landings in Oman (Anon, 2001). The narrow-barred Spanish mackerel, also known as the Indo-Pacific Spanish mackerel, is one of the large pelagic fish inhabiting the epipelagic zone of shallow coastal waters. Its contribution to the total catch by weight is 15–20%, and it fetches a higher price per kilogram than any other marine finfish landed (Al-Hosni, 1996). The total value of narrow-barred Spanish mackerel landed in Oman in 1991 was R.O. (Rial Omani) 2 230 000, and reached R.O. 2 785 000 in 2001 (Anon, 2002) in spite of decreasing landings. The estimated annual catches of *S. commerson* in Oman range from the highest level of 27 762 tonnes in 1988 to the lowest 2558 tonnes, in 2000 (Anon, 2001). However, the total number of boats (fiberglass and launch) in the narrow-barred Spanish mackerel fishery has increased during this period from 7442 in 1987 to 11 751 in 1995 and 13 248 in 2000 (Anon, 1996 and 2001).

Because of its commercial importance a number of research studies has been carried out on *S. commerson* in Oman as well as in the Indo-Pacific regions. Various aspects of its biology and population dynamics have been addressed, including studies of reproduction, age determination, growth, stock identification and stock assessment (Shaklee and Shaklee, 1990; Dudley et al., 1992; Al-Hosni, 1996; Siddeek and Al-Hosni, 1998; Al-Hosni and Siddeek, 1999). Mortality and exploitation parameters of Omani *S. commerson* have also 3 been studied. Dudley (1990) used Pauly's method (Pauly, 1980) to estimate natural mortality (*M*) and (*Z*) for the species, and recorded 0.44 and 1.151, respectively. Estimates of the natural mortality (*M*) and fishing mortality calculated by Al-Hosni (1996); Siddeek and Al-Hosni (1998) and Al-Hosni and Siddeek (1999) varied between 0.35 and 0.77. Recent studies by Siddeek and Al-Hosni (1998) and Al-Hosni and Siddeek (1999) indicated overfishing of the stock.

Different management options have been suggested to improve stock management. Dudley et al. (1992) established a simple yield-per-recruit model, which indicated growth overfishing of the Omani stock and a minimum mesh-size regulation for gillnets of 5–6 inches was suggested. It should be noted that the growth estimates by length and age differed in the study and the length of the time series was limited. Siddeek and Al-Hosni (1998) recommended a sensitive reduction (17%) in fishing mortality in order to optimize the exploitation of the stock. However, no management strategy is adopted in the exploitation of *S. commerson* except for the regulation of the number of boats in the fishery. This regulation dates from 1992 4 (Abdelkader et al., 2000). Also, the minimum allowable catch size of this species and mesh sizes of the nets used are not regulated, but the average minimum catch size observed in landings is around 40 cm.

It should be noted that *S. commerson* is a migratory species, fished at different stages of its lifespan according to the season and the fishing area. Dudley et al. (1992) have shown a substantial seasonal variation in the catch and fishing mortality; the largest part of the catches is landed between September and March. Also, during this fishing period fleets target different stock components, depending on the fishing area and gear (fleet components).

In Omani waters, *S. commerson* is fished in all six coastal regions of the Sultanate: Diba, Al-Batinah, Muscat, Sur (Sharqia), Al-Wusta and Dhofar (Fig. 1), using primarily gillnets. The nets are set in a trap configuration or applied as drift gillnetting at night from dhows using 1000–2000 m nets. Remaining catches were taken by trolling, hook and line. In total, nine fleet components were identified in the kingfish fisheries. The exploitation pattern may differ among fleet

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13 Fig. 1. Map of *Scomberomorus commerson* fishing regions and sampling sites in Oman

Table 1
Relative contribution of different areas to the total landings and different fishing gears to the total catches of *Scomberomorus commerson* within different regions of Oman during 1999–2000

Region	Contribution per region (%)	Trolling, hook and line (%)	Drift gillnet %	Fixed gillnet %
Diba	1.6	70	10	20
Al Batinah	37.0	50	30	20
Muscat	13.9	60	30	10
Sharqia (Sur)	21.7	15	70	15
Al-Wusta (Duqm)	22.1	20	70	10
Dhofar	3.7	90	0	10

components depending on fishing region, gear and techniques used. The aim of the present study is in this context to update stock assessment using a database allowing a more detailed analysis of the exploitation pattern of this stock and an evaluation of different management options for the *S. commerson* fisheries in Oman.

Materials and methods

Definition of fleet components

The Omani fleet uses three different fishing gear/techniques: Lefah (lines and trolling), Mansab (fixed gillnet) and Hayali (drift gillnet). The relative importance of these fisheries differ among and within regions (Table 1). Also, the Hayali fishing technique differs among regions; in the Al-Batinah region and Seeb locality (Muscat region) driftgillneting is used for encircling fish at night (Tahwit techique), while it is used in a trap configuration in the Kurayat locality (Muscat region). In order to analyse the exploitation pattern of different fleet components, the fleets in the two major fishing regions of Al-Batinah and Muscat were separated into specific fleet components depending on the gear/technique used (Table 2). The fleets of the other four regions, Diba, Sharquia, Al-Wusta and Dhofar, were characterized by the gear/technique domination of the catches. In total, nine fleet components have been distinguished (Table 2).

Table 2
Fleet components specified according to region and gear/technique

Fleet component	Region	Gear/technique
Diba-lefah	Diba	Lines, hooks and trolling dominate
Bati-mansab	Al-Batinah	Fixed gillnet
Bati-tahwit	Al-Batinah	Trap driftgillnetting at night
Bati-lefah	Al-Batinah	Lines, hooks and trolling
Seeb-tahwit	Muscat	Trap driftgillnetting at night
Kura-hayali	Muscat	Drift guillnet dominate
Sur-hayali	Sharquia	Drift guillnet dominate
Wusta-hayali	Al-Wusta	Drift guillnet dominate
Dhof-lefah	Dhofar	Lines, hooks and trolling dominate

Catch data and length frequency distributions

The length frequencies sampled per region (Table 3) were limited to the fleet components that contribute significantly to the exploitation of the *S. commerson* stock. The data were collected during the kingfish project conducted by the Arab Gulf Cooperation Council Countries (GCCC) over a 2-year period between 1999 and 2001. Random samples were taken monthly for each fishing gear/technique utilized. The fish length sampling program covered six regions, which contribute to the traditional *S. commerson* fishery: Diba, Al-Batinah, Muscat (Seeb and Kurayat), Sharqia (Sur), Al-Wusta and Dhofar (Fig. 1); fork length was measured to the nearest centimeter. To estimate the demographic structures of the entire catches, length frequency samples were pooled from all fleets and fishing regions (Table 3).

Biological parameters

Parameter estimates used in the length cohort analysis are taken from the previous studies on *S. commerson* in Omani waters, including the von Bertalanffy growth curves ($L\infty$, K and t_0), length–weight relationships, length at sexual maturation (L_{50}), natural mortality (M) and selectivity factor (SF). The parameters estimates used in the present study are:

- $L\infty$ (asymptotic length): 226.5 cm (Dudley, 1990);
- K (growth rate): 0.208 (Dudley, 1990);
- t_0: −0.85 (Dudley, 1990);
- SF: 3.5 (gear and techniques in Omman artisanal fishery, 5 unpublished data)
- L_{50}: 80 cm (Al-Hosni, 1996);
- Length–weight relationship: $W = 1.7 \times 10^{-6} \times \text{length}^{3.31}$ (Dudley, 1990); and
- M: 0.35 (Al-Hosni, 1996).

Natural mortality

New estimates of natural mortality were obtained from the equation (Pauly, 1980):

$$\log(M) = -0.0066 - 0.279\log(L\infty) + 0.6543\log(K) + 0.4634\log(T),$$

with T indicating the mean temperature of the water taken as

Table 3
Length frequencies sampled per fleet from the catch of Omani *Scomberomorus commerson*

Length (cm)	Diba Lefah	Batinah Tahwit	Batinah Mansab	Batinah Lefah	Kurayat Hayali	Seeb Tahwit	Sharqia Hayali	Wusta Hayali	Dhofar Lefah	Total
41	4	2	0	0	0	0	12	0	4	22
45	7	4	0	42	0	0	3	1	0	57
49	9	15	0	65	0	0	3	1	4	97
53	23	6	0	67	4	1	0	0	13	114
57	49	11	0	67	11	16	3	3	0	160
61	84	67	0	56	4	44	38	6	4	303
65	46	80	3	22	15	68	25	13	22	295
69	13	91	24	22	19	46	60	31	22	328
73	3	54	109	11	15	35	69	9	9	314
77	4	20	80	0	0	30	69	22	9	234
81	14	30	59	0	140	35	63	13	13	366
85	2	46	32	11	216	35	60	19	53	473
89	5	41	11	0	4	20	66	19	61	226
93	9	26	29	0	26	8	76	21	48	243
97	13	20	13	0	0	5	50	18	26	147
101	10	6	21	0	8	1	32	12	31	120
105	11	4	32	0	8	0	32	16	48	150
109	11	11	19	53	8	2	25	11	31	170
113	12	4	11	42	26	1	35	13	9	152
117	18	0	8	78	19	1	22	9	22	177
121	18	2	0	53	26	0	19	12	22	152
125	11	0	3	11	30	1	22	10	4	92
129	9	2	8	53	23	0	19	7	4	125
133	11	0	5	42	23	1	6	11	0	99
137	2	0	0	0	23	1	6	14	4	50
141	2	0	0	0	23	1	6	13	0	45
145	1	0	0	0	19	0	3	13	4	40
149	1	0	3	0	0	1	6	16	4	31
153	0	0	0	0	0	0	0	10	0	10
157	0	0	0	0	0	0	0	3	0	3
total	402	539	469	699	687	349	832	346	473	4795
Catch (*t*)	25.37	167.8	117.48	304.6	130.84	90.19	346.8	353.42	59.39	1595.9

25.56°C; this value represents the mean temperature 1 m under the water surface in the Gulf of Oman and the Arabian Sea 6 (Hydrographic of Oman, unpublished data). $L\infty$ and K are taken from Dudley (1990). The equation obtained is provided below and gives a value of 0.348 for M. Because this stock is heavily exploited, the value of 0.35 was adopted in the present stock assessment.

$$\log(\mathrm{M}) = -0.0066 - 0.279 \times \log(226.5) + 0.6543 \times \log(0.208) + 0.4634 \log \times (25.56).$$

Length cohort analysis

The pioneer of the generalized method of cohorts was Gulland (1965); Jones (1981) and Sparre and Venema (1992) provided a clear description of this method. Length cohort analysis was applied to estimate the fishing mortality and abundance vectors by length class. These results were then applied to assess the effect of various changes in fishing effort and the minimum length limit in catches, using the Jones (1974) model of yield per recruit. For this purpose ANALEN software was employed, which was elaborated by Chevaillier and Laurec 7 (1990) for the analysis of data by size class. The stock biomass is calculated from the length–weight relationship and the abundance (N) per length class. The spawning stock biomass is derived by applying L_{50} to the number of survivors.

Before analyzing the data and determining the F vector it is necessary to fix the class of maximum size $L+$ from which calculations of fishing mortalities are initiated. The length ($L+$) has been determined according to the recommendations 8 of Pereiro and Pallares (1984), who recommended using a 'group+' near 70% of L_∞. Pereiro and Pallares (1984) have shown that the F vector varies in relation according to the difference between $L+$ and L_∞, but that the final value of F_t, that was used to initiate the analysis does not have an important effect on the F vector. However, considering the fact that the numbers of fish larger than 130 cm are poorly represented in the catch length distributions, $L+$ was set to 130 cm in the present analysis. This length, which is lower than 70% of L_∞ was chosen in order to avoid the last size classes of fish not being represented (frequency equals 0). It is generally considered that the value of F_t fixed for the group + must be in continuity (similar value) with the fishing mortalities of the previous size groups. The catches in number are estimated by fleet, and results are presented for the global balance and by fleet component.

Exploitation pattern

Each fleet component participating in the *S. commerson* fishery has its own exploitation pattern. For each fish length, the fishing mortality fraction of the fleet j could be estimated according to the contribution of this fleet in the total catch and considering C_i and F_i to be the total catch of *S. commerson* and fishing mortality of the length class i. $C_{i,j}$ and $F_{i,j}$ are the contribution of the fleet j. The estimate of the fishing mortality per fleet component is based on the following equations.

$$F_{i,j}/F_i = C_{i,j}/C_i,$$

where $F_i = \sum_{j=1}^{n} F_{i,j}$ and $C_i = \sum_{j=1}^{n} C_{i,j}$ and n is the number of fishing fleet components participating in the exploitation of the *S. commerson* fishery in Omani waters.

Yield-per-recruit model

This analysis investigated the impact of modifications of the fishing effort and increases in minimum catch size on regulations of the yield per recruit. It should be noted that any modification of effort or minimum length in catches has an immediate impact (immediate) and long-term effects (sustainable), which occur after the new equilibrium conditions of the stock, have established. The applied analysis supposes that the stock is in equilibrium state: constant recruitment, F and M vectors. However, the exploitation pattern can vary slightly from 1 year to another according to the mobility of different fishing fleet components. Also, there is limited information on fish recruitment. To attenuate the effect of the eventual variation of the exploitation pattern or the recruitment intensity, an average of size distributions enlarged over a period of 2 years (1999 and 2000) were therefore used. The yield-per-recruit model used is described by Jones (1974). Chevaillier and Laurec (1990) provide a clear description and mathematical equations used in the yield-per-recruit model.

Simulations

Changes in following parameters were considered in the simulations:

1 Modification of the fishing effort: simulation of variation in total effort in the same proportion for the different fleet components (métiers); the actual length limit in catches is not modified (set constant at 40 cm).
2 Modification of length limit regulation: the simulations suppose that the different fleets keep their actual level of fishing effort, while their exploitation pattern is changed by setting the fishing mortality to 0 for fish length classes lower than the simulated length limit regulation.
3 Combination of effort changes and size-limit regulations: Three sets of simulations were conducted, all of which suppose an increase in minimum length limit to 80 cm and a modification of fishing effort: (i) proportional effort increase using the same multiplier of F for all fleet components; (ii) selective fishing effort increase of the fleets targeting the adult fraction of the stock (Wusta-hayali, Bati-lefah and Kura-hayali), while maintaining the fishing effort of the other fleets at the present level; and (iii) this option simulates a prohibition of the tahwit fishing technique. This simulation is obtained by imposing 0 to the vector F of fleets using this technique.

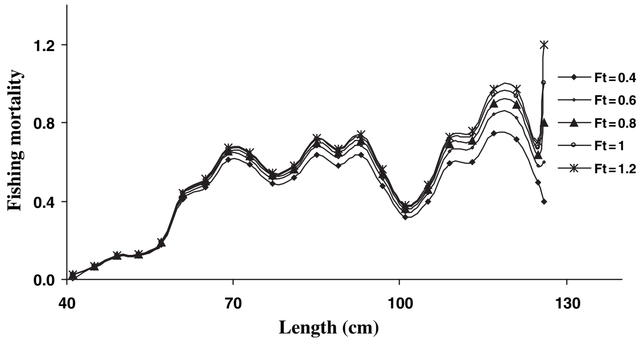

Fig. 2. Estimated fishing mortality of *Scomberomorus commerson* using different terminal *F*-values

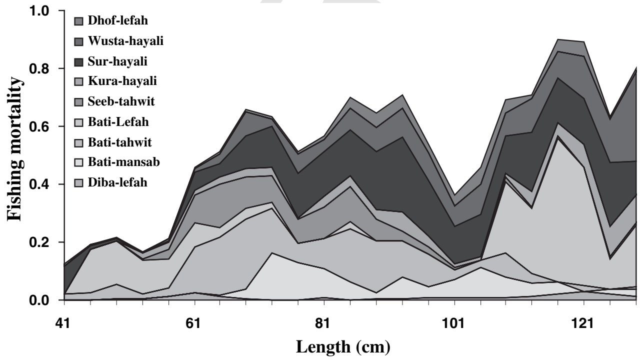

Fig. 3. Fishing mortality of *Scomberomorus commerson* per length group for different fishing fleet components

Results

Fishing mortality $\vec{F}$

The effect of different terminal fishing mortalities (F_t) on the estimated total fishing mortality (F) of Omani *S. commerson* is shown in Fig. 2. The most probable value of F_t was considered to be equal to 0.8. Total efficient fishing mortality was on average 0.52, but F differs significantly in relation to size. F was low (< 0.20) for fish sizes lower than 60 cm. Above this size F increased quickly and surpassed 0.5 at fish sizes around 70 cm. F reached 0.7 for the sizes at which sexual maturity is attained (80–100 cm). F reached its maximum value (around 0.9) for the largest size categories. This variability in fishing mortality suggested differences in the selectivity among fishing gear targeting different fractions of stock. The relatively high fishing mortality on mainly immature (50 and 90 cm) should be noted.

The size-specific of fishing mortality per fleet component is shown in Fig. 3. The fleets of the Diba and Dhofar regions contributed little to the total fishing mortality of the stock, the fraction targeted largely being adult specimens. The Seeb-tahwit and Bati-tahwit fleets targeted mainly the juvenile fraction of the *S. commerson* stock, with high fishing mortalities in the length range between 60 and 80 cm. In contrast, Bati-lefah, Wusta-hayali and Kura-hayali primarily targeted the adult fraction (> 80 cm). Finally, the Sur-hayali, Dhof-lefah and Bati-mansab fleets targeted both juvenile and adult *S. commerson*.

Recruitment and stock biomass

Recruitment was estimated from the Length Cohort Analysis as the number of fish in the smallest class size, in this case 41 cm, i.e. 6.5×10^8 individuals (Fig. 4). This figure also shows the number of survivors per length class. The proportion of survivors larger than 80 cm (L_{50}) did not exceed 18% of the recruits.

Yield per recruit and exploitation pattern

Effort regulation. Any increase in the actual fishing effort (effort = 1) would, in the long-term, lead to a decrease of the sustainable production (Fig. 5) if the minimum length limit is

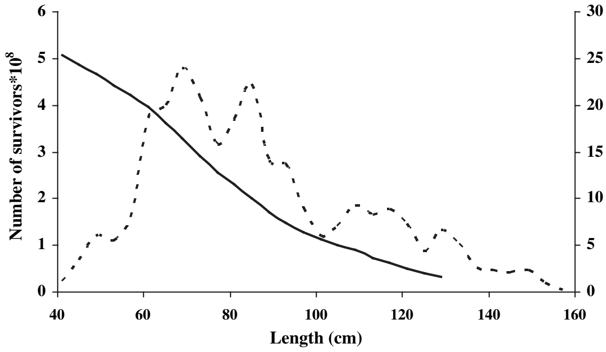

Fig. 4. Stock size and catch composition of Omani *Scomberomorus commerson* in numbers per length group. —–, survivors; - - -, catch length frequency

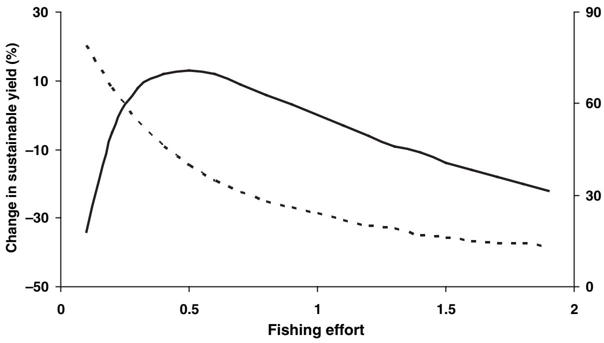

Fig. 5. Relative change in sustainable yield and spawning stock biomass (SSB) of Omani *Scomberomorus commerson* vs fishing effort. —–, SSB; - - -, yield.

not modified. An increase of 50% of the actual fishing effort would lead to a decrease of 14% in sustainable yield. A reduction of the effort would, in the long-term, lead to a gain in production, e.g. an effort reduction of 50% would result in an increase of 13% in sustainable yield. However, the immediate catch loss would reach 50% if the fishing effort is halved. A moderate change of effort has little effect on the sustainable yield; if the effort is increased or decreased by 20%, the change in catch will not exceed 2–3%.

In any case, a reduction in the fishing effort would lead to an increase in spawning stock biomass (SSB) (Fig. 5), e.g. a reduction of the effort by 50% would lead to a 14% increase of the SSB. In contrast, the SSB would decrease considerably if the effort is increased (Fig. 5).

An increase in total effort would lead to long-term losses for all fleet components, except in the Seeb-tahwit and Bati-tahwit fleets (Fig. 6). The losses are highest for fleet components that capture larger specimens, i.e. the Wusta-hayali and Bati-lefah fleets. For example, an increase of 20% in effort would result in a decrease in sustainable yield of 15% and 12% for the two latter fleets, respectively. The losses amount to 32% and 28%, respectively, if the fishing effort is increased by 50% of its present level. The fleet components, which mainly target the immature fraction of the population (Seeb-tahwit, Bati-tahwit and to a lesser degree, Bati-mansab) would increase their catch. Thus, an increase of 20% in the total effort would lead to long-term gains of between 1% for Bati-mansab to a maximum of 8–9% for Seeb-tahwit and Bati-tahwit, respectively.

Size-limit regulation. Increasing the minimum length limit in catches would lead to a substantial increase in sustainable

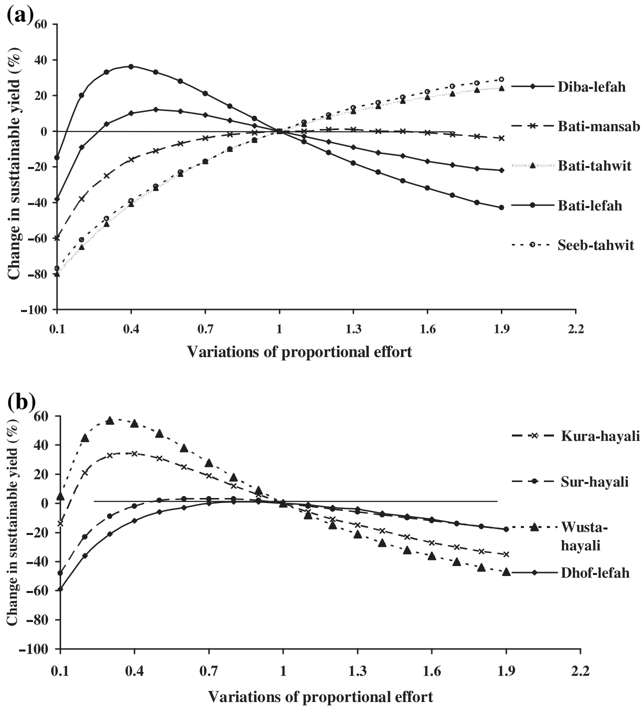

Fig. 6. Relative change in sustainable yield of Omani *Scomberomorus commerson* of fishing fleet components vs fishing effort

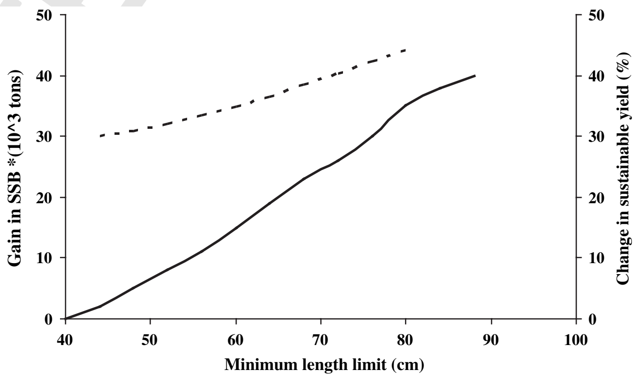

Fig. 7. Change in sustainable yield and spawning stock biomass (SSB) (%) vs minimum length limit of Omani *Scomberomorus commerson*. —–, SSB; - - -, yield.

yield, keeping the fishing effort unchanged. If the minimum length limit equals L_{50} (80 cm), then the sustainable catch would increase by almost 40%. Similarly, an increase in minimum length limit to 52 (30%) and 80 cm (100%) would increase the spawning stock biomass (Fig. 7) by 26 to 40%, respectively. On the other hand, the immediate loss would be 5% if the minimum length limit were increased to 52 cm. The loss would exceed 30% if the minimum length limit were doubled (80 cm). The immediate losses appear to be high and could probably not be sustained by the fleets. Thus this management option must be adopted progressively.

The increase minimum length limit leads to a gain in sustainable yield for the majority of the fleets, while only two fleets, Seeb-tahwit and Bati-tahwit, would suffer long-term losses (Fig. 8). Thus an increase in the minimum size limit to 52 cm would lead to a gain in sustainable yield by at least 12% for the Wusta-hayali, Diba-lefah, Dhof-lefah, Kura-hayali and Bati-mansab fleets. The long-term gain of an increase to 80 cm

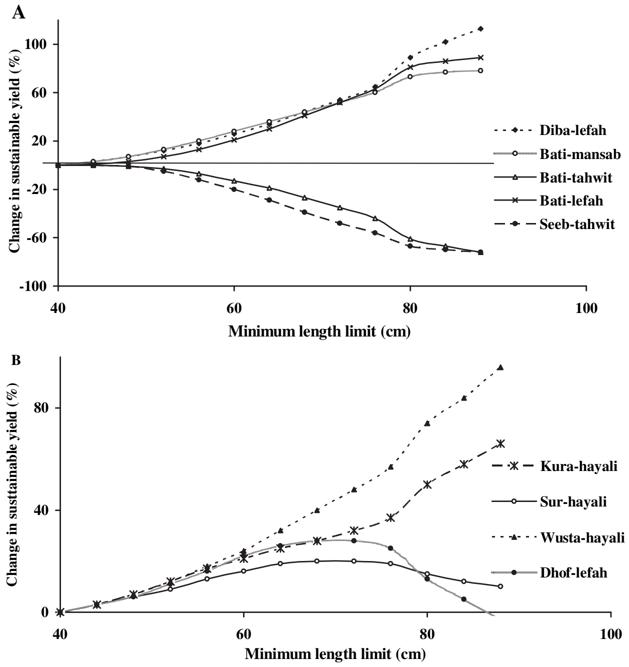

Fig. 8. Relative change in sustainable yield per fishing fleet vs minimum length limit of Omani *Scomberomorus commerson*.

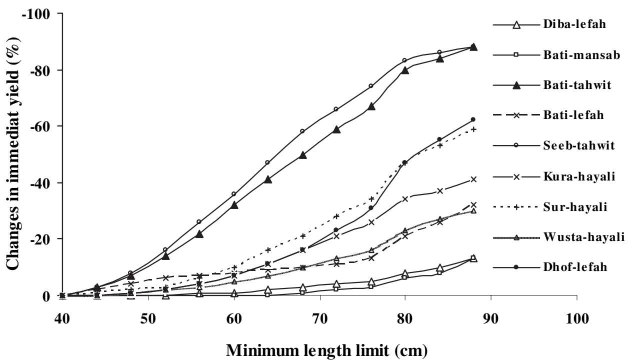

Fig. 9. Relative change in immediate yield per fleet vs minimum length limit (cm) of Omani *Scomberomorus commerson*.

in minimum length amounts to 80% for the Diba-lefah, Bati-lefah, Wusta-hayali and Bati-mansab fleets, but somewhat less (about 50%) for the Kura-hayali fleet, whereas this regulation in the long-term would lead to losses exceeding 50% for the Seeb-tahwit and Bati-tahwit fleets.

The immediate losses would be relatively limited for fleets targeting the intermediate sized fraction of the population (Fig. 9). Losses from an increase in the minimum length limit to 52 cm would be 0 for the Bati-mansab fleet and 10% for the Sur-hayali fleet, whereas the Seeb-tahwit and Bati-tahwit fleets would suffer immediate losses of around 30%.

Combination of effort changes and size-limit regulations. An increase in minimum length limit to 80 cm and a proportional increase among fleets by 50% of its actual level would increase the sustainable catch by 37%. This gain would be slightly higher, if only, the increase in fishing effort focused on the adult fraction of the stock. The most efficient management option was the simulated prohibition of the Tahwit technique. In this case, the long-term gain in production would be around 50%.

Discussion

The various fleet components investigated contributed differently to fishing mortality levels of *S. commerson* in Omani waters and could be divided into three groups. The first group comprised fleets targeting the youngest fraction of the stock (Khabbat), including the Seeb-tahwit and Batitahwit fleets. The second group consisted of Bati-mansab, Sur-hayali, Diba-lefah and Dho-lefah, which caught a combination of immature and adult specimens. The third group mainly targeted the larger specimens; this group comprised three fleets, Wusta-hayali, Bati-lefah and Kura-hayali.

The fishing mortality rate of *S. commerson* stock is, in general, moderate and does not exceed 0.5–0.6, but it does act in part on the immature fraction of the stock. The exploitation pattern differs substantially from one fleet group to another. Al-Hosni (1996) obtained similar estimates of F in a catch analysis for the period 1987 to 1992. The analysis indicated higher F values for the years 1993 to 1995. Siddeek and Al-Hosni (1998), estimating reference points on basis of a stock-recruitment relationship, suggested a 17% reduction in fishing mortality to optimize the exploitation. The most recent study (Al-Hosni and Siddeek, 1999) calculated seasonal rates of total mortality and found exploitation ratios indicating over fishing. However, the result of the present study suggests that this might not result from a general increase in F, but rather is because of changes in the exploitation pattern. The catch of immature (smaller specimens) has increased in recent times in comparison to the 1980s. The sharp decrease in the number of survivors (only 18% of the recruit numbers reach L_{50}) emphasizes a heavy exploitation of the juvenile fraction of the population and indicates a growth overfishing of the stock. Management action should be taken to protect immature fish in order to utilize their growth potential, which is high in the first stages of the species' lifespan.

The sustainable yield could be increased by around 30–40% if the minimum length catch limit is increased to 80 cm. Similarly, Dudley (1990) found that the total catch of *S. commerson* caught by Omani fisheries could be increased by 30% through protection of the younger fraction of the stock to one year in age and a length at about 80 cm. Bertignac and Yesaki (1993) carried out a yield-per-recruit (Y/R) analysis on the Omani *S. commerson* stock and recommended an increase in the minimum length limit.

The optimal management strategy for *S. commerson* stock obtained in the present study was a minimum length limit of 80 cm combined with an increase in selective fishing effort (fleets targeting adult fraction of the stock). The long-term production gain obtained by simulating a change in fishing practices for the Seeb-tahwit and Bati-tahwit fleets is substantial; this management option reflects a regulation that prohibits the Tahwit technique by the Seeb and Batinah fleets. A change of gear/technique or implementation in an area or the season closure of the fisheries during the recruitment period (September–December) would promote stock recovery/development. These management options lead to considerable long-term gains for all other components of the *S. commerson* fleets.

These results should, however, be considered a preliminary investigation of the exploitation pattern of the Omani *S. commerson* fisheries. More investigations should be made to identify stock units and operational management units. It cannot be excluded that the *S. commerson* populations in the Arabian Sea, Gulf of Oman and Arabian Gulf constitute only one stock. If this is the case, catch data collected by each country under the *S. commerson* Gulf Cooperation Council Project should be gathered in a joint database and fisheries management should be carried out in cooperation with all participating countries in the *S. commerson* fishery in this region.

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