6 MANAGEMENT REGULATIONS OF NAMIBIAN ANGLING FISH SPECIES

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Abstract

An economic survey in 1997 showed that recreational angling is the most important sector of the Namibian inshore linefish fishery. Prior to the year 1995, fisheries regulations for Namibian angling fish species were based on regulations adapted from South African legislation enforced prior to Namibia's Independence in 1990, rather than the results of formal stock assessments, because some biological parameters and the total annual catches of shore anglers for the two most important species, silver kob and West Coast steenbras, were not available. Two separate studies were launched to obtain the necessary biological parameters as input for age-based assessment models. To obtain the total annual catch of recreational anglers, a roving-roving creel survey design was developed whereby anglers were interviewed while they were fishing. Their catches were also measured during the interview. Based on some of the results of the assessments, previous management regulations were revised and/or new regulations introduced in December 2001. These include a reduced daily bag per angler, the re-introduction of minimum size limits, and the introduction of a daily limit per species that may be retained over a certain maximum size limit. For transportation purposes, an angler may now accumulate three days' catch, but a limit on the number per species that may be transported, was also introduced. The chapter gives an overview of why and how these new regulations were formulated.

INTRODUCTION

The Republic of Namibia is situated in south-western Africa and is famous for its excellent shore angling opportunities. The Namibian fishing industry,

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well known for its rich stocks of demersal and small pelagic species, is based on the Benguela Current, one of the four major eastern boundary upwelling systems of the world. What these systems lack in terms of species diversity is more than compensated for in abundance. Consequently, for angling enthusiasts, the Namibian coast has for decades been synonymous with large catches of linefish species such as kob (*Argyrosomus* spp.), West Coast steenbras (*Lithognathus aureti)*, galjoen (*Dichistius capensis)*, blacktail (*Diplodus sargus)* and various shark species. However, recreational anglers share the resource with a commercial sector, which makes management complex.

Namibia's inshore linefish fishery can best be described as the fishery that uses rods-and-reels or handlines with baited hooks to catch various angling species either for recreation from the shore or from skiboats, or commercially from skiboats and lineboats (Table l). The linefish fishery therefore supports three different sectors, namely a) the recreational rock-and-surf sector, b) the recreational skiboat fishery and c) the commercial skiboat and lineboat sector. Lineboats are approximately 20 m in length and carry up to 16 fishermen who each operates a handline with two hooks. In order to land fresh fish on ice, these boats are able to put to sea for a maximum of one week and each boat has a carrying capacity of 12 tonnes of fish. Currently, two freezer lineboats are operating in Namibian waters; this type of boat can spend longer times at sea and the fish are also processed and packed onboard. A skiboat is approximately 5-6 m long and can carry between four and six fishermen. Fishing is done with boat-rods and reels and normally only one rod per fisherman is used. Skiboats usually fish just behind the breaker-zone and most skiboat fishing is concentrated in the vicinity of Swakopmund.

Silver kob and West Coast steenbras were identified as the two most important species because these are the two most popular recreational angling

Table 1: Fish species caught by the multi-sector Namibian linefish fishery.

Species	Shore-angling Sector	Lineboat sector	Skiboat sector
Silver kob	×	×	×
West Coast steenbras	×	×	
Snoek		×	×
Galjoen	×		×
Blacktail	×		×
Barbel	×		×
Spotted gullyshark	×		×
Coppershark	×		×
Cowshark	×		×
Smooth houndshark	×		×

species and both are also commercially exploited by other sectors of the line-fish fishery (Holtzhausen *et al.*, 2001a). However, these species were never assessed owing to lack of information on the necessary biological parameters and the total annual catch of anglers, used as input for fishery assessment models. Two separate studies were thus launched in 1995 to obtain the necessary biological data for each species. To obtain the total annual catch of recreational anglers, a roving-roving creel survey design was developed (described by Kirchner and Beyer, 1999) whereby anglers were interviewed while they were fishing. Their catches were also measured during the interview.

For historical reasons South African angling regulations were enforced here before Namibia's Independence in 1990. These management regulations, such as minimum size limits and daily bag limits, were not based on scientific investigations on local species, but were formulated for South African species. After Independence, Namibia amended or abolished some of these regulations (Ministry of Fisheries and Marine Resources (MFMR), 1993); for instance an arbitrarily chosen daily bag limit of 30 fish per angler came into effect while the current roving-roving creel surveys show that an angler catches on average no more than 2.6 fish per day (Kirchner *et al.*, 2000). Thus these bag limits had no effect as a management tool. Minimum size limits were also abolished for all angling species (Table 2). Thus, there

Table 2: Some of the old angling regulations enforced from 1993 and new angling regulations enforced after December 2000.

Old regulations	New regulations
No size limits	Size limits on angling species 40 cm TL kob and West Coast steenbras 30 cm galjoen and 25 cm blacktail Only 2 kob ≥ 70 cm TL and 2 West Coast steenbras ≥ 65 cm TL per angler per day.
Daily bag per angler 30 fish or 30 kg fillets per angler	Daily bag per angler of 10 fish.
For transportation A maximum of 60 fish or 60 kg fillets per vehicle, minimum of two anglers in vehicle.	For transportation An angler may accumulate his catch of 3 days of which only 10 may be of any one species – no restriction on anglers per vehicle.
Fish may be filleted for transportation.	Fish may only be transported in a whole state. This is to be able to enforce the size limits.

was a need to start managing the resource basing management decisions on scientific evidence.

The annual contribution of the linefish fishery to Namibia's Gross Domestic Product (GDP) has not been estimated prior to 1997. Kirchner *et al.* (2000) conducted an economic survey in 1996/97, which showed that recreational angling earned the country approximately N$30 million compared with only N$5 million for the commercial sector. A similar study conducted in 1998 by Zeybrandt and Barnes (2001) confirmed the figure for the recreational shore fishery. It is therefore clear that the recreational sector is the most important of the three sectors.

The movements of a fish throughout its range and in the various stages of its life may have implications for its management as a population or stock. Migratory patterns of adult fish, especially of the spawner stock, and the dispersal of individuals into areas adjacent to where they have spent their early life, must be known if a stock is to be assessed or managed as a unit. The identification of discrete stocks is also basic to the conservation and rational exploitation of all fisheries resources (Holtzhausen *et al.*, 2001a).

Throughout the world, the method of tagging and recapturing specific fish species is used to study their migrations. The main aim of the Namibian tagging programme, launched in the late 1980s, was to investigate the possibility that linefish move out of the Namib Naukluft Park (NNP) and Skeleton Coast Park (SCP) to the West Coast Recreational Area (WCRA; see Figure 1). The NNP is closed to all shore-angling and the SCP is partly closed to shore-angling. The hypothesis was that such areas serve as reserves seeding other parts of the coast, including the angler-accessible WCRA. The possibility also existed that there might be one or more populations of each species occurring in Namibian waters.

Prior to 1995, it was thought that kob (*Argyrosomus hololepidotus)* ranged from northern Natal, on the east coast of South Africa, to around Congo, on the west coast of Africa. As such, all kob in Namibian waters were classified as the species *A. hololepidotus*. However, in the early 1990s, Griffiths and Hecht (1993) suggested that there may in fact be two species of kob off southern Africa, referring to them as kob A and kob B. Specimens of these fish were obtained during March 1995 along the Namibian coastline during a linefish tag-and-release excursion. Taxonomic investigations indicated that the Namibian kob A was a different species from the South African kob A, *Argyrosomus japonicus*. The Namibian kob A has subsequently been described as a new species and named the West Coast dusky kob, *A. coronus*, whereas kob B was described as the same in both South African and Namibian waters, reclassified as silver kob *A. inodorus* (Griffiths and Heemstra, 1995).

Tag-recapture results proved the existence of a separate, closed population of West Coast steenbras in the vicinity of Meob Bay, and a northern population off central and northern Namibia (WCRA and SCP). Also, distinct differences in growth rates, otolith morphology, size at maturity, sex ratios and length-at-age were found between the Meob Bay and the more northern population. Electrophoretic analysis on samples from the two populations showed significant genotypic differentiation at two loci, indicating that effective barriers exist to isolate them (Van der Bank and Holtzhausen, 1998/99). Thus, it was shown that two distinct populations of West Coast steenbras occur in Namibian waters, and they might require different management measures as one population is only accessible to lineboats while the other population is accessible to lineboats and recreational anglers.

The two separate studies on silver kob (Kirchner, 1998) and West Coast steenbras (Holtzhausen, 1999) that were launched in 1995 were aimed at

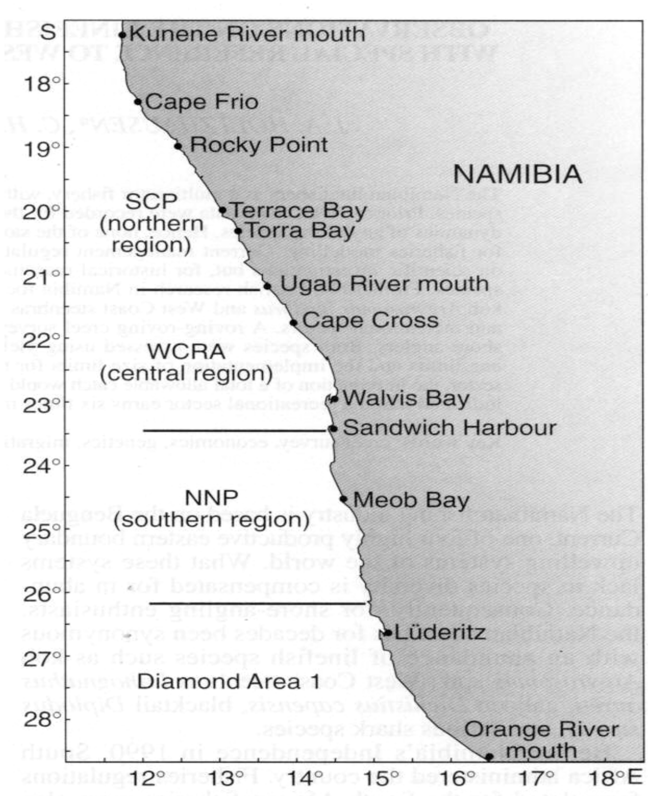

Figure 1: Map of Namibia indicating the closed diamond-mining area (Diamond Area 1) and conservation areas, the partially restricted Skeleton Coast Park (SCP), the closed Namib Naukluft Park (NNP), and the West Coast Recreational Area (WCRA) that is open to angling. It should be noted that lineboats may operate along the entire coastline.

investigating their life histories, obtaining the necessary biological parameters and the total annual catches of recreational anglers for assessing both stocks, and finally at recommending management options to harvest the resources on a sustainable basis. Furthermore, characteristics of sparids that may have serious implications for their management are hermaphroditism, longevity, slow growth and high rates of natural mortality. West Coast steenbras have all these characteristics and it is therefore crucial that all these issues be considered when developing an effective management strategy for the species. This chapter describes the methods that were used to obtain the necessary data and how management options were formulated ~ mostly from the results, but sometimes contrary to the results due to e.g. socio-economic implications. Most of the information in this chapter has been published before and should thus be seen as a review of these. The three most important publications to be consulted for more information on migration, biology, stocks assessments and economics are 1) by Holtzhausen (1999) on the West Coast steenbras, 2) by Kirchner (1998) on silver kob, and 3) by Kirchner *et al.* (2000) on the economics of the linefish fishery.

MATERIALS & METHODS

Migration studies and genetics

Fish were caught with rod and reel from the shore, and standard tag-and-release procedures were followed (Botes, 1994; Kirchner, 1998; Holtzhausen, 1999). During tagging excursions fish were normally tagged over a period of four days, usually making use of the same anglers to keep the effort constant for calculating CPUE at various fishing stations. Approximately 50 such excursions were conducted, mostly in the closed southern and northern areas (Table 3). A yellow monofilament T-bar anchor tag with an alpha-numeric code and "Fisheries, Namibia" imprinted on it, was inserted with a Banox applicator into the muscle posterior and on the top-left side of the dorsal fin.

Table 3: Numbers of silver kob and West Coast steenbras tagged and released and the numbers recaptured in each region along the Namibian coastline.

Area	Silver kob: Number tagged	Silver kob: Number recaptured			West Coast steenbras: Number tagged	West Coast steenbras: Number recaptured		
		South	Central	North		South	Central	North
South	7 888	34	44	0	23 834	329	29	0
Central	2 795	0	236	3	8 555	2	260	4
North	9 337	2	31	87	3 189	0	67	77

Biochemical genetic studies (starch-gel electrophoresis) were performed on both species a) to determine if the silver kob and dusky kob were of the same gene pool, and b) to test the hypothesis that the southern West Coast steenbras population at Meob Bay was a separate and closed population to the stock that occurs in the central and northern shore areas.

Biological data

Biological samples were also collected during these tagging excursions. For example, otoliths were extracted for determination of age and growth rate and to formulate age~length keys, and gonads were weighed and classified to develop gonadosomatic indices (*GSI*) to determine breeding seasons, and macroscopically staged (in the case of West Coast steenbras) to confirm that the species is a protandrous hermaphrodite. Growth parameters were derived for both species from otolith readings and the results were verified with mark-recapture data (Kirchner and Voges, 1999, Holtzhausen and Kirchner 2001b). Size-specific natural mortality was determined for West Coast steenbras by developing a length-based catch curve, and this method was also adapted for silver kob (Beyer *et al.,* 1999). Age-length keys were constructed for each species and used to transform length- to age-frequency distributions. Table 4 depicts the biological parameters used for modeling.

Table 4: Parameter estimates and the range/best estimates of values used in the models for assessment of the northern West Coast steenbras stock (Holtzhausen and Kirchner, 2001b) and the silver kob stock (Kirchner, 2001) off Namibia.

Parameter	Range / best estimate	
	West Coast steenbras	Silver kob
K	0.088 year^{-1}	0.136 year^{-1}
L_∞	84.6 cm	103 cm
T_0	-2.756	-1.58
W_∞	14.19 kg	11.38 kg
M	0.23 year^{-1}	0.15 year^{-1}
F	0.11 year^{-1}	0.22 year^{-1}
Z	0.35 year^{-1}	0.365 year^{-1}
M_∞	0.21	0.19
F_{term}	0.11	
T_r	1 year	0.75 years
T_c	2 years	1 years
A	0.00003	4.8×10^{-5}
B	2.9444	2.71
T_m	5 years	5 years
T_f	10 years	10 years

Table 5: Estimated values for depletion of the stock, long-term biomass, *MSY* and expected catches of Namibian silver kob in 1997/98 determined using the Thompson and Bell model, with catches per age-class = *N*[mean, *SD*], *M* year^{-1} = *U*[0.15–0.25] and F_{term} year^{-1} = *U*[0.17–0.27] for scenarios 1–4. Percentiles (95%) are given with the average value in parentheses (after Kirchner, 2001).

Scenario	Depletion (%)	Biomass (1000tons)	MSY (1000tons)	Catches (1000tons)
1 Current	30–47 (39)	7.8–10.6 (9.1)	1.14–1.36 (1.24)	1.00–1.17 (1.13)
2 Minimum size of 40 cm	36–54 (46)	9.7–12.3 (10.9)	1.05–1.15 (1.10)	0.95–1.05 (1.00)
3 Cut *F* of linefish boats by 25%	34–52 (43)	8.7–11.6 (10.0)	1.10–1.34 (1.20)	1.00–1.10 (1.05)
4 40 cm size limit + cut *F* of linefish boats by 25%	41–58 (50)	10.0–13.2 (11.9)	1.00–1.12 (1.07)	0.88–1.02 (0.95)

Table 6: Estimated values for depletion, biomass (tons), maximum sustainable yield and catches in tons of the silver kob stock for the years 2000/01. Percentiles (95%) are given in parentheses except for yield.

Parameter	Best estimate	Percentiles
Depletion (%)	40	(29-51)
Biomass (tons)	7 175	(5 734–9 125)
MSY (tons)	955	(855–1 114)
Catches (tons)	856	(817–896)

Table 7: Estimated values for depletion, long-term spawning biomass (tons), proportion of females in the spawner stock biomass (SSB) and the total biomass, maximum sustainable yield and catches in tons of the northern stock of West Coast steenbras for the years 2000/01. Percentiles (95%) are given in parentheses except for yield (after Holtzhausen, 1999).

Parameter	Best estimate	Percentiles
Depletion (%)	53	(37-67)
SSB (tons)	2006	(1 294-2 942)
% Females in SSB	44	(38–50)
% Females in biomass	22	(19–26)
MSY (tons)	278	(202–384)
Catches (tons)	191	

Models and assessments

In Namibia, silver kob and West Coast steenbras were first assessed in 1998 (Kirchner, 1998) and 1999 (Holtzhausen, 1999) respectively. The results of these assessments were based on only three years' data and therefore the results are not shown in this chapter but merely mentioned where appropriate.

Two yield-per-recruit approaches were used for silver kob and West Coast steenbras (Tables 5, 6 and 7).

In 1997/98, a Beverton and Holt (1957) yield-per-recruit model was used to investigate the potential effect of different fishing mortalities, natural mortality and age-at-first-capture schedules on silver kob and West Coast steenbras. In a Thompson and Bell (1934) yield-per-recruit model, fishing mortality arrays and recruitment, estimated by cohort analysis and size-specific natural mortality, were used to study different scenarios that could be implemented as management measures for the sustainable exploitation of the two species (Kirchner *et al.*, 2001; Holtzhausen and Kirchner, 2001c).

To estimate the total annual catch and effort of shore-anglers, a roving-roving creel beach-survey design, through which data were collected by intercepting and interviewing anglers while they were fishing, was used (Kirchner and Beyer, 1999). Skiboat and lineboat catches were sampled routinely at offloading sites and the data raised to represent the total annual catch (Kirchner, 1998). The combined catches of the three fishery sectors for six consecutive fishing seasons are illustrated in Figures 2 and 3 for silver kob, and that of the recreational anglers in Figure 4 for West Coast steenbras.

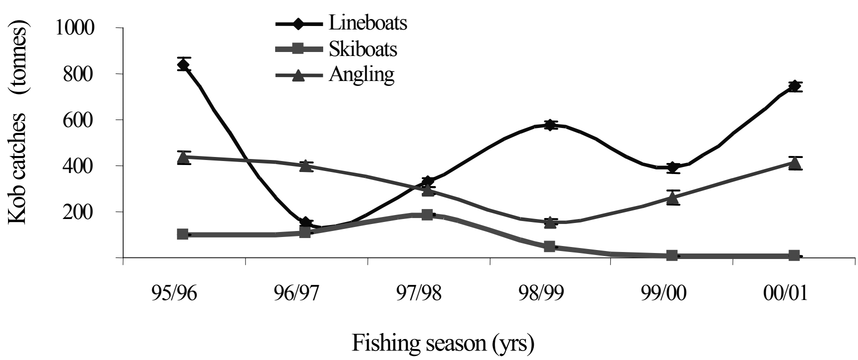

Figure 2: Catches in tonnes of the three forms of kob fisheries for six consecutive fishing seasons off Namibia.

Economics

The economic value of the Namibian recreational rock-and-surf fishery was determined by surveying a stratified sample of 240 anglers over a period of one year (Kirchner *et al.*, 2000). Skiboat owners and lineboat skippers were also surveyed to estimate their annual contributions to Namibia's Gross Domestic Product (GDP) (Kirchner *et al.*, 2000). Zeybrandt and Barnes (2001) conducted a similar survey in 1998 of 626 coastal recreational anglers aimed at measuring further economical characteristics of demand in the fishery. In particular, consumer surpluses and value added for the different market segments, as well as elasticities of demand, were investigated.

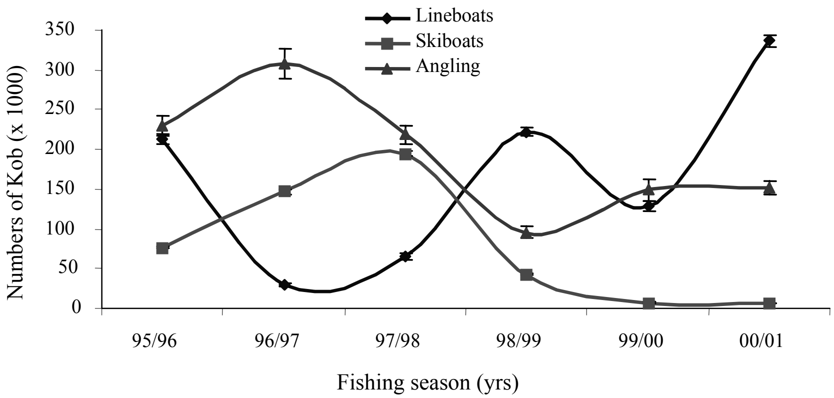

Figure 3: Catches in numbers of the three forms of kob fisheries for six consecutive fishing seasons off Namibia.

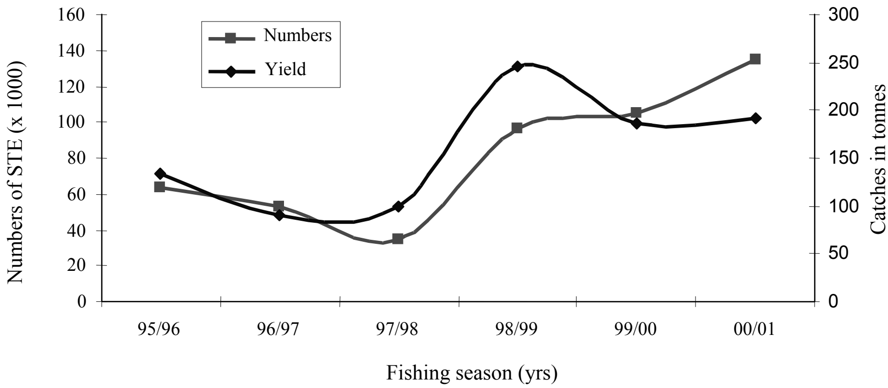

Figure 4: Numbers and catches (in tonnes) of West Coast steenbras of recreational shore anglers for six consecutive fishing seasons off Namibia.

RESULTS

Migration and genetics

Silver kob. - In all, 20 020 kob were tagged and released, 437 (2.18%) subsequently being recaptured (Table 3). The recapture results demonstrate that there is only one stock of silver kob, ranging from Cape Frio in the north to Meob Bay in the south (Kirchner and Holtzhausen, 2001; see Figure 1). Biochemical genetic studies (starch–gel electrophoreses) on specimens from two Namibian populations of *A. inodorus* and one population of *A. coronus* further confirmed that the two species were not from the same gene pool (Van der Bank and Kirchner, 1997). The southern distribution of the latter species ends about 55 km north of Cape Frio (Van der Bank and Kirchner, 1997; Figure 1). As <10% of the annual kob catch (by number) of recreational shore-anglers in Namibia is of this species (Kirchner, 1998), research effort was directed towards silver kob.

West Coast steenbras. - Of the 35 578 West Coast steenbras tagged and released, 768 (2.15%) were recaptured (Table 3). The results strongly indicate the existence of a separate, closed population of West Coast steenbras in the vicinity of Meob Bay, and a northern population off central and northern Namibia (WCRA and SCP). Also, distinct differences in growth rates, otolith morphology, size at maturity, sex ratios and length-at-age were found between the Meob Bay and the more northern population. Electrophoretic analysis on samples from the two populations showed significant genotypic differentiation at two loci, indicating that effective barriers exist to isolate them (Van der Bank and Holtzhausen, 1998/99).

Models and assessments

Silver kob. - Kirchner (2001) calculated that by introducing a minimum size limit of 40 cm TL, the long-term biomass could increase by approximately 10%. By further reducing the catches of lineboats by 25% (i.e. implement a total allowable catch of 350 tonnes gutted and headed weight) it was calculated that the long-term biomass could increase to 11 900 (10 700, 13 200) tonnes. For ages 1–5 only, c. 10% of silver kob mortalities are attributable to fishing (Figure 5). In contrast, fishing mortalities are closer to 50% for ages 6, 10, 11 and 13. Lineboats fish heavily on age-classes 6–7 and, when a Thompson and Bell analysis was run, lowering the fishing mortality for lineboats by c. 25%, the total biomass would reach 50% of its pristine level under steady state conditions. The target reference level of depletion for the silver kob stock is set at 50%. In 2000/01, the stock was assessed with the maximum sustainable yield (MSY) for silver kob estimated at 955 tonnes with 95 percentiles of (855, 1 114) tonnes at a biomass of 7 175 (5 734, 9 125) tonnes and a level of depletion of 40% (29, 51; Table 6). The high fishing mortalities of ages 10, 11 and 13 are the result of shore-anglers and skiboats targeting the large spawners when they aggregate in shallow water during the breeding season (Figure 5). It is clear that some sort of protection should be offered to these spawners to ensure sustainable recruitment.

Kirchner *et al.* (2001), using two different empirical equations, calculated for silver kob the length and age (L_{opt} and t_{opt}) at which the biomass should be at its highest level. These produced similar results, where L_{opt} and t_{opt} were estimated as 68 cm (7.8 yr) and 67 cm (7.5 yr) respectively. These are the lengths (TL) at which silver kob first start to take part in a spawning migration. The highest spawning potential is usually reached at the length of L_{opt}. Therefore the daily bag limit was lowered to 10 fish in total, of which only two may be above 70 cm TL.

Table 8: Catches and yields of the three forms of kob fishery (1 October 1995 to 30 September 1996.

Fisheries	Numbers ±SE (× 1 000)	Mass ±SE (tonnes)
Anglers	230 ± 13	361 ± 22
Skiboats	75 ± 4	97 ± 4
Lineboats	219 ± 6	728 ± 22
Total	524 ± 15	1 187 ± 32

Estimation of catch and effort (Table 8) showed that, in the 1996/97 season, the three kob fisheries combined harvested approximately 1 187 (±32) tonnes of silver kob; most was taken by recreational shore-anglers. Compared to the

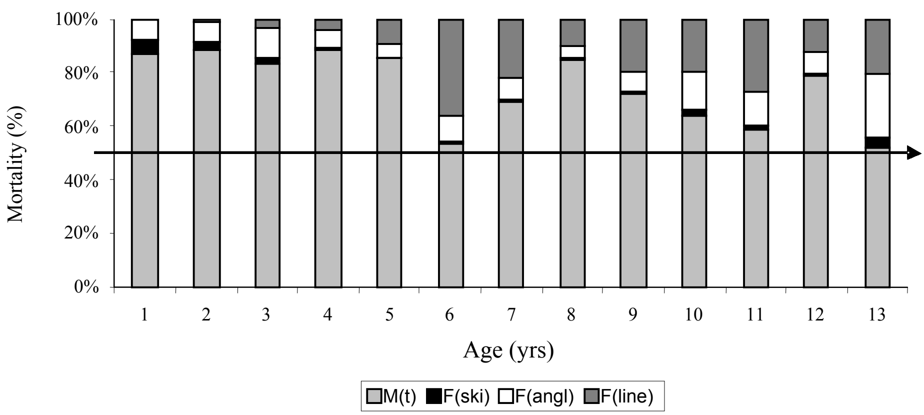

Figure 5: Mortality of silver kob of different ages attributable to natural causes $M(t)$ and fishing mortality by the skiboat fishery $F(ski)$, shore-anglers $F(angl)$ and the lineboat fishery $F(line)$. The arrow indicates 50% mortality.

current MSY of 955 tonnes (Table 6), the stock is evidently optimally utilised. The Thompson and Bell yield-per-recruit model indicated that, if a minimum size limit of 40 cm TL were to be introduced, the long-term biomass could increase by approximately 10% (Table 5). However, Kirchner *et al.* (2001) argued that implementing a minimum size limit for the silver kob fishery would have serious economic implications for coastal communities. Nevertheless, something needs to be done, and therefore a total allowable catch (TAC) of 350 tonnes (headed and gutted) has been proposed for the lineboat fishery. By selectively targeting bigger silver kob with big hooks, this fishery has a large impact on spawner biomass, so effort has to be reduced.

Figure 2 shows that the kob catches of recreational shore-anglers doubled in the last three fishing seasons. However, catches in numbers have remained constant over the last two seasons (Figure 3). This might be as a result of the skiboat sector, which has collapsed during the same period. On average, skiboats have caught smaller kob of about 35 cm TL. Recreational anglers catch larger kob on average, which is reflected in a higher tonnage being caught but in numbers that remain relatively constant.

West Coast steenbras. - In 2000/01, the northern West Coast steenbras population was assessed and the MSY was estimated at 278 (202, 384) tonnes with a spawning stock biomass level of 2006 (1 294, 2 942) tonnes and a level of depletion of 53% (37, 67; Table 7). The target reference level of depletion for the silver kob stock is set at 50%. The proportion of females in the spawning biomass was estimated at 38–50%, with the best estimate at 44% (Thompson

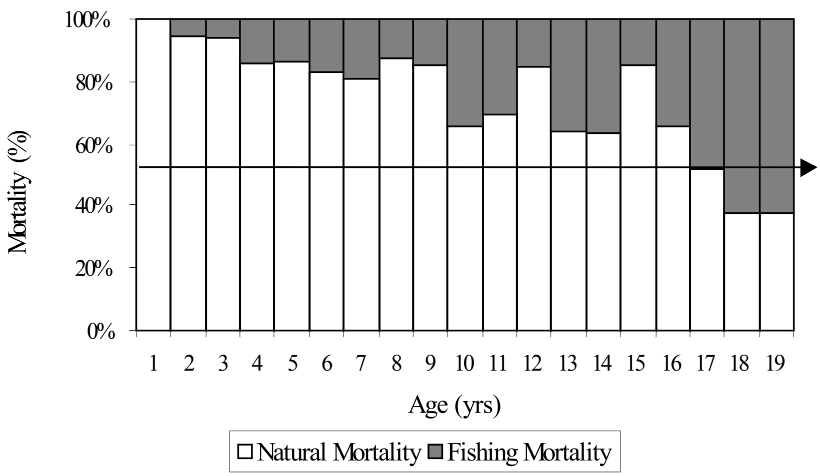

Figure 6: Mortality of northern West Coast steenbras of different ages attributable to natural causes and fishing mortality by recreational rock-and-surf anglers off the Namibian coast. The arrow indicates 50% mortality.

and Bell model). The MSY has been denoted as a limit reference point, in other words catches should not be allowed to exceed this value. In the 1998/99 fishing season, the recreational catch was 245 tonnes, only 33 tonnes lower than the MSY.

Fishing and natural mortality per age group are shown in Figure 6, the latter obtained from values of age-specific natural mortality. Occasionally, for poorly understood fish stocks, a management procedure keeping $F \approx M$ can be advocated (Gulland, 1970). This is possible because it is an adequate approximation of the optimal $F_{0.1}$ criteria in cases when $1 < M/K < 4$ (Deriso, 1987; M/K for northern West Coast steenbras is approximately 2.6). Mortality attributable to fishing for ages 1–8 does not exceed 20% for each of the age-classes. Between ages 10 and 16, mostly females, the mortality attributable to fishing increases to 40%. The high fishing mortality of West Coast steenbras older than 16 years is the result of increased availability of large fish in Terrace Bay, where they aggregate in shallow waters, hence presenting an easy target for shore-anglers. Similarly to silver kob, only two West Coast steenbras larger than 65 cm FL (16 yr) may be retained per angler per day. This management regulation will offer some protection to these large spawners which contribute most to reproduction. The Thompson and Bell yield-per-recruit model indicated that, if a minimum size limit of 40 cm TL were to be introduced, the long-term biomass could increase by approximately 8%.

The southern West Coast steenbras stock could not be assessed with conventional fishery models, because recreational rock-and-surf anglers are not allowed to fish in the Namib Naukluft Park, which is a closed area (MFMR, 1993). However, Holtzhausen (1999) concluded that West Coast steenbras

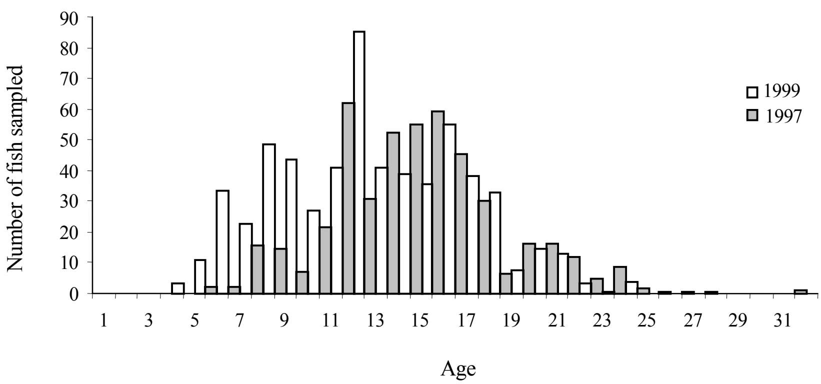

Figure 7: Age composition of West Coast steenbras sampled from commercial catches landed by lineboats at the Walvis Bay harbour, Namibia ($n_{1997} = 466$, $n_{1999} = 600$; after Holtzhausen, 1999).

are protandrous hermaphrodites, in other words that fish first function as males but then change sex to become females, at a FL of approximately 40 cm in the southern population. Female West Coast steenbras from the southern population reach 50% maturity at about 43.2 cm FL, an age of about 10 years. Commercial lineboat catches of West Coast steenbras from the southern population only resumed in 1997 as no West Coast steenbras were harvested in this area from 1985 to 1996. Lineboat catches during 1997 and 1999 are presented in Figure 7 (Holtzhausen and Kirchner, 2001c); 82% of the catch was of fish older than 10 years (93% of the 1997 catch and 73% of the 1999 catch). This means that lineboats target the female component of the population, ultimately leading to a change in the sex ratio of the population that could impair its reproductive potential.

Shore-angling catches of West Coast steenbras, estimated from the roving-roving creel survey data, declined over two years but increased significantly during the 1998/99 season. This could have been due to increased catches in the Torra/Terrace Bay area (Figure 1). Usually, catches from that area contribute up to 20% of the total catches of West Coast steenbras for the northern region, but in 1998/99 the proportion of the catch caught there increased to 50%. These were mostly large fish which must have moved into the area from the northern Skeleton Coast Park area.

It should be noted that there is a high degree of uncertainty in these assessments, which should be expected when dealing with a paucity of data. This was only the second time that these stocks were assessed. This is captured in the formal statistical uncertainty estimates, where the 95% percentiles are fairly wide = e.g. the depletion for silver kob in the 2000/01 assessment ranges from 29% to 51% (Table 6), and that for West Coast steenbras ranges from 31% to 67% (Table 7). In addition, given the uncertainties in these assessments, the changes predicted in biomass, yield per recruit and depletion rates are fairly small and might not be detectable over a period of time. However, the topic of a precautionary approach in fisheries research, management and technology has become an important issue globally (Gabriel and Mace, 1999). Therefore, although it seems that both stocks are in good condition, one has to be careful of implementing radical management measures when there is some uncertainty in the results.

Economics

Results from the economic survey indicated that, between October 1996 and September 1997, some 8 800 recreational shore-anglers went on 173 000 angling outings along the Namibian coast and had direct expenditure amounting to N$29.7 million (US$3.7 million in mid 2001). Similarly, Zeybrandt and Barnes (2001) found that the aggregate angler expenditures per annum amount to about N$30 million. Foreign visitors, mostly South Africans, contributed 55% of the expenditure (Kirchner *et al.,* 2000). The skiboat fishery contributes ±N$2 million annually to Namibia's GDP and the lineboat fishery another ±N$3.4 million (Kirchner, 1998). In total, the linefishery contributes approximately N$35 million annually to Namibia's GDP. The estimated expenditure for each fish (all species) caught by a shore-angler, a lineboat, and a skiboat is given in Table 9.

Table 9: Estimated cost of each fish (all species) caught by population group, area, shore-anglers, lineboats and skiboats off the coast of Namibia during the 1996/97 fishing season (after Kirchner, 1998).

Source	N$/fish
Coastal Namibian	34.00
Inland Namibian	94.10
Foreigner	96.40
Terrace Bay	45.80
Torra Bay	44.20
Recreational anglers (average)	64.30
Skiboats	17.70
Lineboats	24.30

DISCUSSION

Daily bag limit

Bag limits are the one management measure mostly used to regulate a recreational fishery. Results from the roving-roving creel survey (Kirchner and Beyer, 1999) indicated that in Namibia, recreational anglers land on average 2.6 fish per day. Thus, as a management measure, the previous daily bag of 30 fish per angler had no effect as a management measure on Namibian anglers. For a bag limit to have an effect in increasing the biomass, it should thus be set at between two and five fish, but this is unrealistic and would destroy the recreational fishery (Kirchner, 2001). For this reason a daily bag limit of 10 fish per angler was introduced for the four important linefish species that include silver kob and West Coast steenbras.

Silver kob

Tag-recapture results support the assumption that only one stock of silver kob is found between Cape Frio and Meob Bay. As only two silver kob tagged in Namibia were recaptured in South African waters and one off Oranjemund (the border between the two countries, but Namibian territory), it is considered that emigration of silver kob to South Africa is minimal. This theory is further supported by the fact that none of the silver kob tagged in South African waters, 6 904 up to 30 April 2000 (Tagging News **13**, July 2000: p. 5), has been recaptured in Namibian waters to date. Therefore, the Namibian silver kob stock is currently assessed using cohort analysis under the assumption that it is a discrete stock targeted in three different areas by the three Namibian line-fisheries.

Tag-recapture results of silver kob were further used to demonstrate the migratory cycle of adult fish (Kirchner and Holtzhausen, 2001). Spawning adults start migrating southwards against the north-westerly surface currents at the beginning of the austral summer, from the northern end of their distributional range to their spawning grounds, Sandwich Harbour and Meob Bay (NNP), at the southern end of their distributional range. After spawning, larvae probably drift north with the current to the nursery area in the WCRA. When juveniles reach the age of approximately 2 years, they gradually move north towards SCP waters. At the end of the spawning season when the surf-zone water temperature decreases to about 15°C, adult silver kob complete their spawning cycle by returning to the same SCP waters, probably moving slightly offshore and with the current.

The daily bag limit of 30 fish per angler was too high to be effective, and has been reduced to 10. Of these 10, only two (2) should be silver kob >70 cm TL (Kirchner *et al.*, 2001). This is an adaptive management approach (Walters and Hilborn, 1978), whereby a deliberate attempt is made to learn about the effectiveness of a management measure and to improve the knowledge about the system. Introducing the minimum size limit of 40 cm TL could increase the long-term biomass by only 10%, but it might enhance survival of recruits into the age classes that contribute to the spawning potential of the stock (Kirchner *et al.,* 2001). However, after a few years the stock will be re-assessed and the size limits and daily bag limits adjusted accordingly.

Lineboat catches of kob (tonnes) have also increased sharply from 1999/00 to 2000/01 while the numbers that were caught have more than doubled (Figures. 2 and 3). This could be explained by the fact that four freezer lineboats are now employed. These boats can stay at sea for long periods as they do not rely on ice to keep the headed and gutted catch fresh, but instead all fish are being packed and frozen at sea. Therefore, they target all sizes of kob hence the dramatic increase in numbers caught. It was also recommended to reduce the catches of lineboats by 25% (i.e. implement a total allowable catch of 350 tonnes gutted and headed weight). It was calculated that the long-term biomass could increase to 11 900 (10 700, 13 200) tonnes. Due to the negative impact that such a management measure might have upon the socio-economic well-being of some coastal communities, it has not yet been implemented.

West Coast steenbras

Recapture results for West Coast steenbras showed that those from the northern region (SCP) (northern population) move over large distances to the WCRA, whereas the southern population (Meob Bay area) constitutes a closed and separate population. Evidence to support the hypothesis of an isolated population is provided by Agenbag and Shannon (1988), who suggested that the combined effect of changes of circulation and turbulence/stratification causes a biological discontinuity in the vicinity of Meob Bay, so providing a barrier to interchange of biota. The biochemical genetic study by Van der Bank and Holtzhausen (1998/99) confirmed that the southern population is a closed population, separate from the northern population. Also, different life histories and tag-recapture data show that the populations are isolated, and the negative effects of local overfishing will not be cancelled out by immigration from less exploited areas. Therefore, it is proposed that the two populations be managed separately, while taking cognizance of the geographical structure of the resource. West Coast steenbras from the northern population that move from the northern region to the WCRA are mostly males in a reproductive stage. The hypothesis is therefore that these males disperse southwards to find gravid females with which to mate. However, no spawning migrations of large West Coast steenbras, as suggested by anecdotal evidence, were found during the study period (Holtzhausen, 1999).

A daily bag limit of only two (2) large West Coast steenbras >65 cm FL per angler has been implemented in order to protect the female component of the population. At such a size they are 16+ years old, and fishing mortality appears to be too high for this age group (Figure 6). By introducing a minimum size limit of 40 cm FL the spawning stock biomass would increase by approximately 8%, so improving the spawning potential of the population in the long term, e.g. more males would survive to become females. The level of depletion of the stock would also decrease to c. 56%, with 95% percentiles of 43–68%. For the southern West Coast steenbras population, it is clear that the older fish need protection to provide a stable stock structure for optimal recruitment. Although the southern West Coast steenbras population is currently not exploited by shore-anglers and only intermittently by lineboats, as a unique population it needs to be protected.

The yield in tonnes for West Coast steenbras harvested has decreased from 245 tonnes in 1998/99 to 191 tonnes in 2000/01 while the numbers harvested have increased significantly (Figure 4). In 1998/99, more than 50% of the harvest consisted of large spawners caught in the Terrace Bay area. Since then, fewer of these large fish were caught and the average size West Coast steenbras caught is around 45 cm FL.

Economics

The average expenditure per fish caught is highest for visiting foreign anglers (mostly South Africans), approximately N$96 (Table 9). Inland Namibian anglers almost matched that figure, at an average of N$94 per fish. Coastal resident Namibian anglers spent far less, just N$32 on average, to catch each fish. Visitors to Terrace Bay and Torra Bay had the highest expenditures of any angling group but, because their catches there were much bigger, the cost per fish caught was on the order of N$45 (Kirchner, 1998). Kirchner *et al.* (2000) argued that these values could be sustainable if policies to reduce fish mortality without affecting angler numbers were implemented. Therefore, smaller but realistic bag limits need to be set. At N$17.70 per fish landed, the catches of the skiboat anglers are the cheapest of the various fisheries. Approximately N$24.28 is the cost of each fish (excluding snoek) caught by a lineboat, and a fish caught by a shore-angler (all angler categories and localities combined) costs approximately N$64.30. These results indicate that the recreational shore-angler is by far the most valuable (to the Namibian economy) user of the linefish resource. The commercial linefish fishery is worth only a fraction (1/7) of the value of the recreational fishery. Therefore, the ongoing conflict between the different user groups where one group accuses the other for dwindling catches in this multi-user fishery needs resolution with these facts in mind.

Before this economic survey was conducted, the linefishery was not considered an important component of the Namibian fishery as a whole. The results of the survey indicated that the annual revenue derived from utilising the linefish resource is approximately N$35 million. Foreign (mainly South African) recreational anglers buy food, fuel, bait and refreshments from various Namibian suppliers during their holidays in the country. As most of these visitors travel by vehicle and, because Namibian towns are spaced at great distances apart, they stop overnight on their way to and from the coast at various guest farms, game lodges or accommodation establishments in towns. Also, some of the visitors make use of the camping facilities available at various campsites along the coast, which are administered by the Ministry of Environment and Tourism (MET), which collects daily camping and entrance fees. Some visitors hire private houses at the coast for the duration of their stay, some make use of municipal bungalows or caravan parks, and others stay in hotels, at bed-and-breakfast establishments, or with friends and relatives. Therefore, the revenue indirectly derived through the linefish resource is reflected in contributions by other Ministries to Namibia's GDP.

Adding to this, the sociological and psychological benefits to the recreational angler and his family cannot be measured in terms of hard cash, a fact that eludes most economists. However, it is the duty of the Government of any country to guard its natural resources, the ownership of which belongs to its inhabitants. This fact becomes even more relevant if the resource contributes to the economy, small as it may be.

Based on the stock assessment results of the two important linefish species, minimum size limits for these two species were introduced (40 cm TL), a restriction was placed on the daily allowable take of specimens over a certain size (70 cm TL for silver kob and 65 cm TL for West Coast steenbras), and a drastically reduced daily bag for recreational anglers was implemented (30 to 10 fish). It was further recommended that a TAC for the lineboat sector be introduced, but since this would have far reaching socio-economic implications for some coastal communities, this has not been implemented. Table 2 shows some of the new regulations for recreational shore-anglers that have been accepted and implemented in December 2000.

REFERENCES

Agenbag, J.J. and Shannon, L.V. (1988): A suggested physical explanation for the existence of a biological boundary at 24°30'S in the Benguela system. *South African Journal of Marine Science* 6: 119-132.

Beverton, R.J.H. and Holt, S.J. (1957): *On the Dynamics of Exploited Fish Populations*. Fishery Investigations, Series 2, 19. London; Her Majesty's Stationery Office. 533 pp.

Beyer, J.E., Kirchner, C.H. and Holtzhausen, J.A. (1999): A method to determine size-specific natural mortality applied to westcoast steenbras *Lithognathus aureti* in Namibia. *Fisheries Research* 41(2): 133-153.

Botes, F. (1994): Extensive research on angling fish resource. *Namibia Brief* 18: 82–83.

Deriso, R.B. (1987): Optimal $F_{0.1}$ criteria and their relationship to maximum sustainable yield. In: Proceedings of an International Symposium on Stocks Assessment and Yield Prediction (W.J. Christie and G.R. Spangler, eds.), *Canadian Journal of Fisheries and Aquatic Sciences* 44(Suppl. 2): 339–348.

Gabriel, W.L. and Mace, P.M. (1999): A review of biological reference points in the context of the precautionary approach. In: *Proceedings of the Fifth National NMFS Stock Assessment Workshop*: Providing Scientific Advice to Implement the Precautionary Approach Under the Magnuson-Stevens Fishery Conservation and Management Act (V.R. Restrepo, ed.), pp. 34-45. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-40.

Griffiths, M.H. and Hecht, T. (1993): Two South African *Argyrosomus hololepidotus* species: implications for management. In: *Fish, Fishers and Fisheries.* Proceedings of the Second South African Marine Linefish Symposium, Durban, Ocober 1982 (L.E. Beckley and R.P. van der Elst, eds.), Special Publications of the Oceanographic Research Institute South Africa 2: 19–22.

Griffiths, M.H. and Heemstra, P.C. (1995): A contribution to the taxonomy of the marine fish genus *Argyrosomus* (Perciformes: Sciaenidae), with descriptions of two new species from southern Africa. Ichthyology Bulletin J.L.B. Smith Institute of Ichthyology 65: 40 pp.

Gulland, J.A. (1970): The fish resources of the ocean. F.A.O. Fisheries Technical Paper 97: 425 pp.

Holtzhausen, J.A. (1999): Population dynamics and life history of west-coast steenbras (*Lithognathus aureti* (Sparidae)), and management options for the sustainable exploitation of the steenbras resource in Namibian waters. PhD thesis, University of Port Elizabeth: 213 pp.

Holtzhausen, J.A, Kirchner, C.H. and Voges, S.F. (2001a): Observations on the linefish resources of Namibia, 1990–2000, with special reference to West Coast steenbras and silver kob. In: *A Decade of Namibian Fisheries Science* (A.I.L. Payne, S.C. Pillar and R.J.M. Crawford, eds.), *South African Journal of Marine Science* 23: 124-135.

Holtzhausen, J.A. and Kirchner, C.H. (2001b): Age and growth of West Coast steenbras *Lithognathus aureti* in Namibian waters, based on otolith readings and mark-recapture data. In: *A Decade of Namibian Fisheries Science* (A.I.L. Payne, S.C. Pillar and R.J.M. Crawford, eds.), *South African Journal of Marine Science* 23: 169-179.

Holtzhausen J.A and Kirchner, C.H. (2001c): An assessment of the current status and potential yield of Namibia's northern West Coast steenbras *Lithognathus aureti* population. In: *A Decade of Namibian Fisheries Science* (A.I.L. Payne, S.C. Pillar and R.J.M. Crawford, eds.), *South African Journal of Marine Science* 23: 158-169.

Kirchner, C.H. (1998): Population dynamics and stock assessment of the exploited silver kob (*Argyrosomus inodorus*) stock in Namibian waters. PhD thesis, University of Port Elizabeth. 276 pp.

Kirchner C.H. (2001): Fisheries regulations based on yield-per-recruit analysis for the linefish silver kob *Argyrosomus inodorus* in Namibian waters. *Fisheries Research* 12(3): 155-167.

Kirchner, C.H. and Beyer, J.E. (1999): Estimation of total catch of silver kob *Argyrosomus inodorus* by recreational shore-anglers in Namibia using a roving-roving creel survey. *South African Journal of Marine Science* 21: 191-199.

Kirchner C.H. and Holtzhausen, J.A. (2001): Seasonal movements of silver kob *Argyrosomus inodorus* in Namibian waters. *Fisheries Management and Ecology* 8(3): 239-251.

Kirchner, C.H. and Voges, S.F. (1999): Growth of Namibian silver kob *Argyrosomus inodorus* based on otoliths and mark-recapture data. *South African Journal of Marine Science* 21: 201-209.

Kirchner, C.H., Holtzhausen, J.A. and Voges, S.F. (2001): Introducing size limits as a management tool for the recreational line fishery of silver kob, *Argyrosomus inodorus*, in Namibian waters. *Fisheries Management and Ecology* 8: 227–237.

Kirchner, C.H., Sakko, A.L. and Barnes, J.I. (2000): An economic valuation of the Namibian recreational shore-angling fishery. *South African Journal of Marine Science* 22: 17–25.

MFMR (1993): Sea Fisheries Regulations. Government Gazette of the Republic of Namibia. Act 29 of 1992 (Section 32). 55 pp.

Thompson, W.F. and Bell, F.H. (1934): Biological statistics of the Pacific halibut fishery. 2. Effect of changes in intensity upon total yield and yield per unit of gear. Rep. int. Fish. (Pacific Halibut) Commn 8: 49 pp.

Van der Bank, F.H. and Holtzhausen, J.A. (1998/1999): A preliminary biochemical genetic study of two populations of Lithognathus *aureti* (Perciformes: Sparidae). *Southern African Journal of Aquatic Science* 24(1/2): 47–56.

Van der Bank, F.H. and Kirchner, C.H. (1997): Biochemical genetic markers to distinguish two sympatric and morphologically similar Namibian marine fish species, *Argyrosomus coronus* and *Argyrosomus inodorus* (*Perciformes: Sciaenidae*). *Journal of African Zoology* 111(6): 441–448.

Walters, C.J. and Hilborn, R. (1978): Ecological optimization and adaptive management. *Annual Review of Ecological Systems* 9: 157–188.

Zeybrandt F. and Barnes, J.I. (2001): Economic characteristics of demand in Namibia's marine recreational shore fishery. In: *A Decade of Namibian Fisheries Science* (A.I.L. Payne, S.C. Pillar and R.J.M. Crawford, eds.), *South African Journal of Marine Science* 23: 145-156.