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# OBSERVATIONS ON THE LINEFISH RESOURCES OF NAMIBIA, 1990–2000, WITH SPECIAL REFERENCE TO WEST COAST STEENBRAS AND SILVER KOB

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The Namibian linefishery is a multisector fishery, with recreational and commercial sectors targeting overlapping species. Prior to 1990, catch data were recorded for the boat sector, but little research was done on the population dynamics of any of the species. Hence, none of the stocks were assessed owing to the lack of parameter estimates for fisheries modelling. Current management regulations for the Namibian linefishery are therefore not based on scientific investigations but, for historical reasons, were adapted from South African legislation for similar species. From 1994, linefish research in Namibia focused on the life history and population dynamics of silver kob *Argyrosomus inodorus* and West Coast steenbras *Lithognathus aureti*, important species in both commercial and recreational sectors. A roving-roving creel survey was used to determine effort and catches of recreational shore-anglers. Both species were assessed using yield-per-recruit models. Based on the results, reduced daily bag limits and the implementation of size limits for the recreational sector were proposed. For the commercial sector, the introduction of a total allowable catch would seem to be the best option. Results from an economic survey indicated that the recreational sector earns six times more for the country annually than the commercial sector.

Key words: creel survey, economics, genetics, migration, silver kob, West Coast steenbras, yield-per-recruit

The Namibian fishing industry is based on the Benguela Current, one of four highly productive eastern boundary upwelling systems of the world. What these systems lack in species diversity is compensated for in abundance. Consequently, for shore-angling enthusiasts, the Namibian coast has for decades been synonymous with an abundance of linefish species such as kob *Argyrosomus* spp., West Coast steenbras *Lithognathus aureti*, galjoen *Dichistius capensis*, blacktail *Diplodus sargus,* and various shark species.

Before Namibia's Independence in 1990, South Africa administered the country. Fisheries regulations formulated for the South African fisheries were also applied to sympatric Namibian stocks. Therefore, minimum size limits and daily bag limits on kob, West Coast steenbras, galjoen and blacktail were strictly imposed. Unfortunately, however, those management measures were not based on results obtained from studies on Namibian linefish, nor was the status of any of the stocks assessed. Only two localized assessments of shore-anglers' catches in Namibia were carried out prior to 1990, but those studies estimated only part of the annual recreational catch, at Sandwich Harbour and Terrace Bay (Fig. 1; Penrith and Loutit 1982, Lenssen *et al*. 1991).

Up to 1990, only four studies on certain aspects of one of the endemic Namibian species, West Coast steenbras, were conducted. Smith (1962) and Penrith and Penrith (1969) investigated its taxonomy, Lucks (1970) made a preliminary study on some aspects of its biology, and McLachlan (1986) conducted a study on food preferences of its juveniles.

The Namibian linefish fishery is a multisector fishery: the recreational shore-angling sector, the commercial lineboat sector and the commercial and recreational skiboat sector all target specific, but sometimes overlapping, species (Table I). Environmental conditions play a vital role in the availability of fish to shore-anglers or fishers on boats. The strong south-westerly winds that generate upwelling have a negative impact on angling success because they cause large swells and turbulent water, which hampers casting distance, causes the bait to drift and thereby reduces soak time of the bait. When warm-water events occur, fish species such as West Coast steenbras and silver kob do not take bait and are therefore not available to anglers. Similarly, when sulphurous compounds are upwelled, most species are not available to the fishery working from the shore. In the region of Sandwich Harbour and Walvis Bay (Fig. 1) in particular, sulphur eruptions are common in water close inshore because of the decay of the benthos (Copenhagen 1953). The eruptions may last for several days, during which time almost no fish are landed from the shore, and the effect is also felt by the lineboat and skiboat fisheries. Subsequent environmental conditions influence the speed of change in catchability of linefish species as the sulphur eruptions and concentrations disperse.

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Table I: Fish species caught by the multi-sector Namibian line-fishery

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

This paper reports on linefish research, particularly on silver kob and West Coast steenbras, conducted in Namibian waters since 1990. The research includes work on migration patterns and genetics, models and assessments, estimation of catch and effort, and economics. Significant findings, those with clear implications for management, are presented.

## HISTORY

The first land-based commercial fishery in Namibia was established in 1851 at Sandwich Harbour (Kinahan 1991). Fish were caught with hook and line from rowboats, salted and sun-dried, then shipped to South Africa, from where they were exported to Mauritius. However, the natural closing of the entrance to the bay at Sandwich Harbour in 1891 ended fishing operations there.

For the next 73 years, no records of commercial exploitation of the Namibian linefish resource exist. In the early 1960s, some stakeholders in the pilchard *Sardinops sagax* industry switched to trawling and linefishing on a small scale, and two factories started freezing and salting material for sale and export. Thus, the first catches of lineboats were recorded in 1964 for kob and in 1973 for West Coast steenbras respectively (Kirchner 1998, Holtzhausen 1999). In terms of the development of a recreational fishery along the Namibian shoreline, only anecdotal evidence exists about the good catches made before the 1990s. No catch or effort data for the fishery were available. Also, the economic value of the Namibian linefish resource was unknown until comparatively recently, despite it supporting three different fisheries.

In 1979, the South African Sea Fisheries Research

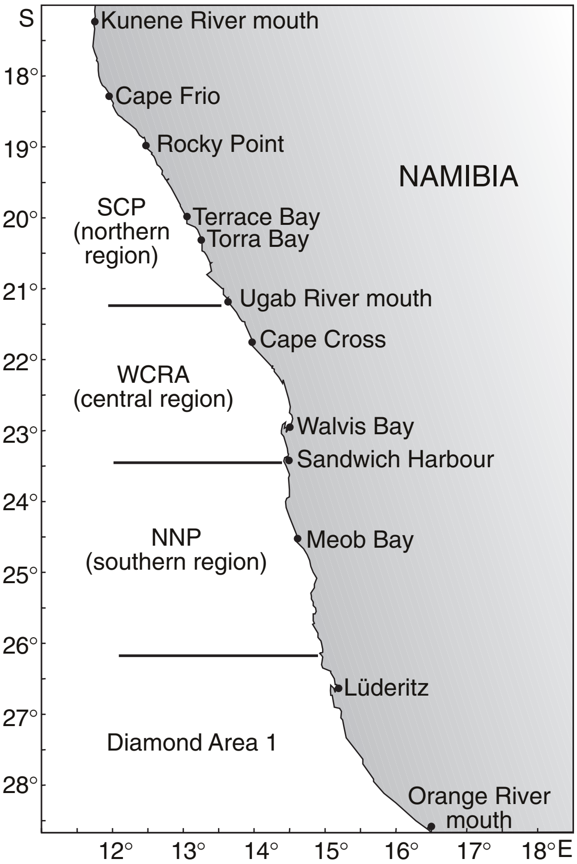


Fig. 1: Map of Namibia indicating the closed diamond-mining area (Diamond Area 1) and conservation areas, the partially restricted Skeleton Coast Park (SCP), the closed Namib Naukluft Park (NNP), and the West Coast Recreational Area (WCRA) that is open to angling

Institute started a long-term project on Namibian linefish species with the aim of estimating the total annual catch and to assess linefish stocks. Data on the annual catches of recreational anglers, using catch cards, were collected over a period of nine years, but the results were never published. From data obtained from catch statistics (1964–1986) of lineboats, Venter (1988) briefly discussed trends in catches of kob *Argyrosomus hololepidotus*, West Coast steenbras and snoek *Thyrsites atun*. In December 1987, a biologist was tasked with initiating intensive linefish research in Namibia, and a long-term tag-and-release programme for angling fish was launched in 1988 (Botes 1994).

Table II: 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 | | | | West Coast steenbras | | | |
|---|---|---|---|---|---|---|---|---|
| | Number tagged | Number recaptured | | | Number tagged | 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 |

The aims were to establish the abundance and occurrence of linefish species along the coast, to determine migration patterns and to collect biological data. Also, during 1988, the commercial skiboat sector was added to the linefishery.

After Independence in 1990, a new National Fisheries Act and Sea Fisheries Regulations were drafted, and with the lack of scientific evidence pertaining to linefish, previous management regulations were revised (Ministry of Fisheries and Marine Resources 1993). All minimum size limits of linefish were abolished and the daily bag limits adjusted to levels that, as a current management measure, make them ineffective (Kirchner 1998, Holtzhausen 1999).

## Migration studies and genetics

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 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.

Until very recently, it was thought that the kob *Argyrosomus hololepidotus* ranged from northern Natal, on the east coast of South Africa, to the latitude of 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).

Biochemical genetic studies (starch-gel electrophoresis) on specimens from two Namibian populations of *A. inodorus* and one population of *A. coronus* 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; Fig.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.

Throughout the world the method of tagging and recapturing fish is used to study fish 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 Fig. 1). The NNP is closed to all shore-angling and the SCP is partly closed to shore-angling. It was hoped that the study would confirm that such areas serve as marine protected areas seeding other parts of the coast, including the angler-accessible WCRA.

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. Approximately 50 such excursions were conducted, mostly in the closed southern and northern areas. 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 III: Parameter estimates and the range/best estimates of values used in the models for assessment of the northern stock of West Coast steenbras (Holtzhausen and Kirchner 2001b) and silver kob (Kirchner 2001) off Namibia

| Parameter | Range/best estimate | |
|---|---|---|
| | West Coast steenbras | Silver kob |
| $K$ | 0.088 year$^{-1}$ | 0.136 year$^{-1}$ |
| $L_\infty$ | 84.6 cm | 103 cm |
| $t_0$ | -2.756 | -1.58 |
| $W_\infty$ | 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$^{-1}$ |
| $M_\infty$ | 0.21 | 0.19 |
| $F_{term}$ | 0.11 | |
| $t_r$ | 1 year | 0.75 years |
| $t_c$ | 2 years | 1 year |
| a | 0.00003 | $4.8 \times 10^{-5}$ |
| b | 2.9444 | 2.71 |
| $t_m$ | 5 years | 5 years |
| $t_f$ | 10 years | 10 years |

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.

In all, 20 020 kob were tagged and released, 437 (2.18%) subsequently being recaptured (Table II). 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 Fig. 1).

Of the 35 578 West Coast steenbras tagged and released, 768 (2.15%) were recaptured. The 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).

## Models and assessments

Linefish stocks in Namibia were not assessed until relatively recently because no biological data existed. To derive the necessary input parameters for age-based stock assessment models (Table III), two separate in-depth studies on the life histories and population dynamics of silver kob and West Coast steenbras were initiated (Kirchner 1998, Holtzhausen 1999). 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 2001a). Size-specific natural mortality was determined for West Coast steenbras by developing a new 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.

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

Table IV: Estimated values for depletion of the stock, long-term biomass, *MSY* and expected yield of Namibian silver kob 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 parenthesis (after Kirchner 2001)

| Scenario | Depletion (%) | Biomass (tons) | *MSY* (tons) | Yield (tons) |
|---|---|---|---|---|
| 1. Current | 30–47 (39) | 7 800–10 600 (9 100) | 1 140–1 360 (1 240) | 1 000–1 170 (1 130) |
| 2. Minimum size of 40 cm | 36–54 (46) | 9 700–12 300 (10 900) | 1 050–1 150 (1 100) | 950–1 050 (1 000) |
| 3. Cut $F$ of linefish boats by 25% | 34–52 (43) | 8 700–11 600 (10 000) | 1 100–1 340 (1 200) | 1 000–1 100 (1 050) |
| 4. 40 cm size limit + cut $F$ of linefish boats by 25% | 41–58 (50) | 10 000–13 200 (11 900) | 1 000–1 120 (1 070) | 880–1 020 (950) |

Table V: Estimated values for depletion, long-term spawning biomass (tons), proportion of females in the spawner stock biomass and the total biomass, and the maximum sustainable yield in tons of the northern stock of West Coast steenbras. Percentiles (95%) are given in parenthesis (after Holtzhausen 1999)

| Parameter | Best estimate | 95% percentiles |
|---|---|---|
| Depletion (%) | 42 | (29–56) |
| Spawner stock biomass (*SSB*, tons) | 772 | (538–1 121) |
| % Females in *SSB* | 42 | (38–47) |
| % Females in biomass | 22 | (19–26) |
| *MSY* (tons) | 134 | (109–173) |

mortality, were used to study different scenarios that could be implemented as management measures for the sustainable exploitation of the two species (Kirchner 2001, Holtzhausen and Kirchner 2001b).

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 sectors are illustrated in Table VI.

### 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 1998). 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). 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 VI.

Table VI: Effort and catch of the three forms of kob fishery (1 October 1995 to 30 September 1996; after Kirchner and Beyer 2000)

| Fisheries | Numbers ±*SE* (× 1 000) | Catch ±*SE* (tons) |
|---|---|---|
| Anglers | 230 ± 13 | 361 ± 22 |
| Skiboats | 75 ± 4 | 97 ± 4 |
| Lineboats | 219 ± 6 | 728 ± 22 |
| Total | 524 ± 15 | 1 187 ± 32 |

## ADVANCES AND IMPLICATIONS

### Migration studies and genetics

Tag-recapture results support the assumption that only one stock of silver kob is found between Cape Frio and Meob Bay. As only three silver kob tagged in Namibia were recaptured in South African waters and only one off Oranjemund (the border between the two countries, but Namibian territory), it is considered highly unlikely that silver kob migrate to South Africa. 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 linefisheries.

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.

Based on this hypothesis, it has been proposed that the introduction of a maximum size limit of 70 cm total length (*TL*) should protect the large spawner stock. The current daily bag limit of 30 fish per angler

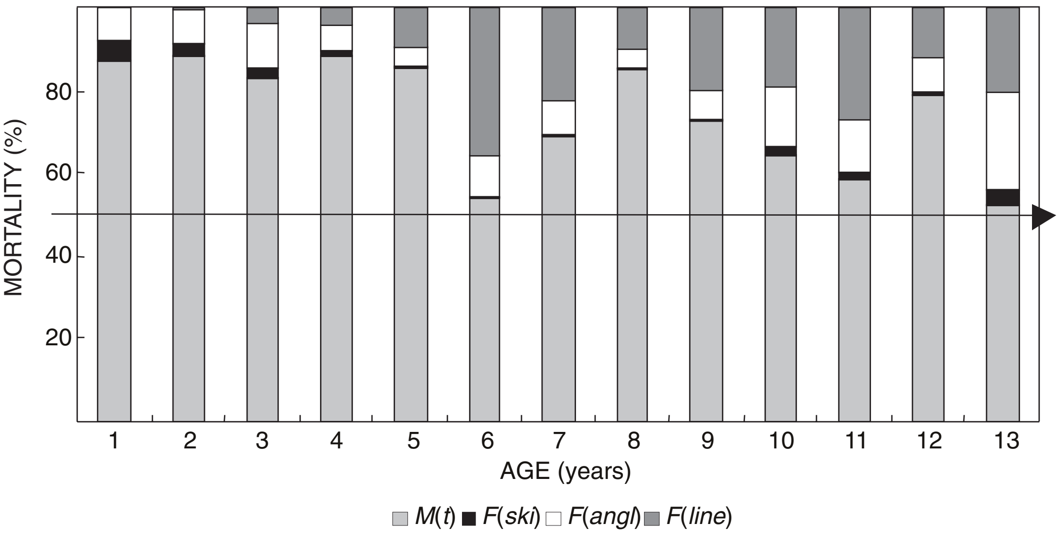


Fig. 2: Mortality of silver kob of different ages attributable to natural causes *M*(*t*) and fishing mortality by the skiboat fishery *F*(*ski*), shore-anglers *F*(*angl*) and the lineboat fishery *F*(*line*)

is too high to be effective, and should be reduced to 10. Of these 10, only two (2) should be silver kob >70 cm *TL* (Kirchner *et al*. 2001). This would be an active 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.

Recapture results for West Coast steenbras showed that those from the northern region (SCP; northern population) move over considerable 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. 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 or migrate southwards to find gravid females with which to mate. No spawning migrations of large West Coast steenbras, even suggested by anecdotal evidence, were found during the study period (Holtzhausen 1999).

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.

## Models and assessments

The maximum sustainable yield (*MSY*) for silver kob was estimated at 1 240 tons with 95 percentiles of (1 140, 1 360 tons) at a biomass of 9 100 (7 800, 10 600) tons and a current level of depletion of 39% (30, 47; Table IV; Kirchner 2001). 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 tons gutted and headed weight) it was calculated that the long-term biomass could

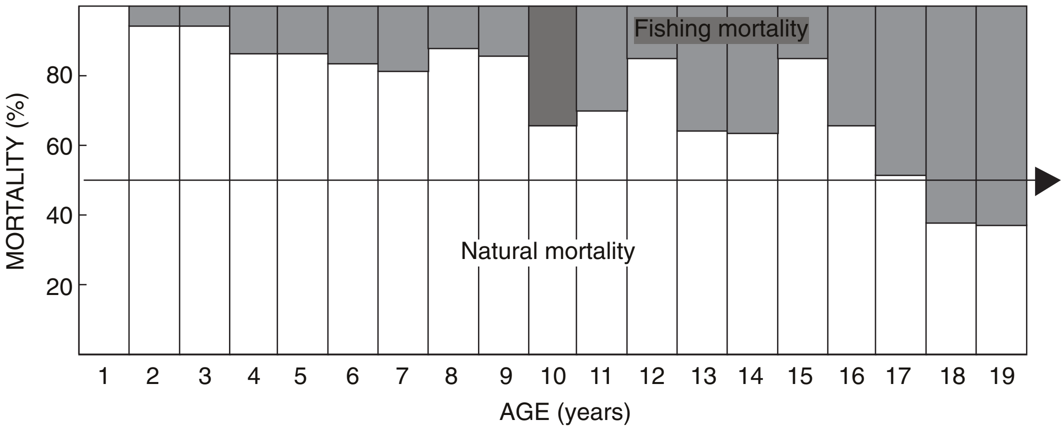


Fig. 3: Mortality of northern West Coast steenbras of different ages attributable to natural causes and to fishing mortality by recreational rock-and-surf anglers off the Namibian coast

increase to 11 900 (10 700, 13 200) tons. For ages 1–5 only c. 10% of silver kob mortalities are attributable to fishing (Fig. 2). In contrast, fishing mortalities are closer to 50% for ages 6, 10 and 11. 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 high fishing mortalities of ages 10 and 11 are the result of shore-anglers and skiboats targeting the large spawners when they aggregate in shallow water during the breeding season. It has therefore been proposed that the daily bag limit include only two silver kob larger than 70 cm total length (*TL*), to offer some protection to spawning fish.

For the northern West Coast steenbras population, the *MSY* was estimated at 134 (109, 174) tons with a spawning stock biomass level of 772 (538, 1 121) tons and a current level of depletion of 42% (29, 56; Table V; Holtzhausen and Kirchner 2001b). Shore-angling catches alone equalled this *MSY* in the 1995/96 season and almost double the *MSY* was taken in the 1998/99 season. More than 50% of this harvest originated in the Terrace Bay area. The proportion of females in the spawning biomass was estimated at 38–47%, with the best estimate at 42% (Thompson and Bell model). It has therefore been proposed that a strict bag limit on large West Coast steenbras be implemented in order to protect the female component of the population, e.g. only two fish >65 cm fork length (*FL*) per angler per day. At such a size they are 16 years old, and fishing mortality appears to be too high (Fig. 3). 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. The level of depletion of the stock would also decrease to c. 56%, with 95% percentiles of 43–68%.

Fishing and natural mortality per age group are shown in Figure 3, 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 water and present an easy target for shore-anglers.

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 the population (Ministry of Fisheries and Marine Resources 1993); the total annual catch is therefore not known. However, Holtzhausen (1999) concluded that West Coast steenbras 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 popu-

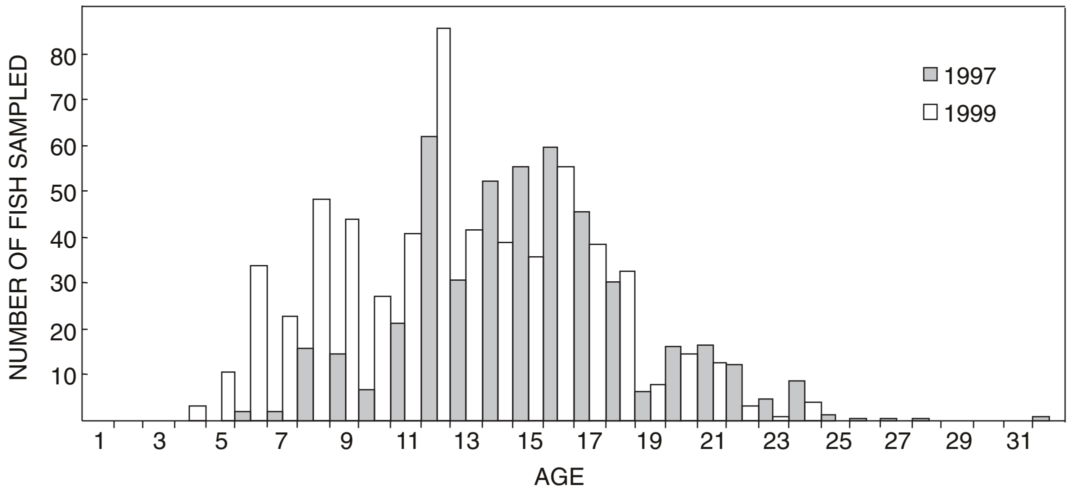


Fig. 4: Age composition of West Coast steenbras sampled from commercial catches landed by lineboats at the Walvis Bay harbour, Namibia ($n_{1997}$ = 466, $n_{1999}$ = 600; after Holtzhausen 1999)

lation 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 during 1997 and 1999 are presented in Figure 4; 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. Clearly, these older fish need protection to provide a stable stock structure for optimal recruitment, which could be obtained if there are more females than males in a population. 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 population ought therefore to be managed separately from the northern population, and lineboat harvests would have to be monitored closely in future.

Estimation of catch and effort (Table VI) showed that, in the 1996/97 season, the three kob fisheries combined harvested approximately 1 187 (±32) tons of silver kob; most was taken by recreational shore-anglers. Compared to the current *MSY* of 1 240 tons (Kirchner 2001), the stock is evidently optimally utilized. 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 IV). 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 tons (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.

Shore-angling catches of West Coast steenbras, estimated from the roving-roving creel survey data, declined over two years but increased remarkably during the 1998/99 season. This could have been due to increased catches in the Torra/Terrace Bay area (Fig. 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%.

The *MSY* for the northern stock of West Coast steenbras has been estimated at 109–174 tons, with a best estimate on the order of 134 tons (Table V). The *MSY* has been denoted as a limit reference point, in other words that catches should not be allowed to exceed this value. In the 1995/96 fishing season, the recreational catch equalled this value, and in the 1998/99 season it amounted to 245 tons. It has therefore been predicted that, if similar catches are made in future, West Coast steenbras would soon become seriously overexploited.

## Economics

The average expenditure per fish caught is highest for visiting foreign anglers (mostly South Africans), ap-

Table VII: 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 | Cost profile (N$) |
|---|---|
| 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 |

proximately N$96 (Table VII). 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 linefishery is worth only a fraction (1/7) of the value of the recreational fishery. Therefore, the ongoing conflict between the different user groups 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 utilizing the linefish resource is approximately N$35 million. Compared to the estimated 1996 landings (before adding value) of marine resources caught by other Namibian fisheries, the linefishery superseded in value the tuna fishery, the deep-sea red crab fishery, the rock lobster fishery and the pelagic fishery for that year (Ministry of Fisheries and Marine Resources, unpublished data).

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. Most of these places are administered by the Ministry of Environment and Tourism (MET), which collects entrance and accommodation fees. Also, some of the visitors make use of the camping facilities available at various campsites along the coast, which are also administered by the MET, who again collect 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 protect 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.

In conclusion, research results over the past decade indicate that the linefish resource could be managed on a sustainable basis if bag limits for the recreational fishery were reduced substantially, size limits be introduced, and a *TAC* for lineboats be implemented. Although the silver kob stock is currently utilized almost to its maximum, the state of the stock seems to be at an acceptable level of depletion. In contrast, catches of large West Coast steenbras by recreational shore-anglers are currently too high, although the situation should change if maximum size limits are introduced.

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