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COLLAPSE OF LINEFISH STOCKS BETWEEN CAPE HANGKLIP AND WALKER BAY, SOUTH AFRICA

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The state of the linefishery between Cape Hangklip and Walker Bay on the Cape south coast, South Africa, is assessed. The coast was subdivided into 20 "beats" to provide high spatial resolution on catch and effort of the shore-based recreational fishery. An observer recorded the number of anglers in each fishery sector, and their catch, during shore patrols over a two-year period. Catch-and-effort data for the commercial boat-based fishery were obtained from an historical database at the turn of last century and from the extant National Marine Linefish System database. Catch per unit effort (*cpue*) of shore-anglers was low and many of the species caught earlier in the century have disappeared from catches. Compared to the early records, contemporary commercial linefish *cpue* had dropped by approximately 80%, despite a greater fishing capacity. It is argued that most targeted stocks have been overexploited (notwithstanding indications of environmental change) and many are severely depleted. Poor management of the fishery, including a lack of control of commercial effort and inadequate enforcement, contributed to overexploitation.

The management of coastal fisheries, including recreational, subsistence and small-scale commercial fisheries, is one of the greatest challenges for the conservation of marine resources in South Africa. With few exceptions, South Africa's coastal fisheries have been controlled by effort limitation (e.g. limits on the number of commercial fishers, or seasons for recreational fishing) and not by catch limitation (limits on the size of the total catch). It follows that, without direct control over catch, the rates of fishing mortality have increased steadily along with the number of recreational fishers and the value of seafood. In addition, many South African fisheries are beset with illegal fishing practises. The combined fishing pressure by all sectors is likely to have had a substantial impact on marine biodiversity. Unfortunately, effort to collect catch statistics for coastal fisheries has been generally poor, with the result that even the massive changes in the abundance and ranges of species over the last century (regarded as common knowledge among resources users) are difficult to substantiate with reliable statistics.

A pattern that is found throughout the world in the development of fisheries is the steady depletion of fish stocks, beginning with large, high-value species, and progressing towards small, low-value species (Jennings and Kaiser 1998). Fishers progressively target species lower down the food chain, a process that Bohnsack and Ault (1996) term "serial overfishing". The extent of this type of overfishing is seldom fully documented, because of the lack of uniformity of fishery data over long periods (Pauly 1998). Contemporary fishery science has been reluctant or unable to incorporate data from early sources, because some essential variables were not recorded (e.g. effort or areas) or fishing methods and gear were not comparable. Early fishery information that is available appears to have been recorded for the purpose of developing the fishery, and for trade reports. Fishery data for stock assessment have been a comparatively recent requirement.

A consequence of the exclusive use of contemporary data in assessments is a poor understanding of the original state of marine ecosystems prior to substantial human disturbance. There are two dangers here. First, the carrying capacity of a stock is not known. Although it is typical for linefish stocks to be assessed in terms of per-recruit analyses (Butterworth *et al*. 1989, Punt 1993), such analysis give no indication of the size of the exploited stock relative to the original unexploited stock. Per-recruit methods can assess the pressure on the stock in terms of relative yield and spawner biomass projections, but the accumulative effect of years of depletion of spawner stocks is not measured. Temporal comparisons of catch per unit effort (*cpue*) between early and modern-day catches and spatial comparisons between protected and exploited populations are the only techniques capable of providing some assessment of the effect of an extended period of exploitation. A second problem that may result from the exclusion of early records is the failure to detect long-term changes in community composition. "Ecosystem overfishing" is the term used to describe changes in ecosystem structure brought about by fishing (Bohnsack and Ault 1996). These changes

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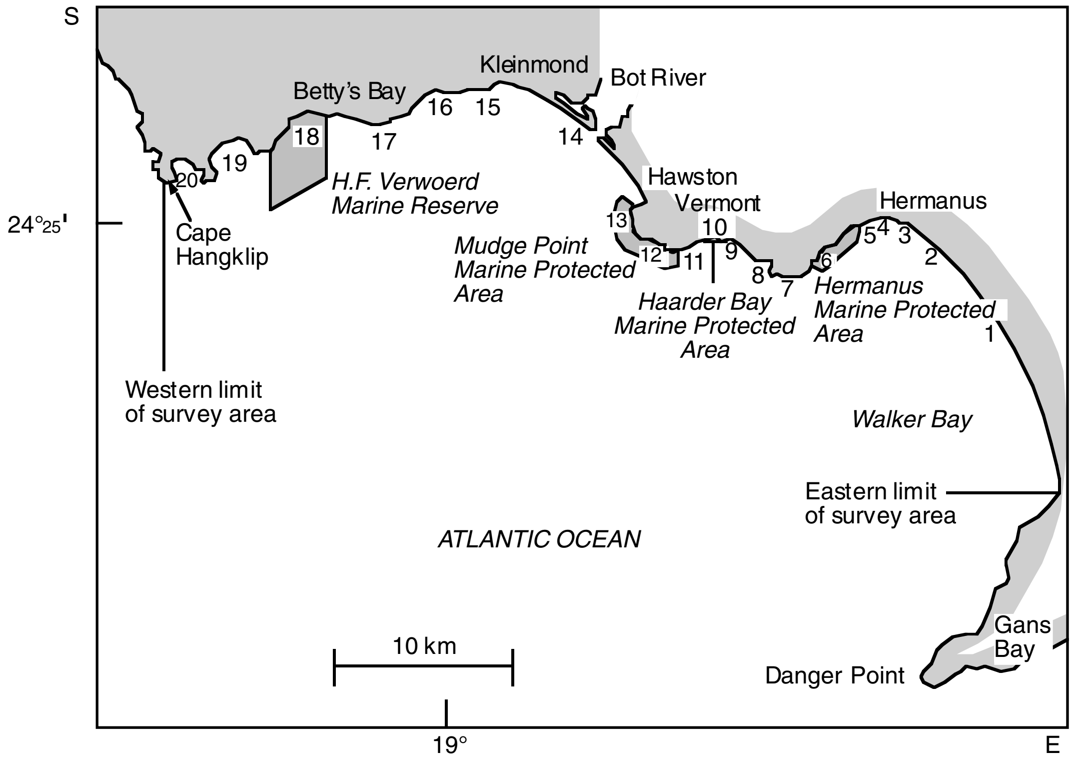

Fig 1: Map of the survey area showing the beats and places mentioned in the text. Marine protected areas are shown by shading

may affect the productivity or carrying capacity of individual populations in the community.

As part of a larger survey of marine biodiversity in the area between Cape Hangklip and Walker Bay on the Cape south coast (Fig. 1), an assessment was made of the state of the linefishery and of linefish stocks. This assessment was facilitated by the availability of old fishery records, which could be compared to the results of a modern survey and a contemporary database.

The area between Cape Hangklip and Walker Bay has been important for linefishing since the last century, with the development of a small harbour at Hermanus (Burman 1989). The linefishery grew from a small but important industry to a large (in terms of capacity) and diverse fishery, including a recreational (largely shore-based) and a commercial (boat-based) component. The coastal area is biologically rich, being an upwelling area with a variety of habitats, including kelp forests, sandy beaches, mixed sand and rocky shores and exposed headlands (Table I).

This paper presents an assessment of the condition of the linefish stocks in the region and reviews the fishery controls that have been applied to manage the fishery.

MATERIAL AND METHODS

High resolution coastal fishery survey

Fishing effort and catches in the recreational shore-fishery were estimated from direct observations by a single observer from 1 March 1995 to 31 January 1997. The 72 km coastline between Cape Hangklip and Walker Bay, referred to hereafter as the "survey area", was divided into 20 "beats" (Fig. 1). These beats were not of uniform length, but were chosen on the basis of access points, uniformity in the marine habitat and protected status. Each beat was numbered sequentially from east to west and their coastline lengths were measured in 100-m increments from 1:10 000 orthophoto maps.

Table I: The popular name, coastline length, habitat type (the dominant type is listed first), and special protected status (if any) of the 20 beats shown in Figure 1

Beat number	Popular name	Length (m)	Habitat type(s)	Protected status
1	Hermanus Plaat	15 000	Exposed sandy beach/mixed rock and sand	
2	Grotto beach	1 600	Exposed sandy beach/mixed rock and sand	
3	Voëlklip	800	Mixed rock and sand	
4	Mosselrivier	500	Kelp forest/mixed rock and sand	
5	Eastcliff	1 300	Exposed headland/kelp forest	
6	Westcliff	4 400	Exposed headland/kelp forest	Restricted area
7	Schulphoek	3 700	Exposed headland/kelp forest	
8	Sand Bay	1 600	Kelp forest	
9	Onrus	800	Kelp forest/sandy beach	
10	Haarder Bay	1 200	Kelp forest	Restricted area
11	Vermont	1 600	Kelp forest	
12	Frans Senekal	2 200	Kelp forest	Restricted area
13	Nuwe Bay	2 600	Kelp forest	Restricted area
14	Sandown Bay	10 000	Exposed sandy beach	
15	Kleinmond	2 900	Exposed headland/kelp forest	Coastal reserve
16	Palmiet	1 700	Kelp forest/exposed headland	Coastal reserve
17	Sunny Seas	7 600	Exposed headland/kelp forest	Coastal reserve (partly)
18	Betty's Bay	3 300	Sandy Beach/kelp forest	Marine reserve
19	Silver Sands	5 700	Sandy beach/kelp forest	
20	Masbaai	3 800	Kelp forest	

SURVEY ROUTINE

For the purpose of the survey, the beats were grouped into three areas: Hermanus (Beats 1–7), Vermont (Beats 8–14) and Betty's Bay (Beats 15–20). The observer covered each of the three areas once a week. Each beat was monitored on foot, but a vehicle was used to drive between access points. The day and the time of the observations were selected randomly. The number of people engaged in recreational shore-angling in each beat was recorded. All observations were instantaneous counts. Catches were counted, measured and recorded against the beat and day. No authority was obtained for these inspections and anglers were under no obligation to reveal their catches. For three isolated inspections, permission was refused by shore-anglers, and no catch was recorded, although it was likely that fish were taken.

Linefish boats adjacent to each beat were also counted during shore patrols. Fishing activity at estuary mouths was included in this survey, but fishing in the estuaries *per se* was outside the scope of this study.

INTERPOLATION OF CATCH-AND-EFFORT OBSERVATIONS

Shore-angling effort and catches were recorded by the observer who intercepted anglers while they were fishing. This survey procedure is technically known as a roving creel census and has been widely used in assessing recreational fisheries (Pollock *et al*. 1997). The observer recorded the number of anglers per beat, and the size and number of each species in the catch of each angler.

The unit of effort was an angler-day (instead of hours), for reasons discussed elsewhere (Attwood and Bennett 1995). To estimate the total effort, the number of anglers intercepted by the observer was converted to a total daily count for that beat and that day. Nearby resident anglers usually make short visits to the shore in the early morning or evening, in addition to those who spend long periods over midday. Consequently, the observer, who passes only once in the day at a randomly chosen time, is likely to miss many anglers. A conversion factor of 2,5 was used to convert from an instantaneous shore-angler count to the total number that fished in a day in that particular area. Brouwer (1997) calculated this factor from two additional sources of information, the time each angler spent on the shore and the time at which the angler arrived on the shore. By calculating the turnover time of anglers on the shore, Brouwer (1997) related an instantaneous count to a daily total and calculated an average scaling factor of 2,48 for data recorded from all parts of the South African coastline (Brouwer 1997). The estimates of daily totals were averaged to give a single daily effort value for each beat/month combination, which could then be converted to a monthly total by multiplying by the number of days in that month. The variance of the daily effort counts was calculated for each beat, from which a coefficient of variation (*CV*) was calculated.

When estimating catch, the simplest assumption was that an angler's catch was inspected half way

Table II: List of species exploited by various fishing methods in the coastal environment between Cape Hangklip and Walker Bay. Ticks indicate an existing fishery and crosses indicate historical catches only (pre-1960)

Species	Common name	SA	CL	SF
Hexanchidae				
Notorynchus cepedianus	Broadnose sevengill shark	✓		
Carcharhinidae				
Mustelus mustelus	Smoothhound shark	✓		
Galeorhinus galeus	Soupfin shark		✓	
Triakis megalopterus	Spotted gulleyshark	✓		
Coracinidae				
Dichistius capensis	Galjoen	✓		
Sciaenidae				
Argyrosomus spp.	Kob	✓	✓	
Atractoscion aequidens	Geelbek	+	✓	
Umbrina canariensis	Belman	✓	✓	
Pomatomidae				
Pomatomus saltatrix	Elf	✓	+	
Sparidae				
Sparadon durbanensis	Musselcracker	✓		✓
Lithognathus lithognathus	White steenbras	✓	+	
Diplodus sargus capensis	Blacktail	✓		✓
Diplodus curvinus	Zebra	✓		✓
Pterogymnus laniarius	Panga		✓	
Gymnocrotaphus curvidens	John Brown	+		✓
Polysteganus undulosus	Seventyfour		+	
Petrus rupestris	Red steenbras	+		
Argyrozona argyrozona	Carpenter		✓	
Chrysoblephus laticeps	Roman	+	✓	✓
Chrysoblephus gibbiceps	Red stumpnose	+	✓	
Pachymetopon blochii	Hottentot	+	✓	✓
Carangidae				
Seriola lalandi	Yellowtail	+	✓	
Scombridae				
Sarda sarda	Katonkel	+		
Scomber japonicus	Chub mackerel		✓	
Thyrsites atun	Snoek		✓	
Tuna spp.	Tuna	+		

SA = shore-angling
CL = commercial linefishing
SF = spearfishing

through the fishing outing. The catch of each intercepted angler was therefore multiplied by a factor of two to arrive at a daily catch estimate for that angler. This daily catch estimate is therefore the *cpue* value (expressed as fish·angler-day^{-1}), because only one unit of effort was expended. Two averaging procedures could be used to calculate average cpue over long time periods (Pollock *et al*. 1997); namely (i) the ratio of mean catch and mean effort or (ii) the mean of the ratios of catch and effort. The choice of procedure does influence the result. Pollock *et al*. (1997) argue for the latter procedure, which was used here also:

The *cpue* (by species) of all anglers observed in a beat on a particular day was averaged. There is no possible ambiguity in the method used for this averaging, because all anglers were deemed to expend a single unit of effort. These daily averages were again averaged to give a mean monthly *cpue* per species and per beat. The total catch for each beat-month combination was estimated as the product of its mean *cpue* and total effort. The estimate of total catch for the entire area and for the entire duration of the survey was the sum of the estimates for all beat-month combinations. The average *cpue* for the entire area and duration of survey was calculated as the mean of the *cpue* values for each beat-month combination.

Angler interviews

A questionnaire (see Brouwer *et al*. 1997) was used to interview shore-anglers on a variety of aspects of their participation in the fishery, including their perceptions of the resource, the effectiveness of regulations and their knowledge and compliance of regulations. Shore-anglers were chosen at random and interviewed while angling.

Existing databases

An historical and a contemporary database were contrasted to assess the change in the offshore linefishery at Hermanus. Because of the great disparities in the time periods involved, as well as the methods of enquiry and the purpose of reporting, the following datasets are not entirely compatible. However, comparisons between different time periods were made as far as the data would allow.

GILCHRIST RECORDS

Reports of the Government Biologist in the years 1897–1906 list the number of fishing vessels and the quantity of fish landed per month at a number of harbours (Gilchrist 1898, 1899, 1900, 1901, 1902, 1903, 1904, 1906a, b, 1907): referred to hereafter as the "Gilchrist records". Landings of each species were recorded in numbers, although an average mass was given for each species for the year. Using these values of the average mass, the numerical data were converted to total mass. Hermanus had the only fishing harbour in the survey area during that period. Additional records of the number of crew and lines were kept, as well as anecdotal comments on fishing areas, mooring conditions and the sale, processing and destination of catches. The catch statistics reported by Gilchrist were discontinued after 1906, and the next comparable dataset began in 1987. Therefore, no linefishery statistics exist for the Hermanus commercial linefishery during the intervening eight decades.

NATIONAL MARINE LINEFISH SYSTEM (NMLS)

Fishery legislation since 1984 required all commercial vessels to be in possession of a permit, of which a limited number were issued as either commercial or semi-commercial permits. The submission of catch records was a condition of both types of permit. Catch (by species in kg) and effort (in terms of crew numbers and boat days) submissions were captured on the NMLS database. This database was interrogated for all records in the area between Wolwefontein (eastern side of Walker Bay) to Cape Hangklip and for the period 1987–1997. Catch locations in submissions were recorded according to the nearest location on the shoreline, so offshore distances could not be reported. The data were also broken down by boat registration area (vessels were licensed in a particular area, but their fishing was not restricted to that area). A second interrogation was chosen as a subset of the first, namely from Wolwefontein (the eastern limit of the survey area) to Mudge Point (Fig. 1) over the same period, to provide statistics comparable to the Gilchrist records when vessels fished only in this smaller area.

RESULTS

Historical and contemporary records show that 26 fish species have been exploited in substantial quantities from the survey area, by three methods of fishing (Table II). Linefishing was the most lucrative industry in the late nineteenth century, and targeted primarily species of the teleost families Sciaenidae, Sparidae and Scombridae. The majority of these catches were cured and shipped to inland markets (Gilchrist records). The linefishery persists today and exploits a greater variety of species, but it is no longer the major industry in the region. Shore-angling appears to have begun at the beginning of the 20th century and reached a peak in the 1950s, but it is still a very popular pursuit among local residents and visitors alike.

Spearfishing was the most recent addition to the fisheries in the survey area. Although no assessment was made of the effort and catch rates of this sector, targeted species were noted and included in Table II. A beach-seine fishery at Hermanus targeted haarders *Liza richardsonii*. It is likely that there was a bycatch of linefish species such as white steenbras *Lithognathus lithognathus* by this fishery, but these were never reported in catch returns (S. T. Lamberth, Marine and Coastal Management [MCM], pers. comm.). This fishery is not included in this analysis.

Recreational shore-fishery

Shore-angling equipment and techniques have been considerably refined over the course of the century, although the same basic technique is used: namely baited hooks cast with the aid of 3–4 m rods and lead sinkers from the shore. No permit was required for shore-angling, but since 1984 anglers were subject to a number of regulations pertaining to the minimum size, season and quantity of their catch. The recreational sector was legally prohibited from selling their catch.

EFFORT: SURVEY DATA

Shore-angling was practiced throughout the region (Fig. 2), particularly along sandy shores, shores of mixed rock and sand, and inside the protection of kelp

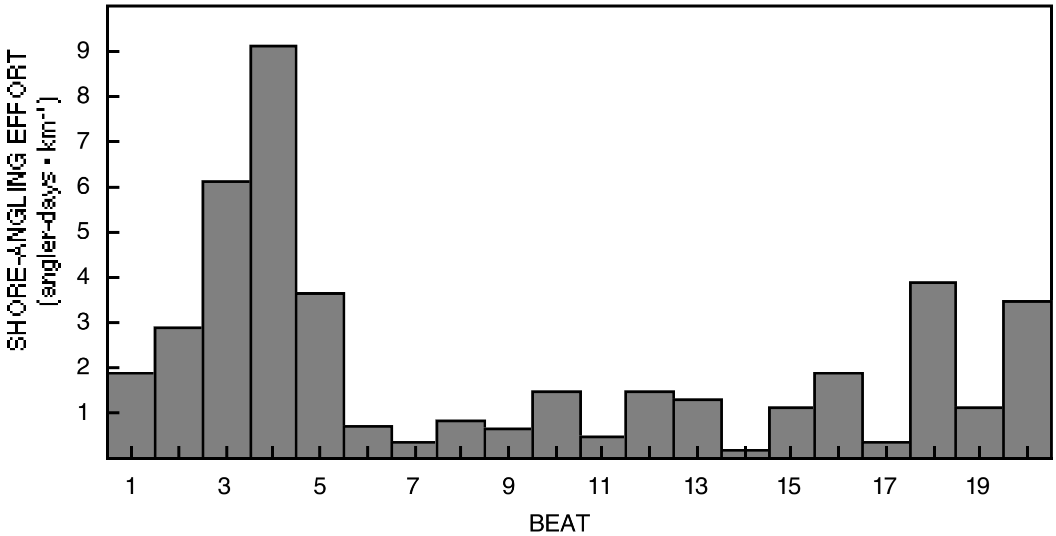

Fig. 2: Estimated shore-angler effort by beat between Cape Hangklip and Walker Bay, 1995–1997

forests (Table I). By contrast, the rocky headlands were not heavily fished. The estimated shore-angling effort per beat ranged between almost zero and 11 angler-days·km^{-1}, but for the entire survey area the estimate was 1.42 angler-days·km^{-1}. The temporal variability of effort was high and angler densities in excess of 20 anglers·km^{-1} were counted frequently in Beats 4, 18 and 20, although for most observations the count was zero. The *CV* of effort for each beat varied between 79 and 209%.

Much of the temporal variability in effort can be explained by the seasonal appearance of fish species in anglers' catches. Combining the data from all areas does not show a clear seasonal pattern, because different species are caught in different areas. Each area should therefore be considered separately, as the following examples demonstrate. Beat 5 is an area where silver kob *Argyrosomus inodorus* are taken from the shore in the summer after strong south-easterly winds. In the two years of the survey, peaks in angling activity in this area were clearly related to the arrival of silver kob in the summer (Fig. 3 shows the monthly effort and Fig. 4 shows the *cpue* by species for each beat). In contrast, galjoen *Dichistius capensis* are caught all year round, but catches peak in spring and early summer, when the fish build fat reserves for the midsummer spawning season (Bennett and Griffiths 1986). Beat 10 is a rocky shore sheltered by kelp forests, where galjoen is the dominant catch. Peaks in angler density in the latter half of the year were therefore evident (Fig. 3). The closed season for galjoen extends from 15 October to 31 February, and as a result very few anglers were encountered in Beat 10 during that period. Beat 12 has a similar shoreline to Beat 10 and the dominant catch there is also galjoen. The density of anglers is similar there, but a considerable amount of effort is expended during the closed season (Fig. 3). Poaching is common in Beat 12, probably because it is adjacent to an undeveloped terrestrial reserve with limited access and where enforcement is difficult. Beat 18 is the H. F. Verwoerd Marine Reserve, where a greater mix of species is caught and where seasonality in effort is less pronounced (Fig. 3).

CATCH: SURVEY DATA

The total number of shore-angler catch inspections was 2 448. The majority of these (89,2%) found no catch. *Cpue* calculated from these data yielded a total catch rate of 0.32 fish·angler-day^{-1}, although the rates varied considerably between areas and species (Fig. 4). Galjoen constituted 74.1% of the catch, followed by white steenbras, silver kob, blacktail *Diplodus sargus capensis*, musselcracker *Sparadon durbanensis*, elf *Pomatomus saltatrix* and belman *Umbrina canariensis* (Fig. 5). Four elasmobranch species were regularly targeted by sport-anglers, but the modern code of practice among this fraternity is to release their catch. For this reason, sharks were seldom found among anglers' catches and they were not included in the species composition.

Galjoen were taken most commonly inside kelp

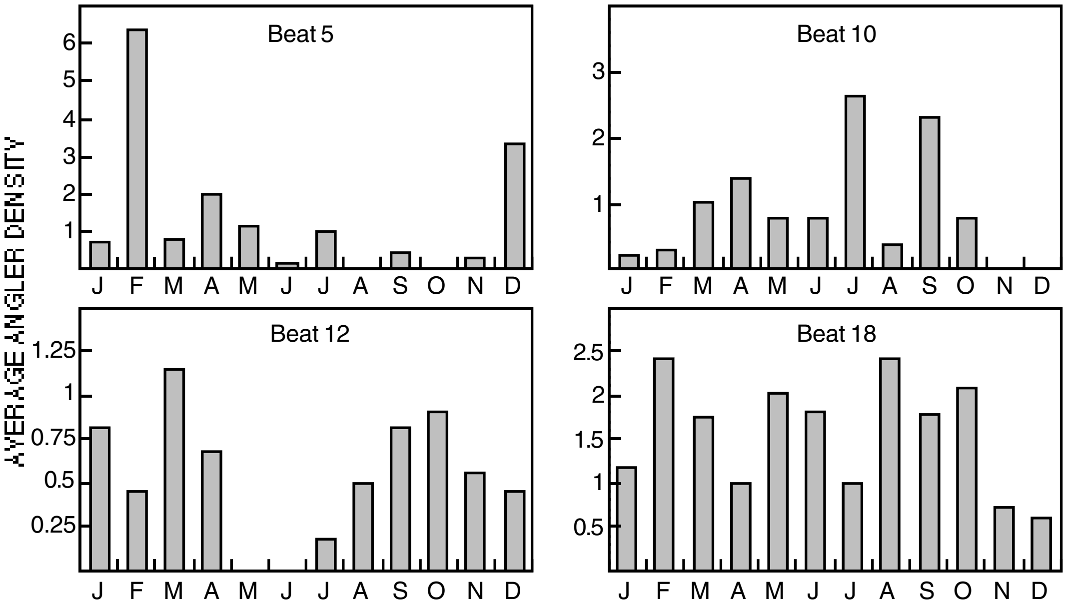

Fig. 3: Average angler density by month for four beats between Cape Hangklip and Walker Bay, 1995–1997

forests and along shores of mixed rock and sand. The three most productive areas were the Hermanus area (Beats 1–3), the Haarder Bay to Hawston area (Beats 10–13) and the Betty's Bay to Maasbaai area (Beats 17–20). Although the *cpue* for galjoen was highest in the Mudge Point Restricted Area, the total catch of this species was similar when compared to the other areas which received far greater effort (e.g. Beats 3, 18 and 20). The size composition of the galjoen catch shows that a substantial quantity of fish kept by anglers were below the legal size limit (Table III). Another 14.3% of the catch was >40 cm long, which corresponds to an age of approximately seven years for females or eight years for males (Bennett and Griffiths 1986). A total of 13% of the galjoen catch was taken out of season (Table III). The average annual catch of galjoen was estimated at 4 558 fish from all beats in the survey area. Given the large variability on the effort estimate, the confidence interval on this estimate (and other total catch estimates) is very broad.

Silver kob were caught in Beats 5 and 18 only, with by far the majority of the catch coming from the former area. The fish from the Eastcliff area (Beat 5) ranged between 80 and 110 cm, whereas those from Betty's Bay did not exceed 50 cm. There are two South African species of kob, and the one taken at Hermanus from boats and by shore-anglers is almost certainly silver kob *A. inodorus*. One of the fish taken at the Eastcliff area was positively identified as silver kob from its otolith (M. H. Griffiths, MCM, pers. comm.). The other species, *A. japonicus*, is usually taken from the shore in shallow, sandy bottom areas. Kob taken

Table III: Percentage of catch, taken by interviewed anglers, that contravened Sea Fisheries legislation

Species	Size limit (mm)	% Undersized	Closed season	% Out of season
Galjoen	350	37	15 Nov. – 31 Feb.	13
White steenbras[1]	400/600	65	na	
Blacktail	20	15	na	
Musselcracker	600	100	na	
Silver kob	400	3		

[1] Size limit increased in 1996
na = Not applicable

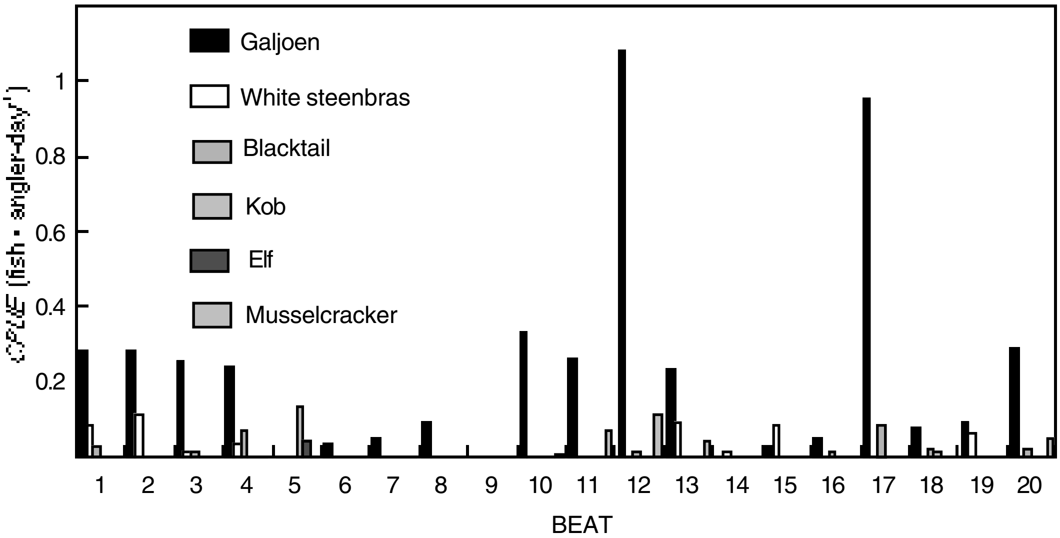

Fig. 4: Catch per unit effort of shore-anglers by species and beat between Cape Hangklip and Walker Bay, 1995–1997

at Hermanus were found in deep, turbid waters adjacent to kelp forests, which is more consistent with the habitat of silver kob (Griffiths 1996a). Only 3% of silver kob taken were smaller than the legal size limit of 40 cm. The average annual catch of silver kob was estimated to be 396 fish from all beats in the survey area.

The most productive angling areas for white steenbras were the Hermanus Plaat and adjacent Grotto Beach and Voëlklip areas, and along sandy shores at Hawston, Kleinmond and Silver Sands (Beats 1–4, 13–15 and 19 respectively, Fig. 4). The fish taken off the Hermanus Plaat and adjacent areas included a proportion (23%) of mature individuals (>80 cm), whereas those taken from the other areas were all immature. During the course of the survey, the legal size limit of this species was increased from 40 to 60 cm. These respective size limits were largely ignored and 65% of all white steenbras were smaller than the size limit applicable at the time (Table III). The average annual catch of white steenbras was estimated to be 1 352 fish from all beats in the survey area.

Musselcracker were occasionally found in anglers' catches in the Haarder Bay to Nuwe Bay area (Beats 10–13), but the few that were found were all below the legal size limit of 60 cm. Blacktail constituted almost 5% of the total catch and were taken in widely separated areas. Despite the small size limit of 20 cm, 14% of the catch of blacktail were undersized. Isolated catches of belman and elf were recorded, but neither species was a regular component of the catch in the survey area.

PROFILE OF ANGLERS

Recreational shore-angling in the study area was male-dominated, and included anglers over a wide range of ages (Table IV). Almost half of the interviewed anglers resided in the area, with the others coming largely from the Cape Town metropolitan area, neighbouring rural areas and occasionally from farther afield. Some anglers admitted to violating fishery regulations, and, when questioned on the regulations, less than half could answer correctly. Approximately half the anglers had had their catch inspected by a fishery inspector the previous year. The majority of anglers were of the opinion that shore-angling catches had declined over the past few decades, but approximately 18% believed they had improved. Among those who suspected a decrease, only 13% blame overfishing by shore-anglers, with the remainder of the blame being apportioned to various forms of commercial fishing and pollution.

Commercial linefishery

The historical information reported below is extracted from the Gilchrist records. In the late 19th century, the fishing vessels were propelled by sail and oars,

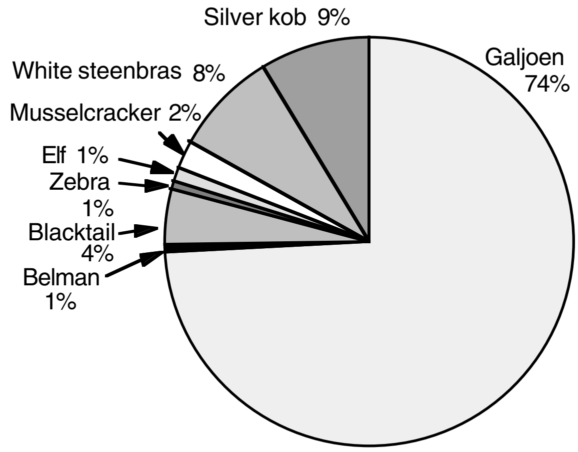

Fig. 5: Species composition of shore-angling catch between Cape Hangklip and Walker Bay, 1995–1997

each vessel carrying between six and eight crew. Fish were caught on hook and line (cat gut). All vessels operated out of the old harbour at Hermanus and fished at two sites in Walker Bay. Summer fishing was on the eastern side of Walker Bay (Beat 1), whereas the prevailing winds restricted vessels to the inshore reef close to the west of the harbour during winter (Beat 7).

Table IV: Summary of data derived from interviews with anglers from Cape Hangklip to Walker Bay

Sample size:	67
Age (mean, min, max):	39, 20, 71
Sex (male:female):	100:1
Admission to disobeying:	
Size limits:	12%
Closed seasons:	18%
Bag limits:	24%
Ban on sale:	15%
Correctly answering questions on the regulations, for the three most popular species:	
Size limits:	47%
Bag limits:	52%
Closed seasons:	46%
Catch inspected at least once in the last year:	49%
Belief that catches have declined:	68%
Reason for decline:	
Pollution:	29%
Beach seine-netting:	29%
Trawling:	24%
Commercial linefishing:	7%
Shore-angling:	13%

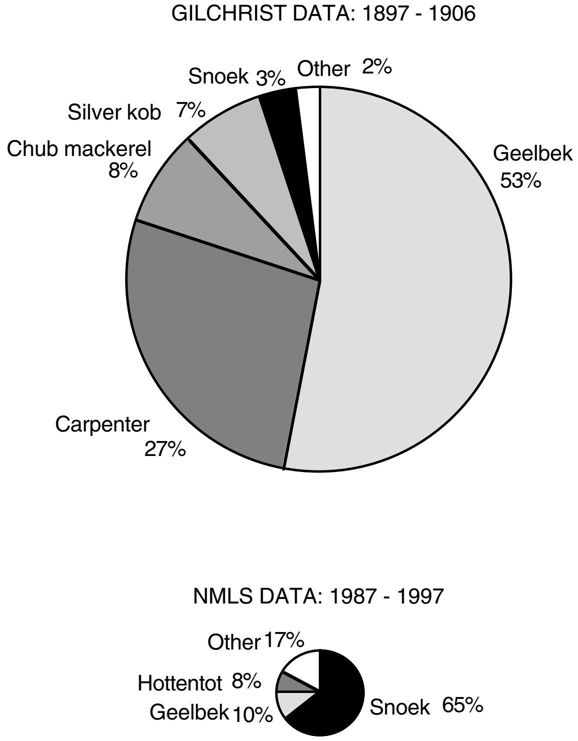

Fig. 6: Species composition of commercial linefish catches in Walker Bay for the years 1897–1906 (Gilchrist data) and 1987–1997 (NMLS data). The area of the pie is proportional to the average annual catch (by mass)

In the period 1897–1906, the total number of fishing vessels at Hermanus ranged between 10 and 15, although it was reported that those operational at any one time were half that quantity. Assuming this to be true, the total effort could be expressed as the product of the number of vessels and 15 days (half of a month) summed for all months. The estimated average effort during the decade was therefore approximately 2 268 boat-days·year^{-1}. The number of crew on these vessels ranged between 59 and 87 in total.

The catches included 17 species and were dominated by geelbek *Atractoscion aequidens*, carpenter *Argyrozona argyrozona*, silver kob and chub mackerel *Scomber japonicus* (Fig. 6). Other species that appeared erratically or in lower abundance included roman *Chrysoblephys laticeps*, seventyfour *Polysteganus undulosus*, snoek *Thyrsites atun*, hake *Merluccius capensis*, white stumpnose *Rhabdosargus globiceps* and white steenbras (Fig. 6). Annual landings

Table V: *Cpue* by species for the periods 1897–1906 in Walker Bay, 1987–1997 in Walker Bay and 1985–1996 from Cape Hangklip to Walker Bay. The % change is the increase in *cpue* in Walker Bay as a percentage of the earlier value

Species	Kg·angler-day^{-1}		% change	Kg·angler-day^{-1}
	Walker Bay			Cape Hangklip to Walker Bay
	1897–1906	1987–1997		1987–1997
Geelbek	53.72	2.17	-95.9	3.78
Silver kob	6.57	0.87	-86.7	0.81
White steenbras	0.07	0.00	-100.0	0.00
Carpenter	26.1	2.79	-89.3	1.81
White stumpnose	0.06	0.01	-83.3	0.02
Hottentot	0.14	2.32	1 557.0	3.74
Red stumpnose	0.03	0.04	31.0	0.04
Roman	0.21	0.72	242.8	0.77
Seventyfour	0.16	0.00	-100.0	0.00
Elf	0.02	0.01	-53.0	0.03
Yellowtail	0.35	0.61	74.2	0.06
Snoek	3.34	4.62	38.3	10.13
Chub mackerel	7.78	0.90	-88.4	1.18
Hake	0.37	0.58	56.7	0.27
Soupfin shark	0.00	2.84	100.0	1.01
All species	98.99	20.52	-79.2	22.64

of geelbek, carpenter, silver kob and chub mackerel were on average 656, 328, 98 and 86 tons respectively, and the total for all species was 1 231 tons per annum. The *cpue* of all species combined amounted to 99 kg. angler-day^{-1} for the decade 1897–1906 (Table V).

By the mid-1980s, the linefishery had changed in response to new technology, but fish were caught by the same basic method, namely single- or double-baited hooks on a synthetic line. Boats were motorized and consisted of two types:

(i) deck-boats, large vessels (>8 m) with inboard motors and long-range capacity, which are moored in harbours;
(ii) skiboats, small (4–8 m), fast vessels with outboard motors that can be trailered by road to any launch site.

The modern fleet was therefore considerably more mobile, on land and in water, than the vessels used 90 years earlier. These vessels also had a longer range than their predecessors.

Hermanus offers the only mooring and offloading site for deck-boats in the study area. Three small deck-boats, which operated as day vessels, fished in the survey area. The remaining deck-boats stayed out for many days at a time and fished outside the survey area over the Agulhas Bank on the South Coast. These vessels were not relevant to this survey. Skiboats were the most important component of the commercial linefishery within the study area. These launched at the (New) Hermanus, Hawston and Kleinmond harbours and at slipways at Betty's Bay and Cape Hangklip. The number of linefish boats counted at any one time was small, seldom exceeding five vessels in the entire area, and usually none, except during those periods when snoek were caught in abundance. In both years of the survey, the "snoek run" occurred during August and the number of skiboats that launched from the Hermanus, Hawston and Kleinmond harbours reached maxima of 42, 11 and 30 respectively. Less than half of the effort expended in Hermanus was by local vessels. The remainder originated from other registration areas as far afield as East London (1 080 km away) and Lambert's Bay (360 km away, Fig. 7), although the large majority originated from nearby towns. The average number of boat-days fished per month by the commercial fleet was 1 782, less than the number of days fished per month at the turn of the century. Recreational skiboat anglers would have contributed additional effort to the modern linefishing fleet, but the catch and effort of this sector was not reported. The recreational component is unlikely to have added substantially to the total catch, because their catches were restricted to recreational bag limits (5 or 10 fish per person per day), and the sale of fish by this sector was prohibited.

Reported linefish catches for the period 1987–1997 were considerably more diverse than in the earlier years. The modern-day catches were dominated by three species, snoek, geelbek and hottentot *Pachymetopon blochii*, with another 33 species (including elasmobranchs) accounting for 17% of the total catch in Walker Bay (Fig. 6). Reported landings give average annual total landed masses of 165, 26 and 20 tons for snoek, geelbek and hottentot respectively for the entire survey area. The reported total annual landed mass was 255 tons on average for the entire survey area, and 68 tons for Walker Bay alone (Fig. 6). The combined *cpue* for all species was 23 kg·angler-day^{-1} for the entire survey area.

The combined *cpue* of the latter period was approximately 25% of that of the earlier period (and only 20% if the Walker Bay data are considered alone, Table V). When comparing catches between the 1900s and the 1990s from the Walker Bay area only, the *cpue* data for individual species show large drops for most (geelbek, carpenter, silver kob, yellowtail *Seriola lalandi*, white stumpnose, red steenbras *Petrus rupestris*, seventyfour and chub mackerel), but increases in others (snoek, hottentot and Roman, Table V). Red steenbras

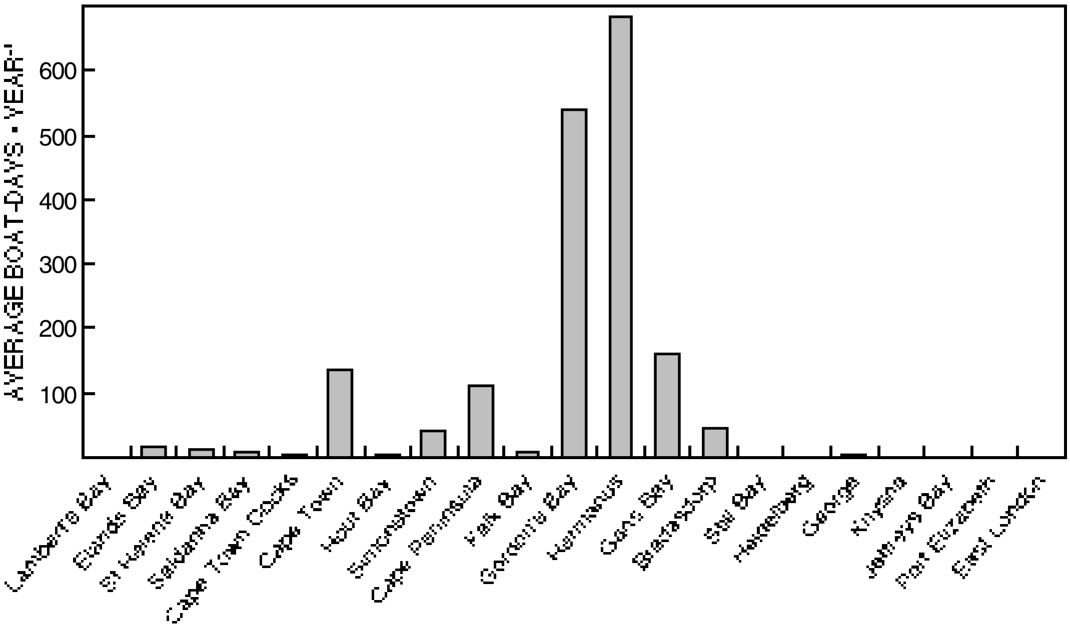

Fig. 7: Commercial linefish effort in Walker Bay by boat registration area, 1995–1997

and seventyfour were entirely absent from linefish catches in the latter period.

DISCUSSION

Fishery participation

The average amount of shore-angling effort in the southern Cape (Cape Point–Still Bay) was recently estimated at 1.29 angler-days·km^{-1} (Brouwer *et al*. 1997), similar to the value of 1.42 angler-days·km^{-1} estimated here for the survey area. The angler counts showed large temporal variation, some of which could be explained by season, but a general feature of the fisheries that were monitored was a great disparity between within-month and within-beat counts. The most intensely fished area had an average of almost 10 angler-days·km^{-1}. The high spatial variability in effort can be explained on the basis of habitat, access and proximity to high density residential areas. The shallow areas of mixed rock and surf were the most popular shore-angling areas, whereas the deep water and rocky headlands were seldom fished. The two most popular areas are adjacent to the town of Hermanus and the Betty's Bay and Cape Hangklip area. The former can be explained largely by its proximity to the town, whereas the latter is within close reach of anglers from the Cape Town metropolitan area. The H. F. Verwoerd Marine Reserve includes some areas that are popular among shore-anglers. Approximately half the anglers found in the survey area were visitors.

There was a poor correspondence between the areas that yielded high catch rates and areas that were popular among anglers. Any cause and effect relationship here is difficult to resolve, but it is likely that the catch rates in the popular areas were once high, but have now declined. In contrast, those areas where the catch rate was high have limited access, and hence are fished less intensely. The bulk of the Mudge Point Marine Protected Area is a 5 km stretch of coast, accessible only to pedestrians at either end, and the Sunny Seas area (Beat 17), which is largely restricted by the Kleinmond Coastal Reserve and private land ownership.

The amount of commercial linefishing effort at the turn of the century was greater than the modern-day effort, despite a larger fishing fleet and more mobile, motorized vessels in the latter period. The cause of this decline is most likely the worsening of fishing success. Currently, the commercial linefishery in the survey area consists almost entirely of skiboats. A number of vessels are registered within the area, but this total has no bearing on the number of vessels that operate commercially between Cape Hangklip and Walker Bay, as permit conditions do not restrict vessels to specific areas. During runs of fish, it is therefore common for large numbers of commercial vessels from throughout the South-Western Cape to be trailered by road to the slipways at Hermanus, Kleinmond and Cape Hangklip. It follows that the fleet is considerably more efficient at harvesting fish once they are located in harvestable quantities. The negative side of a mobile fleet is higher fishing mortalities and no incentive for local fishers to develop a sense of resource husbandry. Cooperation among a small community of fishers for the purpose of conserving stocks may be possible, provided that those from distant areas do not take advantage of any stock improvements that may result.

Shore-fishery catches

Prior to this survey, no study of the shore-angling fishery at Hermanus or Betty's Bay has been undertaken. The only other records of shore-angling catches are found in archives, historical accounts and popular angling books.

HISTORICAL INFORMATION

The books by Biden (1930), Horne (1955) and Schoeman (1978) were written for anglers. All three authors cover Hermanus; Horne (1955) and Schoeman (1978) discuss the angling possibilities along all sections of the South African coast in turn, whereas Biden (1930) mentions Hermanus in various places when discussing the capture of each species. Schoeman (1978) is the third edition of a book that was first published in 1957, and information quoted from this source originates prior to the first edition. All three books draw their experience from at least three decades prior to the publication date and therefore together span the period from 1900 to 1957. In addition, Burman (1989) gives an historical account of the town of Hermanus and surrounds, and makes reference to events related to commercial linefishing, dating from the late 1800s and rock-angling from about 1910.

Apart from serving as guides to angling in Cape waters, these above-mentioned authors present accounts of notable angling outings and related events. Several of the observations, including the size and species composition of catches, provide references for comparison of the status of the fish populations between the present and the earlier part of the 20th century. These descriptions are relevant to the present investigation, because they are the only accounts of a coastal ichthyofaunal community that is now severely depleted. All the authors reported that Hermanus was an outstanding shore-angling area, where consistently large catches of a variety of species were made.

This "angling paradise" has changed considerably. The survey revealed a *cpue* of 0.32 fish·angler-day^{-1} for Hermanus, substantially lower than the 1.55 fish·angler-day^{-1} of the remainder of the South-Western Cape (Brouwer *et al*. 1997). The historical authors present hundreds of observations that suggest that fish stocks were considerably larger than they are today, notwithstanding the difficulty of extracting quantitative information from discursive reports. Some species have vanished from catches altogether.

Six species that were described as regular catches by all those authors were not recorded in the shore-anglers' catches in the present survey. These include three reef-associated species, geelbek, red steenbras and red stumpnose *Chrysoblephus gibbiceps*, and three pelagic piscivores, katonkel *Sarda sarda*, tuna (species not specified) and yellowtail. Large catches of geelbek and red stumpnose were regularly taken from the rocky area between (Beats 6 and 8). Whereas catches of red steenbras may not have been plentiful, by comparison to other species, the fish were of enormous sizes, with reports and photographs of several fish over 45 kg (100 lbs). But it was apparent that the decline of this species was already observed at the time of their writing. "There was no explanation for their [red steenbras] mysterious absence, ..." (Horne 1955, p. 42). Biden (1930, p. 158) noted that "It is difficult to account for the present scarcity – the few hundreds as compared with thousands of twenty years ago –".

The disappearance of the pelagic piscivores is not the result of local shore-angling pressure, in view of the fact that they are migratory and that the bulk of the catches of these species have always been made from boats. Overfishing remains a very likely explanation for their disappearance, because all these species are direct targets of recreational and commercial fisheries. However, the effects of long-term change in oceanographic conditions and forage fish distributions can not be easily discounted.

Reports of individual angler's catches suggest that fish must have been, at least locally, very abundant. For example, Horne (1955) reported that, on one day in summer, the catch of kob and geelbek from the rocks in 1953 was an estimated 1 500 fish. This is more than three times the current total annual catch estimate of these species along the entire suvey area, of which Hermanus is only a part. The collapse of these stocks is also suggested by reductions in the commercial *cpue* and per-recruit assessments (Griffiths 1997b, in press). Likewise, elf catches were reported to exceed 800 fish in one day, with some anglers exceeding 100 for one day (Horne 1955).

Historical galjoen catches were also extraordinary large by today's standards. Past catches commonly exceeded 30 galjoen per angler-day (Biden 1930, Burman 1989). Horne (1955) recorded one angler's catch of seven large white steenbras, 45 galjoen and five white musselcrackers in one day. However, these reported large catches are consistent with maximum daily catches taken by experimental anglers as part of a research programme in the 50 km De Hoop Marine Protected Area, which has been protected from all forms of fishing-related mortality since 1984 (Bennett and Attwood 1991, 1993, CGA unpublished data). These temporal and spatial comparisons suggest that all the reef-associated fish species in the Hermanus area have been depleted as a result of fishing pressure over the course of this century.

Commercial linefish statistics

The comparison of linefish catch data from Hermanus between the 1900s and the 1990s is presented here as evidence of major changes in the ichthyofauna of the region. The total landed mass in the decade 1987–1997 was 5.5% of the landed mass during the decade 1897–1906 for Walker Bay. Taken at face value, such a statistic suggests a complete fishery collapse when it is considered that the modern fleet is larger, more mobile and more able to locate fish. However, there is some concern over the accuracy of the data captured on the NMLS, concerns related to the habit of fishers to submit false returns, either under-reported or over-reported. Most catch masses are estimated by fishers, usually without catches being weighed. The NMLS was primarily designed to provide indices of catch and effort, to monitor major trends in the fishery, and to quantify the relative contribution by the various sectors to these trends (Penney 1997). The problem stems from the system, which requires fishers to submit their own statistics. A decision has been taken recently to alter the data collection procedure in favour of a scientific observer programme (Penney 1997), which is the system that Gilchrist used a century ago. Attempts have been made to validate the NMLS data, in response to criticisms concerning its accuracy. From these comparisons, the data on the NMLS appear to correctly reflect major trends in the fishery (Penney 1997). Most inaccuracies stem from incomplete submissions, and it is accepted that under-reporting has occurred. Nonetheless, these errors are likely to have had a greater effect on the accuracy of the total landings than on the *cpue* or catch composition data. These latter sources therefore should be used to estimate changes in fish abundance.

Cpue rates may be used as a relative measure of fish abundance (Gulland 1983), provided that the technique used for capture remains consistent. This has not been the case in the South African linefishery. Steady improvements in fishing gear, navigation and fish finding have made it considerably easier to catch fish, although the effect has never been quantified. Long-term *cpue* trends are therefore likely to overestimate the trends in population size. The species composition of catches should reflect broadly the changes in relative abundance, provided that the relative market value of the species has not altered substantially.

The *cpue* rates of most species were lower in the second period (1987–1997) than in the decade 80 years earlier, but for a few the rate was higher. There is no information to indicate the trends in the intervening years. It is typical for fisheries to go through a boom and bust cycle. The two windows that we have for the Hermanus linefishery are 80 years apart, and miss the most important period in the growth of the fishing industry. For those fisheries that are suspected to be overexploited, the boom (maximum total catch) might have occurred in this intervening period.

CPUE RATES THAT WERE HIGHER IN THE FIRST PERIOD

At least three separate populations of silver kob are found off the South African coast: in the Eastern Cape, the Southern Cape and the South-Western Cape (Griffiths 1996b, 1997a). The latter stock includes the fish found within the study area. The fishing pressure on the population of silver kob has been so great that the spawner-biomass-per-recruit was reduced to between 4.4 and 10.4% of the original unfished level (Griffiths 1997b). A commonly accepted threshold reference point for linefish species is a spawner-biomass ratio of 25% (Griffiths 1997c), which classes silver kob as a collapsed population. The comparison of the catch rate of this species and the catch composition between the two periods suggest that a collapse has indeed occurred in this region. The recent catch rates were approximately 10% of the original rates, despite technological advances.

In contrast, geelbek exist as a single stock, which is separated geographically by age (Griffiths and Hecht 1995). Spawning occurs on the East Coast, whereas subadults (1–4 years) are found in the South-Western Cape. The Gilchrist records report that the average size of geelbek in the catches of the South-Western Cape was 8 lbs (or 3.6 kg), equivalent to a fish 3–4 years old. The stock has been shown to be overexploited, with a spawner-biomass per recruit ratio of <10% of the unfished value (Griffiths in press, Hutton *et al*. in prep.). Similar to silver kob, the geelbek population appears to have collapsed, on the basis of *cpue* data and species composition. Geelbek was once the major contributor to the linefishery in Hermanus, but catch rates have now dropped to <10% of the original rate.

Another piscivorous species, the carpenter, has shown a similar trend to that of geelbek. They are strongly shoaling fish that form aggregations over reefs. Carpenter were the mainstay of winter catches, being caught on the rocky banks west of Hermanus (Beats 7) and contributed 27% to the total annual catch from Hermanus. The *cpue* has dropped to 10% of the original rate, and their contribution to the total catch is now only 2.2% of the original catch. The stock structure of this species is not known, although it is highly likely that it constitutes a metapopulation with a number of fairly isolated populations or subpopulations. If so, the population in this study area appears to have collapsed.

Catch rates of chub mackerel have also declined by an order of magnitude. The cause for the decline may be entirely natural, because elsewhere the species varies widely in abundance as population growth parameters vary greatly to cause potentially large synergistic effects (Parrish and Mallicoate 1983). However, the effect of the large catches that were made around the turn of the century cannot be ignored and it is equally likely that chub mackerel have succumbed to fishing pressure. Following the early linefish catches, chub mackerel were subsequently caught by purse-seiners, whose catches of this species peaked in 1967 and has since never recovered (Crawford *et al*. 1987). Seventyfour were once caught at Hermanus in appreciable quantities, but they are now a rarity everywhere, following the overexploitation of spawning aggregations on the eastern Agulhas Bank in the 1960s. The red steenbras population has collapsed (Griffiths 1997c), and they are not caught by either shore or commercial fishers at Hermanus. White stumpnose catches declined in the early 1900s as a result of a combination of linefishing, beach-seine netting and trawling (C. G. Wilke, MCM, pers. comm). Although their population is naturally highly variable, the massive catches of white stumpnose in the past have disappeared throughout their range.

No comparative early data exist for the remainder of the study area (i.e. Beats 8–20). The contemporary data for the entire area, however, show very similar catch rates to those from Walker Bay alone, and suggest that the changes that occurred in Walker Bay have been widespread along the entire region.

CPUE RATES THAT WERE HIGHER IN THE SECOND PERIOD

The most notable of these is the snoek fishery, which is now the most important linefish species in South Africa in terms of landed mass and total value. The snoek fishery appears to be more resilient than others, which may be attributed to a combination of it being short-lived and early maturing, and a stock distribution that makes it largely inaccessible to linefish boats, except at certain times. The improvement in *cpue* of snoek is therefore likely to reflect a shift away from the more valuable species that appear to have collapsed, rather than an indication of stock-size increase.

Catch rates of roman and red stumpnose were marginally higher in recent years. Their scarcity in the early catches could be explained by the fact that they were not as valuable or as abundant as geelbek or carpenter. From available linefish statistics it is difficult to assess their stock status in the Hermanus area, but elsewhere in the Southern Cape the roman fishery has exhibited signs of heavy exploitation (Buxton and Smale 1989). Roman are long-lived, protogynous hermaphrodites that are vulnerable to overexploitation (Buxton 1996). Very little is known about red stumpnose, despite its importance in the linefishery.

Hottentot is an abundant, low-value species that was caught in low numbers at the turn of the century, but now accounts for the second largest contribution in terms of mass to the catches in Walker Bay. Catch rates of this species in the decade that NMLS data are available have declined consistently, which indicates that this species too has been overexploited.

Another low-value species that was ignored in the past, but that is now being targeted, is soupfin shark *Galeorhinus galeus*. The shark fishery started in the 1930s and grew rapidly to meet demand, largely in the oil (vitamin A) markets. In the late 1930s, the annual harvest of soupfin shark from the South-Western Cape was 5 000 tons (Sea Fisheries Research Institute 1996). The average annual combined catch from longline, linefish and trawl fisheries between 1989 and 1993 was only ± 600 tons (Kroese *et al*. 1995). This change may be attributable to market shifts (the soupfin shark market is now used entirely for protein rather than oil), but it may also reflect a dramatic decrease in abundance. Soupfin sharks are vulnerable to overfishing, because of their slow growth, late maturity and complex social structures (Stevens *et al*. 1997).

Marine ecosystem change

Evidence is presented here to show that there has been a substantial change in the fish community structure in the study area since the early 1900s. It is considered that the decline in catch rates and abundances of targeted species is a result of overfishing, although alternative explanations could include changes in the oceanographic environment, forage-fish regime shifts and changes in predator populations.

There is some evidence to support the hypothesis that the oceanographic environment of the South-Western Cape has been in the process of long-term change. Climate records show that the equatorward wind stress has increased since 1950 (Taunton-Clark and Shannon 1988, Shannon *et al*. 1992). Although the sea surface temperature in all areas showed a slight increase between 1920 and 1980, it is likely that the increased equatorward wind stress would have reduced the sea temperatures close inshore, where the effects of upwelling are manifest. Crawford and Crous (1982) suggested that cooling of inshore waters may explain the change in catch composition of red-fish (Sparidae) along the Southern Cape coast, but the temperature data are too variable seasonally to confirm such a trend. Further evidence in favour of an oceanographic shift is the increase in rock lobster *Jasus lalandii* along the Cape south coast, which is thought to be a result of an eastward migration (Tarr *et al*. 1996, Mayfield 1998). This shift in the rock lobster distribution could not with certainty be attributed to a change in any physical variable.

Another possible cause of change in the populations of linefish species is the variations in abundance of pelagic fish such as sardine *Sardinops sagax* and anchovy *Engraulis capensis*, which are important in the diet of piscivorous linefish. Sardine and anchovy have formed the basis of a large pelagic fishery that has exhibited marked declines and dominance shifts in the two populations at various periods over the last century (Crawford *et al*. 1987). In addition, the population size of an important piscivorous predator, the Cape fur seal *Arctocephalus pusillus*, was reduced to very low levels at the turn of the last century, following its extensive exploition (Shaughnessy 1984). The effect of this perturbation on linefish species, either directly or indirectly through the foodweb, is unknown.

The arguments for overfishing are:

(i) There has been a removal of a massive biomass of piscivorous and shellfish-feeding predators by fishers over the course of the century. For the longest part of the history of the fishery, entry into the fishery was unrestricted and catches were totally unchecked.
(ii) If environmental change were the responsible factor, fish distributions would have shifted, as it has for rock lobster (Tarr et al. 1996, Mayfield 1998), but instead those species that have declined in abundance appear to have declined everywhere.
(iii) Overall, catch rates have fallen dramatically, rather than there being a replacement of one species by another.

The change in community structure may have caused further changes in the ecosystem that are not directly related to fishing. There is currently no means of assessing the impact of such a change on the marine ecosystem as a whole, and specifically on the capacity of the community to recover should measures be taken to achieve such a goal. Nonetheless, the impacts are likely to be profound, judging from the experiences of other fisheries (Norse 1993, National Research Council 1995, Jennings and Kaiser 1998).

Evaluation of coastal fishery management

The declines in fish abundance in the survey area may be explained as recruitment overfishing in many cases. Spawner-biomass-per-recruit indices are markedly depressed for most targeted linefish species (Griffiths 1997c). For those species with a limited dispersal capacity, local depletion of the spawning fish would have led to a local stock collapse. Examples of these include silver kob, galjoen and blacktail. For other species with a single stock that aggregates during spawning, a spawner-stock depletion would have been the result of excessive harvesting rates throughout the range and not in just one area. Examples of these include geelbek, red steenbras, yellowtail and elf. Growth overfishing may also play a role in depressing yields. Where recruit-strength is determined (partially) by the total stock size, local fishing pressure may prevent the recruits from attaining an age that corresponds to optimal yields. The primary reason for overfishing is ineffective management and control, and in some cases the biology and dynamics of fish populations have been poorly understood, leading to ineffective management.

The major difficulty with the shore fishery is the continuous increase in the number of anglers that cannot be limited without removing the general right to recreational marine exploitation. The growth in effort was estimated at 6% by Van der Elst (1989), but the restrictions on catches have not compensated accordingly. A further problem with shore-angling is the attitude of the anglers themselves. A substantial number of anglers admit to breaking certain regulations, whereas an even larger fraction has an incomplete knowledge of the regulations. These results were substantiated by the creel census, which revealed many illegal catches. The failure to respect fishery legislation may be explained partially by the anglers' assessment of the fishery. A minority did not suspect that catches had declined at all, possibly because the declines in fish catches occurred over time periods that were longer than their personal experience with the fishery. Of those who did realize that a change had occurred, few suggested shore-angling as a contributing factor.

The size of the commercial linefishing fleet was frozen at the 1985 level, but this action came too late because overexploitation can be attributed to small fleets that operated many decades prior to today. Moreover, since 1985 many single boat licences have been split to enter two smaller vessels in place of one large one, which has had the effect of increasing effort. The effort cap also did not account for the effect of technological advances. The problem of skiboat mobility was likely to have added to the fishing mortality in any one region. The size of the recreational fleet was not limited and grew steadily, although recreational fishers were subjected to bag- and size-limit restrictions. The linefishery management system is still not capable of controlling the size of the catch directly.

CONCLUSIONS

A century of fishing has substantially reduced the abundances of a number of teleost species between Cape Hangklip and Walker Bay. Fishing success has declined markedly and the linefishery (commercial and recreational) has shifted from high-value species to short-lived and less valuable species. The collapse can be attributed to poor control of effort and catches. In terms of accepted objectives for the linefishery (Penney 1997), stock rebuilding strategies should be applied in an attempt to restore the fisheries of this once productive area.

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